ICE REMOVAL EFFECTS OF FUNCTIONAL BLOCKS

MASAO INUZUKA, PROFESSOR OF CIVIL ENGINEERING, HOKKAIDO INSTITUTE OF TECHNOLOGY
7-1-5-4-1 Maeda, Teineku, Sapporo, Hokkaido, Japan
TEL.+81-011-681-2161 FAX+81-011-681-3622
E-Mail inuzuka@hit.ac.jp
SHIGEKI NAGATA, DIRECTOR, TECHNICAL DIVISION, HOKKON Co., Ltd.

ABSTRACT

Functional concrete blocks have an extra function on top of the load bearing capacity in conventional blocks. One of the characteristics of block paving is that each block can make a small independent movement, which can prevent the stress concentration to fracture concrete. Another point is that it is easy to change physical properties at locations of paving. Ice removal is of top priority in the winter in a cold region. A simple system of rubberized blocks arranged in a liquefied deicer is proposed with experimental results. The system works as a deicer supplier to the road surface, allowing the deicing to operate automatically. The system of a liquid supplier to the road surface can also work as a watering system for laying the dust or cooling the air in the summer. The study is to obtain information on the trial to combine the points to make each block move so that the ice on the road surface is removed by passing vehicles. Thus the removing energy can come from passing vehicles and the energy for ice removal will be proportional to a number of vehicles that benefit from the removal. The work centers on estimating conditions for the deicing performance of the system. In order to keep the function for required period of time, the rubber layer is in a liquefied deicer, filling space where water can freeze. Similar combination systems are experimented with geometrical factors of constitutive elements and thickness' of ice on the road surface.

1. INTRODUCTION

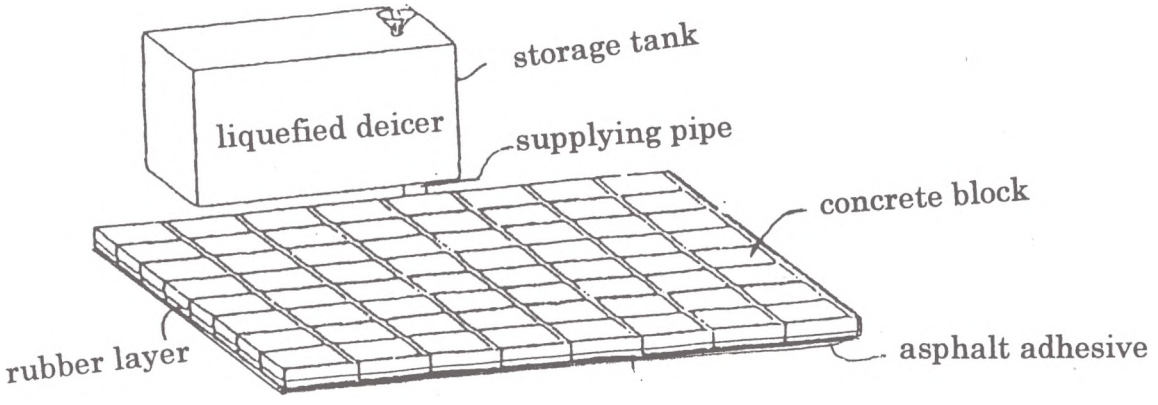


Figure 1 Outline of Deicing System

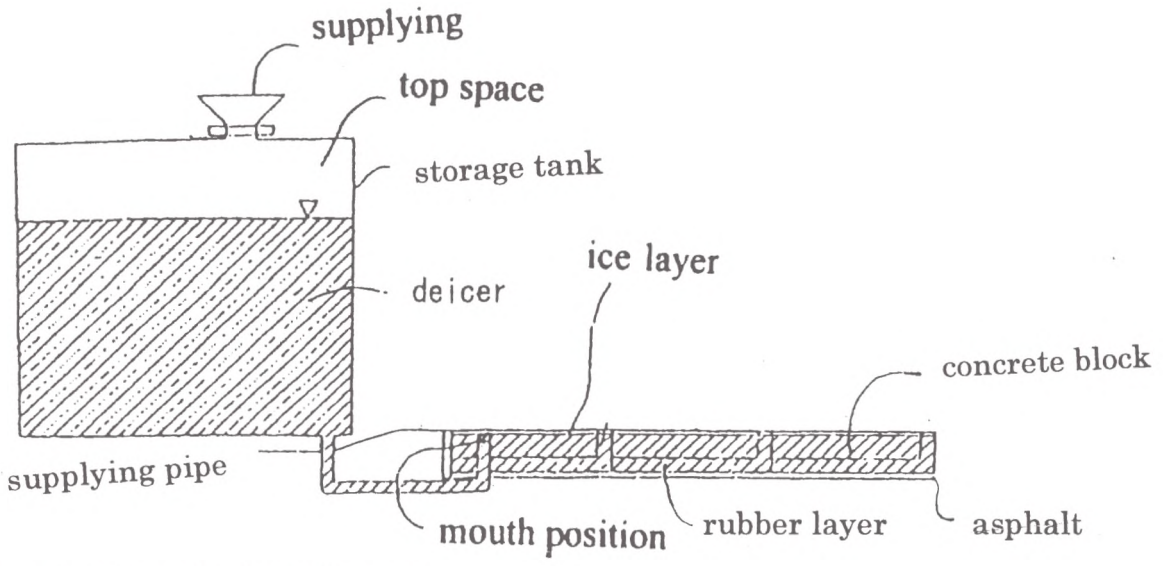


Figure 2 Cross Section of System

What are functional blocks all about? Functional blocks have an extra function on top of their load bearing capacity. The functions being demanded according to the local traffic conditions, the ice removal is the top priority of the road maintenance in winter in a cold region. This report centers on the ice removal performance, derived from the differential motion of the blocks, which is given by the vehicles passing over them. A proposed system with a rubber base was used for the experiment with a liquefied deicer of sodium chloride. Experiments were carried out on the ice removal to estimate the effects of base rubber.

2. DEICING BLOCK SYSTEM

One of the advantages of concrete blocks is that an independent motion at joints reduces stresses in each block. The size of a block will give the maximum stress in a paving block [1]. This characteristic motion can also be used for other objectives such as the removal of ice on the road surface. The elastic base can give the blocks the required movement. The ice removal performance is obtained in the block system on condition that the rubber is free of the deterioration and blocks are stable. The deterioration is mainly due to sunbeam effects. Covered with blocks, the rubber layer beneath blocks is able to avoid being subjected to the sunbeam. The traffic movement will act to shift blocks. And yet, blocks, arranged on the rubber layer base, have to stay in place. The adhesive layer of asphalt may be able to prevent blocks from shifting position. Thus the adhesion ought to be strong enough to resist the shifting force between the rubber and concrete [2]. Another point is how to keep the deicing motion in the secondary ice after the previous ice is solved. The combination between the rubber base and the deicing agent could keep the motion. The function, however, would be lost if the joints are fixed by frozen ice. Therefore it is vital to secure the motion at joints for the successful operation. The maintenance cost depends on the choice of mechanisms to keep blocks movable. The rubber part can be made of chips of used tires, since these are available with much merit except a drawback of the water absorption. Some means have to be taken to prevent the freezing of water absorbed in the joints, which should be free of solidification with deicing liquid supplied. The aspect ratio of a block will give the object thickness of ice to be removed, since the size of the blocks if movable is a main parameter for the stresses in the surface ice. Thus a system combining the tire rubber and the

deicing agent is a possibility. This system was proved on an experimental road to be effective with a liquefied deicer of CMAG or a composition of calcium, magnesium, acetic acid and glycerin [3]. A general view of the model system is shown in Figure 1. Figure 2 shows the cross section, illustrating the liquid channel. The tank supplies the joints and the base with a deicing liquid. The head of the supplied liquid is controlled by the surface height in the tank ___ the head of the liquid is kept constant by closing the tank and maintaining the mouth position of the connecting pipe at the same level. As consumption or evaporation reduces the liquid amount, compensatory amounts are pumped from the tank. Thus the successful system proposed is dependent on four factors ___ coverage of the rubber layer, asphalt adhesion, deicing means and geometrical conditions of constitutive elements. The mechanism as such can de-ice not only the very place where the system is applied but also the neighboring road surface supplied with the agent. The system can work like an inkpad for a stamp, which transfers ink on paper surface from the pad. The area of the system can be limited since vehicle tires will drag the liquefied agent on the road surface after they tread the system, breaking and removing the ice.

3. ASPHALT ADHESION

In order to keep blocks in the original positions, the adhesive strengths should be provided over the minimum amount. A characteristic mechanical condition of the adhesive layer is that the layer is subjected to repetitive stress due to passing vehicles. The adhesion does not have to be very strong in the system, but it is should be able to resist repetitive stress. The adhesive layer made of asphalt has proved to be practical in a dry condition [4]. An asphalt layer is advantageous in that the adhesion, even if damaged due to any deterioration, can recover when it is heated over certain temperatures. Therefore the damage can be repaired in the summer even in the most adverse year in a cold region. In summer, however, a considerable amount of the mixture can be lost when the inappropriate mixture flows in a very low viscosity at high temperatures. Therefore the asphalt adhesion tests were carried out on mix proportions of asphalt at varying temperatures. The test gave results as follows;

a. Adhesion was strong enough to sustain concrete blocks on the rubber layer.
b. Stress repetition did not cause the removal even at high temperatures in summer.
c. Blocks survived on the layer in all seasons. Their stability in winter is to be ensured, since the strength increases with lower temperatures.
d. The adhesive layer functioned to keep the deicer for a test period.

4. DEICING PERFORMANCE

4.1 Experimental Procedure

The test included four trial systems. Test specimens from A to D are shown in Figure 3. The rubberized block available in the market is a combination between a resin concrete block, 40mm thick, and a layer of rubber underneath. The u-u of A specimen indicates the test piece having both layers under each block. The elastic base is made of a rubber sheet, which is10mm thick. The rubber part of each block and the sheet is made of granular chips of used tires. The concrete block is of high strength. The blocks are combined with rubber cord forming joints in the tests. The cord of joint rubber is 1cm thick and 2cm high. Specimen blocks are arranged on the concrete base with asphalt adhesion and covered with an ice layer.

The thickness of the ice layer is given in three levels from 0.5cm to 2.0cm according to the experimental design. The liquefied deicer of calcium chloride is supplied to the level of the road surface from the tank thirty minutes before testing. The vehicle passing over specimens is of the lightweight category. The tests were carried out for the number of vehicles passing over the test pieces.

Vehicles will drag liquefied deicer on the adjacent road surface so that the limited area of the system may cover what is required for the traffic safety. If timing in supplying the deicer can be controlled automatically, the maintenance procedure may be simplified considerably. The periodical change of a supplying tank requires less time than the deicer sprinkling that is the current practice.

The dilution of deicer should be noticed. If its consumption is mainly due to the dragging effects, supplied deicer of proposed solution can keep out the problem. This would normally be the case on the roads where the traffic amount is over a certain level in sufficient drainage. The dragging distance was influenced by the road surface roughness, the liquid level, the spewing response and the vehicle speed. The speed employed was about 10 km/hr. The deicer level was 5 mm from the surface. Each tire was found wet when it rolled through a specimen. The extent of removal is measured after a test, as shown in Photo 1 and Photo 2.



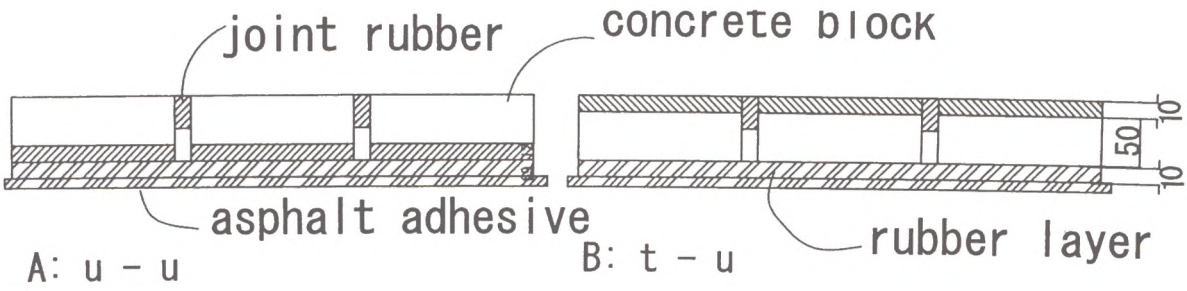
Photo 1 Tested Specimens (ice thickness = 5 mm)



Photo 2 Tested Specimens (ice thickness =15 mm)

Thus the experimental pavement is subjected to a given number of vehicles according to the test plan. The ice removal index is given for the extent in ten degrees of the ice removal levels as follows;

0 No change in ice
1 Total crack length in unique area is under 60 cm.
2 Total crack length in unique area is over 60 cm
3 Ice at joints is crushed.
4 Ice at joints is removed.
5 Acreage rate of ice removal is between 0 and 20 %.
6 Acreage rate of ice removal is between 20 and 40 %.
7 Acreage rate of ice removal is between 40 and 60 %.
8 Acreage rate of ice removal is between 60 and 80 %..
9 Acreage rate of ice removal is over 80 %.



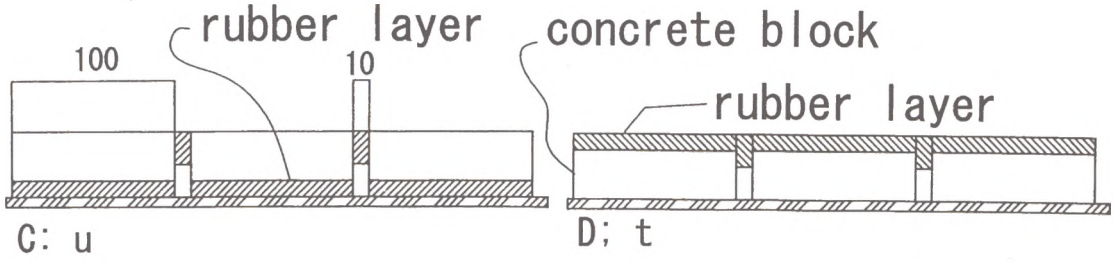


Figure 3 Cross Section of Specimens

4.2 Experimental Results and Observations

Curves were obtained for the relationship between the surface ice thickness and the removal extent. Four specimens were tested in the identical conditions. The results of the ice removal extent after five vehicles passed over the test pieces are shown in Figure 4. Those for the thirty vehicle passages are shown in Figure 5. The traffic amount gives the degrees, as shown in the difference between the two figures. The ice removal would not take place when the ice was over 30mm.

These curves also show that the required traffics to remove ice to the necessary extent of degrees is a function of the ice thickness and other factors such as rubber base geometry. The curves show that the base rubber plays an important role for the ice removal and any increased rubber amount enhances the performance.

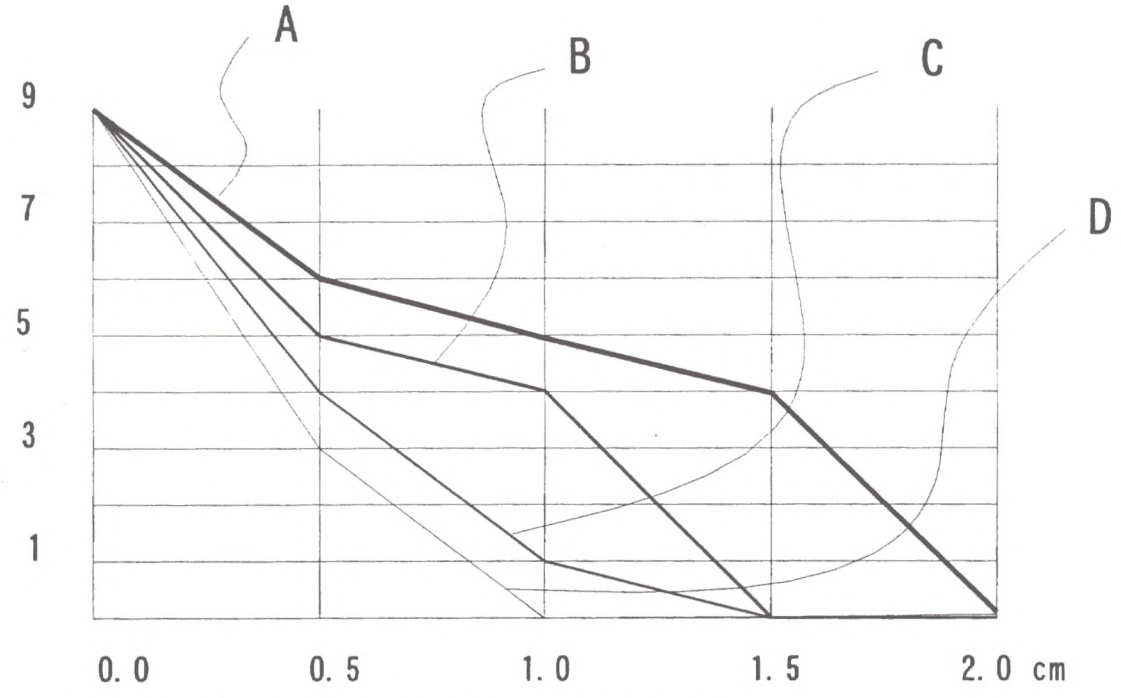


Figure 4 Ice Removal Index after Five Vehicles

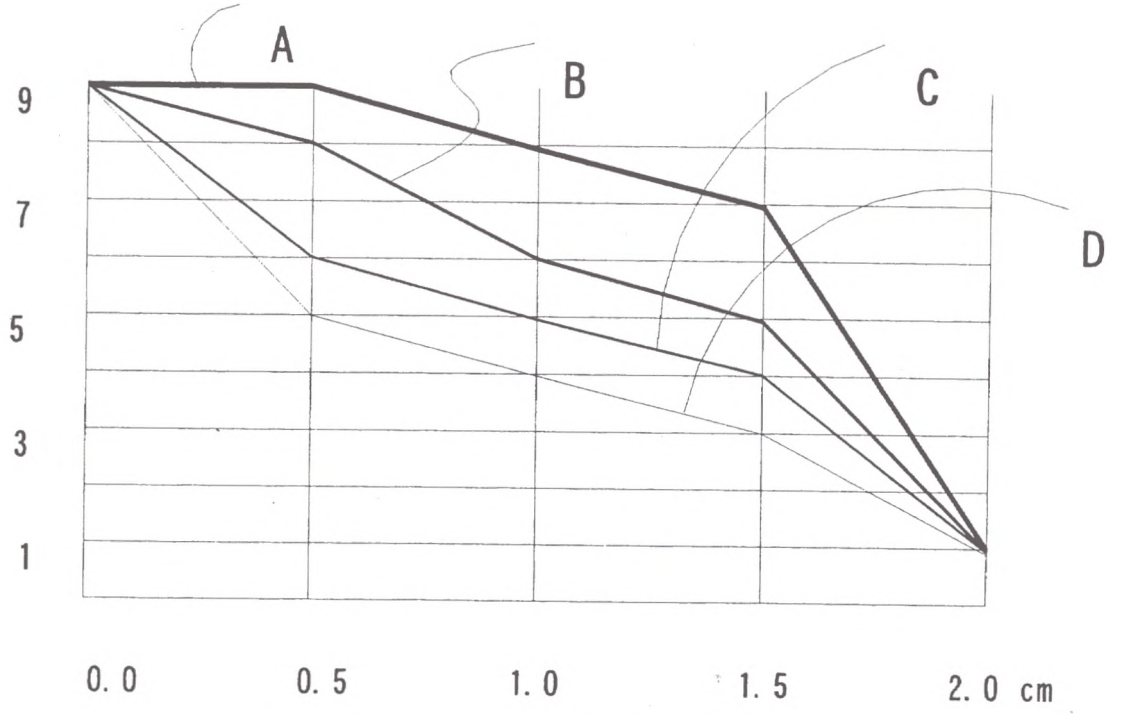


Figure 5 Ice Removal Index after Thirty Vehicles

Although the nine-degree seems obviously promising to cause only a trivial problem, if any, the minimum required degrees for safety have to be estimated in broader views. If the larger

amount is allowed for the initial traffic to get to required removal level, the thinner rubber base will be satisfactory. Consequently the rubber base proved to be effective for the ice removal rather than that used on the surface.

Concrete blocks can stay in place by the asphalt adhesive, which works to keep a liquefied deicer in position. As the elastic layer of rubber was applied to the surface of concrete blocks mainly in pavements, it was exposed to the sunbeam as well as the traffic. Therefore the material deterioration and the mechanical damages would cause problems and its durability has been wanted.

Concrete blocks, covering the surface, may protect the base rubber. This system is accompanied with a dragging effect, spreading the deicer. The ice layer, thicker than the underneath rubber layer, showed little effect of the vehicle passage. The dragging action began to take place after cracks developed over 3 degree. Most of the liquid, squeezed out by the tire tread, is absorbed by the area adjacent to the tread. The dragging effect of the liquid is due to the direct contact with tires. Similar function is found with water in stead of the deicer.

Thus the required removal level is to be estimated from corresponding conditions, especially the thickness of the ice and the vehicle speed. A quick response to supply the system with deicer will reduce the rubber layer thickness, since the objective ice is expected less than that in no change in the tests. The required area to spray with the deicer is given by the level of the liquid surface.

Vehicles will drag liquefied deicer on the adjacent road surface so that the limited area of the system may cover what is required for the traffic safety. If timing in supplying the deicer can be controlled automatically, the maintenance procedure may be simplified considerably.

The dragging distance was influenced by the road surface roughness, the liquid level, the spewing response and the vehicle speed. Thus the speed employed was about 10 km/hr. The deicer level was 5 mm from the surface. Each tire was found wet when it rolled through a specimen.

The liquid deicer is to be supplied through a tank, which can allow a variety of supply such as the exchange of a bag. The periodical change of the supplying tank requires less time than the deicer sprinkling procedure that is of the current practice. The pipe nozzle can accurately keep the head of the deicer, although the supplying time depends on a pipe diameter.

The dilution of deicer should be noticed. If its consumption is mainly due to the dragging effects, supplied deicer of proposed solution can keep out the problem. Roads in some conditions, however, are subjected to the secondary ice due to freezing of diluted deicer.

5. CONCLUSION

1. Rubber base, protected by concrete blocks against deteriorating actions, proved effective to remove the surface ice with liquefied deicer. The thickness of the rubber base layer gives the thickness of a deicing limit.
2. A proper drainage ought to be employed in order to prevent the secondary freeze due to the excessive dilution of deicer in permeable rubber.
3. The dragging was found over a meter, influenced by factors such as the liquid level.
4. The asphalt adhesive proved to be strong enough throughout a year to keep blocks in place and to be watertight for liquefied deicer.
5. The spewing system of water is to act for watering functions in other seasons.

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