STUDY ON A SALTING STRATEGY THAT CONSIDERS PAVEMENT TYPES

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1. INTRODUCTION

In the snowy cold regions of Japan, salting is the primary measure against road surface icing, and it's an important measure for securing safe, smooth trafficability on roads in winter.

Rough-surface pavements, such as drainage pavement and high-performance SMA, have been installed on roads to afford greater sliding friction. Laboratory tests, outdoor track tests and field tests have shown such pavements to have high sliding resistance.

However, few studies have addressed the effect of salting on rough-surface pavements.

1. INTRODUCTION

In this study, we used a "laboratory wheel-tracking test machine on ice" owned by the Hokkai-Gakuen University to make two tests:

1)A water sprinkling and freezing test, to assess the extent to which rough-surface pavement affords higher sliding friction than dense-graded pavement.

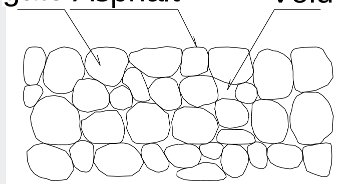
2) A salt application test on icy pavement surfaces, to assess the effect of salting on sliding resistance.

The coefficient of sliding friction, the thickness of the ice and the bare pavement ratio (BPR) were measured to assess how salting affects the sliding resistance of rough-surface pavements.

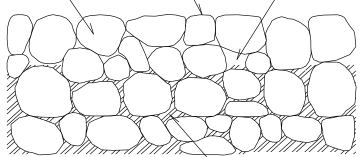
"Laboratory wheel-tracking test machine on ice"

2. TEST PAVEMENT

We tested three pavements: dense-graded pavement, drainage pavement (void ratio: 17%) and high-performance SMA. The second and third types of pavement afford high coefficients of sliding friction due to their rough surface texture.



Drainage pavement



High-performance SMA

3. SPRINKLING AND FREEZING TEST

We generated an icy pavement surface by sprinkling water on the pavement and causing it to freeze.

Using the measured data on bare pavement ratio, coefficient of sliding friction and ice thickness, we clarified how the sliding resistance differs with differences in pavement type, amount of sprinkled water, number of wheel passes and temperature.

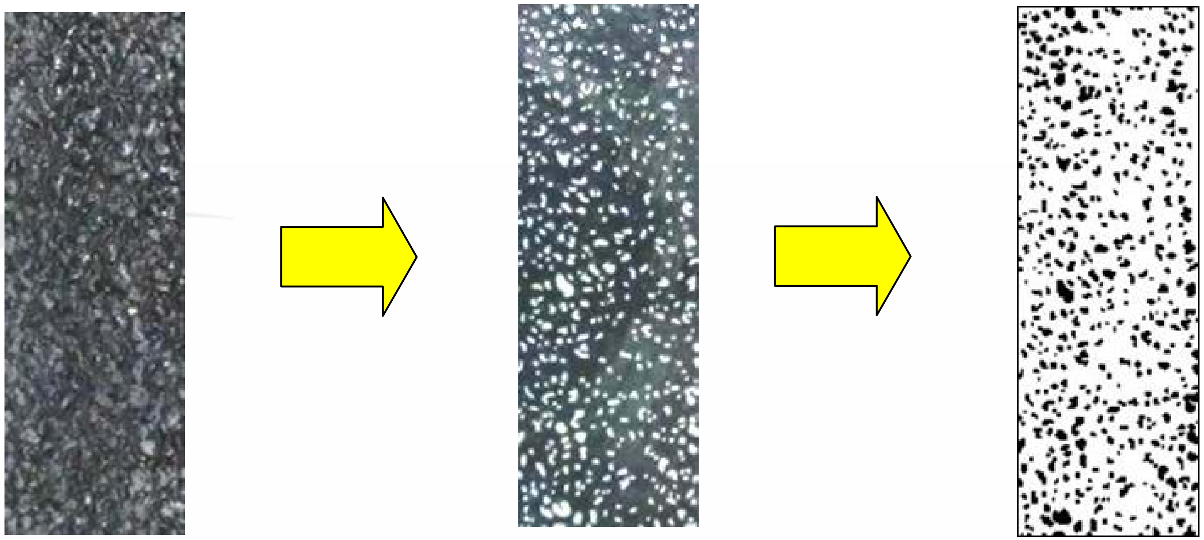
Bare pavement ratio (BPR)

$$BPR(\%) = \frac{Area\ of\ exposed\ pavement\ surface\ (pixel)}{Area\ of\ analyzed\ image\ (pixel)}$$

3. SPRINKLING AND FREEZING TEST

A thin, transparent layer of ice on the pavement surface is difficult to recognize.

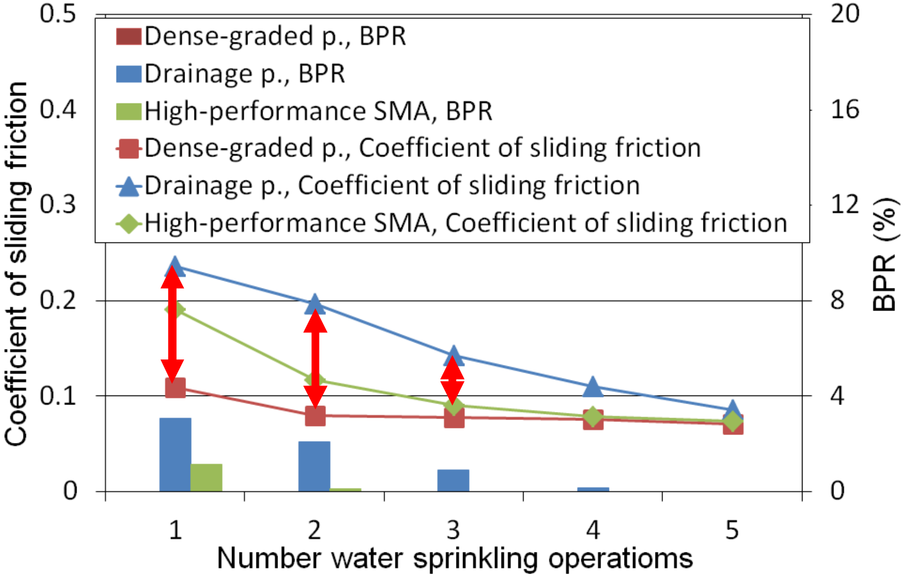
In this study, we used laminated polystyrene and white permanent markers to facilitate the clear recognition of the exposed pavement area for calculation.



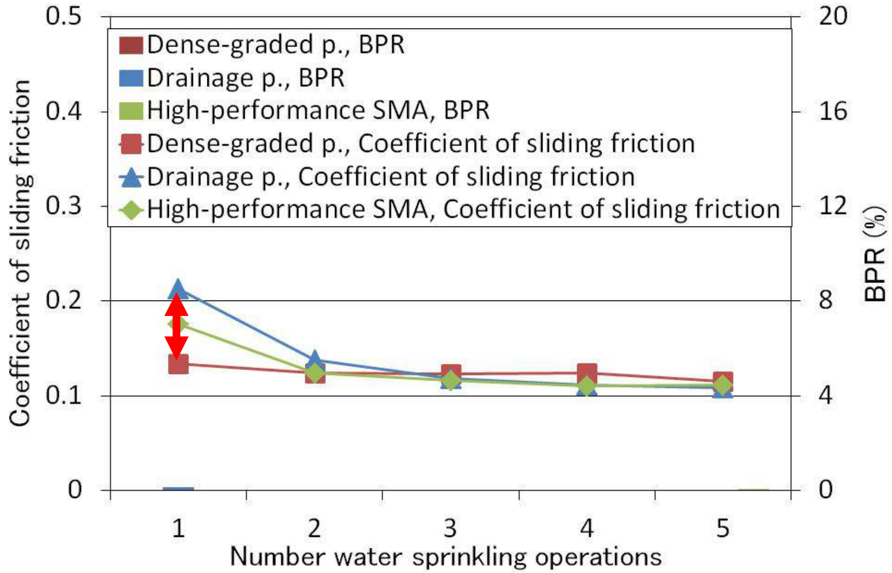
3.1 Test conditions

Test pavement	Dense-graded, Drainage, High-performance SMA		
Test temperature	−3 °C	−5 °C	−8 °C
Water applied per sprinkling operation	0.5 l/m^2		
Wheel passes	0 passes (measured 30 min. after water sprinkling) 300 passes		
Number of tests	5 tests (water sprinkling, repeated wheel passes, braking)		
Wheel traveling velocity	Repeated wheel tracking test: 5 km/h; Braking test: 10 km/h		
Wheel load	5 kN (ground contact pressure: 0.196 MPa)		

3.2 Test results



−3℃□300 passes

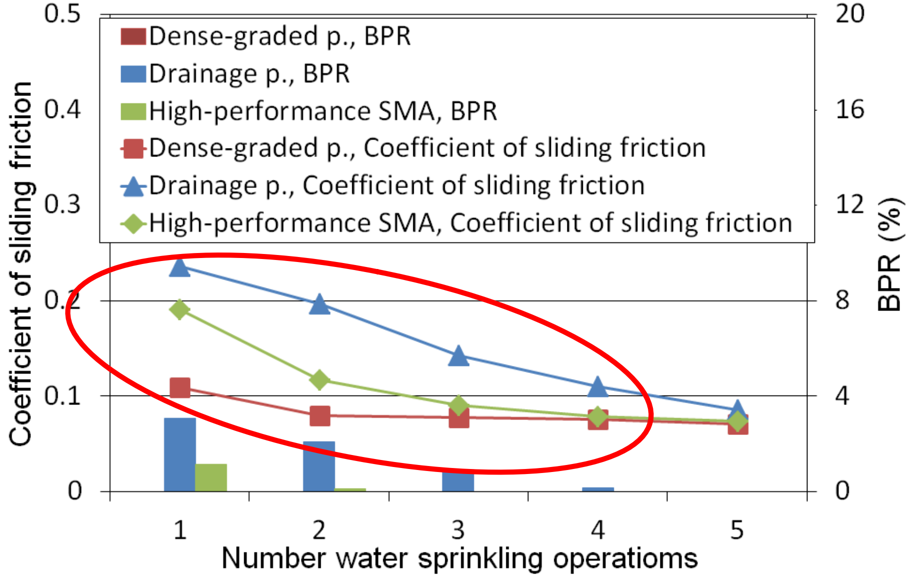


−8℃□300 passes

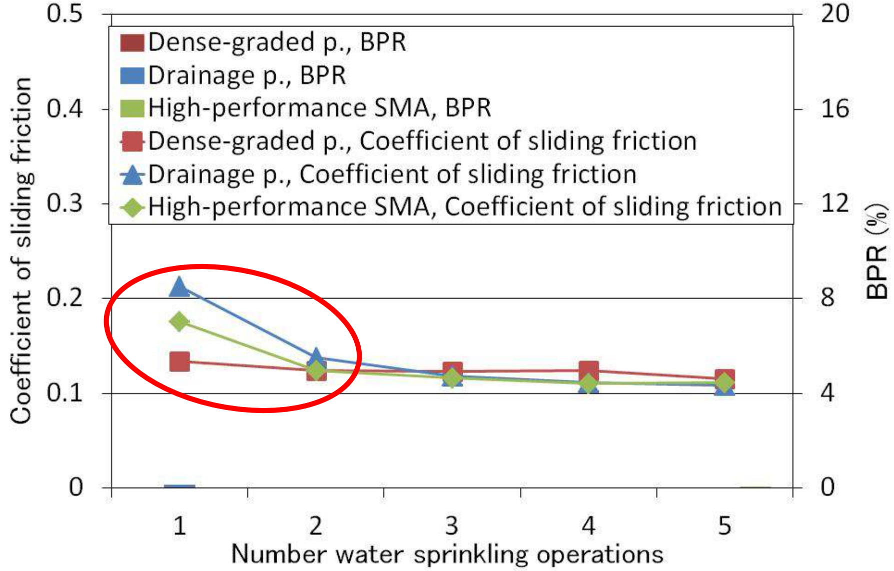
For the rough-surface pavements, the coefficient of sliding friction and BPR decreased with increase in the number of water sprinkling operations.

For the dense-graded pavement, the coefficient of sliding friction was around 0.1 for the entire test, and little exposure of the pavement surface was observed.

3.2 Test results



−3℃□300 passes

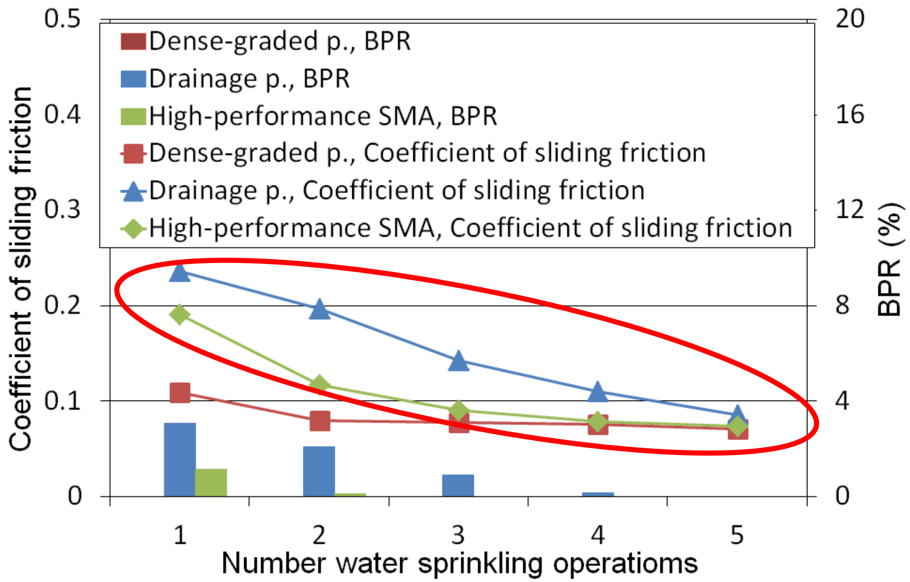


−8℃□300 passes

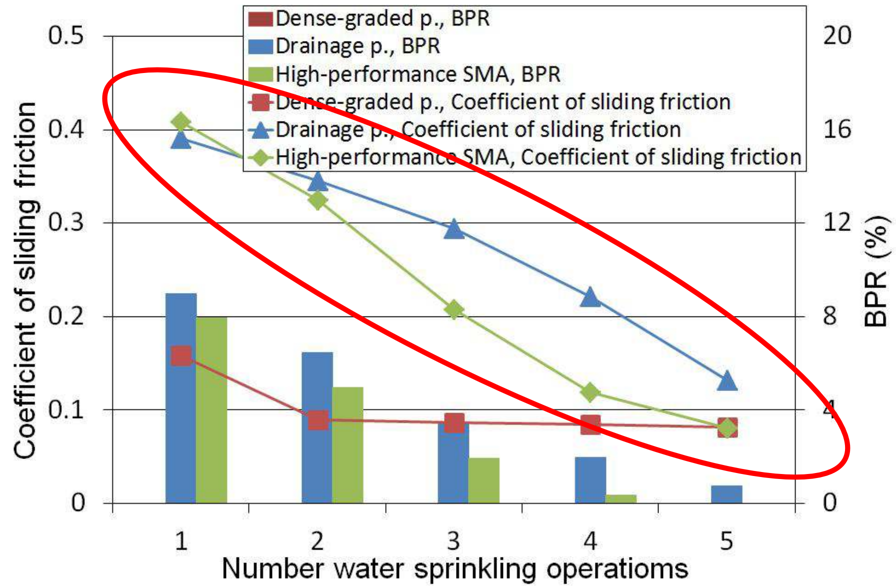
Regarding the influence of temperature, at lower test temperatures, fewer water sprinkling operations were needed to reach a coefficient of sliding friction of 0.1 on the rough-surface pavement.

However, the sliding resistance decreased with decrease in temperature.

3.2 Test results



−3℃□300 passes



−3℃□0 passes

Regarding the influence of differences in the number of wheel passes, regardless of pavement type, the coefficient of sliding friction and the rough surface exposure ratio were higher without wheel passes than with 300 wheel passes.

4. SALTING TEST

In this test, first we generated the icy pavement surface.

Then, we applied salt and conducted the wheel tracking tests.

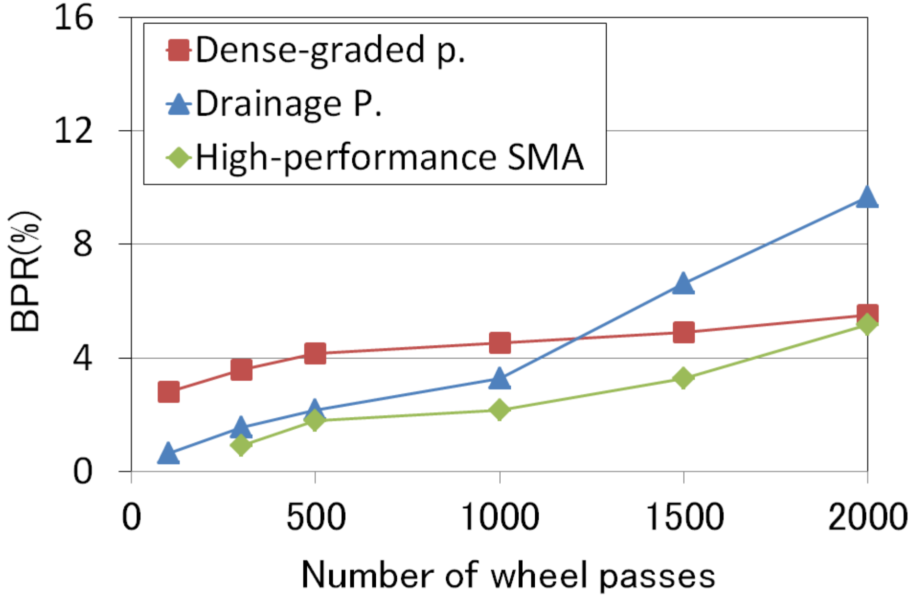
We measured the coefficient of sliding friction, the BPR and the ice thickness for each type of pavement to clarify the effectiveness of salting.

This test reproduces the winter road maintenance conditions of ice control by salting after road surface icing.

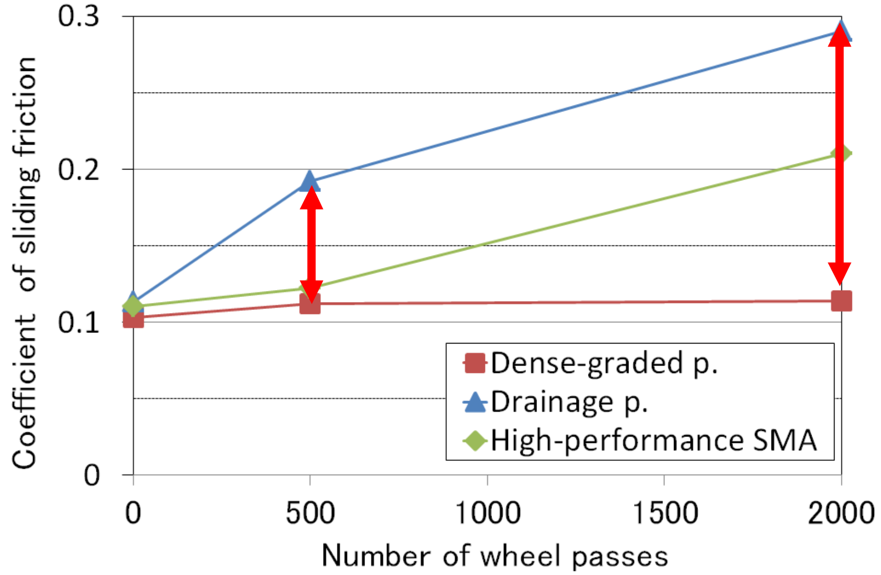
4.1 Test conditions

<table>
<tr><td colspan="2">Test pavement</td><td>Dense-graded, Drainage, High-performance SMA</td></tr>
<tr><td colspan="2">Test temperature</td><td>−5 °C</td></tr>
<tr><td colspan="2">Road surface conditions</td><td>Icy pavement surface
Amount of sprinkled water: 2.0 l/m²</td></tr>
<tr><td colspan="2">Salt</td><td>NaCl at 20 g/m² applied wet</td></tr>
<tr><td rowspan="3">Test item</td><td>Road surface exposure ratio</td><td>Measured at 100, 300, 500, 1000, 1,500 and 2,000 wheel passes</td></tr>
<tr><td>Sliding friction coefficient</td><td>Measured at 500 and 2,000 wheel passes (braking test)</td></tr>
<tr><td>Thin layer of ice (black ice)</td><td>Measured at 100, 300, 500, 1000, 1,500 and 2,000 wheel passes</td></tr>
<tr><td colspan="2">Wheel traveling velocity</td><td>Repeated wheel tracking test: 5 km/h
Braking test: 10 km/h</td></tr>
<tr><td colspan="2">Wheel load</td><td>5 kN (ground contact pressure: 0.196 MPa)</td></tr>
</table>

4.2 Test results



−5℃ BPR

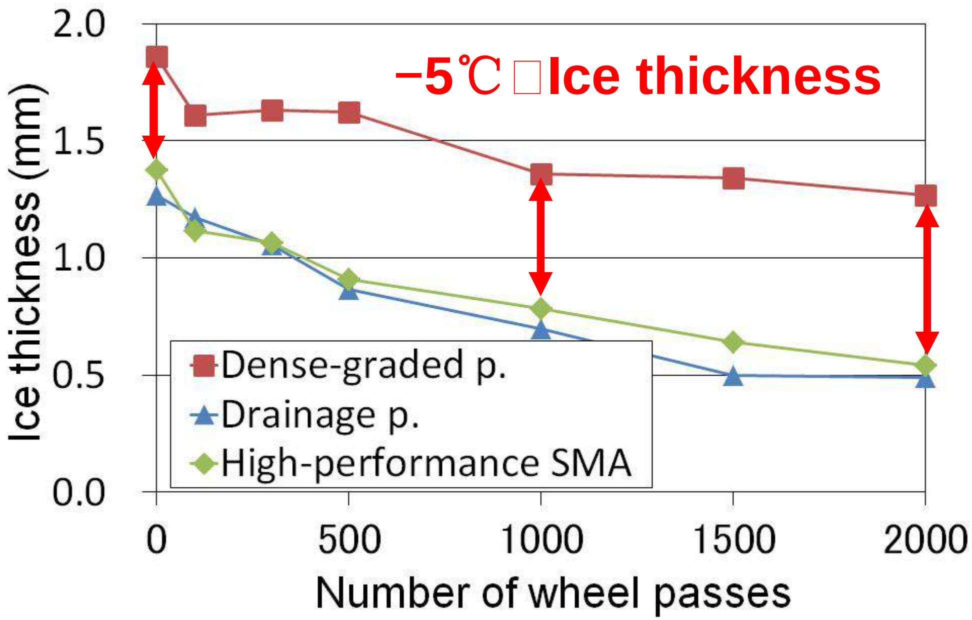


−5℃ Coefficient of sliding friction

Regardless of the pavement type, BPR increased with increase in the number of wheel passes.

The coefficient of sliding friction for the dense-graded pavement was around 0.1, and it did not increase with increases in the number of wheel passes, whereas that for the rough-surface pavement greatly increased after 500 passes.

4.2 Test results



The ice that formed on rough-surface pavement was thinner than that on dense-graded pavement: It was 0.5 mm thinner before the wheel passes started and 0.8 mm thinner at 2,000 wheel passes.

The results suggest the possibility of more effective salting by tailoring the salt application amount and the number of salting operations to the pavement type.

5. SUMMARY (Sprinkling and freezing test)

1) Drainage pavement and high-performance SMA were proven to have high sliding resistance. However, in the field application of rough-surface pavement on actual roads, durability and maintenance of permeability need to be considered.

2) The drainage pavement has higher sliding resistance than the high-performance SMA has. This is because drainage pavement has a higher permeability than high-performance SMA, and thus, the former has less water remaining on the pavement than the latter has.

3) The permeability and rough surface texture of rough-surface pavement contribute to the high sliding resistance; however, that resistance declines with decreases in temperature.

4) The sliding resistance is higher with no wheel passes (left for 30 minutes after sprinkling water) than with a certain number of wheel passes. This is attributed to the supply of water from the wheel. However, further study is needed.

5. SUMMARY (Salting test)

5) The coefficient of sliding friction for the dense-graded pavement was around 0.1 (very slippery), and it did not increase with increases in the number of wheel passes, whereas that for the rough-surface pavement greatly increased after 500 passes.

6) The ice on rough-surface pavement is thinner than that on the dense-graded pavement: It is 0.5 mm thinner before the wheel passes and 0.8 mm thinner at 2,000 wheel passes. This suggests that rough-surface pavement has higher sliding resistance than dense-graded pavement has. The surface condition recovered due to exposure of the rough texture of the pavement.

7) The drainage pavement afforded higher sliding resistance than high-performance SMA did. This is because the drainage pavement had less water remaining on the surface than high-performance SMA had.

6. CONCLUSION

The characteristics of three types of pavement were clarified by laboratory tests, and the effectiveness of salting in increasing the surface friction of these pavements was assessed.

Currently, criteria for deciding salt application are more qualitative than quantitative, but it is important to quantitatively assess the sliding resistance of different types of pavement.

Our future study will include outdoor track tests and field tests toward establishing effective salting methods for winter road management and maintenance.

Thank you for your kind attention!

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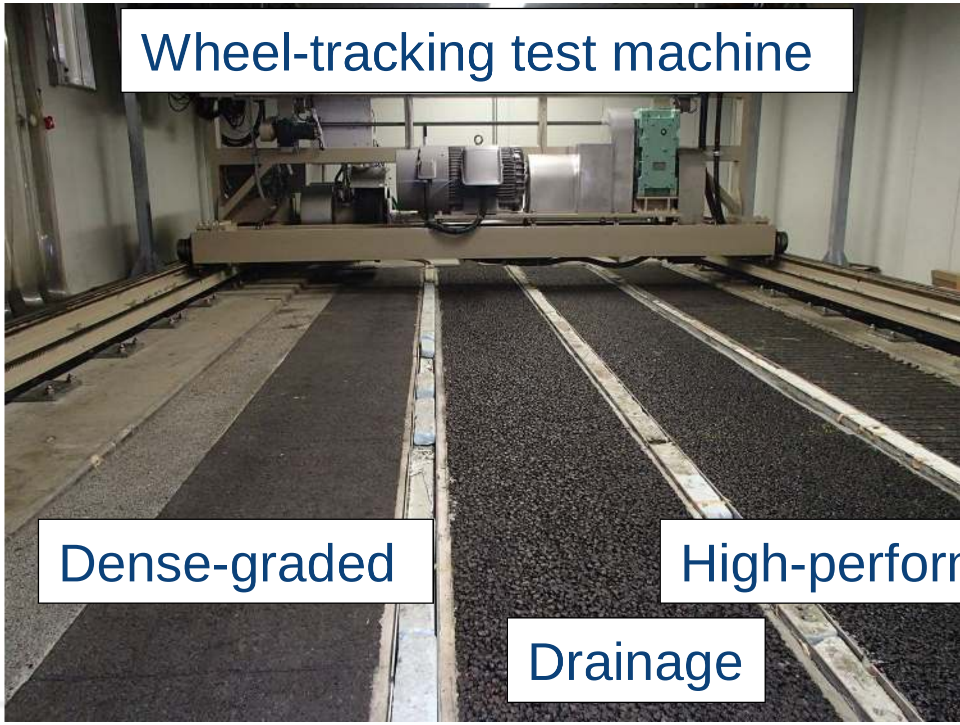
1. INTRODUCTION



Air temp.: -20～+60℃
Wheel load: 1.5～5 kN
Travel speed: Repeated wheel tracking test…5 km/h
Braking test…10 km/h