MEASURES FOR PREVENENTING DROPPING SNOW FROM ROAD ACCESSORIES ON EXPRESSWAYS

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ABSTRUCT

Japan's latitude is similar to that of the Mediterranean, but heavy snowfalls are frequently observed on the Sea of Japan side. This is because a huge amount of water vapor from the Sea of Japan supplied to the seasonal winds from the Siberian continent, then interrupted by a mountain range about 2,000 m.

Service area of Nexco Maintenance Tohoku Co. ("NMT", hereafter) covers northern Japan with average annual snowfall of 7 m, countermeasures against snow and ice disasters are of crucial importance. Specifically, lumps of snow attached to road accessories hanging over the road may fall and damage vehicles, so prompt removal of such snow required.

Removal of such lumps of snow is usually carried out manually by closing part of the lanes. In winter season, however, road work faces difficulties in realizing good performance because the heavy snowfall requires frequent traffic control thus limits the work.

To cope with such a situation, NMT has investigated effective methods to reduce accretions of snow on road accessories hanging over roads. The first method involves countermeasures applied to the gantry sign beam materials. The second countermeasure is to utilize banners installed in the balustrade part of over-bridges to alert drivers. This countermeasure saves on snow removing costs with successful results.

1. INTRODCUTION

"Tohoku" is the region which is characterized with heavy snowfall in Japan. This is caused by snow clouds that form from the large amounts of water vapor coming from the surface of the Sea of Japan blown over Tohoku due to the seasonal winds from Siberia. In addition, a

backbone mountains running through the middle of the region with a maximum height 2,000m above sea-level and the mountains blocks the snow clouds causes such heavy snowfall in Tohoku region. Though the Tohoku region is a heavy snowfall area, latitude is rather low and average temperature is not so cold enough, thus the snow covering road melts during the day and, more worse, often freezes at night. Maintenance work need not only to remove snow on the road, but also to manage snow adhered to traffic /road signs and over-crossing bridges. The adhered snow to such accessories and bridges sometimes accumulates and falls on the road traffic, therefore careful attention must be paid. This paper reports the methods for countering problems against such situations and validations for these methods.

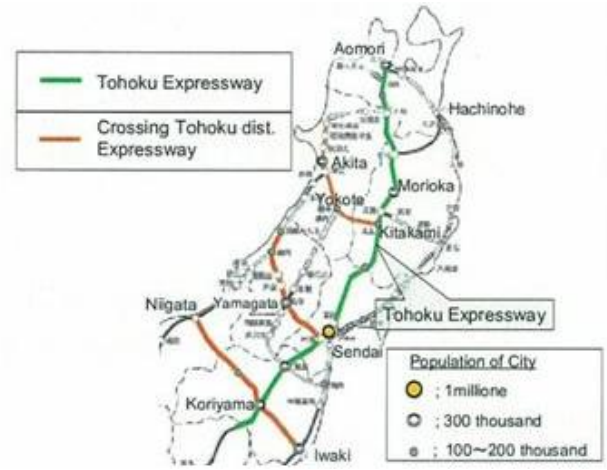

Fig. 1: Operating Are of NMT

2. MANAGEMENT CONDITIONS

Nexco Maintenance Tohoku ("NMT" hereafter) is a company for maintenance and rehabilitation of expressways all over the Tohoku region. The total expressway length covered by NMT over 1300km, and approximately 80% of this area of which is made up of snowy cold regions (Fig.1).


Photo 1: Snow Removal Work in Tohoku

The annual cumulative snow accumulates to 8m in average in winter and reach to max. of 22m. Therefore, the work for controlling snow/ice is quite important issue on NMT's operations. Snow control work of NMT includes 400,000km of snow removal covering road and 600,000km of spreading anti-icing material in total every year. NMT carries out such work during and after snowfall day and night. The works are often in bad conditions, such as blizzards caused by wind and snow (Photo 1). Furthermore, since the NMT's works are always carried out on expressways in close proximity to high speed vehicles, therefore a lot of labor is working beside high risks during work. Hence, NMT reviews working condition daily to ensure the performance of works in a safe manner that suits the weather conditions.

3. PROBLEM WITH OPERATIONS TO CONTROL SNOW AND ICE

There are various structures installed on expressways such as gate type posts with traffic/roads signs made from round steel tubes, and over-bridges for roads overpass the expressways. In winter, snow


Photo 2: Snow Accumulated on Road-sign Post

accumulated and formed lumps of snow during snowfall to road accessories such as beam members of gate-post for road signs and on side-wall of bridges over the expressways (Photo 2). When these lumps of snow fall, they may cause damage to high speed travelling vehicles and also might lead severe accidents once vehicles swerving to avoid them. It is therefore necessary to observe the snow accretion situation carefully through visual checks through daily check as well as while snow removal works and to take the appropriate actions to remove lumps of snow when observed.

3-1. Snow accretion on gate post for road signs

Snow accretion occurs on the top of gate type post of road signs. Currently, snow is removed from the post manually using an extendable pole (Photo 3). The problem with this work is that the worker conducts the work while standing under the gate post and takes significant time. There is also a concern that snow may slide and fall onto the worker and may cause an accident. Further, because work is carried out with lane regulations in place on the expressway, work is limited to keep traffic safe, avoiding snow fallen on the road surface or causing poor driving visibility. It is difficult to carry out work properly.

Photo 3: Snow Removal Work for Preventing Snow Drop

3-2. Snow accretion of road accessories

Lumps of snow due to snow accretion on side-wall of bridges and overpasses are generally removed from the ordinary roads. The removal of the lumps of snow by knocking the snow on to the expressway from the ordinary road using a shovel or extendable pole and then removing the snow to the shoulder of the road (Photo 4). In many cases, barriers are installed preventing material fall to expressways beneath the bridge and it is necessary to climb up on top of them for removal work of lumps of snow. The problem with this method is that it is necessary to work on an unstable footing creating a risk of falling. Further, in some locations ordinary roads are closed during winter and snow removal work cannot be carried out, therefore certain locations cannot be reached using ordinary roads. In this case, the snow is dealt with in the same way as with the aforementioned gate post of road signs whereby lane regulations needs to put in place, then snow is removed manually from beneath

Photo 4: Snow removal Work for Preventing Accumulated snow falling from Over-bridges

the bridge. This method raises the concern that snow may fall on to the worker, may cause accidents and the work cannot be carried out properly.

4. EFFORTS TO PREVENT SNOW DROPPING

In order to solve the aforementioned problems, NMT concerted our efforts on developing methods of effectively reducing snow accretion on road accessories above the road using relatively simple measures. We came up with three measures that could prevent snow from dropping and studied the results according to the circumstances for each measure.

(1) Snow accretion prevention method
Develop structures to which snow does not adhere easily (shape change) and change to materials to which snow does not adhere easily (property change)

(2) Snow accretion removal method
Manual, forcible removal or removal by melting the snow using a heater, etc.

(3) Method to prevent dropping of snow
Prevent snow accretion from dropping or allow the snow to drop in amounts that will not cause damage. (Nets to prevent snow from dropping, etc.)

4-1. Measures for beam members of gate type road signs

We studied the measures to prevent dropping of snow for beam members of gate type road signs.

(1) Changing the shape of beam members of gate post
(snow accretion prevention method)
We studied modified shape of the beam members to prevent snow adhering to the road signs and added a delta-shaped inclined panel to the round steel tube beam members.

(2) Property change to gate type road sign beam members
(snow accretion prevention method)
We also conducted a study relating to property change. The top of the round steel tube member was coated with water-shedding paint with the hope of achieving two effects. First, the moisture would be repelled causing the snow accretion to fall. Second, adhesion of dust and dirt would be reduced, thereby reducing the surface area available for the snow to adhere to the beam member and reducing frictional force, causing the snow accretion to fall. The water-shedding paint used was the polyurethane resin paint, MISTERON, which has superior water resistance, sea water resistance and shock resistance. Misteron paint is lightweight with high thermal insulation properties. By applying a thick coating of it to Styrofoam, which is easy to process,

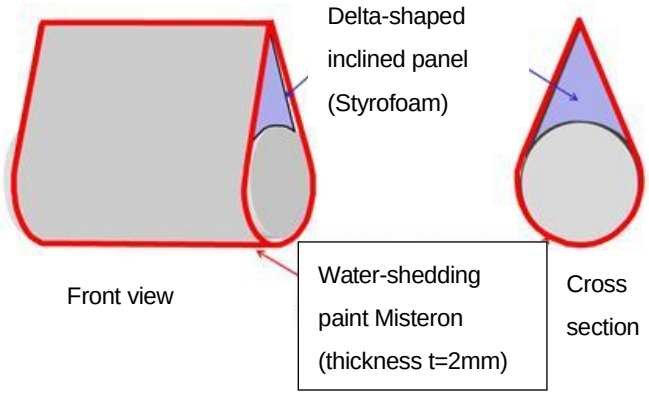

Fig.2: Property change to beam member

it is possible to integrate the Styrofoam and the gate type road sign round steel tube using the adhesiveness and tensile strength characteristics of this paint without the need for fixing with bands or bolts. This material does not contain solvents and is not harmful to the environment.

(3) Removal of snow from gate type road sign beam members by melting (snow accretion removal method)

We studied the effect of removing the snow by melting, anticipating that by using Styrofoam, which has high thermal insulating properties and is lightweight, as the material for the inclined panel, we could prevent a drop in the temperature of the contact area between the material and the snow making adhesion difficult.

4-1-1. *Experimental installation*

Based on the above considerations, experimental installation was conducted by preparing three test pieces for which the shape conditions were changed. The first test piece was a round steel tube beam member to which water-shedding paint was directly applied. The second test piece was a delta-shaped inclined panel attached and to which water-shedding paint was applied. The third test piece was a round steel tube beam member with a delta-shaped inclined panel with a sharper incline of 67.5° attached and to which water-shedding paint was applied (Fig.2). The three test pieces were installed on controlled premises and filmed using a camera and the accretion of snow and falling snow were observed.

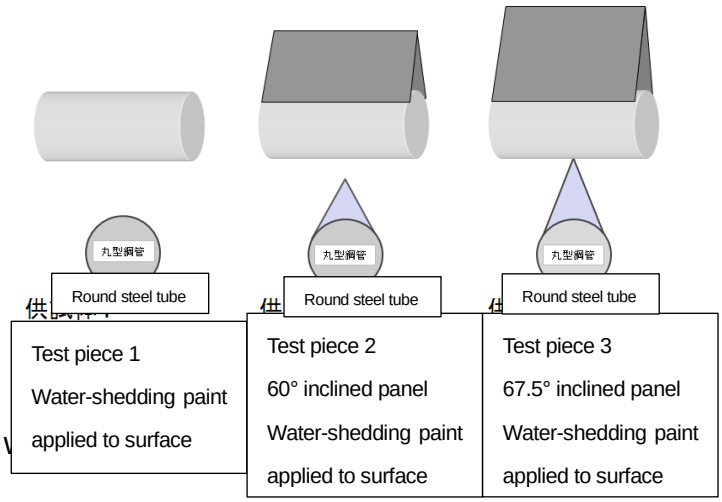

Fig.2: Experimental installation

4-1-2. *Results of the experimental construction*

According to the experimental construction results and camera images, there were 15 occurrences of snow accretion. With regards to the test piece without an inclined panel, it was verified that snow accretion continued for six hours from sunrise and it remained likely that lumps of snow would develop. With regards to the two test pieces with an inclined panel, it was verified that there was snow falling from the post with little snow accretion and that the effectiveness of the snow accretion prevention methods was clear. Moreover, in the case of the test piece with the delta-shaped inclined panel with a sharp


Photo 5.: Test construction conditions

incline of 67.5°, we verified that the amount of snow accretion was little due to the steep incline. Lumps of snow that formed fell to the ground early in the morning due to solar radiation, because of the heat insulation effect of the Styrofoam (Photo 5).

4-1-3. *Structural problems*

Before installing new structures to existing structures, it is necessary to check whether there are any structural problems. Therefore, structural calculations were redone based on the “Standards for Road Sign Installation” and “Specifications for Highway Bridges” by the Japan Road Association with the new panel installed. As a result, it was found that there were no structural problems even when the 67.5° delta-shaped inclined panel was installed.

4-1-4. *Actual construction*

We installed a 67.5° delta-shaped inclined panel to an existing gate type road sign. The construction procedure and construction costs for the actual construction are detailed below.

（1） Surface preparation … 150,000 yen ($1,500, ¥100=1US$)

（2） Lining … 480,000 yen ($4,800)

（3） Delta-shaped foam body installation … 880,000 yen ($8,800)

4-1-5. *Progress report*

We conducted a progress report after one year had passed since construction. In the locations where actual construction had taken place, there were no cases of snow removal work conducted manually in the conventional way. We will continue to monitor progress in the future, because accumulation of dust and dirt may increase due to deterioration of the water-shedding paint. This may lead to the increase in frictional force and increase in the surface area available for the snow and the beam member to adhere. As a result, dropping off of snow would be less likely.

4-1-6. *Cost comparison*

Cost comparisons were made between the work for installing the delta-shaped inclined panel and the conventional work done to prevent dropping off of snow (Table-1). When the costs were compared, the cost of installing a delta-shaped panel in one location amounted to ¥1,510,000. An estimated calculation of the cost of the conventional work, including the implementation of lane regulation on expressways, amounted to ¥904,500. When the two methods are compared, installing a delta-shaped inclined panel is approximately 1.7 times more expensive. However, we found that because work to prevent dropping off of snow was

not required from the second year, implementing the measure of installing the delta-shaped inclined panel actually proved less expensive from the second year onward.

4-1-7. *Future challenges*

We verified the validity of this measure to prevent dropping of snow for gate type road signs through an experimental construction. It was verified, from the results for the actual construction, that the snow dropped at a stage when there was little snow accretion, similar to what happened with the test piece. This measure enabled a reduction in the number of occasions of manual labor to prevent snow from dropping and also ensured the safety of workers. Further, we also found that, from a cost perspective, this method was less expensive than the conventional work that would be needed, spanned over several years. However, for lattice sections of gate type road signs and locations in which an inclined panel cannot be installed because of an inspection road that runs along the top, we obviously needed a new measure.

	Year 1	Year 2	Year 3
Conventional work	¥904,500 =¥60,300 (actual figures for work to prevent snow from dropping) @ 15 times (actual figures for snow accretion)	¥1,809,000	¥2,713,500
Delta-shaped inclined panel installation	¥1,510,000 =¥150,000 (surface preparation) + ¥480,000 (lining) +¥880,000 (delta-shaped foamed body installation)	¥1,510,000	¥1,510,000

Table-1. Comparison of delta-shaped inclined panel and conventional work

Furthermore, the method installed this time may not be effective in all areas, since the snow quality, solar radiation time and weather conditions vary significantly in the Tohoku region depending on the area. Specifically, with regards to snow quality, in areas where there is a lot of snow with high moisture content, it is likely that, depending on the amount of snowfall, the snow will not drop in time and lumps of snow will form. Therefore, it is necessary to verify the validity of this measure for each area by experimental construction prior to installation.

4-2. Measures for gate type road signs with lattice sections

We studied measures for gate type road signs with lattice sections, which were highlighted as an issue when carrying out the aforementioned work to prevent snow from dropping on gate type road signs.

(1) Forcible removal of snow by installing a snow removal device to the gate type road sign (snow accretion removal method)

We installed a movable brush to the road sign and forcibly removed the snow accretion by moving the brush using a winch and rail.

Photo 6: Installation conditions for Snow Clearing Device

4-2-1. *Experimental construction*

A rail parallel to the beam was installed at the center of the beam of the lattice section and then a pulley with a brush attached was installed. The pulley was fixed with a wire, like a cable car, and a hand-operated winch installed, so that the brush can move in both directions parallel to the beam. The winch was installed to the supporting column of the gate type road sign to enable manual operation (photo 6). Galvanized steel was used and a movable plate was attached to the base of the brush to allow it to ride over the beam joining sections.

4-2-2. *Results of experimental construction*

The results of the experimental construction showed that there was no change in the frequency of the work to prevent snow from dropping was conducted. However, because the winch was attached to the support column and work could be conducted from the shoulder of the road, work safety was improved, since no work had to be conducted on the roads. Further, the work time required was approximately halved and the number of workers required was also reduced (Table 2).

Item	No. of workers	Time required	Lane regulations
Conventional work	3	60 minutes	In place
Work by snow-clearing machine	2	30 minutes	None

Table-2. Chart comparing the work by a snow-clearing machine and conventional work

4-2-3. *Cost comparison*

We conducted a cost comparison of the installation costs for the snow-clearing machine and the annual cost of work to prevent snow from dropping (Table-3). The cost of installing a snow-clearing machine amounted to ¥341,450 per machine. After installation, use of the snow-clearing machine to remove snow also costs money. In comparison, we conducted an estimated calculation of the cost of the annual work to prevent snow from dropping, including the implementation of lane regulation on expressways, which amounted to ¥904,500. As a result, we found that the operating cost of installing a snow-clearing machine was less expensive.

	Year 1	Year 2	Year 3
Conventional	¥904,500	¥1,809,000	¥2,713,500

work	=¥60,300 (actual figures for work to prevent snow from dropping) @ 15 times (actual figures for snow accretion)		
Snow-clearing machine installation	¥341,450 =¥96,450 yen (material cost) +¥200,000 (installation cost) +¥3,000 (operating cost of snow-clearing machine) @ 15 times (actual figures for snow accretion)	¥386,450 =¥341,450 (first-year expense) +¥45,000 (annual operating cost for snow-clearing machine)	¥411,450 =¥386,450 + ¥45,000

Table-3. Cost comparison chart for a snow-clearing machine and conventional work

4-2-4. *Future challenges*

By installing a snow-clearing machine we were able to improve work safety compared to the conventional work method and also reduce the number of workers required. We also found that installing a snow-clearing machine was less expensive from a cost perspective. Future challenges include the need to design snow-clearing machines specific to particular gate type road signs, because gate type road signs with lattice sections vary slightly in shape and dimensions depending on the location. Another challenge is that time is required to install the machine and to repair the machines when they break down because the replacement parts are not in mass production. During this time of repair, conventional work will have to be carried out.

5-3. Measures for wall balustrades of bridges and overpasses

We studied the measures to prevent snow from dropping for wall balustrades of bridges and overpasses. We concluded that the financial burden of modifications to the structure itself would be significant and therefore we studied methods that did not involve modifications to the structure itself.

(1) Shape change to wall balustrades of bridges and overpasses
(snow accretion prevention method)
We studied a method in which the bridge side-wall is slanted so that the snow accretion drops before lumps of snow

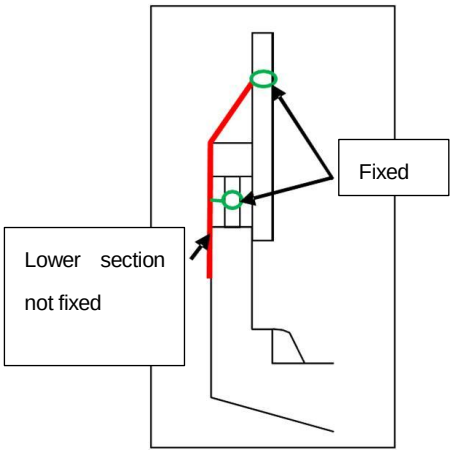

Fig. 3 Diagram showing installation of the horizontal banner

accumulate. A horizontal banner was installed to the drop prevention barrier, which is installed on the overpass to create a slant in the section to which snow adheres.

(2) Property change to side-wall of bridges and overpasses (snow accretion prevention method)

The frictional force that acts upon concrete surfaces is significant. Therefore, we studied the changing material of the section to which snow adheres with the goal to make it easy for snow to drop. To do so, we changed the material of the snow accretion section by installing a horizontal banner made by enclosing polyester fibers in synthetic resin and reduced the frictional force.

(3) Forcible removal (snow accretion removal method)

We studied a method that enabled the forcible removal of snow accretion. To do so, the upper section of the horizontal banner was only fixed and was installed so that it covered the railings. We anticipated that the flapping of the lower part of the banner would create vibration, which would promote regular dropping of snow.

4-3-1. *Experimental installation*

For the experimental trial, we decided to install horizontal banners to three bridges. We fixed the horizontal banners to the wall balustrades installed on the bridges and to the guard nets using rope. We did not fix the lower part of the banner to allow it to flap in the wind (Fig.3). For the purpose of comparing snow accretion conditions, in this experimental trial we installed the banner to approximately half of the bridge and left the other half of the bridge in its original state. Under these circumstances, we conducted a progress report and verified the effectiveness of the measure. The installation procedure and construction costs were as follows.

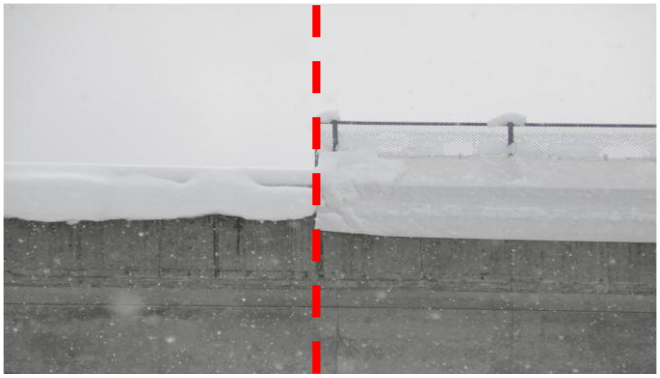

Photo 7. Snow accretion conditions in a location with a horizontal banner installed

（1） Cost of installing the horizontal banner … ¥33,000

（2） Material costs … ¥268,000

4-3-2. *Progress report*

Following installation, we conducted regular checks of the snow accretion conditions during rounds. We found that when compared to the section to which a banner had not been installed, the snow accretion in the section with the banner installed was dropping before lumps of snow formed (Photo 7). Further, we also compared the number of occasions of work and number of working days required for work to prevent snow from

dropping for the section with a banner installed with before the banner was installed (Table-4). The results of a comparison of work over the period of one year showed that seven days less work per year and 14 occasions less per year were required compared to before the installation of the banner. If we focus on the number of occasions of work required after installation, we find that it is one occasion of work to prevent dropping of snow per year after installation of the horizontal banner and almost all of the remaining occasions are for bridges without banners installed. The one occasion that work to prevent dropping of snow was required was on a day when there continued to be light wind conditions or no wind at all.

	Before installation					After installation				
Month	Dec.	Jan.	Feb.	March	Total	Dec.	Jan.	Feb.	March	Total
Working days (days)	7	16	8	2	33	8	15 (1)	3	0	26
No. of occasions of work (no. of times)	7	20	11	2	40	8	15 (1)	3	0	26

Table-4. Comparison chart for work to prevent dropping of snow *Number in (): Times for sections to which a banner is installed

4-3-3. *Cost comparison*

We conducted a cost comparison of the installation costs for installing the horizontal banner and the annual cost of work to prevent snow from dropping (Table-5). The cost of installing a horizontal banner amounted to ¥309,400 per bridge. This value is including the cost of purchasing materials, but because in practice horizontal banners previously used for advertising would be reused, this figure would be lower since material costs would not be required. In comparison, we conducted a calculation of the cost of the annual work to prevent snow from dropping assuming that the work time required for each bridge is one hour. This amounted to ¥218,400.

Item	First year	Following year
Horizontal banner installation	¥309,400 =¥268,000 (material costs) +¥33,000 (installation costs) +¥8,400 (actual figure for work to prevent snow from dropping)	¥41,400 =¥33,000 (Installation cost) +¥8,400 (actual figure for work to prevent snow from dropping)
Work to prevent snow from dropping (manual)	¥218,400 =¥ 8,400 /hr (labor costs) @ 26 days (actual figure)	¥218,400 (same as the first year)

Table-5. Cost table by work

In the first year, the material costs of the horizontal banner are included and therefore the

horizontal banner installation work is more expensive. However, when the banner has been used for more than 1 year (Table-5), the cost of conventional work to prevent snow from dropping is greater than the cost of the installation work for the horizontal banner from the second year onwards. By the fourth year, the cost of horizontal banner installation work would be less than half that of the cost of work to prevent snow from dropping.

Item	Year 1	Year 2	Year 3	Year 4	Year 5
Horizontal banner installation	¥309,400	¥350,800	¥392,200	¥433,600	¥475,000
Work to prevent snow from dropping (manual)	¥218,400	¥436,800	¥655,200	¥873,600	¥1,092,000

Table-5. Cost comparison over several years

4-3-4. *Development to other locations*

As a result of conducting the test construction, because we were able to verify an improvement in safety and that the cost was less than that of conventional work, we developed the measure to prevent snow from dropping using a horizontal banner horizontally within the company and installed the banners in a total of 26 locations. As a result of installing the horizontal banners, we reduced the number of occasions of work required to prevent snow from dropping by approximately 30%.

4-3-5. *Future challenges*

We were able to verify the validity of this measure through a experimental construction, by installing a horizontal banner as a countermeasure for dropping of snow. Also, it was found that the cost was lower than the conventional work over several years. However, depending on the structure of the bridges and overpasses, some bridges do not have anywhere to which the horizontal banner can be fixed. Thus, it is necessary to implement a different measure for locations where installation is difficult. Furthermore, because the horizontal banner is fixed in place with rope, if the rope was to snap for some reason or if the installation point itself was to become damaged, there is a risk that the horizontal banner itself may fall. Therefore, it is necessary to carry out regular visual checks to make sure the banners have not deteriorated.

5. CONCLUSION

When constructing a structure, a high level of safety is required, thus there are many safety standards in place. Various efforts are made in each region and for each location to meet these safety standards. Therefore, various structures exist in each region and for each location. As a maintenance company, we use every possible means to maintain and manage these various structures in such a way as to provide safe, secure, and pleasant roads. In this report, we introduced three of these methods for addressing snow accretion in periods of snow and ice.

(1) Lumps of snow adhered to gate post of road signs

As a result of installing a delta-shaped inclined panel coated with water-shedding paint, we were able to ensure that the snow accretion dropped before lumps of snow were formed, eliminating the need for conventional work to prevent snow from dropping. In so doing, we improved worker safety and the method was also less expensive spanned over several years.

(2) Lumps of snow adhered to gate post of road signs with lattice sections

We installed a snow-clearing machine that uses a pulley and winch to remove snow. We were able to reduce working time and the number of workers required compared to the conventional work for preventing snow from dropping and the cost was lower.

(3) Lumps of snow adhered to railings of overpasses

We installed a horizontal banner to the wall balustrades and used the flapping of the horizontal banner in the wind to ensure that the snow accretion dropped before lumps of snow were formed. As a result, we virtually eliminated the need for conventional work and the cost was also lower.

This report was created to review work we carry out every year and to improve the safety of our workers. As a result of the review, it is evident that safety can be improved, but it is also possible to decrease cost depending on the solution. Rather than aimlessly going about our daily business, we continue to regularly review our work to ensure and achieve more effective maintenance works of expressway.