Wheel Track Rutting Due to Studded Tires

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The extent of pavement rutting attributable to studded tires was investigated to determine the extent to which pavement wear has contributed to rut development in Alaska. The investigation is based on an extensive literature review as well as a survey questionnaire sent to all highway agencies in the snow zones of North America and Northern Europe. In addition, measurements of studded tire use and wheel track rutting taken at several locations in Alaska during the winter of 1990 provided new information. Very little research has been done since 1975 in this area, except in Scandinavia. Nearly all agencies continue to prohibit or restrict the use period of studded tires, but enforcement of stud use is typically minimal. Very little new information on the percentage of vehicles using studded tires or on tire wear studies is available, except for recent stud use surveys performed in Alaska from 1989 to 1991. At the sites studied, approximately 25 percent of all tires were studded during winter. Factors affecting wear rates are defined, and limited wintertime wear rate measurements in Alaska indicate that pavement wear occurs at a rate of about 0.1 to 0.15 in./million studded tire passes. The contributions of wear from studded tire abrasion in pavement rut development must not be ignored when factors in pavement rutting are analyzed. This analysis will be very difficult in many states because there is almost no information available on actual stud use or on the wear rates from modern vehicles and tire types.

The public has long associated the use of studded tires with improved traction on highways during the winter months when the road surfaces are often icy. However, studded tires also have been shown to increase road wear on both asphalt and portland cement concrete pavements. This paper has been prepared to document the use and effects of studded tires, particularly in terms of producing wheel track ruts.

Specific objectives of this paper are to

1. Quantify the current use of studded tires throughout North America and Northern Europe. This includes data on (a) percentage of vehicles using studded tires, (b) characteristics of the studs (type and number), and (c) periods that studded tires are permitted.
2. Summarize the results of road wear studies (field and test tracks) in each of the following areas: (a) mechanism of pavement wear, (b) rate of pavement wear, and (c) factors affecting the wear rate.
3. Identify the reported consequences and benefits of using studded tires such as (a) increased pavement maintenance to repair ruts, (b) increased safety problems due to splash and spray from rutted pavements, and (c) reduced stopping distance on icy roads.

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To accomplish the stated objectives, several work activities were undertaken. These included

1. A computer literature search (using Transportation Research Information Services). Many publications identified in this search were reviewed and evaluated in the preparation of this paper.
2. A survey of agency practices. A survey form was developed and mailed to 30 highway agencies in the United States, 11 Canadian provinces and territories, and 4 foreign countries (Norway, Sweden, Finland, and the former West Germany).
3. A telephone survey of selected tire manufacturers to identify the types and number of studs being used.
4. A field survey of studded tire use in Alaska at Fairbanks, Anchorage, and Juneau.
5. Roadway rut depth measurements made in Juneau at four roadway locations. Measurements were taken at fixed points using five dial indicators mounted on rut measurement bar.

STUDDED TIRE PRACTICES

The data presented in this section are the result of an extensive literature review, the survey of selected transportation agencies and selected calls to manufacturers of studded tires. Information was obtained from various agencies in the United States, Canada, and Europe.

Use of Studded Tires

The results of the 1990 survey of snow zone agencies in North America and Northern Europe provided an indication of studded tire use. The results shown in Table 1 indicate that a number of agencies permit their use. When compared with the results of a similar survey from 1975 (*1*), it is seen that three states that allowed studded tires in 1975 now prohibit their use: Arizona, Maryland, and Michigan. Of the agencies surveyed in 1990 that formerly prohibited studded tires, only California has passed legislation allowing their use. It should also be noted that in all cases where studs are permitted, chains are too.

In addition to the increasing number of states prohibiting the use of studded tires, most states restrict their use to winter months. On the basis of the results of the literature review, the periods to which studded tire use is restricted in the United States and Canada is shown in Figure 1 (*1*). Note that in the 1970s 14 states and 2 provinces had no restrictions and that 9 states and 1 province prohibited the use of studded tires.

TABLE 1 AGENCIES PERMITTING THE USE OF STUDDED TIRES (*14*)

United States[a]	Canada[b]	Europe[c]
Alaska	New Brunswick	Sweden
California	Nova Scotia	Norway
Colorado	Quebec	Finland
Connecticut	Saskatchewan	
Delaware		
Idaho		
Indiana		
Iowa		
Kansas		
Maine		
Montana		
Nebraska		
Nevada		
New Jersey		
New York		
North Dakota		
Oregon		
Pennsylvania		
Rhode Island		
South Dakota		
Utah		
Vermont		
Washington		
Wyoming		

[a]Survey forms were sent to 34 states. States not allowing studs: Illinois, Maryland, Michigan, Minnesota, and Wisconsin. New Hampshire, Massachusetts, Ohio, and New Mexico did not respond.
[b]Survey forms were sent to 11 provinces. Provinces not allowing studs: Alberta, NW Territories, and Ontario. British Columbia and Yukon Territory did not respond.
[c]Germany does not allow studded tires.

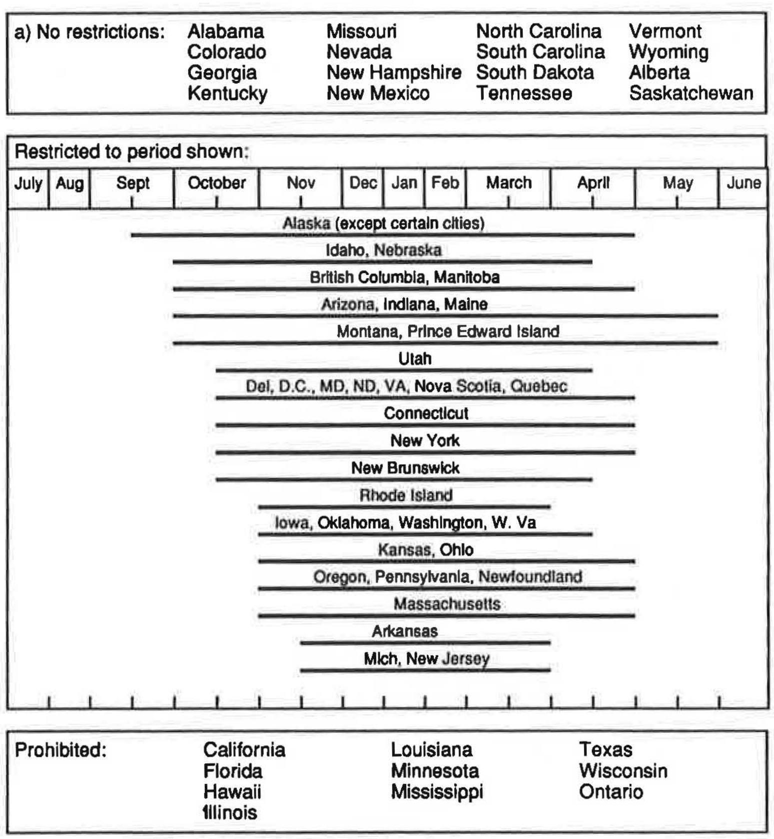

FIGURE 1 Legal restrictions on use of studded tires (*1*).

The remaining states and provinces allow the use of studded tires only during fall, winter, and spring. The results of the 1990 survey (Table 2) showed, for North America, that only three agencies had no restrictions, 25 states or provinces restricted stud use to a given time period, and eight agencies prohibited their use. Of those agencies restricting the use of studs to a specific period, most restrict use to the period from October through April. Similar results from the European countries surveyed are also given in Table 2.

Percentage of Vehicles with Studs

The surveys did not provide much useful information on studded tire use. In fact, only a few agencies were able to provide an estimate of current usage. Therefore, heavy reliance was placed on results from the literature (pre-1980) because the actual use rates are virtually unknown in the United States and Canada.

Historical data on the percentage of studded tire use in the United States and abroad are given in Table 3. These data show studded tire use ranges from 0 to approximately 75 percent of all vehicles. In areas that have harsh winters, it ranges from about 20 to 75 percent. In general, Sweden and Finland have higher rates than most North American agencies. Only Finland had information comparing truck and car use.

A 1990 survey of studded tire use in Alaska is given in Figure 2. As indicated, studded tire use varies by season as well as by year and location. However, it can be seen that wintertime use (through March) by light vehicles is between 20 and 35 percent. It is also noteworthy that between 3 and 6 percent of the surveyed vehicles used studded tires in summer, when Alaska prohibits their use. Data from Anchorage, Fairbanks, and Juneau were averaged, and the studded tires per vehicle pass are shown in Figure 3. Use rates in studded tires passes per vehicle pass range from a low of 0.05 in the summer to about 0.5 during the winter.

Enforcement

The results from the 1990 questionnaire also investigated the role of enforcement during prohibited periods. Generally, the risk of getting caught is considered low to moderate. Only South Dakota, Washington, Illinois, Minnesota, Nevada, Ontario, and Quebec indicated a high risk. Highway agencies in three of these locations (Illinois, Minnesota, and Ontario) do not allow studded tires, eliminating the need for seasonally based enforcement. The cost of being cited also varies considerably; fines range from less than $25 to $500 plus vehicle impoundment.

Characteristics of Studded Tires

A typical studded tire is essentially a normal winter or all-season tire with studs embedded in the tread. Typical specifications for studded tires for passenger cars are shown in Table 4.

Although many types of studs were found in the literature, all have similar parts: a pin (typically tungsten carbide) surrounded by the stud housing or body (typically steel), which has a flange at its base to hold the stud in the tire tread. Four basic stud types have been used; Table 5 summarizes the characteristics of each type. Conversations with tire manu-

TABLE 2 RESTRICTIONS ON USE OF STUDDED TIRES (*14*)

a)	US/Canada			
a)	No restrictions	Colorado Vermont Saskatchewan	Note: Several other states outside the snow zone were not surveyed. These states may or may not restrict the use of studs.	
b)	Restricted to time period shown	Alaska	(September 15 - April 30 (north of latitude 60°N) (October 1 - April 14 (south of latitude 60°N)	
		Connecticut	(November 15 - April 30)	
		Iowa	(November 1 - April 1)	
		Kansas	(November 1 - April 5)	
		Maine	(October 1 - May 1)	
		Nevada	(October 1 - April 30)	
		New Jersey	(November 1 - April 1)	
		New York	(October 15 - May 1)	
		Rhode Island	(November 15 - April 1)	
		Utah	(October 15 - March 15)	
c)	Restricted (period unreported)	California Delaware Idaho Indiana Montana Nebraska	North Dakota Oregon Pennsylvania South Dakota Washington Wyoming	New Brunswick Nova Scotia Quebec
d)	Prohibited	Arizona Illinois Maryland	Michigan Minnesota	Alberta Northwest Territories Ontario
b)	Northern Europe			
a)	No restrictions			
b)	Restricted	Norway Sweden Finland	(Period unreported) (31 October to Easter) (1 November to 31 March)	
c)	Prohibited	Germany		

TABLE 3 HISTORICAL DATA ON USE OF STUDDED TIRES

Agency		% of Vehicles with Studs	Agency	% of Vehicles with Studs
United States (*1*)	Alabama	1	Nevada	6
	Alaska	61	New Hampshire	30
	Arizona	1	New Jersey	20
	Arkansas	1	New Mexico	NA
	California	NA	New York	30
	Colorado	30	North Carolina	2
	Connecticut	25	North Dakota	32
	Delaware	18	Ohio	20
	Florida	NA	Oklahoma	1
	Georgia	NA	Oregon	10
	Idaho	27	Pennsylvania	28
	Illinois	12	Rhode Island	NA
	Indiana	10	South Carolina	3
	Iowa	25	South Dakota	40
	Kansas	7	Tennessee	NA
	Kentucky	12	Texas	0
	Maine	NA	Vermont	60
	Maryland	NA	Virginia	10
	Massachusetts	32	Washington	35
	Michigan	12	West Virginia	10
	Missouri	14	Wisconsin	20
	Montana	60	Wyoming	35
	Nebraska	38		
Canada	Ontario (*15*)			32
	Manitoba (*11*)			20-25
	Quebec (*11*)			50
	Maritime Provinces (*11*)			50+
	Ottawa (*15*)			48
Finland (*16*)	Cars			90-95
	Trucks			40
Sweden (*3*)				60

facturer and distributor personnel revealed that only the controlled protrusion (Type I) stud is currently used in the United States. The principal reason is that as the stud housing or body wears, coinciding with the tread wear, the tungsten carbide pin is pushed deeper into the stud housing, providing a uniform protrusion length throughout the life of the stud. This benefit is not fully realized with the other stud types, because the protrusion length of the stud can vary over time. Figure 4 gives the dimensions for the controlled protrusion stud. The number of studs per tire generally ranges from 64 to 120.

In Sweden it has been long recognized that conventional studs cause excessive pavement wear. In Sweden, therefore, a new ice stud was developed that features low noise and reduced road wear. It weighs only 0.7 g yet reportedly retains ice grip and durability. The reduction in weight is possible because of the use of a new polymer in the stud body (B. Simonsson, personal communication, Aug. 1990).

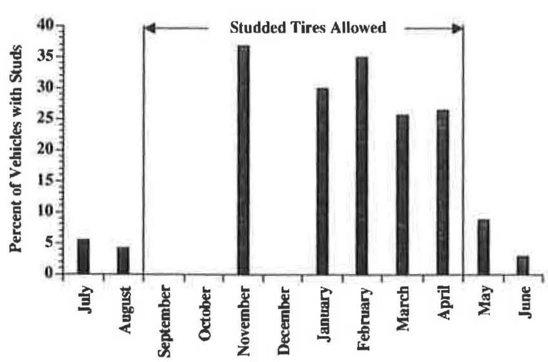

FIGURE 2 Studded tire use survey results from Alaska (*10*).

ROAD WEAR STUDIES

This section of the paper summarizes the results of studies from throughout the world to identify the cause (mechanism) of pavement wear owing to studded tires, the factors that affect the rate of wear, and the rate of pavement wear.

Cause of Pavement Wear

The results of the literature review indicated that the mechanism of wear is primarily by abrasive action. Niemi (*2*) has identified four mechanisms that contribute to pavement wear, as shown in Table 6. Which of the mechanisms is most important is still open to debate. In Alaska it is generally thought

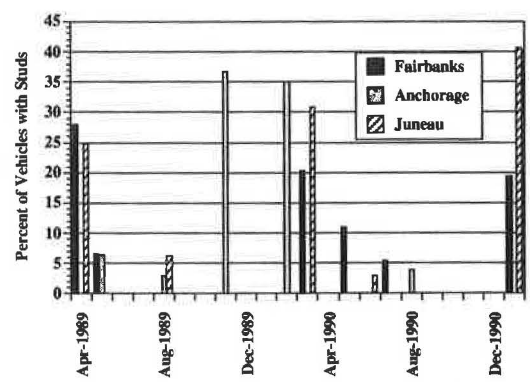

FIGURE 3 Average seasonal studded tire usage patterns in Anchorage, Fairbanks, and Juneau, Alaska (*10*).

TABLE 4 TYPICAL CROSS-SECTIONAL AREA SPECIFICATIONS (1)

Nominal Car Size	Tire Data		Tire Stud Data		
	Nominal Size	Typical Tread Surface Area (sq. in.)	Typical Maximum Number of Studs	Typical Cross-Sectional Area (sq. in.)	Percent of Tread Surface Area
Compact	B78x13	250	96	.0314	1.25
Intermediate	F78x14	270	96	.0314	1.10
Full Size	H78x15	312	96	.0314	1.00

that the primary mechanism of studded tire wear is by scraping off the mastic and subsequent abrasion of the aggregate.

Factors Affecting Wear Rate

Several factors have been identified as affecting the rate of pavement wear. Keyser (3) has prepared an excellent summary of these factors. As shown in Table 7, Keyser identified the characteristics of the pavement, traffic, and vehicle and tires that affect the rate of wear. In addition, Keyser (4) stated the most important factors for bituminous pavement wear were wheel load, stud protrusion, temperature, and humidity.

Figures 5 and 6 show the effect of pavement type on wear rate. The "regular" bituminous pavements consisted of fine-graded mixtures for thin overlays with 85 to 100 penetration asphalts; the "high-type" bituminous pavements contained either rubber or asbestos admixtures and 85 to 100 penetration asphalts. The regular pavements contained a filler, but the high-type pavements did not. For both tests (on a test track and on typical highway pavements), the wear rate was considerably greater for asphalt concrete than for portland cement concrete pavements. Aggregate type also had an effect for the portland cement concrete pavements.

Other factors can also affect the wear rate. For example, the wear rate in acceleration can be 2½ times the wear rate in deceleration that is 2 times the rate at a constant speed (5). In addition, temperature affects wear rates for asphalt concrete. The work by Krukar and Cook (6–9) shows the lowest wear rate at or near 0°C. Increases in pavement wear as pavement temperatures go below 0°C are reportedly associated with increased tire hardness and pavement stiffness. As pavement temperature decreases, pavement stiffness increases, as does the force required to push the stud into the stiffer tire so that it is flush with the pavement surface. Thus for a given loading situation, more of the stud will protrude when the temperature is lower, which results in higher stud forces. This combination of high stud force and increased pavement brittleness may result in increased wear rates. Keyser (3) reported increases in the rate of wear when the pavement is wet.

Pavement Wear Studies

The number of pavement wear studies is limited. Some agencies have conducted both field and laboratory studies; most studies have not shown good correlation between field and

TABLE 5 CHARACTERISTICS OF STUDS (6)

Stud Type	Characteristics
Type I "Controlled Protrusion Stud"	• Carbide pin will move further into stud body if protrusion limit is exceeded • 18 percent lighter in weight than conventional stud • 5 percent smaller flange than conventional stud
Type II "Perma-T-Gripper Stud"	• Pin found in other studs has been replaced with relatively small tungsten carbide chips in a soft bonding matrix enclosed in a steel jacket • Designed to wear within 10 percent of tire wear, thus maintaining a protrusion of approximately 0.020 in. or less
Type III "Conventional Stud"	• Tungsten carbide pin • Stud protrusion will increase with tire wear
Type IV "Finnstop Stud"	• Complete stud of light plastic casing with a tungsten carbide pin • Stud can be adjusted close to the tread rubber eliminating oscillation of the stud • Pin angle contact with road varies little with speed • Plastic housing tends to reduce effect of centrifugal force and heat build-up between rubber and stud • Air cushion can be left under stud to reduce stiffness (floating stud)

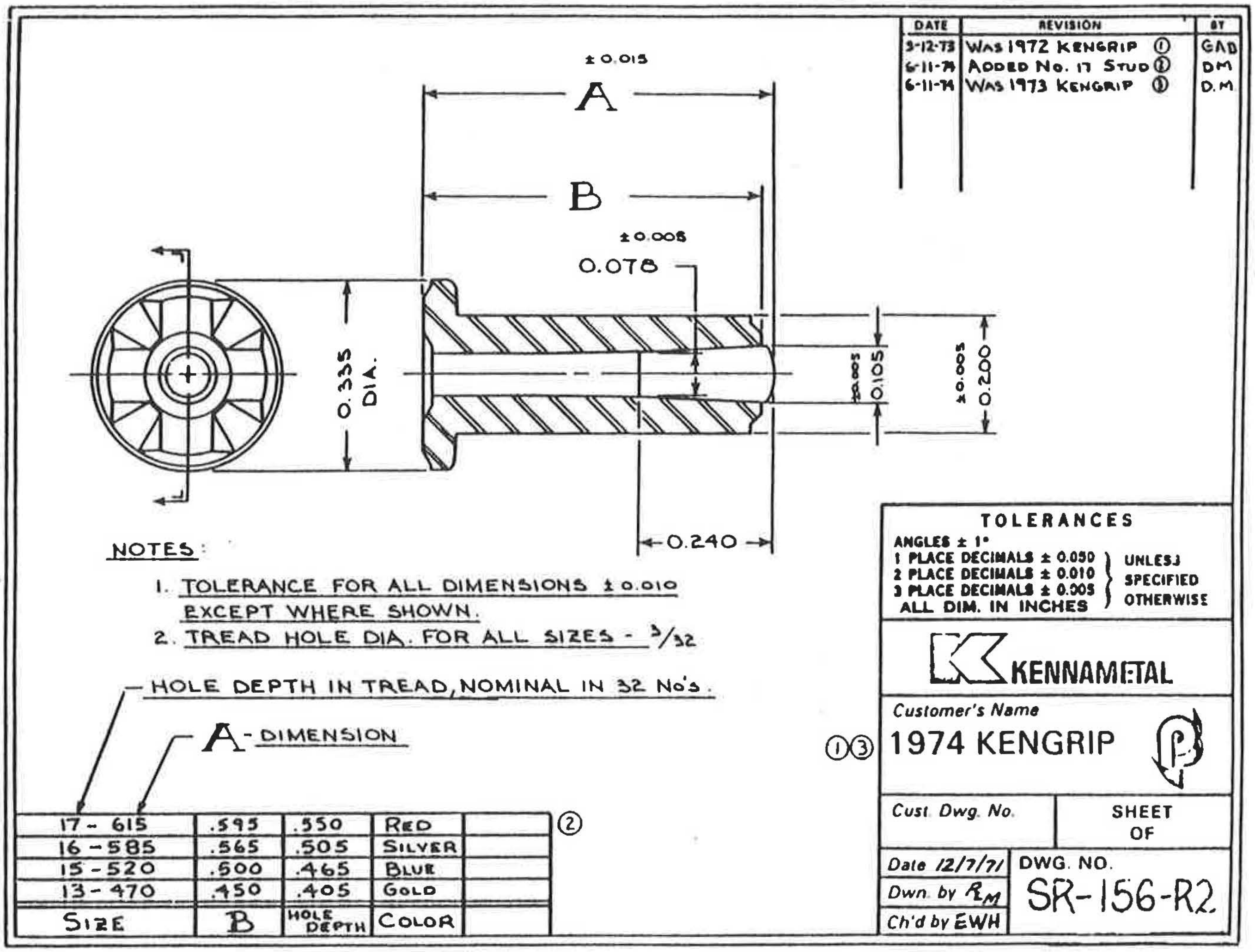

FIGURE 4 Typical dimensions for a controlled protrusion stud (*1*).

laboratory testing. The literature review and survey yielded some basic information, as shown in Table 8. In general, these results indicate

1. Reported wear rates, and the units used, vary considerably between agencies. Differences in wear rates are probably due to differences in materials and in percentages of vehicles with studded tires.
2. Pavement type has a great effect on pavement wear. Asphalt surfaces wear at a faster rate than portland cement concrete.
3. In areas of acceleration and deceleration, pavement wear increases substantially.

As part of an Alaskan investigation of wheelpath rutting, measurements of rut depths were correlated with rates of studded tire use. Data were collected at three locations in Juneau using the device shown schematically in Figure 7. The results are summarized in Table 9. The wear rate was computed by dividing the maximum rut depth by the estimated studded tire passes. The area of wear is characterized by rut-depth values taken at five locations across the 5.5-ft measure-

TABLE 6 CAUSE OF PAVEMENT WEAR UNDER STUDDED TIRES (*2*)

Cause	Description
1	The scraping action of the stud produces marks of wear on the mastic formed by the binder and the fine-grained aggregate.
2	The aggregate works loose from the pavement surface as a result of scraping by studs.
3	Scraping by the stud produces marks of wear on stones. Only in very soft aggregate does a rock fragment wear away completely by this action.
4	A stone is smashed by the impact of a stud and the pieces are loosened by the scraping action of the stud.

TABLE 7 FACTORS AFFECTING PAVEMENT WEAR (*3*)

Factor	Component	Characteristic
Vehicle, tire, and stud	Vehicle	Type and weight Axle load Number of studded tires (front, rear)
	Tire	Type (snow or regular with or without stud receiving holes) Pneumatic pressure Age Configuration of studs Number of studs
	Stud	Type (material, shape) Protrusion length Orientation of studs with respect to tire wear
	Stud wear vs. tire wear	
Pavement	Geometry	Cornering (curve, sharp turn) Straight section Intersection Slope (up and down)
	Surfacing Material	Type and characteristics (bituminous mixtures, surface treatment, precoated, chipping, portland cement, hardness) Age
	Surface Condition	Surface texture and profile Icy Compacted snow (compactness) Sanded or salted icy surface Slush
Environment	Humidity, temperature	Wet, dry, humid
Traffic	Volume	Number of passes and composition
	Speed	
	Wheel track	Width; Distribution of wheel load
	Contact mode	Start (normal, abrupt) = spin Stop (normal, abrupt) = skid Acceleration (rate) = spin Deceleration (rate) = skid
Measure	Method and precision	

ment bar in each wheelpath. This area was used to estimate the loss of material per lane mile.

The rates of wear are very consistent at each of the three sites and are much less than any rate reported by the other agencies surveyed (except Connecticut). The data collected on the bridge and before the bridge (see Table 9) produced very similar wear rates, eliminating the possibility that the measured rutting resulted from subgrade deformation. Measurements were also taken at different times of the year to isolate the pavement wear attributable to stud use during the winter and the "no studs allowed" summer seasons. Esch (*10*) reported that rut depths increased much more rapidly during the winter than the summer months. Furthermore, about 10 percent of the total rutting comes from stud use during summer.

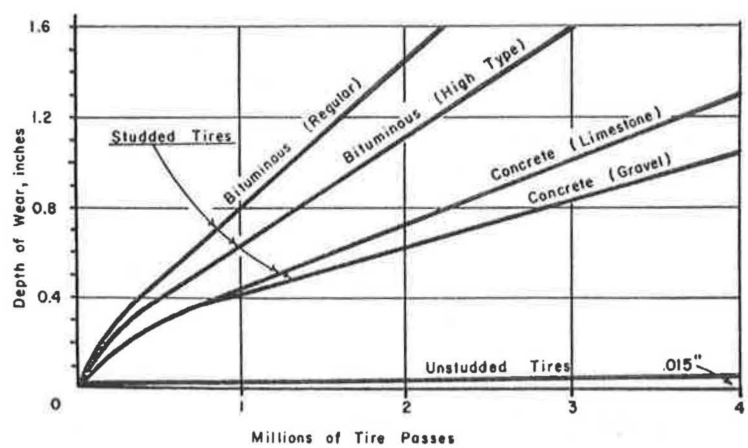

FIGURE 5 Relationship of studded-tire–induced wear versus pavement type, Minnesota research: wear rates of pavement specimens at test track (*19*).

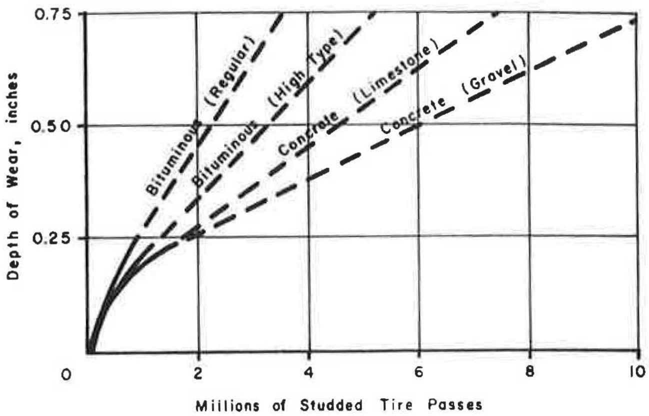

FIGURE 6 Relationship of studded-tire–induced wear versus pavement type, Minnesota research: wear rates of pavements of typical Minnesota highways (*19*).

IMPACTS OF STUDDED TIRE USE

The impacts of studded tire use are twofold: (a) increased costs to the agencies through accelerated pavement wear and through safety problems created by the wheel track ruts, and (b) benefits derived through increased traction during icy conditions that either improve safety or allow increased speeds

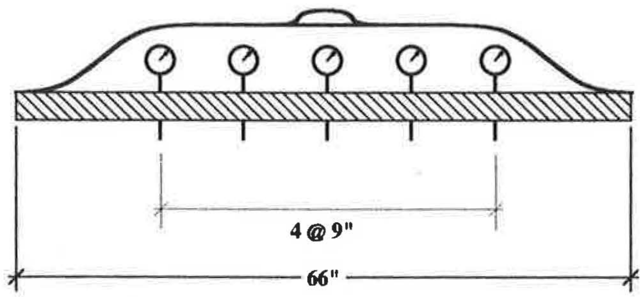

FIGURE 7 Rut-depth measurement device used for data collection in Alaska.

(Table 10). This section discusses each of these effects; it is based on the literature review, the survey of agencies, and limited cost analysis.

Benefits

The literature has some data that are useful in defining the economic benefits of studded tire use (Table 11). Finland and Sweden show significant benefits attributable to the increased safety. In contrast to the findings in Scandinavia, studies conducted in the United States in the 1970s show mixed results.

TABLE 8 SUMMARY OF ROAD WEAR STUDIES

Reference		Rate of Wear (in./passes)	Avg. Rate in inches/ 100,000 passes
a) Literature (14)			
Quebec		0.25/100,000	0.25
Quebec	Acceleration	0.36-0.44/100,000	0.40
	Deceleration	0.18-0.20/100,000	0.19
	Normal	0.11/100,000	0.11
Germany		0.11/120,000	0.09
Finland		.15-.2/10,000 AADT	
Sweden		0.5/40,000 AADT	
Maryland		0.28-1.07/100,000	0.7
Minnesota		1.5/4,000,000	0.04
Oregon	Concrete	0.026/100,000	0.03
	Asphalt	0.066/100,000	0.07
b) Survey (14)			
California		0.0005-0.0018/1000	0.12
Connecticut		0.08/1,000,000	0.01
Maryland		0.028-0.107/10,000	0.68
New Jersey		0.05 per year for 5400 AADT per lane	
New York		0.009-0.016/year PCC pavements 0.022-0.025/year ACC pavements	
Oregon		0.032/100,000 PCC pavements 0.073/100,000 ACC pavements	.03 .07
Norway		SPS[a]: AC = 25 Topeka = 15 Mastic stone = 10-15 PCC = 10	
Sweden		35 g/vehicle (4 studded tires)/km driven	

[a]SPS = g/cm (specific wear in grams worn out of the surfacing when a car with 4 studded wheels drives a 1 km distance)

TABLE 9 JUNEAU PAVEMENT WEAR PER MILLION STUDDED TIRES

Location	Total Stud Passes by 4/91 (Millions)	Wear per Million Passes		
		Wear Rate (inches)	Wear Area (inches)^2	Tons/Lane/Mile
Juneau-Douglas Bridge				
On Bridge	5.37	0.148	9.31	23.9
Before Bridge	5.37	0.134	9.92	25.5
Douglas Road	3.87	0.122	9.08	23.3
Mendenhall Loop	5.84	0.102	7.56	19.3

TABLE 10 IMPACT OF STUDDED TIRE USE

Factor	Consequences	Benefit
Effect on safety	• Increased rutting, ponding and hydroplaning • Increased splash and spray • Increased stopping distance on wet or dry concrete pavement	• Improved stopping distance on ice • Improved maneuverability on ice
Effect on pavement	• Increased rutting • Destruction of pavement markings • Build up of snow and ice in ruts	• Possible improvement in surface roughness
Effect on agency	• Increased frequency of maintenance/rehabilitation due to rutting	• Possible reduced winter maintenance costs

TABLE 11 ANNUAL COST EFFECTS OF STUDDED TIRES ON PAVEMENT WEAR AND SAFETY

Agency	Pavement Wear Costs	Winter Maintenance Costs	Accident Costs
Oregon DOT (*17*)	+1.1 million	NA	NA
Finland (*18*)	+175 to 250 million mks	-44 million mks	-0 to 190 million mks
Sweden (14)	+160 to 250 million SEK (national roads)	NA	-560 to 1160 million SEK (switch to snow tires)
	+95 to 150 million SEK (municipal roads)	NA	-1230 to 2590 million SEK (switch to summer tires)

Notes: 6 SEK = 1 U.S. dollar; 4 mks = 1 U.S. dollar
+ Increase in costs; - Decrease in costs
NA = Not available

Smith et al. (*11*) show a minor benefit in terms of stopping distance on asphalt pavements and mixed benefits on concrete pavements when the pavements are not icy. Other studies (*12,13*) attempted to determine the improvement in safety resulting from the use of studded tires. Neither study could conclusively associate a reduction in traffic accidents with the use of studded tires. Figure 8 clearly indicates the benefits of studded tires on ice.

Finland reportedly is able to reduce the level of winter maintenance as a result of the use of studded tires. This reduction is probably due to the high percentage of vehicles that use studded tires (90 to 95 percent of cars, 40 percent of trucks). It is doubtful that other agencies, with lower use rates, would be able to reduce winter maintenance and therefore realize this benefit.

Consequences

As shown in Table 10, the surveyed agencies identified several consequences of studded tire use. Almost all are precipitated by the development of ruts and the associated decrease in safety or pavement life. Little information was found in the literature regarding the decrease in road safety associated with hydroplaning, spray and splash, and rut avoidance.

The cost of increased maintenance and rehabilitation attributable to the use of studded tires can be estimated if pavement wear rates, use rates, and the approximate area of wear is known. For example, data were collected in Juneau over several years (see Table 9). Pavement wear rates ranged from 0.10 to 0.15 in./million studded tire passes. The measured cross-sectional area of wear and the wear rate resulted in

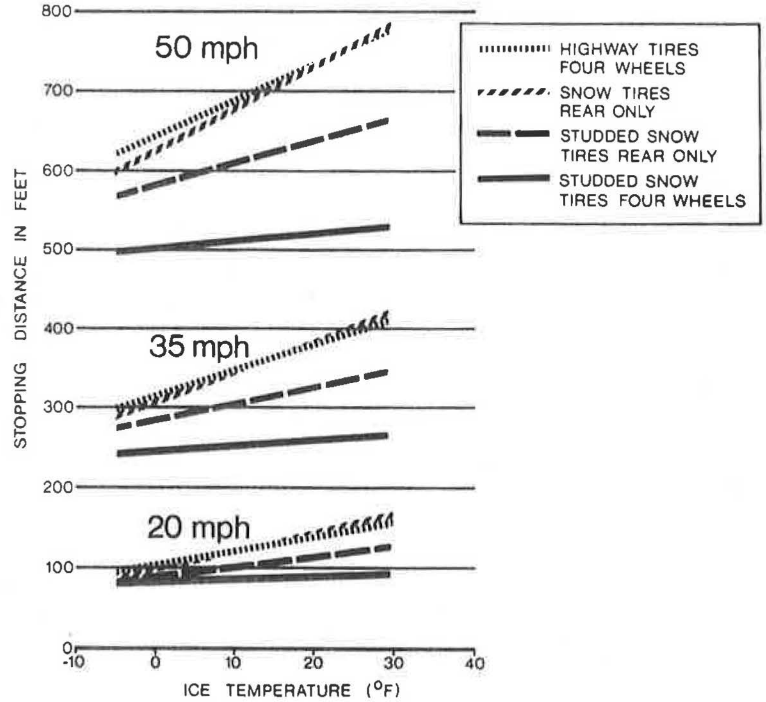

FIGURE 8 Stopping distance versus ice temperature for four cars traveling at 20, 35, and 50 mph (*11*).

asphalt pavement surfacing losses of between 19 and 25 tons/lane-mi/million studded tire passes. If a studded tire is assumed to last 30,000 mi and rehabilitation costs are equal to material costs only, then each studded tire could be equated to 0.5 and 0.75 tons of asphalt concrete mix. For this particular example, the cost of material replacement alone would range from $8 to $15/studded tire, depending on material costs.

Car owners continue to spend millions each year on studded tires for perceived or real benefits. The benefits associated with radial versus bias-ply tire designs and all-season tread versus snow-tire tread designs have not yet been assessed in this country. Furthermore, the continuing shift from rear- to front-wheel-drive vehicles will affect the effectiveness and the wear rates of studded tires. This factor has also not been investigated. The combination of these factors may alter many of the commonly held notions about the costs and benefits of studded tire use. Because several agencies still allow the use of studded tires, further studies on these issues appear to be warranted.

SUMMARY

This paper presented a summary of the results of a literature review, a survey of agencies on the use and effects of studded tires, and the results from a field study of studded tire use and pavement wear rates conducted in Alaska. Significant findings include the following:

1. Very little research has been done since 1975 in this area, except in Scandinavian countries.
2. Telephone conversations with the manufacturers and distributors revealed that only the controlled protrusion type stud is currently used in the United States.
3. Many agencies continue to prohibit or restrict the use of studded tires, but enforcement efforts appear minimal in most areas.
4. Very little new information on the percentage of vehicles using studded tires or on tire wear studies was available. Only Alaska has completed recent data collection, which shows about one studded tire for every two vehicle passes.
5. Factors affecting wear rates were defined and wear rates in Alaska were shown to be about 0.10 to 0.15 in./million studded tire passes.
6. Studded tires contribute greatly to the development of ruts in pavements, and most agencies do not have data to factor effectively this contribution into their rutting analysis.
7. The public attributes a substantial safety benefit to the use of studded tires, yet the costs of studded tire use remain largely unquantified.

On the basis of this limited study, it is clear that the use of studded tires should be reevaluated. Furthermore, the benefits derived from radial tires and front-wheel-drive vehicles need additional study.

ACKNOWLEDGMENTS

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