ENVIRONMENTAL CONSIDERATIONS CONCERNING ANTI-ICING/DEICING AGENT APPLICATION

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1. Abstract

Every year Japan Highway Public Corporation (JH) applies 150,000 to 200,000 tons of salt (NaCl) as an anti-icing/deicing agent. Although the environmental impact of salt is thought to be smaller than that of special deicing chemicals because salt is highly soluble in water, there could still be various adverse environmental impacts under certain conditions. In view of these possibilities, JH is exploring ways to minimize adverse environmental effects, such as optimization of deicer dosage. This paper reports on JH's ongoing efforts to minimize the adverse environmental effects of anti-icing/deicing agents. The main topics of this paper as follows,

(1) Study and investigation of methods for measuring the amount of salt dispersion.

(2) Concrete methods for reducing salt dispersion and verification of their effectiveness.

Keywords: deicing agent, NaCl, salt, sodium chloride, salt dispersion, control works, porous asphalt pavement, net fence, noise barrier, particle size, environment

2. Introduction

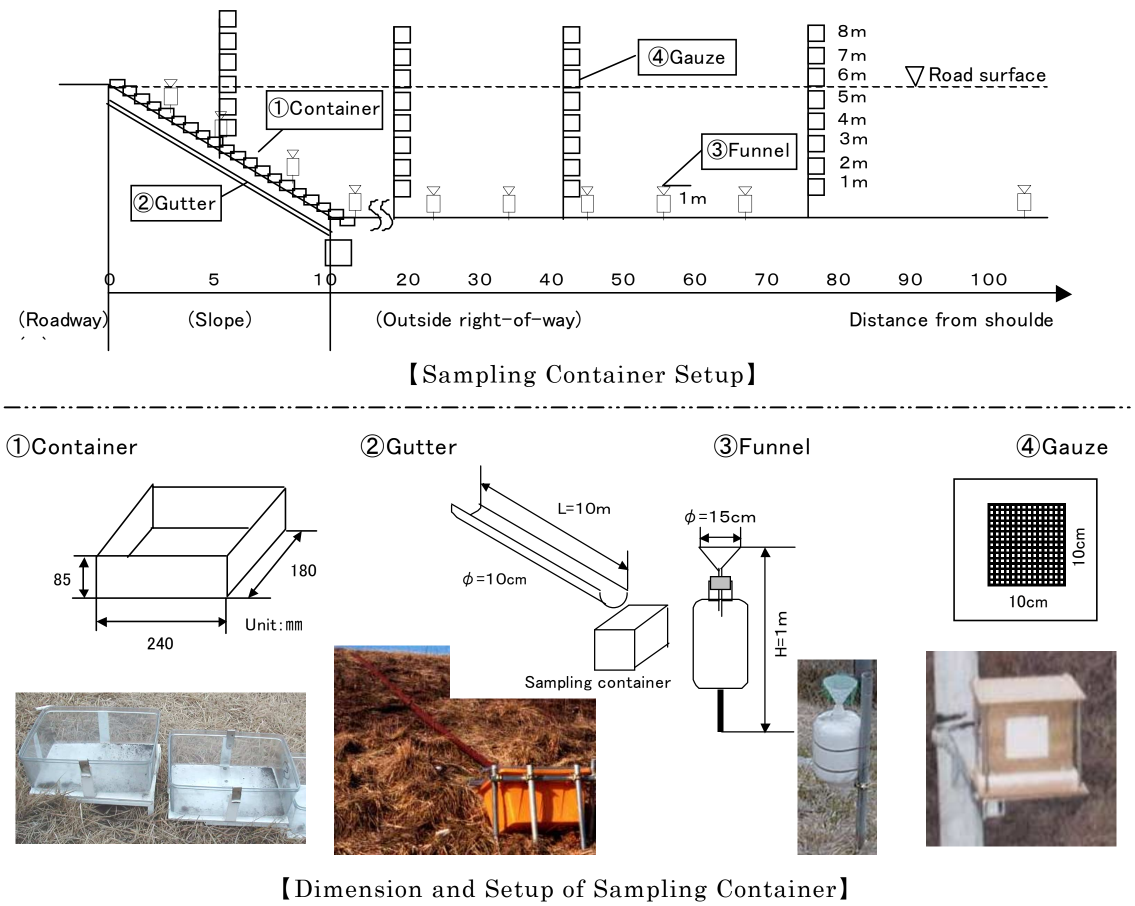
Of the 11,520 km of expressways conceived under Japan's expressway network plan, 6,851 km (about 59% of planned total length) has gone into service by April 1, 2001. Japan Highway Public Corporation (JH) is a government-affiliated organization responsible for the construction and maintenance of expressways. About 50 percent of the existing expressways pass through cold, snowy regions (regions where 10-year average maximum snow depth exceeds 30 cm). Since snow falls several times even in other regions, snow and ice control measures are necessary for almost all expressways.

Photo.1 Wilting of Apple Tree's Young Shoot Tips

The anti-icing/deicing agent (hereafter called simply as a "deicer") most commonly used is common salt (NaCl). The total amount of salt used in fiscal year 1999 was about 160,000 tons. This translates to about 23 tons of salt per road kilometer. The total amount of deicer salt used in Japan in one year is about 300,000 tons, about a half of which is used for road surface management of expressways in winter.

Salt is highly soluble in water and is considered to be less harmful to the environment than special chemicals. It has been pointed out that in regions growing apple, peach or other orchards, salt blown (and/or spiled) away from roads causes wilting of young shoot tips **(Photo. 1)** and yields losses in orchards adjacent to expressways. Effort is underway to come up with corrective measures, but no solution is in sight yet.

In the past, JH had no quantitative information on the process by which salt dispersion out of the roadways to which it has been applied. A typical action



(1) Container method: Forty-four（240×180×85 ㎜） containers were arranged end to end in a row to capture salt blown to the slope.

(2) Gutter method: A 10m gutter was installed on the slope to capture all salt blown to the slope.

(3) Funnel method: Funnels were installed at intervals from the shoulder of the expressway (H=1m) to capture salt that is blown and carried by air horizontally and falls to the ground.

(4) Gauze method: A number of 10×10 cm vertically-positioned pieces of gauze (H=1 to 8 m) were installed to capture salt blown up vertically and carried away by winds.

Figure 1 Methods of Measuring Quantity of Salt Blown Away from Expressways

that JH took, therefore, in response to a salt-related complaint in a particular area was merely to investigate the cause-effect relationship only after a complaint has been raised and to take necessary measures on a case-by-case basis.

JH is now thinking of predicting the dispersion patterns of salt and taking effective control measures accordingly in order to prevent salt damage. This has made it necessary to establish methods for quantifying the amount of salt blown away and investigate the present conditions.

3 Method of Measuring the Amount of Blown-Away Salt

Salt spread on roads is swept up by passing vehicles or blown up by wind. Road salt becomes air-borne in various way. For example, salt may be blown away in solid form, as part of surface moisture that becomes air-borne, as part of snow plowed away onto the roadside slopes. If the amount of road salt dispersion, which takes place in various forms, is to be quantified, it is necessary to determine not only the amount of air-borne salt that falls down to the ground but also a certain amount of wind-blown salt that remains wind-borne and does not fall to the ground. Many organizations including JH have tried to measure the amount of air-borne salt, but the methods used varied and only a small number of those attempts used a combination of two or more methods. We decided, therefore, to measure the amount of salt blown away by the methods shown in **Figure 1** and evaluate those measuring methods.

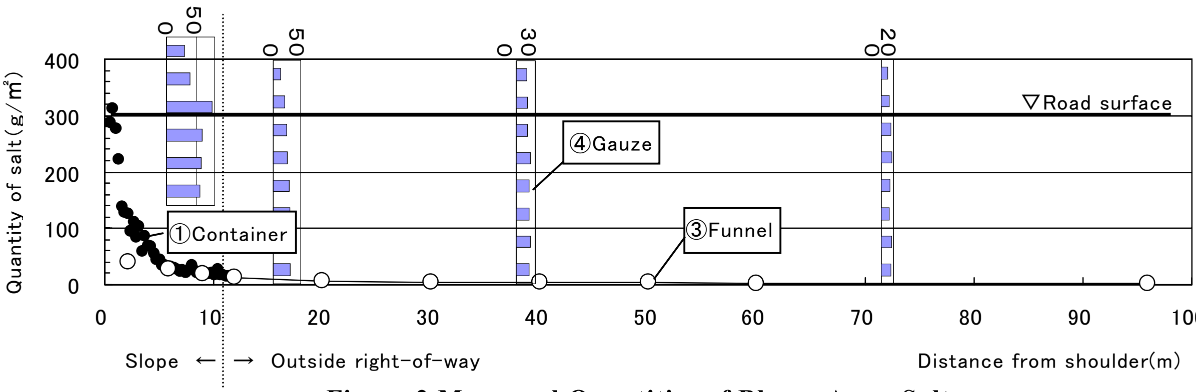


Figure 2 Measured Quantities of Blown-Away Salt

The measurement site is an expressway section where an annual usage of salt is 22 t/km (national average: 23 t/km), which is average for JH. The measurement was conducted for four months from November 10, 1999, to March 18, 2000.

The results of measurement are shown in **Figure 2**. According to the measured values obtained by (1) the container method and (3) the funnel method, the amount of blown salt that falls to the ground becomes close to zero at distances of 10 m or more from the top of the slope, indicating that the influence on the roadside environment can be ignored. According to the measured values obtained by (4) the gauze method, however, the amount of air-borne salt decreases only slightly even at distances of 40 m and even more than 70 m from the top of the slope. This means that as the distance from the top of the slope increases, the amount of air-borne salt that is carried horizontally increases in difference to the amount of salt that falls to the ground. Consequently, it is possible that the first row of fruit trees, buildings and the like that face an expressway and are exposed to wind from that direction are affected by air-borne salt.

Figure 3 shows the amounts of blown salt measured by (1) the container method and (3) the funnel method for distances of 0 to 12 m from the top of the slope. As shown, compared with the (1) container method, which permits accurate measurement of salt blown to the slope, the (3) funnel method gives small values at distances of 0 to 5 m from the top of the slope. The reason for this is thought to be that the funnels were installed at a height of 1 m from the ground surface, salt contained in plowed snow and large-grained salt could not be caught directly. The method of installing containers directly on the ground, therefore, is effective in catching salt in the vicinity of the top of the slope. The measured values obtained from the methods tested in this study showed that at distances of more than 5 m from the top of the slope, (1) the container method and (3) the funnel method were equally reliable in measuring the amount of salt blown away from the road.

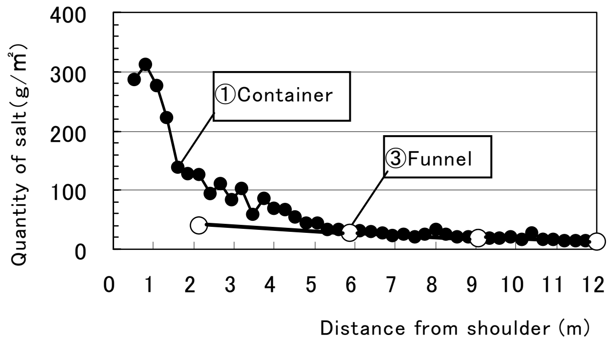


Figure 3 Comparison of Measured Quantities of Salt: Container vs. Funnel

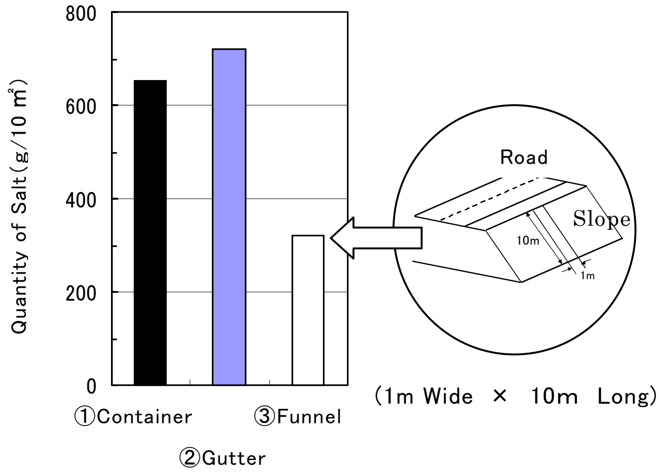


Figure 4 Quantities of Salt Blown to Slope

Figure 4 shows the total amounts of salt blown to the slope measured by (1) the container method, (2) the gutter method and (3) the funnel method. As can be seen from **Figure 4**, if the total amount of salt blown to the top of the slope (within the road right-of-way) is to be measured, the gutter method is accurate enough for all practical purposes. The reason the funnel method was less accurate than the other methods is thought to be that the amount of salt caught at distances of 0 to 5 m was relatively small.

From the above results, it was decided to use a method in which containers used are installed at low levels such as the container method and the gutter method if the amount of deicer salt blown to a slope near the shoulder of the road is to be measured, and the funnel method or the gauze method if it is to be measured at more distant locations outside the road right-of-way. In conducting the measurements, however, it was kept in mind that in the container method and the gutter method, it is difficult to retrieve containers if they are buried deep in snow, and that in the gauze method, salt adsorbed on the gauze could be washed down during a strong snowstorm or heavy rain.

4 JH's Efforts to Mitigate Environmental Impact

JH is reducing the amount of salt blown away from expressways by reducing (1) the amount of salt used, (2) the amount of salt that can be blown away from road surface and (3) the amount of salt blown away. This section introduces JH's efforts to reduce the air-borne dispersion of salt, that is, reduce adverse effects on the environment around expressways.

4.1 Reducing the Amount of Salt Used

JH's standard dosage of salt for expressways was 30 g/m2 of solid salt. In 1994, JH switched to the wet salting method commonly practiced in Europe. In preparation for the switch, JH compared road-surface residual salt concentrations achieved by the conventional salt application method and the wet salting method. As shown in **Figure 5**, 30 g/m2 of solid salt and 23.2 g/m2 of wetted salt (21.4 grams of solid agent + 8.6-gram 20% solution) resulted in roughly equal residual salt concentrations. In some expressway sections, the dosage has been further reduced to 20 g/m2 in view of the site conditions. This reduces salt usage by 20 to 30% and also reduces the amount of salt blown away from the road surface.

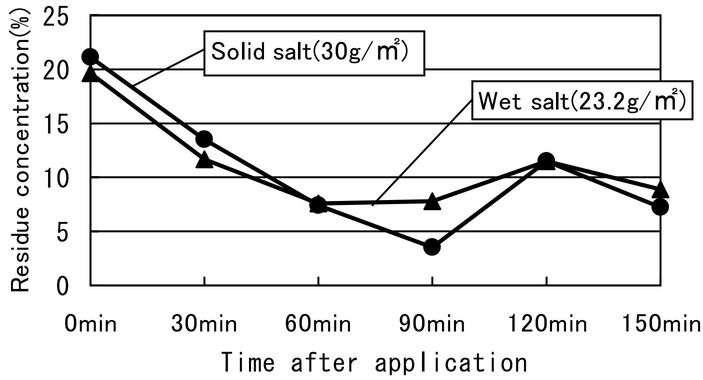


Figure 5 Salinity Concentration Test Results

4.2 Reducing the Amount of Salt That Can Be Blown Away

Porous asphalt pavement is designed to drain stormwater and other water through interconnected pores in the pavement structure, thereby contributing to traffic safety on expressways under wet weather. High porosity of porous asphalt pavements helps reduce road traffic noise, and their surface is sound absorbent. Because of these advantages, JH is introducing porous asphalt pavement throughout the country. So far, about 20% (1,300 km) of the total length of expressways in Japan has been paved by this method. Studies have shown that there are cases where salt existing on the road surface in the form of a water solution is swept up by passing vehicles or blown up by winds and is blown away by winds out of the expressway in the form of mist. Porous asphalt pavement can be expected to reduce the amount of salt blown away because the drainage function of the porous asphalt pavement shortens the time moisture is retained on the road surface.

Figures 6 and **7** show measured quantities of salt blown away from a dense asphalt pavement and from a porous asphalt pavement, measured by the gauze method (10cm∞10cm=1dm2) at the top and toe of the slope. The measurement period was three months. In the graphs, the height at which the gauze was installed is shown on the vertical axis, and the amount of salt adsorbed on the gauze on the horizontal axis. As shown, the amount of salt blown away from the porous asphalt pavement is about half the amount of salt blown away from the dense asphalt pavement. In particular, the amounts of air-borne salt at heights of 4 to 5 m near the top of the slope clearly show that the porous asphalt pavement reduces the amount of air-borne salt.

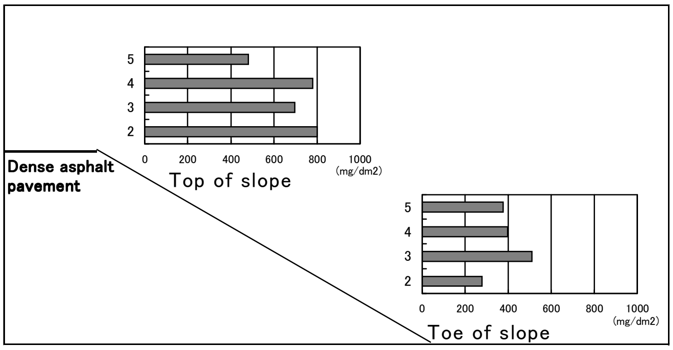


Figure 6 Dense Asphalt Pavement

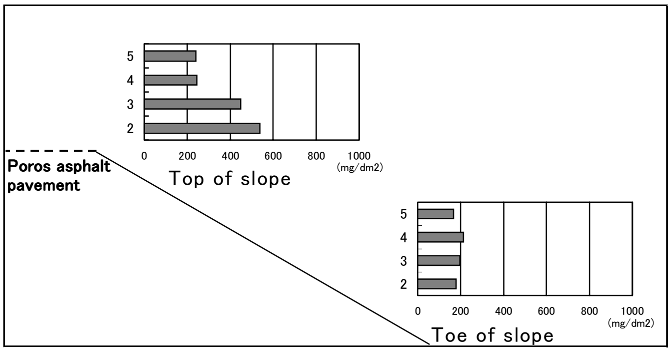


Figure 7 Porous Asphalt Pavement

Figure 8 shows a particle size distribution (H=7m) of air-borne salt measured with an Andersen air sampler, an instrument commonly used to measure the particle size distribution of dust contained in exhaust gas. In all particle size ranges, the amount of salt blown away from the porous asphalt pavement is smaller than that from the dense asphalt pavement. In general, the influence of gravity on particles smaller than 10 μm is so small that they might be carried away, without settling, over a very long distance. It is therefore necessary to reduce the amount of salt that becomes air-borne. The consistently small measured values for the porous asphalt pavement indicate effectiveness of the porous asphalt pavement.

In the porous asphalt pavement section, there was little seepage from the bank of snow on the shoulder of the expressway. Consequently, the number of salting operations, which used to be carried out in conventional pavement sections to prevent such seepage from freezing, was also reduced.

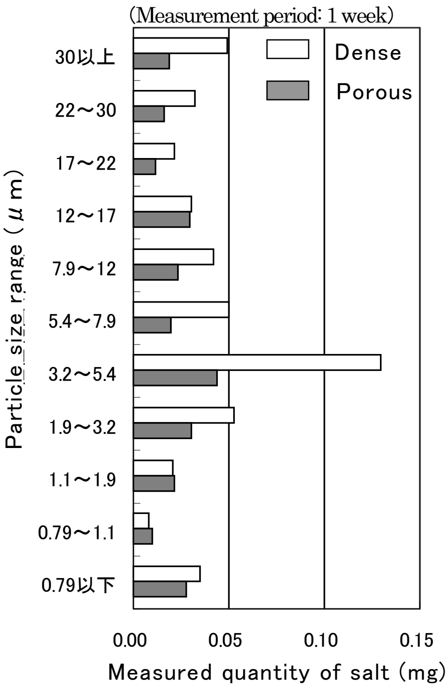


Figure 8 Particle Size Distribution

The measurement verified that porous asphalt pavement is effective in reducing the amount of salt blown away. In road sections where care needs to be taken to reduce the amount of salt blown away, use of porous asphalt pavement should be considered as one of a number of control measures.

4.3 Reducing the Amount of Salt Blow Away with Barriers

In road corridors passing through residential areas, JH construct noise barriers (**Photo. 2**; total installed length: 2,411 km), embankments or tree buffer zones as measures friendly to the environment around an expressway. In cases, for example, where there are orchards near an expressway, a net fence (H=2 to 3 m) such as the one shown in **Photo. 3** may be erected along the shoulder of the road to reduce the amount of salt blown away.

Photo.3 Noise Barrier (H=2m)

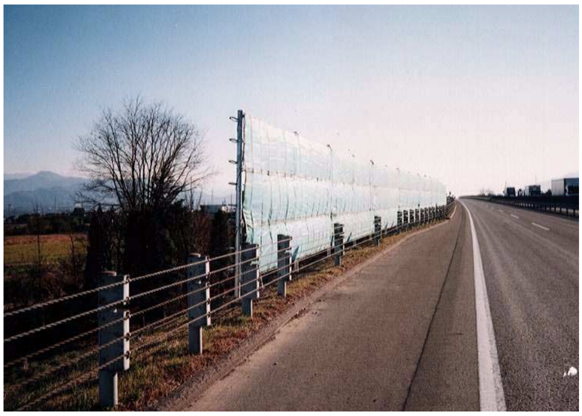


Photo.4 Net Fence (H=2m)

The purpose of a noise barrier is to lower the level of noise generated by expressway traffic, and it is not erected as a means of reducing the amount of salt blown away. Noise barriers, nevertheless, are considered effective in controlling the dispersion of air-borne salt.

Effectiveness of netting, on the other hand, was at first considered questionable because netting does not completely cut off winds. **Figures 9** to **11** show measured quantities of air-borne salt in "no control" areas, using net fence (H=2m) and using noise barrier (H=2m) areas, obtained by the gauze method (10cm∞10cm). The measurement period was three months. In each graph, the vertical axis is the height of the gauze point, and the horizontal axis the amount of

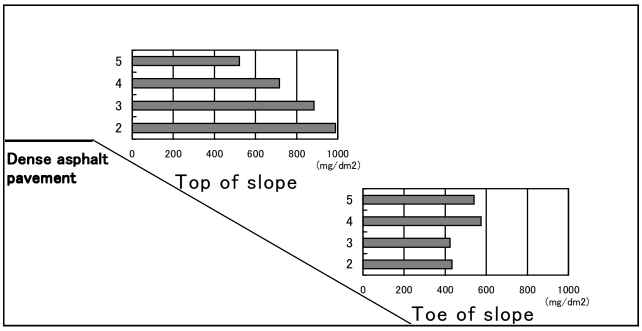


Figure 9 Corrective Measures: None

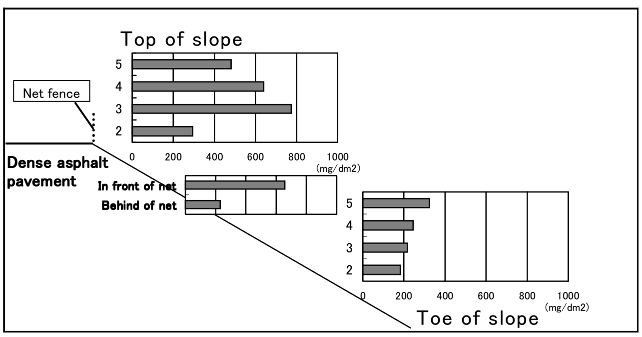


Figure10 Corrective Measures: Net Fence

salt adsorbed on the gauze.

As shown, the amounts of air-borne salt in the net fence area and the noise barrier area are smaller than those in the "no control" area. The quantities of salt adsorbed on the gauzes at the top of the slope show that the net fence and the noise barrier have reduced the quantities of air-borne salt at heights lower than their respective heights. In the measurement, the quantities of air-borne salt at the height of 2 m were small because both the net fence and the noise barrier were 2 m high. **Figure 10** shows the quantities of salt adsorbed on the gauzes on both sides of the net fence. The amount of salt adsorbed on the gauze in front of the net fence was about 600 mg/dm2, while that behind the net fence was about 200 mg/dm2. This indicates that the net fence reduced the amount of air-borne salt passing that location to about 1/3. The amount of air-borne salt adsorbed on the gauze placed at the toe of the slope was about 1/2 of the "no control" value, indicating that the net fence and the noise barrier were effective even if they were only 2 m high.

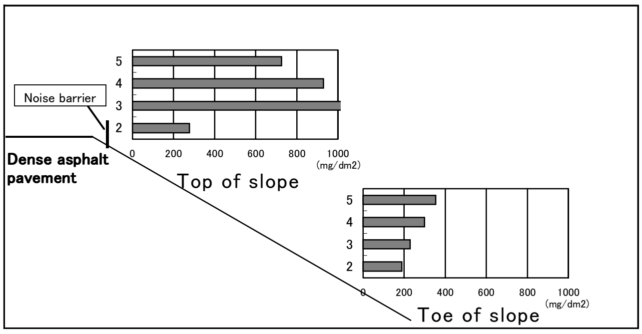


Figure11 Corrective Measures: Noise Barrier

For the above reasons, in areas where there is no noise barrier on embankment, JH uses net fence (H=2 to 3 m) along road shoulders to reduce influence on the surroundings.

Since net fence along road shoulders also helps the growth of roadside plantings, it will contribute to early formation of woodlands.

5 Summary

Concerning JH's efforts to dispersion the environmental impact of deicing salt application, this paper has reported the following:

(1) As for methods of measuring the quantity of salt that is blown up and falls to the ground, the container method, which uses sampling containers installed at low heights, and the gutter method are useful for slopes close to road shoulders, and the funnel method is useful at locations 10 m or more away from the shoulder of the road outside the right-of-way. The quantity of salt that is transported over distance of 10 m or more from the shoulder of the road is almost nil.

(2) The gauze method, which uses vertically oriented pieces of gauze, is suitable for the measurement of the quantity of air-borne salt. Care should be taken if there are fruit trees, buildings and the like facing the expressway and directly exposed to winds because the amount of air-borne salt at a distance of 40 m from the shoulder of the road does not differ significantly from that at a distance of 70 m.

(3) The newly introduced "wet salting" method has reduced salt usage by 20 to 30%, thereby reducing the quantity of salt blown away from the roadway.

(4) Compared with dense asphalt pavement, porous asphalt pavement reduces the amount of salt blown away by half. Porous asphalt pavement, therefore, can also be used as an effective means of salt dispersion control.

(5) Shielding devices such as net fences and noise barriers can be used to reduce air-borne salt dispersion below the height of their installations. In areas where air-borne salt migration needs to be controlled, therefore, net fences are erected to reduce adverse environmental effects.

6 Concluding Remarks

The topic covered in this report is an important one that needs to be addressed in order to secure traffic capacity in winter while living harmoniously with the environment. It is required to increase accuracy of measurement of salt blown away from expressways so that appropriate and rational measures can be taken.