Influence of Regulation of Studded Tire Use in Hokkaido, Japan

NOBUO KONAGAI, MOTOKI ASANO, AND NOBUO HORITA

The law prohibiting the use of studded tires has been in effect in Japan since the 1991–1992 winter; its purpose is to prevent the dust pollution generated by such tires. According to the law, studded tires are to be prohibited (except for emergency vehicles) in areas designated by the Environment Agency. Since April 1992, infringements of the law have been punished with a fine of no more than 100,000 yen. Before the law was effective, tire manufacturers already had voluntarily stopped manufacturing and selling studded tires and had begun developing and supplying high-quality rubber tires with no metal studs—"studless tires." The circumstances that forced the law; the effects of the enforcement of the law on the road environment, road pavement and marking, traffic accidents, and traffic characteristics; and the performance of studless tires are reported.

When the temperature is very low, much snow falls in winter in snowy and cold regions in Japan, especially in Hokkaido. Road authorities remove snow by means of machines such as the snowplow and rotary snow-removal machine. However, salting is not a primary method of snow and ice control. The authorities cannot adopt a bare-pavement policy because of Japan's severe cold and great amount of snow.

Studded tires began to be used widely in Japan in the late 1960s. They were extremely useful in ensuring safety and keeping steady winter traffic in snowy and cold regions. However, studded tires raised problems of dust pollution, road surface damage, and traffic accidents caused by ruts in the 1980s. The dust pollution created by the pavement wearing of studded tires was the serious problem. The causal relationship between the dust and disease was not clear, but the dust that blew up was like a dark cloud veiling a whole city; it obstructed breathing.

Under the circumstances, citizen activists, medical concerns, and lawyers groups appealed to the public to prevent the dust pollution. After many activities and debates, municipal and prefectural regulations related to the prevention of dust pollution have become effective, and tire manufacturers voluntarily stopped manufacturing and selling studded tires. The studded tire prohibition went into effect April 1, 1991, and the punishment of a fine has been in effect since April 1, 1992.

In short, the law prohibits the use of studded tires on nonsnowy or nonfrozen road surfaces (except for emergency vehicles such as fire engines) in areas designated by the Environment Agency. It actually means that vehicles cannot use studded tires even though the vehicles may be passing through these areas only briefly, because we ordinarily do not change tires on the border of these areas.

The following is extracted from the law concerning prevention of dust generation caused by studded tires:

> Article 3 (people's duty): All people must make an effort not to generate dust caused by studded tires and must cooperate with national and prefectural projects that relate to the prevention of dust generated by studded tires.
>
> Article 4 (national, prefectural, and municipal governments' duty): The national government must make an effort to promote basic and general projects related to the prevention of dust generation caused by studded tires such as the diffusion of knowledge related to preventing dust generated by studded tires, improving road facilities, supporting the development of a substitute for studded tires, and promoting education for safe driving. The national government must make an effort to advise or otherwise promote prefectural and municipal government projects that prevent dust generation.
>
> Article 5 (area designation): The Minister of the Environment Agency must designate areas in which people are dwelling densely and in which the environment must be especially preserved and the health of inhabitants protected by preventing dust generation caused by studded tires.
>
> Article 7 (prohibition of studded tires): No one may use studded tires in nonsnowy or nonfrozen sections (except for tunnels and the sections designated by government ordinance) on cement or asphalt concrete pavement in the designated areas. This article excepts fire engines, emergency vehicles, and other vehicles designated by government ordinance.
>
> Article 8 (punishment): Infringement of Article 7 is punished with a fine of no more than 100,000 yen.

STUDY OBJECTIVES

This paper includes a performance test of winter tires and a questionnaire of drivers' concerns; also included are observations of studded tire use, traffic characteristics, and effects on asphalt pavement, road markings, and the environment.

RESULTS

Performance Test for Winter Tires

The Civil Engineering Research Institute was conducting performance tests of winter tires several years before the prohibition went into effect. The measurements tested were stopping distance, lengthwise skid resistance, and sideways skid resistance.

Winter tires of known characteristics manufactured in 1990 were used in the stopping distance test. The stopping distance was observed at 40 km/hr on compacted snow and frozen

Civil Engineering Research Institute, Hokkaido Development Bureau, 1–3 Hiragishi Toyohiraku, Sapporo 062 Japan.

surfaces at the test course in northern Hokkaido; results are given in Table 1. On compacted snow, the stopping distances of studded and studless tires were nearly equal. The stopping distance of used studless tires was also nearly equal. In this case, used studless tires were artificially worn tires that were equivalent to the 10 000-km (6,211-mi) used tire.

On frozen surfaces, the stopping distances of studded and studless tires are also nearly equal. However, sometimes the stopping distance of the used studless tire was longer.

In summary,

- Stopping distances of any tire on a frozen surfaces are longer than those on compacted snow at the test course.
- On slippery compacted snow, the stopping distance of the studless tire is longer than that of studded tire, but on soft compacted snow, the stopping distances are nearly equal. The stopping distance of a studless tire varies according to its manufacturer. On compacted snow, the marginal cornering speed of a vehicle with studless tires was a little faster than that of a vehicle using studded tires.
- On frozen surfaces, the marginal cornering speed of studded tire was faster than that of studless tires.
- The newer the studless tire, the better the stopping performance. Newly manufactured studless tires' stopping performance is more durable than previously manufactured studless tires' stopping performance.
- Although not discussed here, the results of the climbing test are given in Table 2.
- Future objectives are to improve the stopping performance of studless tires on frozen surfaces and the durability of the stopping performance of studless tires.

Percentage of Studded and Studless Tire Use

Since 1986 the Hokkaido prefectural and Sapporo municipal governments have been observing the percentage of tire use in two ways: observation at parking areas and at the roadside. The parking area observation distinguishes tires into three types: studded, studless, and other. The roadside observation distinguishes tires into two types—studded and other—by watching and by listening.

TABLE 1 Results of Stopping Distance Test

types of tire	road surface	
	compacted snow surface	frozen surface
stud tire	23.3m (-7.7℃) (25.5yd (18.1°F))	56.0m (-7.5℃) (61.3yd (18.5°F))
studless tire A	26.2m (-7.3℃) (28.7yd (18.9°F))	56.1m (-5.5℃) (61.4yd (22.1°F))
used studless tire A	24.0m (-3.8℃) (26.3yd (25.2°F))	51.0m (-9.1℃) (55.8yd (15.6°F))
studless tire B	25.3m (-4.6℃) (27.7yd (23.7°F))	59.8m (-5.1℃) (65.4yd (22.8°F))
used studless tire B	24.6m (-5.2℃) (26.9yd (22.6°F))	60.6m (-7.3℃) (66.3yd (18.9°F))
studless tire C	22.5m (-5.2℃) (24.6yd (22.6°F))	62.5m (-2.5℃) (68.4yd (27.5°F))

( ) is road surface temp

TABLE 2 Results of Climbing Performance Test

types of tire / gradient	soft compacted snow			hard compacted snow		
	6.3%	8.9%	9.9%	6.3%	8.9%	9.9%
stud tire	100	100	88	100	92	100
studless tire A	100	100	100	100	92	88
used studless tire A	100	100	88	100	42	25
studless tire B	100	100	100	100	92	38
used studless tire B	75	50	25	100	33	0
studless tire C	100	100	100	100	92	50

Figures are percentage of the vehicles that were able to climb.

The percentage of studded tire use has been declining in Hokkaido (Figure 1). Use in the middle of the 1991–1992 winter was 56 percent less than use during the 1986–1987 winter. (Early, middle, and late winter are November and December, January and February, and March and April, respectively.) The percentage of studded tire use is different according to the period of the season. The percentages in the early and late winter are less than in the middle of winter, and the difference in percentages between the early and late winter and the middle of winter has grown since 1988–1989. The percentage of studded tire use will become nearly zero in several years because of the prohibition and fine and because tire manufacturers have stopped manufacturing and selling studded tires and are selling studless tires instead; also, the efficacy of existing studded tires will disappear soon.

Questionnaire Research of Drivers' Concerns

The questionnaire surveyed drivers' concerns about studless tires and whether drivers shifted transportation modes or changed routes during their commutes.

A questionnaire was distributed in Sapporo, which is an area in which the Environment Agency has prohibited studded tires. In Sapporo during 1990–1991, 19.9 percent of drivers used studded tires in the early winter, 41.0 in the middle of winter, and 21.6 in late winter. However, in 1991–1992 the percentages were 6.2, 22.1, and 6.6, respectively.

Of those who usually drive themselves to work in seasons other than winter, 16.9 percent change routes or shift to public transportation on snowy days and 80.9 percent do not change routes or shift modes. Among those who do, 41.6 percent change their routes and 49.5 percent shift from car to public transportation. The main reason for changing routes is that snow is removed better on the substitute route than on the usual route and that the substitute route is safer than the usual route. The main reason for shifting to public transportation is that travel is shorter, more reliable, and safer than travel by car. Those who do not change routes or modes said that they have no substitute or that they are more patient.

In winter, it takes 61.6 percent of those who go to their offices longer than 40 min, but in seasons other than winter, it takes that long for only 36.1 percent. And 25.2 percent commute fewer than 10 km (6.2 mi), 38.9 percent commute

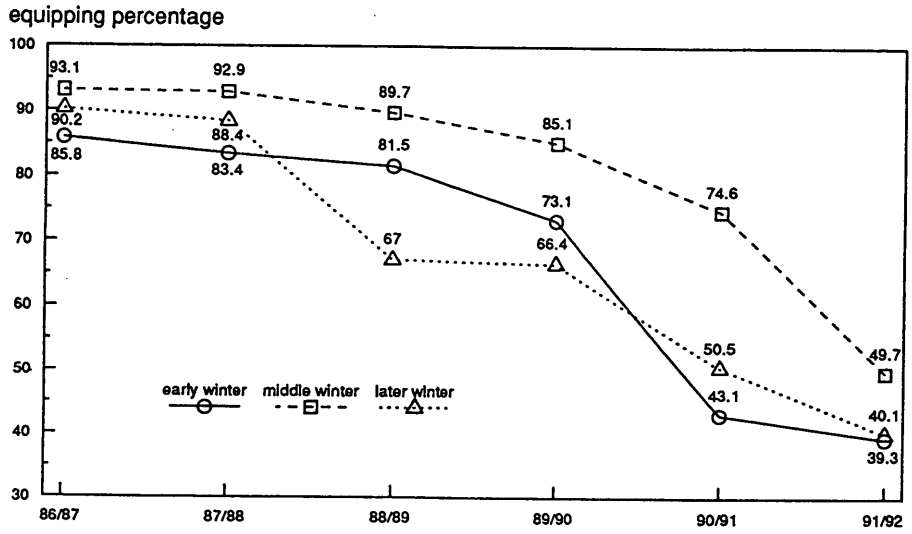

FIGURE 1 Percentage of studded tire use.

10 to 20 km (6.2 to 12.4 mi), and 32.8 percent commute farther than 20 km (12.4 mi).

Since the studded tire prohibition went into effect, 17.6 percent have shifted their modes of long-distance travel from car to another, 51.2 percent travel long distances by car with studless tires, and 26.2 percent travel long distances by car with studless tires and tire chains.

Of those surveyed, 68.7 percent believe that the performance of studless tires is more than 75 percent that of studded tires in soft compacted snow, and 55 percent believe that the performance of studless tires is less than 55 percent that of studded tires in slippery sections such as intersections.

Traffic Characteristics

The observation of traffic characteristics concerned overall travel time, overall travel speed, standing time, standing frequency, running speed, running space, and traffic accidents at the rush hours on snowy or frozen road surfaces in winter urban areas.

The observations were carried out six times by running tests on snowy or frozen road surfaces on six general national road routes going into the center of the city of Sapporo during the rush hour 7:30 a.m. to 9:30 a.m. for 1 hr.

The overall travel time was 15 percent longer in the 1990–1991 winter than in the 1989–1990 winter; the overall travel speed was 20 percent faster in the 1990–1991 winter than the 1989–1990 winter (Figure 2). The standing time in the 1990–1991 winter was 15 percent longer than in the 1989–1990 winter (Figure 3). The stopping frequency was 20 percent higher in the 1990–1991 winter than in the 1989–1990 winter.

In the suburbs of Sapporo, running speed and running space were also observed by means of a sensor wire and video camera on roads going into the suburbs. In this observation, differences of running speed and running space between studded and studless tires were not observed.

Traffic accidents involving skidding vehicles with studless tires have been increasing. Figure 4 shows the number of such

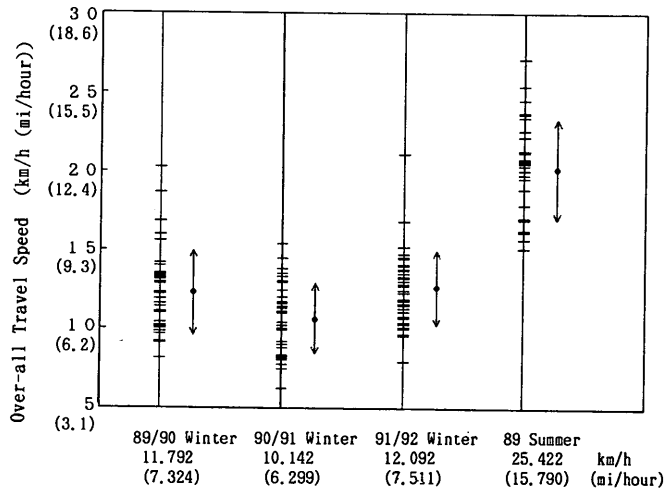

FIGURE 2 Overall travel speed.

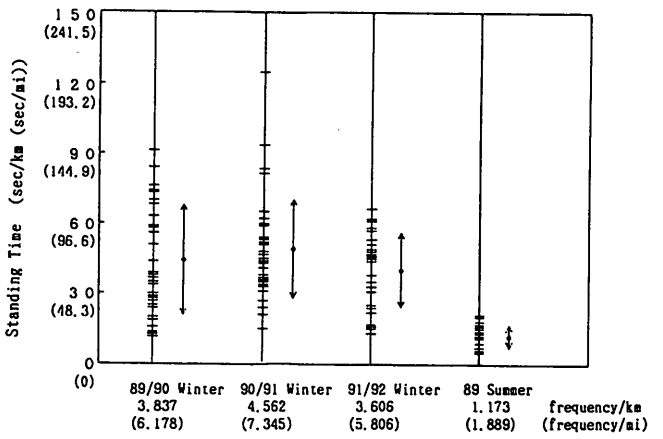

FIGURE 3 Standing time.

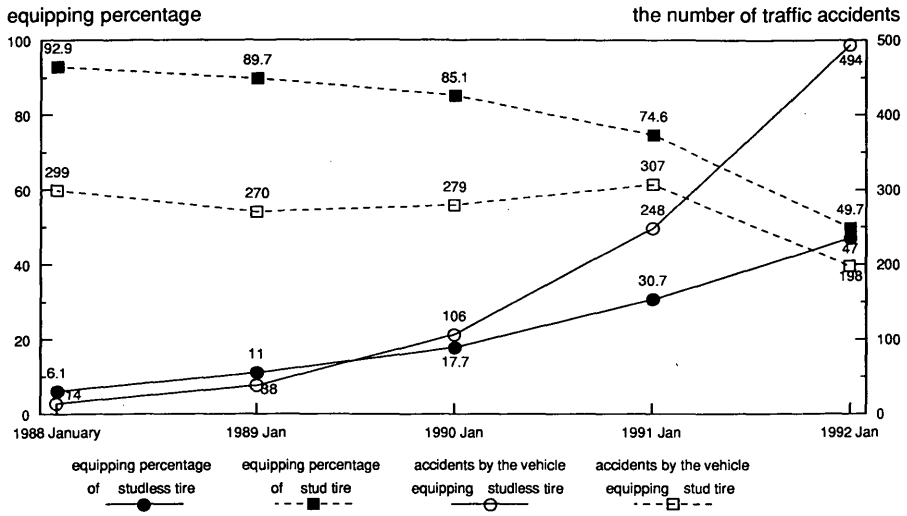

FIGURE 4 Number of accidents and percentage of tire use.

accidents and the percentage of studded and studless tire use in January. The growth in the rate of these accidents is larger than the growth in the rate of studless tire use.

Effects on Asphalt Pavement and Road Markings

The wear on asphalt pavement during winter was observed at a section on Route 36 at which pavement repair was completed in August 1989. This section's surface course is fine- and gap-graded asphalt concrete with rubber. The time it took for road markings to disappear was observed by diffuse reflectometer.

The worn amount of asphalt pavement during the 1990–1991 winter was 33 percent less than it was in the 1989–1990 winter (Figure 5). This drop was linked to the declining percentage of studded tire use. Therefore, we can assume that there is intensive interrelation between worn asphalt pavement and studded tire use.

The disappearance time of road markings in the 1990–1991 winter was shorter than it was in the 1989–1990 winter. The decreasing percentage of studded tire use also affected this aspect. Road markings are so thin and weak that they will disappear even if studded tire use becomes lower than ever.

Effects on Environment

We obtained results of the observation of the density of suspended particulate matter and the amount of fallen and piling dust from the Hokkaido prefectural government and Sapporo municipal government.

The lower the percentage of studded tires, the weaker the density of suspended particulate matter. The average density of suspended particulate matter is shown in Figure 6; according to the environmental standard, the average density of suspended particulate matter must be less than 0.1 mg/m^3 (0.12 moz/ft^3) in 24 hr or less than 0.2 mg/m^3 (0.25 moz/ft^3) each hour.

The Sapporo municipal government set up the amenity standard on the amount of fallen and piled-up dust. The municipal government has been observing it continuously since the early 1988 winter. According to the standard, the fallen and piled-up dust must be less than 200 mg/m^2 (8.44 moz/yd^2) or visibility might be hazy for 200 m (218.8 yd). The numbers of days and hours in which the standard was exceeded are shown in Tables 3 and 4; for example, the visibility standard was exceeded on 40 days during the 1988–1989 winter, but on only 3 days during the 1991–1992 winter. The decline of the percentage of studded tire use has certainly affected these numbers.

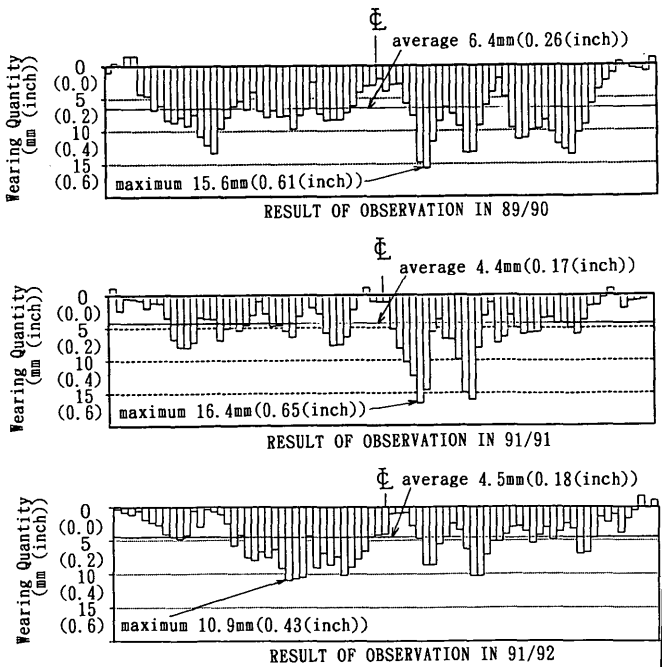

FIGURE 5 Pavement wear.

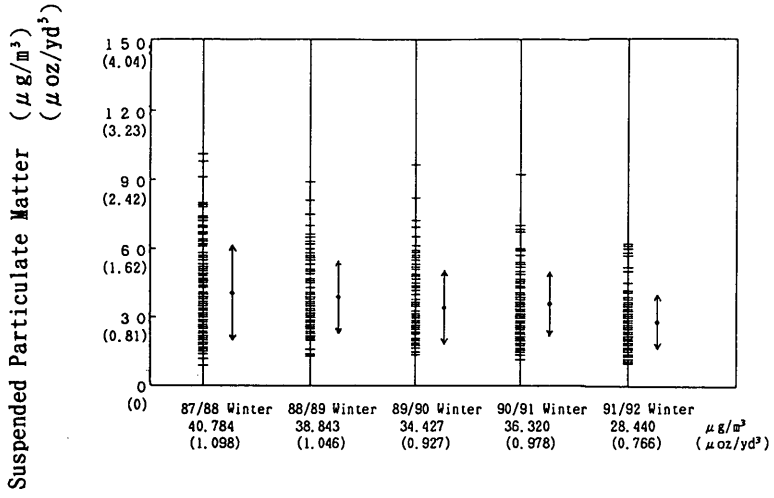

FIGURE 6 Density of suspended particulate matter.

TABLE 3 Number of Days Exceeding and Passing Amenity Standard

	88/89 Winter	89/90 Winter	90/91 Winter	91/92 Winter
Days over the amenity standard	40days	17days	10days	3days
Days clear the amenity standard	61days	84days	91days	98days

from November to December and from March to April 10

TABLE 4 Number of Hours Exceeding Amenity Standard

	November	December	March	April	total
88/89 Winter	21h	36h	102h	11h	170h
89/90 Winter	0h	11h	41h	0h	52h
90/91 Winter	0h	0h	19h	0h	19h
91/92 Winter	0h	0h	6h	0h	6h

CONCLUSIONS

It is certain that the use of studless tires in Japan will increase because tire manufacturers have stopped manufacturing and selling studded tires and the prohibition law has come into effect. However, people are still anxious about the starting and stopping performance of the studless tire. The improvement of the studless tire's performance and more careful control of snow and ice on the roads are expected. To ensure the safety of traffic in winter with the studless tire, not only should tire manufacturers better the studless tire's performance and road authorities improve their methods of snow and ice control, but drivers should adapt their techniques to the characteristics of the studless tire. This study will continue observations until the 1993–1994 winter, when the studless tire will be fully used.