The Relation between Winter Road Surface and Weather Conditions and Road Maintenance

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1. Introduction

Hokkaido is the northernmost island in Japan. It has a total area of approximately 80,000 km^2 and a population of 5.7 million. The Hokkaido Development Bureau is responsible for the management of national highways in Hokkaido (total length: 6,000 km). Table 1 shows the mean minimum temperatures in January and mean snowfall during winter months in various municipalities in Hokkaido (Figure 1). As shown in the table, climatic conditions in the prefecture differ greatly. In addition, many roads in Hokkaido cross steep mountain passes or run along coasts, making management of national highways difficult. The recent enforcement of studded tire regulation has also made winter road management more difficult.

In the Sapporo area, where studded tire regulation was enforced in the winter of 1992-1993, public demand for improved winter road management grew because the use of studdless tires created very slippery frozen road surfaces. Before studded tire regulation was enforced, the focus of winter road maintenance had been snow-removal operations and de-icers had not been applied in large amounts. There had been few serious problems because drivers were used to driving on frozen surfaces. However, frozen road surfaces in the winter of 1992-1993 were more slippery than drivers had experienced before. Skidding accidents occurred frequently, and even professional drivers were no exception.

Given these developments, the authors began to research measures against very slippery frozen road surfaces. First, we sought to clarify weather conditions under which very slippery frozen road surfaces are created.

2. Classification of winter road surfaces

The investigation of road surfaces began in February 1993, but application of existing winter road classification methods failed to identify characteristics of problematic very slippery frozen road surfaces. Akitaya and Yamada then established a new classification method for snow and ice on roads from the viewpoint of snow and ice science (Akitaya and Yamada, 1994). Their method included visual estimates of slipperiness on roads. We met several times with Dr. Akitaya and improved their

classification method so that it could be used by road administrators. As a result, we devised a new surface classification method to identify very slippery frozen road surfaces, and applied it in the winter of 1994-95 (Figure 2).

Under the new method, road condition is determined based on "reflection of light on the surface," "snow property" and "underlying slippery frozen road surfaces." The terms used in this classification method are as follows:

1) Slipperiness is determined by the reflection of light on the road surface. When sunlight or a headlight reflects well on the surface, the term "very slippery" is placed before any one of the following "snow property" levels.

2) Snow property is classified into "compacted snow," "ice crust," "ice film," "slush," "powder snow" and "grain snow." Each type of snow can be distinguished by appearance, and even those with no technical knowledge can determine snow property.

3) When a slippery frozen road surface is covered with powder snow or grain snow, the term "on ice" follows the snow property mentioned above. In such conditions, the underlying ice affects vehicles more significantly than powder snow or grain snow on the surface. Thus, underlying ice must therefore be clearly distinguished from common powder snow or grain snow.

4) Dry surfaces and wet surfaces (bare pavements) are included, making 13 possible road surface conditions under the above-mentioned classification method. In this

report, surface conditions described as "very slippery" are referred to as "very slippery frozen road surfaces."

3. Winter road conditions and weather conditions

We studied road conditions from December to March for two winter periods (1994-1995 and 1995-1996). The study was conducted at 66 and 64 sites in Hokkaido in 1994-1995 and 1995-1996, respectively. Researchers visually estimated road surface conditions for each site between 8 and 9 a.m. In addition to the results of visual estimations, we also collected weather data from observation stations of the Japan Meteorological Agency located near the sites. The relationship between road and weather conditions was analyzed based on these data. The analysis was conducted by classifying the 13 different road conditions into five classes by appearance (Figure 3). This method of classification is referred to as "Surface-class classification." This "Surface-class classification" was revised slightly, however, with the results of a recent investigation in which skidding test vehicles were utilized.

3.1 Snowfall depth and road surface conditions

Here, snowfall depth is defined as the difference between the depth of accumulated snow measured at 9 a.m. one day and that measured at the same time the previous day. Daily depths of snow, which were recorded at weather observation stations related to each survey site, were calculated and totaled. Figure 4 shows occurrence rates of all surface classes by snowfall depth. Very slippery frozen road surface (Class 1) appears at a rate of more than 10% when snowfall depth was between 1 and 10 cm.

3.2 Minimum temperature and road surface conditions

Here, minimum temperature is defined as the lowest temperature measured between 9 a.m. one day and the same time the previous day. Figure 5 shows occurrence rates of all surface classes by minimum temperature. The rate of appearance of very slippery frozen road surfaces (Class 1) increased as the minimum temperature decreased.

4. Winter road maintenance techniques in Hokkaido

We studied the details of winter road maintenance conducted before the very slippery frozen road surfaces (Class 1) were observed. Figure 6 shows that no maintenance was conducted in 45% of cases and that both snow removal and de-icing were implemented in only 13% of the cases.

5. Conclusions

The results of this investigation clarified that occurrence of very slippery frozen road surfaces depends greatly upon weather conditions. It was also made clear that prevention of very slippery frozen road surfaces requires both snow removal and de-icing. In the past several years, amounts of de-icers applied in Hokkaido have increased rapidly, increasing costs related to winter road maintenance. Accordingly, effective winter road maintenance must be implemented within budget limitations. De-icing has only begun recently, however, and there is little history of its use in Hokkaido. In this respect, it is important that we learn more about advanced winter

road management techniques practiced in Europe and the U.S., including road weather information systems and anti-icing, and that these techniques be introduced in a form best suited to Hokkaido.

Reference:

Akitaya E. and Yamada T.(1994), Classification of Snow and Ice on Roads, *Proceeding of '94 Cold Region Technology Conference (in Japanese)*, pp. 63-69.

Table 1. Weather conditions in some municipalities in Hokkaido

	Sapporo	Asahikawa	Kucchan	Obihiro	Urakawa
Total accumulation snowfall during a winter (cm)	480	616	1301	242	106
Mean minimum temperature in January (°C)	-8.4	-13.4	-11.3	-14.7	-6.4

Figure 1: Some municipalities in Hokkaido as shown in Table 1

Snow/ Ice exist?	Reflection of light on the surface	Snow property				Underlying slippery frozen road surfaces	**Road Surface Condition**
		Tire's trace	Features of snow	Color	Thickness		
Yes	Reflect light well (Glazed)	Not so Apparent		White			**Very slippery compacted snow**
				Dark	1mm or more		**Very slippery ice crust**
					Less 1mm		**Very slippery ice film**
	Not reflect light well			White			**Compacted snow**
				Dark	1mm or more		**Ice crust**
					Less 1mm		**Ice film**
		Apparent	Snow cloud is observed			No	**Powder snow**
						Yes	**Powder snow on ice**
			Granular (Loose)			No	**Grain snow**
						Yes	**Grain snow on ice**
			Contain much water				**Slush**
			Others				**Compacted snow**
No	Dry						**Dry**
	Wet/Moist						**Wet**

Figure 2: The new classification method on the winter road condition

Surface-class	Appearance	Road condition classified by the new classification method
Class 1	Very Slippery	Very Slippery Compacted Snow
		Very Slippery Ice Crust
		Very Slippery Ice Film
Class 2	Icy	Ice Crust
		Ice Film
		Powder Snow on Ice
		Grain Snow on Ice
Class 3	Snowy	Compacted Snow
		Powder snow
		Grain Snow
Class 4	Wet/Moist	Slush
		Wet
Class 5	Dry	Dry

Figure 3: The Surface-class and the Road conditions

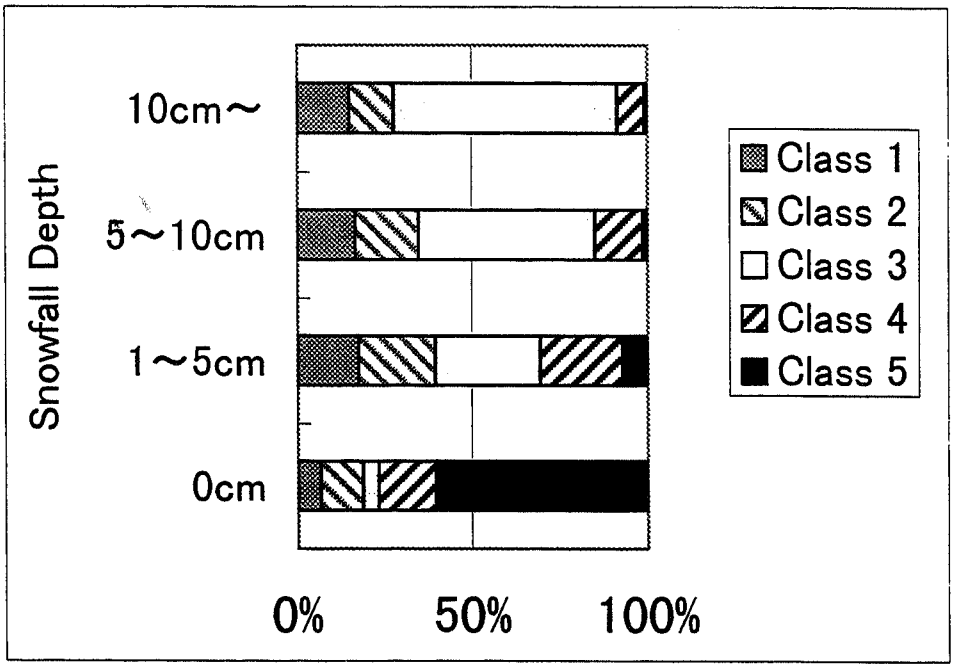

Figure 4a : Snowfall depth and the surface class (1994/95)

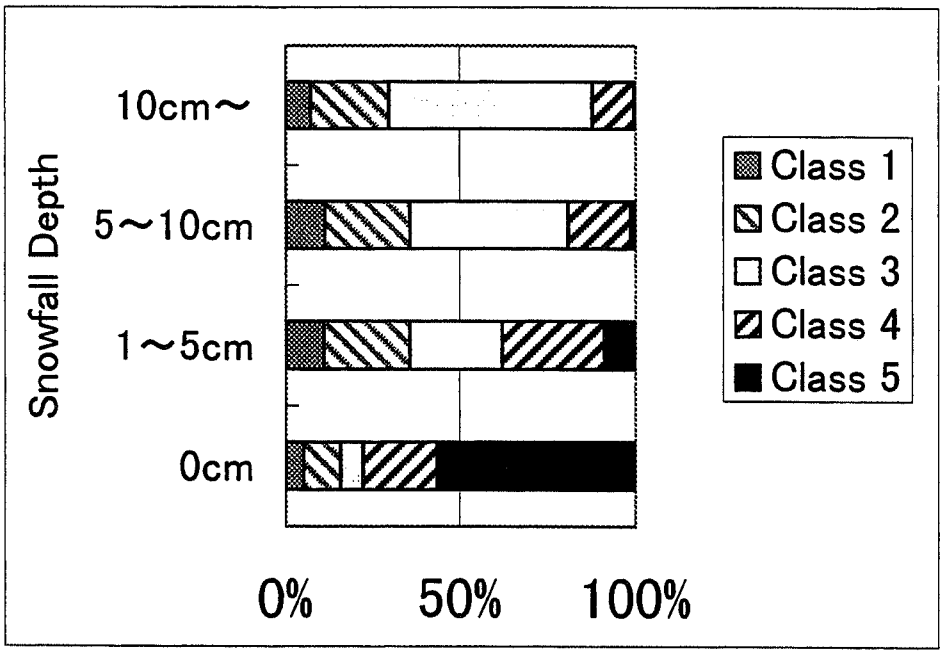

Figure 4b : Snowfall depth and the surface class (1995/96)

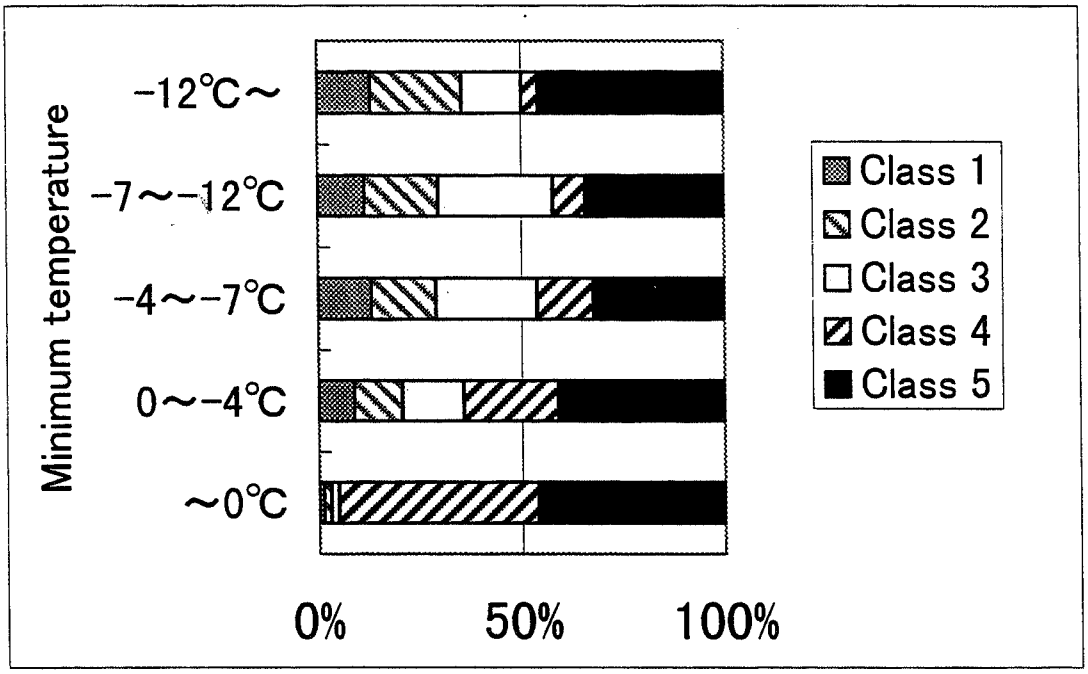

Figure 5a : Minimum temperature and the surface class(1994/95)

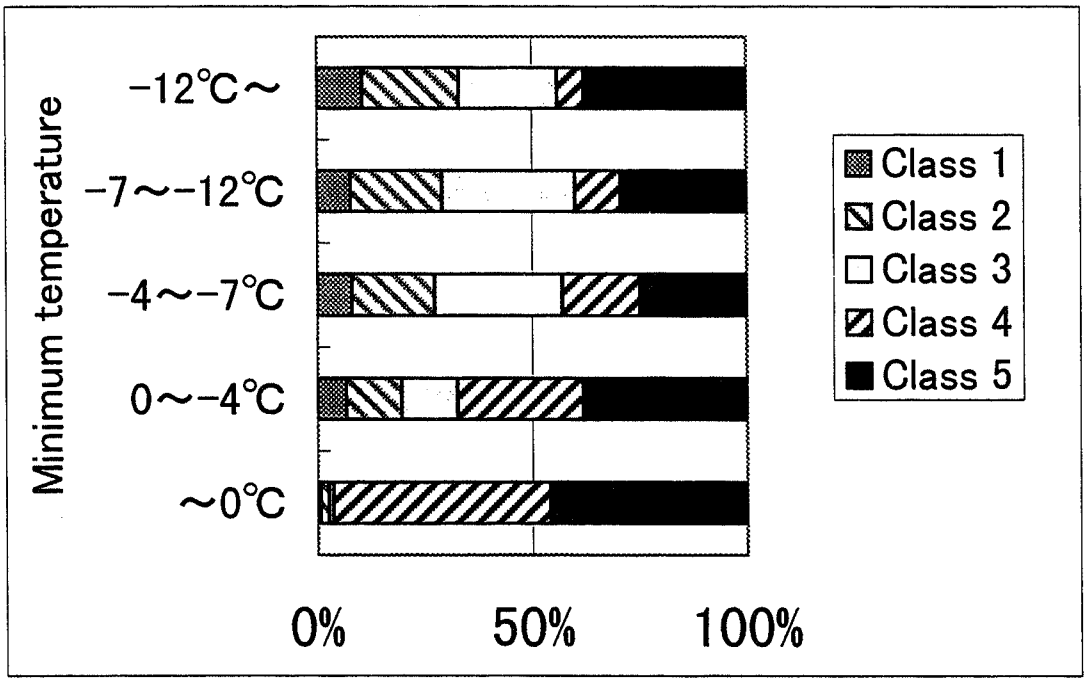

Figure 5b : Minimum temperature and the surface class(1995/96)

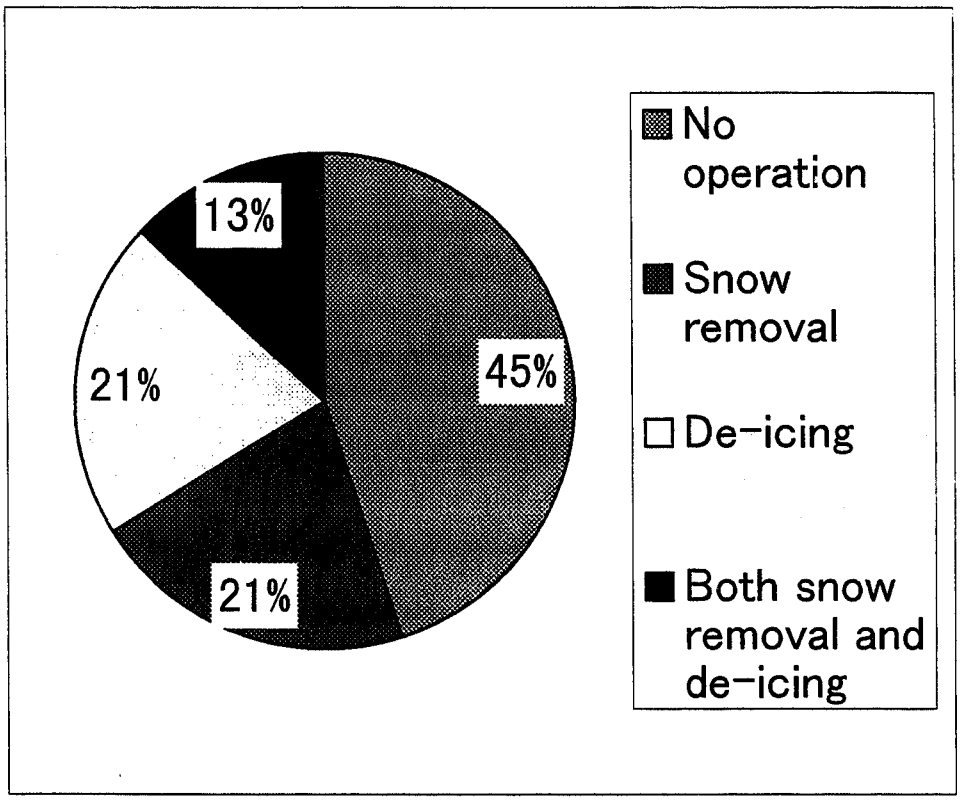

Figure 6 : Operated maintenance method before the very slippery frozen road surface (Class 1) was appeard