SB
156

FISCAL NOTE

STATE OF ALASKA
1997 LEGISLATIVE SESSION

BILL NO. SB 156

Revision Date:
Title: An Act relating to limitatin on studded tires and on the use of certain studded tires;....
Sponsor: Senate Transportation
Requestor: S. TRAN

Department Affected: Administration
BRU: Motor Vehicles
Component: Driver Services

COMPONENT SERIAL NO. 0501

EXPENDITURES/REVENUES: (Thousands of Dollars)

OPERATING EXPENDITURES	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03
PERSONAL SERVICES						
TRAVEL						
CONTRACTUAL						
SUPPLIES						
EQUIPMENT						
LAND & STRUCTURES						
GRANTS, CLAIMS						
MISCELLANEOUS						
TOTAL OPERATING	0.0	0.0	0.0	0.0	0.0	0.0
CAPITAL EXPENDITURES						
CHANGE IN REVENUES ( )						

FUND SOURCE: (Thousands of Dollars)

1002 Federal Receipts						
1003 GF Match						
1004 GF						
1005 GF/Program Receipts						
1037 GF/Mental Health						
OTHER						
TOTAL	0.0	0.0	0.0	0.0	0.0	0.0

Estimate of any current year (FY 97) cost: $

POSITIONS:

FULL-TIME						
PART-TIME						
TEMPORARY						

ANALYSIS: (Attach a separate page if necessary.)

This bill does not impact the Division of Motor Vehicles.

Prepared by: Juanita M. Hensley
Division: Motor Vehicles
Phone: 465-2650
Date: 4/21/97

Approved by Commissioner: Mark Boyer [signature]
Agency: Department of Administration
Date: 4/21/97

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Rev 11/96

FISCAL NOTE

STATE OF ALASKA
1997 LEGISLATIVE SESSION

BILL NO. SB 156

Revision Date:
Title: Studded Tires
Sponsor: Senate Transportation By Request
Requester: Senate Transportation

Dept. Affected: DOT&PF
BRU: Commissioner's Office
Component: Office of the Commissioner
COMPONENT SERIAL NO. 530

Expenditures/Revenues (Thousands of Dollars)

OPERATING EXPENDITURES	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03
PERSONAL SERVICES						
TRAVEL						
CONTRACTUAL						
SUPPLIES						
EQUIPMENT						
LAND & STRUCTURES						
GRANTS, CLAIMS						
MISCELLANEOUS						
TOTAL OPERATING	0.0	0.0	0.0	0.0	0.0	0.0
CAPITAL EXPENDITURES	0.0	0.0	0.0	0.0	0.0	0.0
CHANGE IN REVENUES ( )	0.0	0.0	0.0	0.0	0.0	0.0

FUND SOURCE (Thousands of Dollars)

1002 Federal Receipts						
1003 GF Match						
1004 GF						
1005 GF/Program Receipts						
1006 GF/MHTIA						
Other						
TOTAL	0.0	0.0	0.0	0.0	0.0	0.0

Estimate of any current year (FY97) cost: $ 0.0

POSITIONS

FULL-TIME	0	0	0	0	0	0
PART-TIME	0	0	0	0	0	0
TEMPORARY	0	0	0	0	0	0

ANALYSIS: (Attach a separate page if necessary)

DOT&PF estmates significant savings in pavement resurfacing costs through mandated sales of lightweight studs. While not providing additional funding for the department, the legislation would all use of existing Federal Aid Highway funds for other purposes.

The legislation may also result in prolonged life of pavement marking materials which would allow more operating funds to be used for maintenance.

Prepared by: Sam Kito III, Special Assistant — Phone: 465-3900
Division: Office of the Commissioner — Date: 4/22/97
Approved by: [signature], Commissioner — Date: 4/22/97
Agency: Department of Transportation and Public Facilities

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OPTIONS FOR REDUCING STUD-RELATED PAVEMENT WEAR

SEPTEMBER 1996

prepared by
The Alaska Department of Transportation and Public Facilities

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16. Abstract

This report summarizes the findings of a literature search, previous Alaska Department of Transportation & Public Facilities (DOT&PF) research, and a fact finding trip to Norway, Finland and Sweden to meet Scandinavian researchers to learn how they minimize pavement wear due to studded tires. The report includes findings: (1) Research shows that lightweight studs (studs that weigh less than 1.1 grams) provide approximately the same stopping protection as older, heavier studs and last just as long; (2) Requiring the use of lightweight studs can reduce pavement wear by up to 50 percent; (3) The use of stone mastic asphalt concrete mix, which contains a high percentage (70%) of coarse aggregate, can reduce pavement wear by 25 to 50 percent; (4) Using harder durable aggregate in the pavement mix resisted studded tire wear much better than aggregates found in local material sources. The harder aggregate as measured by the "Nordic Ball Mill Tester" can reduce studded tire wear by a factor of three to five. The results of "Nordic Ball Mill" testing correlate much better with stud related pavement wear than do traditional aggregate quality tests.

17. Key Words	18. Distribution Statement
Studded Tires, SMA, Stone Mastic Asphalt, Rutting, Aggregates	

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Options for Reducing Stud-Related Pavement Wear

September 12, 1996

prepared by

The Alaska Department of
Transportation & Public Facilities

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CONTENTS

Prepared by Tony Barter, P.E., and Eric Johnson, P.E.,
Alaska Department of Transportation & Public Facilities

EXECUTIVE SUMMARY

The purpose of this paper is to present specific information regarding the state's options for reducing stud-related road wear.

The Alaska Department of Transportation & Public Facilities has reviewed current technical and scientific materials, and reached the following conclusions:

- Alaska spends $5 million annually to repair stud-related pavement damage.
- The majority of "rutting" on high-volume roads is caused by studded tires on passenger vehicles rather than heavy trucks.
- Twenty percent of Alaskan pavement wear is caused by a small number of vehicles (3 to 6 percent) that continue to use studs during the summer. These vehicles are directly responsible for $1 million per year in pavement rehabilitation projects.
- Lightweight studs (≤1.1 grams) can reduce pavement wear by 50 percent, compared with conventional studs (≥1.9 grams).
- Remaining pavement wear can be reduced an additional 30 percent with wear-resistant Stone Mastic Asphalt (SMA) using high-quality aggregates.
- Lightweight studs and conventional studs offer virtually identical handling characteristics and stopping distances. Both lightweight and conventional studs use the same tungsten carbide pin for traction.
- There is no difference in retail cost between conventional and lightweight studs, and both stud types offer a service life of three to four winters.
- The mountainous terrain typical of Juneau and Anchorage provides a strong reason to continue allowing the use of studded tires.

Recommendations:

The Alaska Department of Transportation & Public Facilities (DOT&PF) will continue to work in partnership with the driving public and tire retailers to encourage voluntary compliance with existing stud regulations. This can be accomplished, in part, through pul lic information campaigns, direct contacts with tire retailers, and presentations of technical information alread initiated by the Department. In addition, the DOT&PF will continue ongoing efforts to locate deposits of wear-resistant aggregate rock, continue to test new wear-resistant paving mixes, and continue to work in partnership with contractors and suppliers to develop cost-effective pavement improvements.

The Department further recommends that consideration be given to mandating the use of lightweight studs ($\leq$1.1 grams) for passenger vehicles. Lightweight studs are capable of cutting annual pavement repair costs by 50 percent, offering a cost-effective method for significantly reducing stud-related road wear.

Subsequent mandates could include measures to:

- control stud quality at the retail level,
- limit the number of studs per tire,
- require that the number of studs per tire not vary by more than 25 percent on a given vehicle,
- encourage mandated use of studded tires on more than one axle,
- shorten the season for studded tire use.

ISSUE STATEMENT

Many drivers use studded tires as an aid to winter driving because studs are associated with improved traction and safety when pavement surfaces are icy or slippery. While a variety of Alaskan and international studies have demonstrated that traction on ice or snow can be improved with studs, an analysis of Alaskan winter driving conditions shows that primary roads are covered by snow or ice approximately 5 percent of the time. During the remaining 95 percent of the "studded tire season" pavements are bare and/or dry.

Drivers also feel that studded tires provide an increase in winter-driving mobility, and an associated decrease in travel times. However, these are matters of perception and convenience, rather than safety. In fact, by providing a feeling of heightened safety, studded tires may actually encourage dangerous driving behaviors. A Finnish study[1] placed video cameras in vehicles to monitor driver performance. The study found that drivers without studs drive more carefully than those with studs.

On the other hand, Alaska spends $5 million a year to repair ruts caused by studded tire use. State studies indicate that approximately 20 percent of the rutting and $1 million in annual road damage is caused by vehicles that continue to use studs throughout the summer. Approximately 3 to 6 percent of all Alaskan vehicles use studded tires during the summer.

Alaskan pavement wear rates average 0.13 inches per million studded-tire passes (approximately 22 tons of lost road materials per million passes). To put it another way: if 250,000 cars with conventional studs on all four tires pass over a single mile of road, the studs will tear up enough pavement to fill a large dump

[1] "Effects of Studded and Unstudded Winter Tyres on Driver Behavior," Tapani Mäkinen, Technical Research Centre of Finland, findings summarized in FinnContact, published by Finnish Highway Transportation Technology Transfer Center, September 1995; Vol. 3, no. 3, p. 3.

truck. This per-mile pavement loss applies to each lane of a road; figures should be doubled for two-lane roads, quadrupled for four-lane routes, etc.

While this is a severe problem, the situation in Scandinavia was at least as serious when those nations began to address the problem of stud-related pavement wear. Studs were introduced to Scandinavia in the 1970s, and prior to studying the problem, Norway's road surfaces were lasting for approximately 8 months before ruts had to be repaired.

However, following a $30-million, multi-year program of intensive study, the Scandinavian nations have developed a set of preventive measures with proven success. Now heavily trafficked roads in Scandinavia that are 4 to 5 years old show pavement wear comparable to heavily trafficked Alaskan roads after just one year.

By taking steps to reduce the loss of road surface, Alaska could also reduce the quantity of airborne asphalt particulates, and reduce construction detours and/or delays on heavily traveled roadways.

STUDDED TIRE USE AND HIGHWAY SAFETY

Given the state's limited resources, administrators must concentrate expenditures on the highway projects that offer the highest yield in terms of public safety. At present, excessive funds are being used to repair stud-induced road wear, with the consequence that the state cannot afford other improvements throughout the highway system.

When studded tires were introduced, they were undoubtedly the most effective winter-driving aid. However, other innovations have dramatically increased winter driving safety, including:

- ABS (anti-lock braking systems),
- radial all-season tires,
- increased availability of all-wheel-drive vehicles, and
- increased availability of front-wheel (vs. rear-wheel-drive) vehicles.
- aggressive maintenance programs
- chemical de-icing
- siped tires
- blizzak tires
- early storm detection

Socioeconomic Costs of Studded Tire Use

On one side of the equation, studded tires provide the driving public with a valued safety measure and increased mobility. On the other hand, road damage results in ongoing state expense, an increase in airborne particulates, a decrease in the effective service life of traffic markings, and undesirable driving conditions.

Deep pavement ruts are among the most visible signs of road wear produced by studded tires. Pavement ruts can result in:

- **hydroplaning**, which occurs primarily at higher speeds, when the tires "float" on water trapped in the ruts; as a result, tires lose contact with the pavement surface, reducing the driver's braking ability and steering control,
- "**channeling**" of the tires, which can cause the driver to lose steering control when making lane changes,
- **poor visibility**, due to splash and spray from water accumulated in the ruts,
- **increased costs** to vehicle maintenance.

Despite the abundance of motorist complaints and anecdotal information regarding these problems, there is very little quantified evidence regarding decreased road safety due to ruts.

Furthermore, there is widespread scientific disagreement regarding the overall effectiveness of studded tires as a safety measure, due to the sheer number and complexity of variables that are usually involved in road accidents. There is some evidence of an *increase* in accidents due to a studded tire ban, unless the ban is accompanied by a comprehensive, high-intensity road maintenance program. For more information, see the graphic on page 8.

During the first year that the Studded Tire Dust Reduction Law was implemented in Japan, skidding accidents increased by 150 percent, and injuries and fatalities increased; statistics leveled off after the first year.

Statistical data also shows that the *severity* of accidents is reduced by the use of studded tires.[2] However, overall traffic safety may be reduced as a direct result of Alaskan motorists' faith in studded tires as a safety measure. Motorist over-confidence can lead to dangerous driving behaviors according to a 1995 study conducted by the Finnish Road Administration (FinnRa). This study indicated that the leading cause of accidents on ice was the driver's loss of directional

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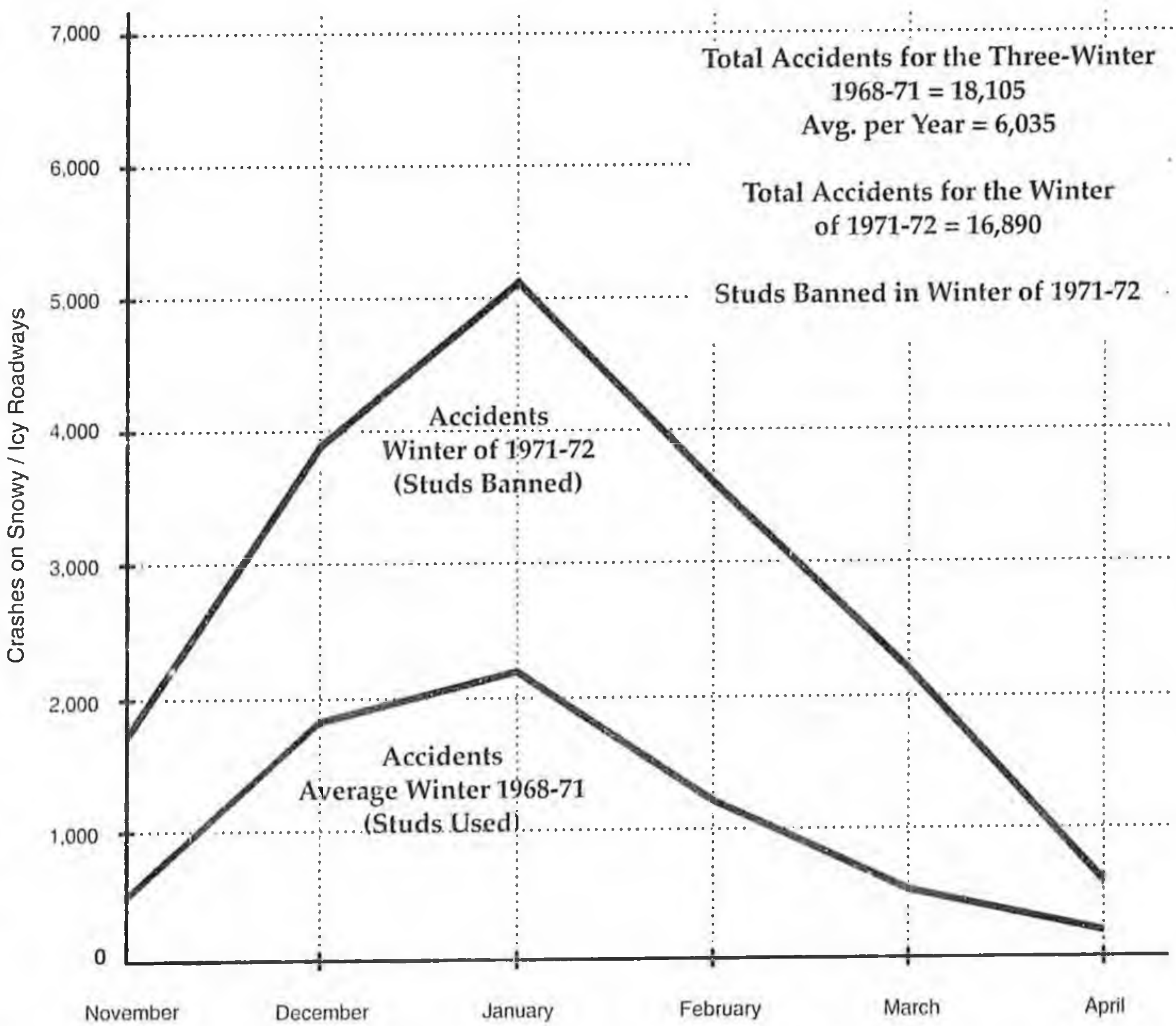
[2] "Influence of Regulation of Studded Tire Use in Hokkaido, Japan," N. Konagai, M. Asano, N. Horita, Transportation Research Board, Highway Research Record N1387, 1993.

control, *not* lack of stopping ability. In other words, motorists were driving too fast for the road conditions.

Swedish studies have also determined that steering ability decreases, and the risk of violent skidding increases, when only tires on one axle are studded.[3] In Scandinavia, studs are required on all four wheels to enhance directional control.

[3] Study synopsis by Olle Nordström, Swedish Road and Transport Research Institute, September 1995.

Accidents on Snowy/Icy Minnesota Roadways for the Three-Winters of 1968-71 and the Winter of 1971-72



Regulation vs. Banning

In 1995, Oregon passed a law promoting the use of lightweight studs (studs weighing less than 1.5 grams).

As of September 1995, all types of tire studs are banned in:

California	Louisiana	Wisconsin**
Florida	Minnesota**	
Hawaii	Mississippi	
Illinois	Texas	

**limited use by out-of-state motorists is permitted

There are no prohibitions or restrictions on the use of studded tires in:

Alabama	Nevada	South Dakota
Colorado	New Hampshire	Tennessee
Georgia	New Mexico	Vermont
Kentucky	North Carolina	Wyoming
Missouri	South Carolina	

In Alaska, the condition of road surfaces and the extremity of terrain are key factors in the decision to regulate or ban the use of studded tires. Because studs offer improved traction on ice, continued use of studs must receive serious consideration, especially in areas with mountainous terrain and high population density such as Juneau and Anchorage.

It has been demonstrated that banning studs and going to an all-season radial results in the polishing of highway ice, while studded tires roughen the surface and improve traction for all vehicles. Alaska does not use chemicals to implement its "clear pavement" policy, with the exception of limited use in Southeast Alaska. Instead we plow snow accumulations of 2 inches or more, and rely on traffic to cut through icy layers, thereby reducing the burden on the state's maintenance program. Roads are sanded as slippery conditions develop. If studded tires are prohibited without a complete change in maintenance activities, a significant increase in accidents can be anticipated.

The use of studded tires during the winter provides some benefit for all drivers, by improving traction on wet pavement. During summer, the pavement becomes smooth and polished from heat and wear; during the winter, the grinding action of studs wears down the polished surface, improving traction. The net benefit of some pavement grinding, in terms of accident reduction, is not quantifiable. However, any plan considering restricting or prohibiting the use of studs must be accompanied by a commitment to increase anti-freezing and anti-skidding measures through an aggressive road maintenance program, in conjunction with an active public education program to inform motorists of the need for changes in driving behavior.

Comparative Safety of Winter Tire Options

As stated above, studded tires have performance advantages on icy surfaces. For many years, Finland and Sweden have conducted friction testing of studded and unstudded tires. Significantly, the studies show there is *no appreciable difference in the traction effectiveness of conventional studs versus lightweight studs*. Both lightweight and conventional studs use the same tungsten carbide pin for traction.

Although the tests showed that studded tires have better traction on ice than unstudded tires, on snow there is little difference. Traction for unstudded tires is increased significantly when pavement ice has been roughened by studs.[4] However, on dry or bare pavement, studded tires have no advantage over unstudded snow tires. In fact, studded tires can reduce stopping ability.

In the Scandinavian countries, skid control is considered to be a more important safety factor than straight stopping distance.[5] This is one of the reasons that Sweden, Finland and Norway prohibit using studs on one axle only. If Alaska continues to allow the use of studded tires, strong consideration should be given to requiring studs on all four tires for directional control.

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[4] "Studded and Non-Studded Winter Tyres," Olle Nordström, Swedish Road and Traffic Institute Report Nr. 233, 1994; p. 32.

[5] "Winter Tyres, Studs, Safety and the Environment," Halvard Nilsson, Gislaved Tire Company, Sweden, presented at Rubbercon 1995, Gothenburg, Sweden; p. 3.

DYNAMICS OF STUD-RELATED ROAD WEAR

Tires specifically designed for use with studs have softer rubber than all-season tires, and offer an average wear-life of 30,000 miles. Both lightweight and conventional studs are engineered to wear at approximately the same rate as the tire. However, all studs lose significant stopping capability after three or four winter driving seasons.

An article appearing in a 1994 Finnish publication also suggests that the choice of a stud brand is important to the length of the stud's service life.[6] After assessing grip during braking, changes in wear, and stud protrusion after 6,250 miles of driving, the authors concluded that even the worst *new* stud provides more benefit than a top-quality stud that's been *driven too long*.

There are five manufacturers of studs in the world: two in Finland, two in Germany and one in France. All tire studs consist of two main components: a tungsten carbide steel pin, and an outer sleeve. Differences in weight are determined by the material used in the outer sleeve. The current lightweight (≤1.1 gram) stud designs that offer the best performance have sleeves made of either aluminum oxide or plastic.

The dynamics of stud action include three phases. As the tire and stud move over the pavement, there are measurable "spikes" in force at the beginning and end of contact. During these spikes, energy is transferred to the pavement in the form of scratching. Between these energy spikes, the studs have a "punching" action that breaks up aggregate and picks out asphalt. For more information, see the graphic on page 12.

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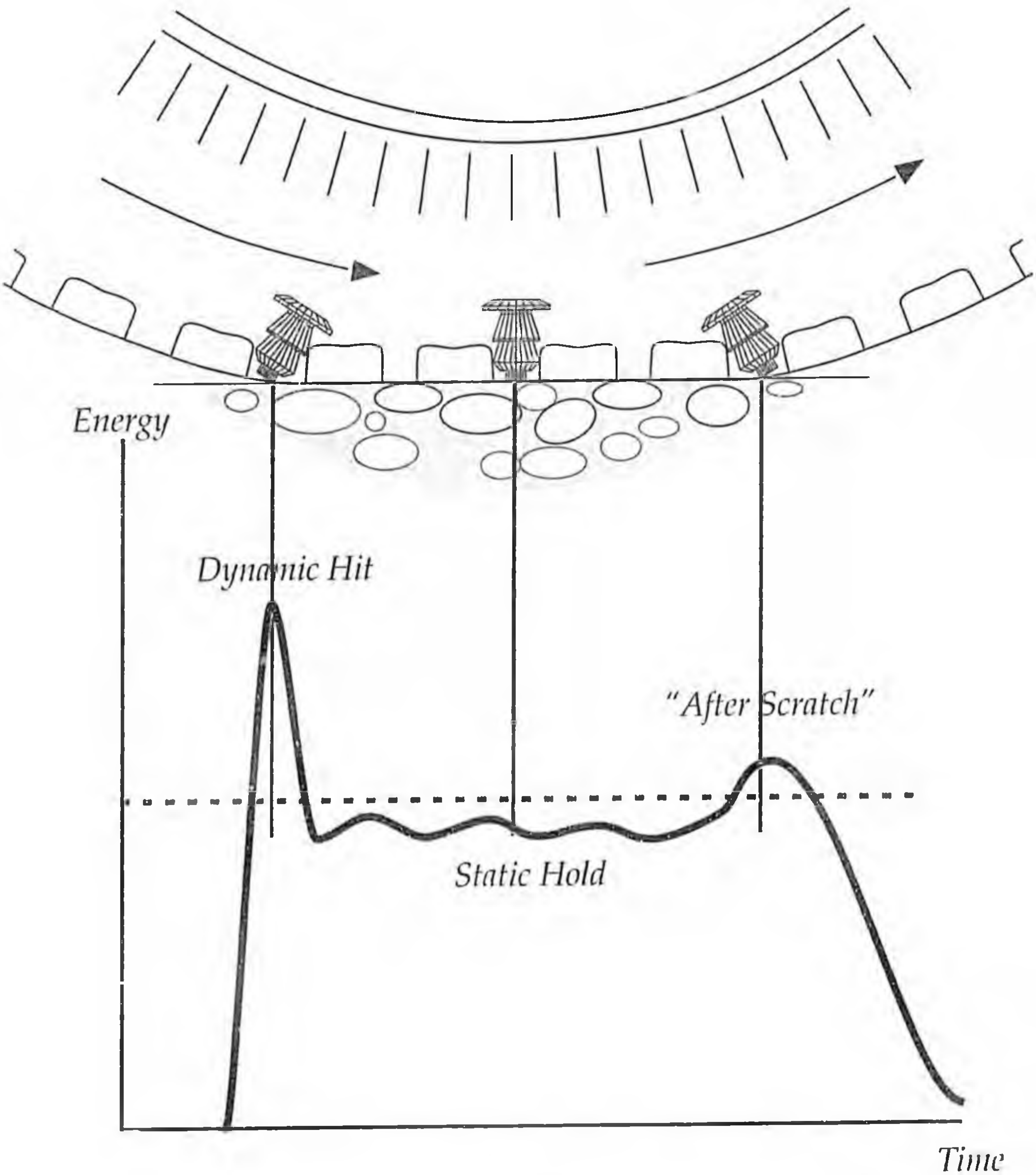
[6] See Attachment: "More Durable Than One Would Expect: Studs in a 50,000 km driving test," translated from an article in Tekniikan Maailma, August 31, 1994.

Kinetic Forces of Studs on Pavement



Scandinavian nations restrict the number of studs per tire, based on the tire diameter to maximize performance and minimize the energy being transferred to the pavement:

Tire Diameter (in inches)	Number of Studs Allowed
13	90
15	110
> 15	150

Speed As A Factor in Pavement Wear

Several studies in Scandinavia have concluded that pavement wear and abrasion increase exponentially with increasing speed. One study also compared the impact of lightweight versus conventional studs, within the context of driving speed. The conventional stud was passed over local aggregate pavement for 150,000 rotations at 60 kph (38 mph), and then again at 85 kph (53 mph); the increased speed generated *100 percent more pavement wear.* By comparison, the lightweight stud increased pavement wear by 44 percent under the same conditions.

Stud Weight As A Factor in Pavement Wear

Pavement wear rates have a direct correlation to the weight of studs. On average, a conventional stud weighs 2.1 grams; aluminum-sleeved studs weigh 0.95 grams; a plastic-sleeved stud weighs 0.7 grams.[7] A 3 gram steel-sleeved stud is available for use on heavy trucks. The composition of housing from other materials is directly related to the quality.

Contrary to popular belief, the vast majority of road damage is caused by passenger vehicles rather than truck traffic. The damage is caused primarily by the number of studs passing over the road surface; in Alaska, passenger vehicles with studded tires outnumber trucks by 20 to 1. As further evidence, the width

[7] Sweden is experimenting with a ceramic pin in hopes of further reducing stud weight.

between road ruts matches the axle width of a typical passenger vehicle, which is 58" wide.[8] Full-size vehicles run 64" wide, while the axle width of trucks is 82" wide.

Scandinavia has mandated the use of lightweight studs, weighing less than 1.1 grams. The unregulated conventional stud currently used in Alaska weighs 1.9 grams. By requiring the use of studs weighing 1.1 grams or less on all passenger vehicles, Alaska can reduce stud-related pavement wear by 50 percent; commercial trucks would be allowed to use the 3 gram steel-sleeved stud.

Other Factors in Pavement Wear

The amount of damage inflicted by studs on dry/bare pavement could be reduced by shortening the studded-tire season, increasing seasonal enforcement activities, and by continuing existing DOT&PF public education activities regarding timely removal of studded tires. The graphic on page 15 provides a comparison of other states' studded-tire seasons.

The average daily traffic (ADT) on a given route is another significant factor in pavement wear. The higher the traffic volume, the faster the wear rate. The chart on page 16 shows the incremental increase in wear rate as a function of traffic volume.

The map on page 17 shows major routes in Anchorage that are subject to wear/rutting; the map also indicates routes currently in need of rehabilitation work, and routes that are recommended for repairs subject to budget considerations and changing priorities.

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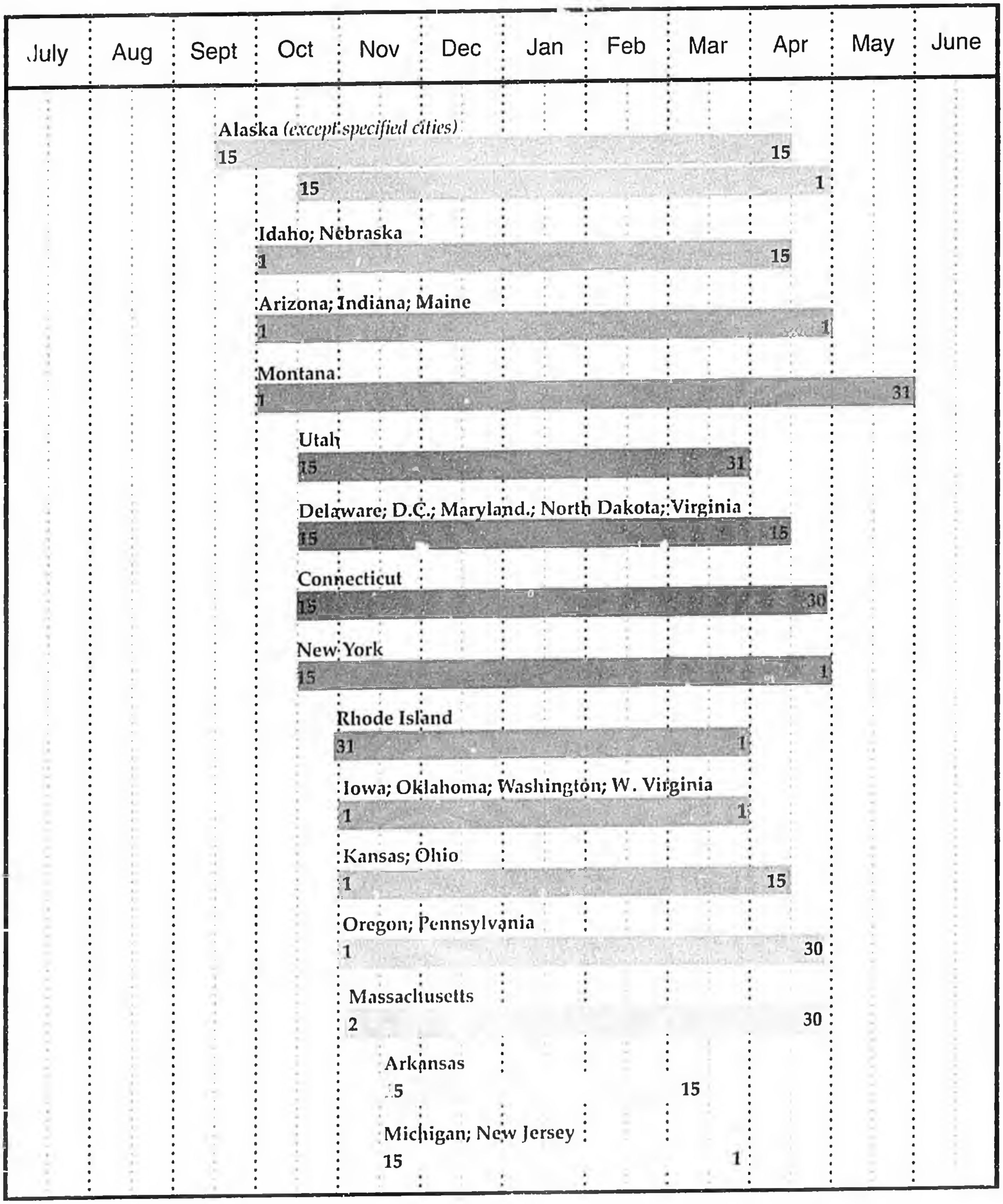
[8] Response to House Bill 301, Studded Tires, File No. 3555, memorandum to B. Wessel from D. Esch, April 5, 1994.

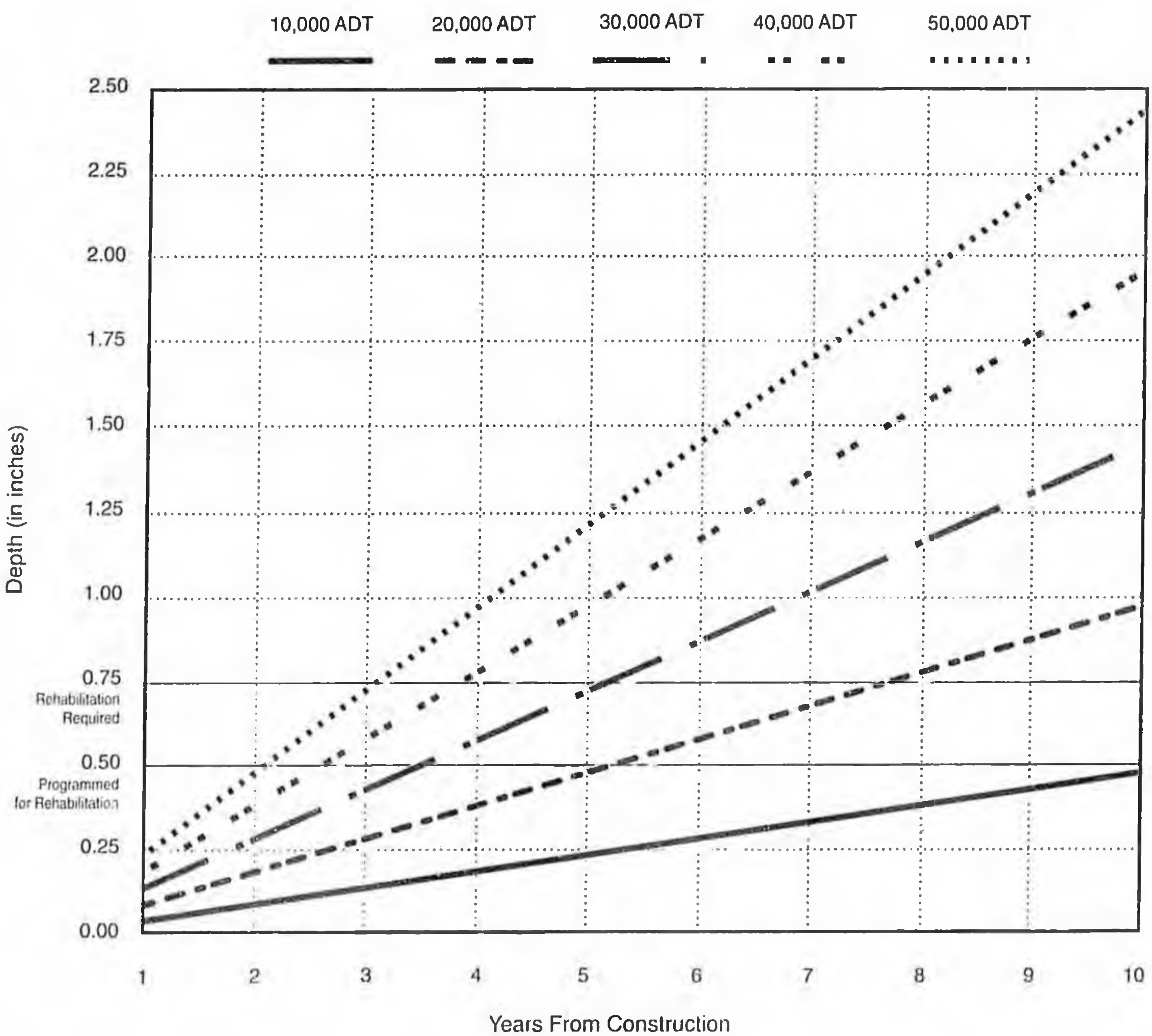
Studded Tire Authorized Usage by State



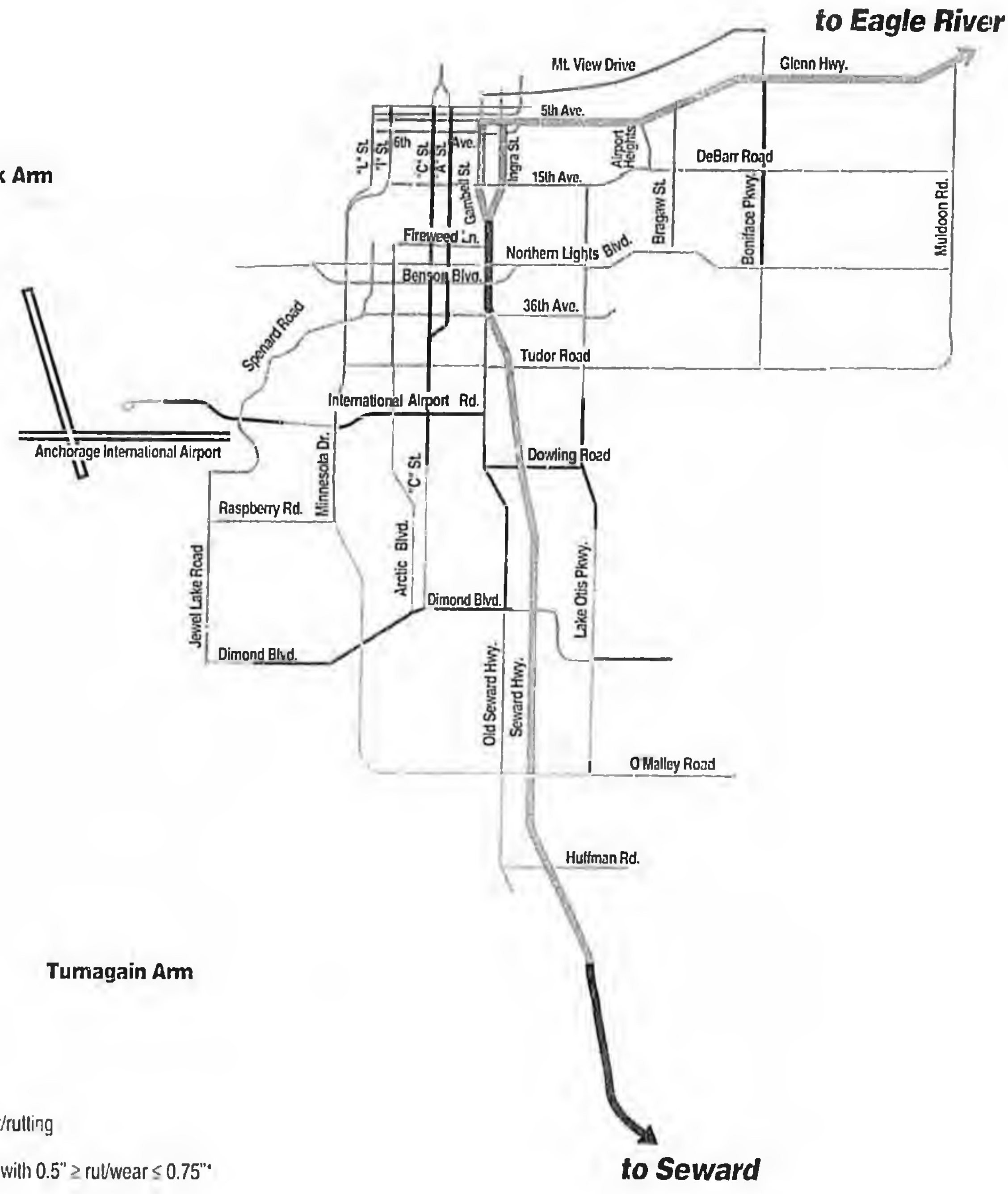
Predicted Wear/Rutting on Urban Roads

Based on 0.13"/Million Studded Tire Pass

ADT = Average Daily Traffic



Stud-Related Road Wear Patterns in Anchorage



Routes subject to wear/rutting

Programmed • Routes with 0.5" ≥ rut/wear ≤ 0.75"*

Rehabilitation req'd • Routes with rut/wear > 0.75"*

* Based on 1995 data

WEAR-RESISTANT PAVEMENT TECHNOLOGIES

The pavement-wearing differential between lightweight studs and conventional studs is relatively constant for different pavement types. In general, lightweight studs produce 50 percent of the road wear inflicted by conventional studs. The absolute wear is also dependent on the "wear resistance" of a particular pavement.

Like the United States, the Scandinavian nations originally relied on the Los Angeles Abrasion Test as an indicator of paving aggregate quality, but they quickly realized that there was little correlation between the test values and actual studded tire wear rates. This knowledge led to the development of the Nordic Ball Mill Tester, which has become the new standard in determining the quality of paving aggregates.

In addition to achieving a 50 percent reduction in pavement wear by mandating the use of lightweight studs, Scandinavia has been able to reduce pavement wear by an additional 30 percent by specifying higher quality aggregates (based on the Ball Mill Test), and by adjusting the mix of aggregates in pavements (e.g. Stone Mastic Asphalts). See the graphic on page 20 for more information.

It has been proven that, given a "good" aggregate, a pavement will resist stud-abrasion better if it is "loaded" with coarse aggregate.[9] The conventional name for this type of mix is Stone Mastic Asphalt (SMA), and it contains ± 70 percent coarse aggregate.

While a transition to lightweight studs can reduce Alaskan road wear by 50 percent, the use of high-quality aggregates in SMAs could also contribute to a reduction in pavement wear. The DOT&PF is conducting ongoing research in

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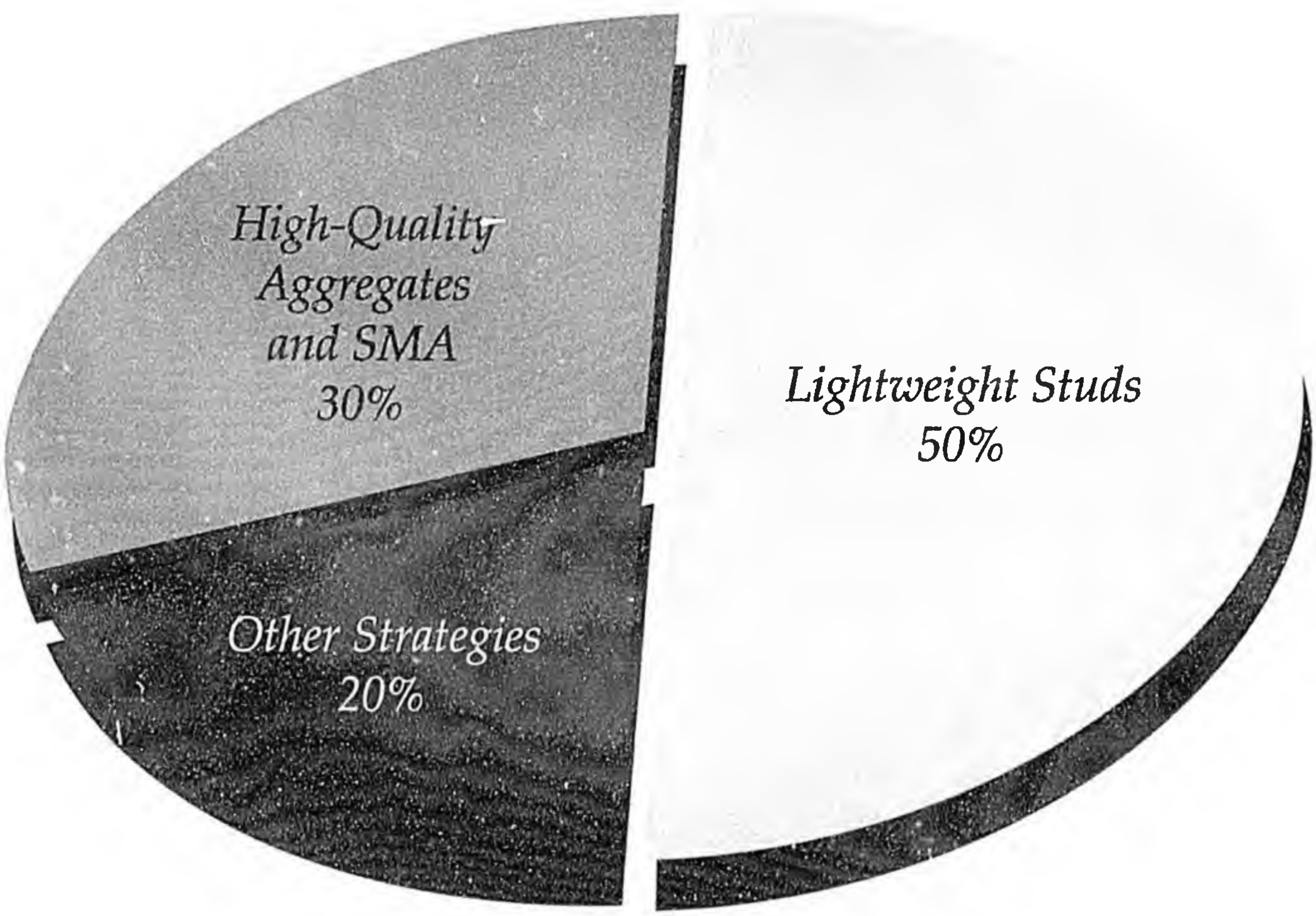
[9] "Study of Wear Resistance of Bituminous Mixes to Studded Tyres—Tests with slabs of bituminous mixes inserted in roads and in VTI's road simulator," Torbjörn Jacobson, Swedish Road and Traffic Institute, lecture at the Meeting of Nordic Road Association (NVF) Committee 33, Tälberg, June 1994; p. 15.

the area of high-grade aggregates, and is actively searching for deposits of high-quality aggregates that can be developed cost-effectively.

Some tests with SMA have been conducted in Alaska. Roads that have received SMA surfacing including portions of the Seward and Glenn highways, DeBarr and Muldoon roads, Minnesota Drive, Tudor Road, I and L Streets in Anchorage. The overall result has been a 45 percent improvement in the pavement wear rate, based on a standard wear rate of 0.13 inches per million studded tire passes on conventional pavement mixes.

Potential Reduction in Pavement Wear Provided by Various Approaches



DOT&PF ACTIVITIES

The DOT&PF has already taken some measures to reduce the road wear inflicted by studded tires. These efforts will be continued for the foreseeable future.

- In autumn of 1994 a statewide DOT&PF publicity campaign was launched to create awareness, and stimulate use, of lightweight stud alternatives. The program resulted in significant public demand for the lighter studs; available stocks were rapidly depleted. The following spring, another phase of the public education campaign encouraged drivers to remove their studded tires as soon as road conditions allowed.

- The Department will continue efforts to demonstrate the benefits of lightweight studs to all major tire retailers statewide. There is still some resistance to overcome at the retail level.

- The Department purchased two Nordic Ball Mill Testers in October, 1995, and is actively searching for concentrations of high-quality aggregates in Alaska.

- The Department will continue its ongoing research on aggregates, mix designs, pavement management systems, and new test procedures.

- The Department will continue to road-test SMAs for cost-effectiveness.

- The Department will deliver presentations to appropriate audiences and organizations, regarding the benefits of lightweight studs and SMAs.

- The Department has received $75,000 from the Federal Highway Administration to construct test sections using high quality aggregates to resist studded tire wear.

- The Department continues to contract with Scandinavian Institutes for specialty testing of asphalt mixes.

CONCLUSION

At present, SMA wear-resistant surfaces are still being tested in Alaska, and accessible sources of top-quality aggregate are still being sought.

However, the pavement wear problem in Alaska can be brought under control relatively quickly, through some simple and cost-effective measures. At present, Alaska spends $5 million annually to repair the damage caused by conventional studded tires. By implementing the following measures, that cost can be substantially reduced.

Current Annual Cost	**$5.0 million**
Potential savings through enforced ban on summer stud use	- 1.0 million
Potential savings through mandated use of lightweight studs	- 2.0 million
Revised Annual Cost	**$2.0 million**

(given 3-5 years for conventional studs to be wear out and be replaced)

To achieve these cost savings, the driving public, tire retailers, law enforcement agencies, the DOT&PF, and the Alaska Legislature must work in partnership.

- The public needs to become more aware of the problem of stud-related road wear, and adopt a proactive role in prevention of road damage through the purchase of lightweight studs or specialized winter-traction tires. This can be accomplished, in part, through education efforts and public information activities conducted by the DOT&PF. Because there is no cost differential for consumers between lightweight and conventional studs, this imposes no financial burden on motorists.

- Tire retailers need to begin working cooperatively with the DOT&PF to promote the use of lightweight studs. To achieve this, the Department will need to work closely with retailers to prove the benefits (and comparable wear-resistance) of lightweight studs. Because some retailers cite unavailability of lightweight studs as a problem, the Department may also need to help retailers locate wholesale suppliers of lightweight studs.

- Law enforcement agencies should make an aggressive effort to reduce or eliminate illegal use of studs during the summer months. The 3 to 6 percent of drivers who use studded tires during the summer generate 20 percent of all stud-related road damage.

- The DOT&PF needs to continue working with the public, tire retailers, and the state legislature to develop cost-effective methods for reducing stud-related road damage. These measures may include public education, legislation, and in the long-term, a transition to wear-resistant pavement surfaces.

- There is an opportunity to make a significant and cost-effective reduction in stud-related road wear, by mandating the use of lightweight ($\leq$1.1 gram) studs. Use of lightweight studs has been proven to reduce road wear by as much as 50 percent.

  To give motorists and tire retailers time to adjust to new regulations, the law could be designed to take effect at some future date. If the law was written to prohibit the retail sale of conventional studs and/or tires embedded with conventional studs, enforcement could be controlled at the retail level, and the cost of enforcement, if any, would be minimal.

ATTACHMENT

"MORE DURABLE THAN ONE WOULD EXPECT:
Studs in a 50,000 km driving test"

(Translation of an article published in Tekniikan Maailma, Finland, August 1994)

MORE DURABLE THAN ONE WOULD EXPECT

Studs in a 50,000 km driving test

(Translation of an article in the August 31, 1994 issue of the Finnish Tekniikan Maailma magazine.)

MORE DURABLE THAN ONE WOULD EXPECT

Studs in a 50,000 km driving test

Take eight Nokia Hakkapeliitta 10 winter tires. Fit them with different brands of studs. Then drive 50,000 kilometers with the tires. Measure the protrusion of the studs and perform a braking test every ten thousand kilometers. Finally, remove the studs from the tires to study how they have worn. We did all this and now we know even more. For example, we know that there is no reason to spoil good winter tires with inferior studs.

The studs that were tested:

* **Kometa P8-11**
* **Miba 8-11**
* **Nesspike 7-11**
* **Nesspike WIP**
* **Scason 8-11**
* **Tikka 8-11**
* **Turvanasta L42**

Anti-skid studs for winter tires are a Finnish invention. There is nothing amazing about that. In Finland we drive in slippery weather more than perhaps anywhere else in the world.

In principle, the structure of a stud is quite simple. But in practice, a lot of work has been done to make the stud function as it does today.

A stud is made of two parts, the body of the stud and a hardened metal spike inside the body. The Turvanasta, previously known as a sleeve stud, also has a third part, a plastic sleeve that allows the spike to move back and forth inside the stud body.

The stud body may be made from steel or light-alloy metal. The hardened steel spike is usually made from tungsten silicon carbide mixed with other materials. These materials are trade secrets that the manufacturers do not readily disclose.

Studs improve the grip of winter tires. Even so, not everyone approves of them. Studs are resisted because of the assumption that they tempt drivers to drive "too" fast, lowering traffic safety.

It is hard to believe this theory, because research has indicated that safety improves when friction between the tires and the road increases. That is exactly why roads are sanded and salted.

What difference does it make if friction is increased with the help of road maintenance or with studs?

In any case, Finnish drivers have drawn their own conclusions about the matter. Over 95 percent of Finnish drivers use studs in the winter.

Strict regulations

It is known that the greatest disadvantage of studded tires is that they wear down asphalt and cause ruts in the roads and streets. It has been estimated that it costs about two hundred million Finnish marks per year to repair the damage caused by studs. For this reason, the season during which studs can be used is restricted and the studs themselves have been developed over the years to make them more road-friendly.

The number of studs per tire is also limited. Small 13" tires can only contain up to 90 studs. Up to 15" tires can have no more than 110 studs and over 15" tires no more than 150.

The average protrusion of studs on new tires cannot be more than 1.2 mm and no more than 2.0 mm on used tires.

The mass of the studs is also limited. If the protrusion force of a stud measured in a type approval test is no more than 120 newtons, the mass must not exceed 1.1 grams. If the protrusion force is under 100 newtons, the mass can be up to 1.4 grams.

Stud regulations were not as strict in the past. It is generally felt that studs have lost some of their grip as a result of the new regulations.

In any case, there are several brands of studs on the market, and they certainly differ from each other due to their technical differences. We decided to find out what those differences are today.

Driving and more driving

Seven commonly used studs were chosen for the test. Six of them were "light studs" that met the new regulations and the seventh one, Tikka 8-11, was manufactured according to the older regulations and was heavier.

The studs were installed on Nokia Hakkapeliitta 10 tires. The tires were driven 50,000 km on main roads. A braking test on smooth ice was performed every ten thousand kilometers. At the same time, the tread depth and stud protrusion were measured.

The driving was easier on the tires and studs than normal, but it met the requirements set for the purpose of comparing wear.

The braking tests were done on ice that was smoothed by an ice conditioning machine. This ensured that conditions were the same during each round of tests. The smooth, conditioned surface also emphasized the effect on grip that the studs and their protrusion had.

The driving test was done with eight tires. Each brand of stud was installed on a different tire. The remaining eighth tire was fitted with a mixture of all seven types of studs. In this way the evenness of wear could be checked.

The test cars were Volkswagen Vento 2.0 CLs. A 70 kilogram weight was placed on the floor of the right front seat to simulate a passenger and even the load on the car. Otherwise the cars were in standard condition.

The tires were rotated between cars and from the front axle to the rear axle. The direction of rotation of the tires was not changed, so the tires remained on the same side throughout the test. All of the tires were driven an equal distance on the front and rear axles.

Based on tread depth measurements, it was noted that the tires wore the same amount on both sides of the cars. Tire changes were made every 1,200-1,300 km. The tire pressure was checked at the same time.

Grip during braking

Grip was analyzed with braking tests in which only one wheel locked. During the test only one front brake was functioning and the brakes of the other wheels were disconnected with special shut-off valves.

In a single wheel braking test the test car is steerable during braking, and the driver can steer the car to make sure that braking always happens on unused ice. In this way braking conditions were always the same.

Each tire was braked 20 times on unused ice. The braking distance was measured with a Peiseler unit that measured the actual distance traveled during braking with a sensor mounted on a freely turning rear wheel. The final braking distance was calculated as an average of all the measured distances and the result was statistically checked.

Changes in conditions during the tests were monitored with a reference tire. The braking distance of the reference tire was measured after every two test tires in order to correct for changes in weather conditions.

The braking tests were done in Ivalo, on the ice of Rahajärvi lake, where a test track 1.6 kilometers long and 40 meters wide had been prepared. The surface was levelled with a road grader and swept just before the tests. After sweeping, the surface was finished with a FICO ice conditioning machine that smoothed the ice before each round of tests.

The results indicated that the Nesspike, Scason, Turvanasta and Tikka studs suffered a noticeable loss of grip between the 10,000 and 20,000 kilometer tests.

Kometa functioned extremely well up to the 40,000 kilometer test. After that it lost its grip faster than the other studs.

Turvanasta and Kometa had the best grip at the beginning of the test. However, Turvanasta's results dropped to average after 20,000 kilometers.

Miba was the worst stud at the beginning of the test, but it improved near the end of the test and was the best in the end.

Nesspike WIP had the poorest results in nearly all the braking grip measurements.

The most notable observation was that after somewhat over 10,000 kilometers, the grip of the best stud was no longer as good as the grip of the worst stud when new.

Changes and wear in stud protrusion

The protrusion of all the studs decreased during the wear test. Nesspike's protrusion changed the most. Nesspike's average protrusion was only 0.29 millimeters at the end of the test.

Kometa's protrusion remained nearly unchanged throughout the whole test.

The average protrusion of the studs on all the tires at the end of the test was 0.60 millimeters, which is a relatively low value.

Stud protrusions in normal traffic are usually over one millimeter. The difference was due to the fact that driving during the test was more even compared to normal driving, which includes more acclerating, braking and curves per driven kilometer.

The protrusion of all the studs decreased during the first 20,000 kilometers - quite a lot in some cases - and then evened off at a certain level that no longer changed for most of the studs.

Stud wear cannot be decided based on changes in protrusion. Therefore, at the end of the test we removed 24 studs from each tire. We measured their length and compared the results to the original 11 millimeter studs.

Kometa wore the least during the test. Furthermore, its hardened steel spike wore in suitable proportion with the body of the stud. The next best was Miba, and its hardened steel spike was also worn the least, except for Kometa, in relation to the stud body. Kometa was the best in this category.

Scason and Nesspike wore the most during the test, losing about three millimeters of their length. Their hardened steel spikes also wore nearly to the level of of the stud body, which is not desirable from the point of view of grip.

Turvanasta was nearly the poorest as far as wear, but what was more important from the functional point of view, the stud had loosened in its sleeve.

Everything affects everything else

All of the studs remained fastened to the tires throughout the whole test. It can be said that stud loss is not a problem with Nokia Hakkapeliitta 10 tires.

The tires were worn very little after 50,000 kilometers. Above all, this was due to the driving pattern during the test. Driving was done at winter speed limits almost entirely on main roads. Acceleration and braking was done evenly without spinning and skidding the tires. The main goal was to have the different tires wear as similarly as possible.

Even though the tires themselves wore very little during the test, stud protrusion was smaller than it is on average on cars in normal traffic conditions. This was partly caused by the driving pattern of the test, which did not force the studs to move outward in their holes.

Weather and road conditions were observed to have a definite effect on tire wear. Naturally, the tires wore faster near the end of the test in March, when most of the asphalt was clear of ice and snow. Stud protrusion changes were the greatest near the beginning of the test, when more of the roads were covered with ice and snow.

There are differences

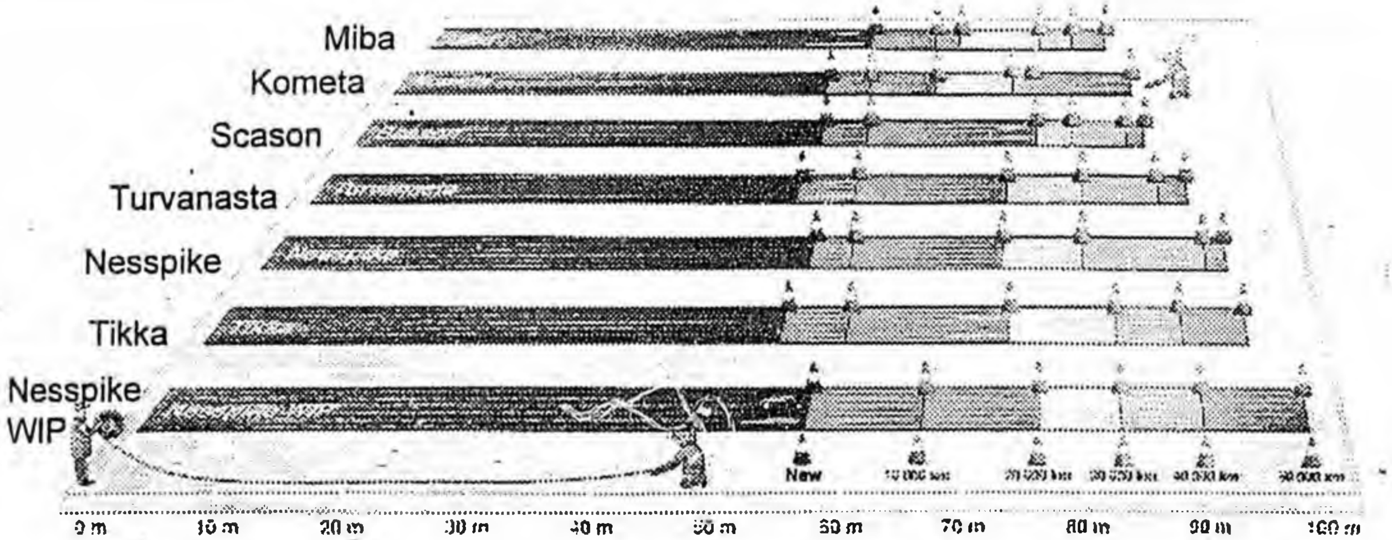
We were surprised that the differences between studs was even greater than we had expected. The test clearly indicated that the brand of stud you select is not of little importance.

So it is worth asking what studs have been installed on the winter tires you are buying. It is the studs that determine how good a grip the tires have on icy roads and how long that grip will last.

Tikka 8-11 represented the previous generation of studs in this test. It has a steel body and is heavier than the rest. It can no longer be used on new tires. Even so, its poor grip placed it in second to last place at the end of the test. Its protrusion was only average and it wore more than average. There is no reason to argue that it had better grip than the new light studs. In this case, development has gone ahead.

We evaluated the studs by awarding half of the points for grip, or the results of the braking tests. The other half was weighted evenly between protrusion and stud wear.

Each stud passed the test at least satisfactorily. On the other hand, studs can still be improved, so the best evaluation we gave was four stars out of a possible five. We feel this reflects the present stage of development.



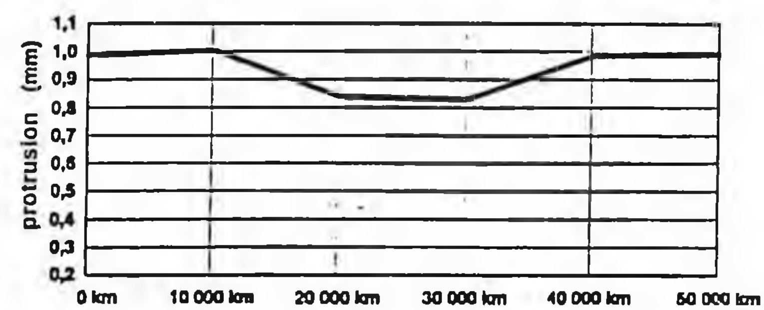
Braking distances were measured the first time with new tires and then after every 10,000 kilometers of driving. The measurements were made with one wheel locked up, from 20 km/h to 5 km/h. The results were converted to values that correspond to four-wheel braking from 50 km/h to 0 km/h, based on verification measurements. Each braking transaction was performed on smooth ice that was treated with an ice conditioning machine.

FINAL EVALUATION

Kometa 8-11
Wear: 1.4 mm

Manufacturer: Tikka-Nasta Oy, Tikkakoski
Length: 11 mm
Weight: 1.02 g
Body: pressed composite light metal alloy
* * * *

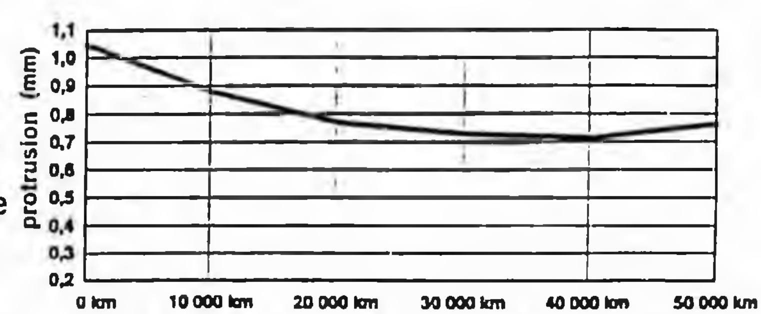
Kometa was the best stopper of the group, up to 40,000 kilometers. It clearly also wore the least. The hardened steel spike was visible a suitable amount at the end of the test. Its protrusion was almost unchanged throughout the test. This was the most reliable and recommendable stud in this test.



Miba 8-11
Wear: 2.1 mm

Manufacturer: Eurovulk Oy, Tammisaari
Length: 11 mm
Weight: 1.10 g
Body: pressed aluminum alloy
* * *

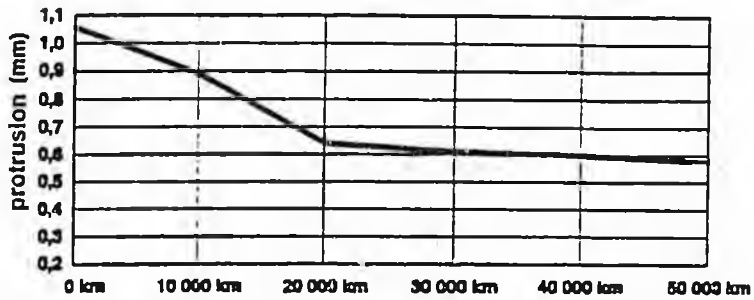
Miba's grip was below average at the beginning of the test. The more it was driven, the better it became, though, and at the end of the test it produced the best results in the braking tests. It wore second to the least and its hardened steel spike was clearly visible at the end of the test. Miba retained its protrusion reasonably well.



Scason 8-11
Wear: 2.9 mm

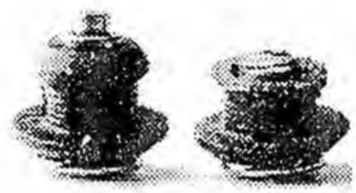
Manufacturer: Scason Oy, Turku
Length: 11 mm
Weight: 0.98 g
Body: pressed aluminum alloy
* *

Scason was among the worst of the group as far as wear was concerned. Its hardened steel spike also wore nearly to the level of the stud body. Its grip dropped noticeably in the braking tests after 10,000 kilometers. This can be explained by the fact that its protrusion decreased markedly at the beginning of the test.

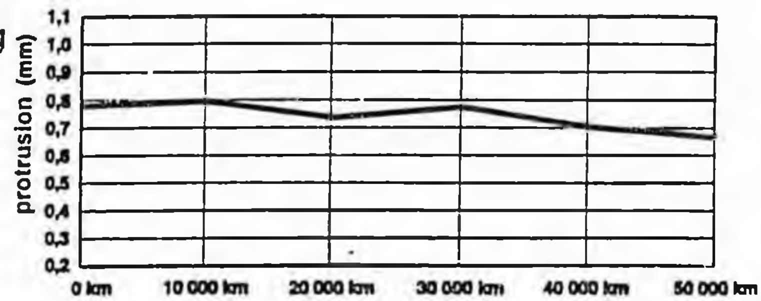


Turvanasta L42
Wear: 2.7 mm

Manufacturer: Turvanasta Oy, Turku
Length: 11 mm
Weight: 1.35 g
Body: tempered and nitrogen hardened steel, plastic sleeve
* *

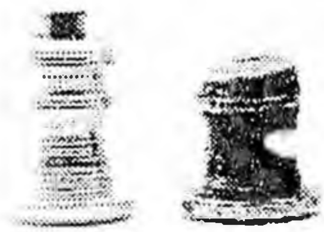


Turvanasta was the worst of the group as far as wear was concerned. Its hardened steel spike also wore nearly to the level of the stud body. It produced average results in the braking tests throughout the test. Its protrusion was smaller than that of the others in the beginning, but it retained its protrusion well. At the end of the test we observed looseness between the stud body and the sleeve.

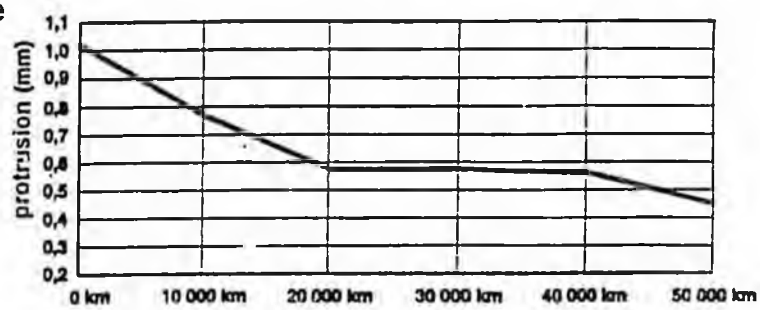


Nesspike WIP
Wear: 2.5 mm

Manufacturer: Turvanasta Oy, Turku
Length: 11 mm
Weight: 1.30 g
Body: turned steel
*



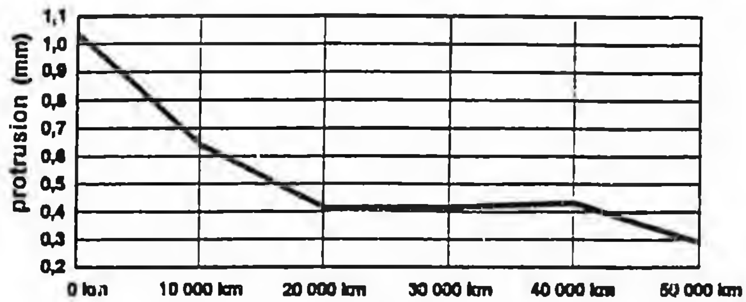
Nesspike WIP was the worst stud of the group in the braking tests. Its wear was about average and its hardened steel spike also wore nearly to the level of the stud body. It suffered notable lost in protrusion during the first 20,000 kilometers. Its protrusion curve is similar to the other Nesspike stud.



Nesspike 7-11
Wear: 3.0 mm

Manufacturer: Turvanasta Oy, Turku
Length: 11 mm
Weight: 1.35 g
Body: turned steel
*

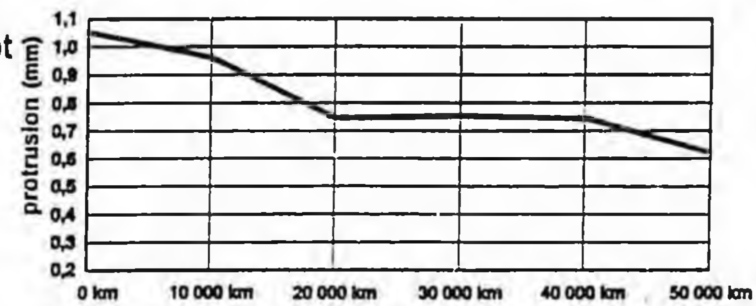
Nesspike wore more than any other stud in the test. It also lost its protrusion the most and its hardened steel spike wore to the level of the stud body. It performed better than its sister model in the braking tests, which could mean that it stays upright in the tire better.



Tikka 8-11
Wear: 2.5 mm

Manufacturer: Tikka-Nastat Oy, Tikkakoski
Length: 11 mm
Weight: 1.80 g
Body: drawn steel
*

Tikka was included in the test for comparison. It belongs to the previous generation of heavier studs, and cannot be used in new tires. Tikka's performance was only average in all evaluated characteristics. The result was good, because it indicates that studs have not been weakened by the new regulations.



CS FOR SENATE BILL NO. 156(TRA)

IN THE LEGISLATURE OF THE STATE OF ALASKA

TWENTIETH LEGISLATURE - FIRST SESSION

BY THE SENATE TRANSPORTATION COMMITTEE BY REQUEST

Offered: 4/22/97
Referred: Transportation, Labor and Commerce

A BILL

FOR AN ACT ENTITLED

"An Act relating to limitations on studded tires and on the use of certain studded tires; prohibiting certain trade practices regarding studded tires; and providing for an effective date."

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF ALASKA:

* **Section 1.** AS 28.35.155 (b) is repealed and reenacted to read:

(b) The studs in a studded tire on a motor vehicle being driven, operated, or moved on a paved highway or paved vehicular way or area may not

(1) protrude more than three-sixteenths of an inch from the tire surface;

(2) individually weigh more than

(A) 1.1 grams for a tire size less than 14 inches; and

(B) 1.5 grams for a tire size of 14 inches or more but less than 16.5 inches; and

(C) 3.0 grams for a studded tire on a commercial motor vehicle.

* **Sec. 2.** AS 28.35.155 is amended by adding a new subsection to read:

(c) In this section,

(1) "commercial motor vehicle" has the meaning given in AS 28.32.900;

(2) "studded tire" means a tire with metal studs imbedded in the periphery of the tire surface.

*** Sec. 3.** AS 45.45.200 is amended by adding new subsections to read:

(f) A shop may not sell or offer for sale a studded tire, or install studs in a tire for a customer, unless each stud weighs not more than

(1) 1.1 grams for a tire size less than 14 inches; and

(2) 1.5 grams for a tire size of 14 inches or more but less than 16.5 inches; and

(3) 3.0 grams for a studded tire on a commercial motor vehicle.

(g) A shop may not install metal studs in a tire against manufacturers recommendations.

(h) In this section,

*** Sec. 4.** AS 45.45.240 is amended by adding new paragraphs to read:

(5) "commercial motor vehicle" has the meaning given in AS 28.32.900;

(6) "studded tire" means a tire with metal studs imbedded in the periphery of the tire surface;

*** Sec. 5.** This Act takes effect July 1, 1998.

TO: SENATORS WARD, WILKEN, GREEN, HALFORD, LINCOLN
(SENATE TRANSPORTATION COMMITTEE)

RE: SB156, AN ACT TO LIMIT THE USE OF STUDDED TIRES

SENATORS:

IT HAS COME TO OUR ATTENTION THAT SB156 INCLUDES A PROVISION TO RESTRICT OR BAN THE PRACTICE OF RESTUDDING TIRES, IN ADDITION TO THE REQUIREMENT OF USING "LIGHTWEIGHT" STUDS IN TIRE STUDDING.

THE RESTUDDING OF WINTER TIRES HES BEEN PRACTICED IN ALASKA FOR MANY YEARS. THIS PRACTICE SAVES THE PUBLIC THE COST OF PURCHASING NEW TIRES PREMATURELY. RESTUDDING ALLOWS CONSUMERS TO GET SIGNIFICANTLY LONGER USE OF THEIR WINTER TIRES.

TIRE RESTUDDING IS DONE WHEN ORIGINAL STUDS HAVE WORN DOWN BEYOND THEIR USEFUL LIFE- WHEN THEY NO LONGER TOUCH THE PAVEMENT OR ICE TO PROVIDE TRACTION. THEREFORE THE IMPACT OF RESTUDDED TIRES ON THE ROAD IS NO DIFFERENT THAN THE IMPACT OF ANY OTHER STUDDED TIRES.

SHOULD SB 156 PASS, REQUIRING THE USE OF LIGHTWEIGHT STUDS, THE NEED FOR RESTUDDING WILL BE EVEN GREATER- A TEST PERFORMED THIS WINTER, IN ANCHORAGE, SHOWS THAT LIGHT-WEIGHT STUDS WEAR DOWN MUCH MORE RAPIDLY THAN OLD-SYTLE STEEL STUDS, THEREFORE HAVING A MUCH SHORTER USEFUL LIFE.

PERHAPS THE BEST WAY TO ADDRESS THE ISSUE OF RESTUDDING TIRES IS TO INCLUDE IN SB156, SHOULD IT PASS, THAT ANY RESTUDDING OF TIRES MUST BE DONE WITH LIGHTWIGHT STUDS, OR STUDS WEIGHING 1.1 GRAMS OR LESS.

BRAD BYLSMA AMERICAN TIRE ANCHORAGE	DAVE SNYDER DIVERSIFIED TIRE WASILLA	ROBERT NIETZ NORTHERN TIRE ANCHORAGE
MATT SIEDLER ALASKA TIRE ANCHORAGE	JEFFREY CALL VIKING MOBILE TIRE EAGLE RIVER	MARK MCMAHAN AMERICAN TIRE FAIRBANKS

ATTENTION: CRAIG JOHNSON, SENATOR WARD'S OFFICE

PAGE 1 OF 2

PLEASE CALL 276-7878 IF BOTH PAGES NOT RECIEVED
PLEASE DO WHAT YOU CAN TO GET THE FOLLOWING LETTER INTO COMMITTEE TESTIMONY, AS WE DISCUSSED EARLIER TODAY.

ALSO, BEFORE ANY LEGISLATION IS PASSED, SERIOUS CONSIDERATION SHOULD BE GIVEN TO SHORTENING THE LEGAL DATES FOR STUD USE: CURRENTLY SEPT 15 - APR 30. CHANGING TO OCT 1 - APR 15 COULD REDUCE PAVEMENT WEAR DRASTICALLY, AS EARLY FALL & LATE SPRING ARE THE TIMES WHEN THE PAVEMENT TEMPERATURES ARE AT THEIR WARMEST AND MOST SUSCEPTIBLE TO DAMAGE FROM STUDS. SHOULD YOU OR SEN WARD LIKE TO DISCUSS THIS FURTHER PLEASE CALL ME AT THE ABOVE NUMBER.

THANK YOU,
BRAD BYLSMA
AMERICAN TIRE

Committee File SB 156

TONY KNOWLES, GOVERNOR
3132 CHANNEL DRIVE
JUNEAU, ALASKA 99801-7898

TEXT: (907) 465-3652
FAX: (907) 586-8365
PHONE: (907) 465-3900

DEPARTMENT OF TRANSPORTATION
AND PUBLIC FACILITIES
OFFICE OF THE COMMISSIONER

May 2, 1997

The Honorable Rick Halford
Alaska State Legislature
State Capitol, Room 121
Juneau, Alaska 99801-1182

Dear Senator Halford:

During the Senate Transportation hearing held on April 22, you expressed some concerns on the department's implementation of programs to help decrease road wear on our state highways.

A specific item in which you expressed interest was whether the department has considered offset striping on our roads. The short answer is yes, we have discussed this approach. The concept of offset striping has be tried in European countries to extend pavement life by several of years prior to rehabilitation. The European program has met with limited success.

A concern we have with offset striping is in the difficulty associated with removing a residual stripe. If the stripe is completely worn, this situation does not present a significant problem. Frequently, however, striping on a roadway is not completely worn off prior to installation of striping for the next season. Removing a residual stripe leaves distinct marking on the pavement which has the potential of creating confusion for drivers.

The department is experimenting with a wider, 13 foot, traveled lane, and a narrower, 7 foot, shoulder. This configuration allows vehicles to meander slightly so that the wear pattern is spread out over the width of the roadway. Initial review of these sections of road do indicate decrease in rutting.

The above solutions will help to extend a pavement life but will really not decrease road wear significantly. We believe that switching to lightweight studs is an important component in the department's overall program to decrease road wear. Other aspects of our program include the use of Stone Mastic Asphalt and our continuing search for more durable aggregate.

I appreciate your personal interest and welcome your assistance in dealing with the road wear problem. Please contact me if you have any additional questions.

Sincerely,

Boyd J. Brownfield, P.E.
Deputy Commissioner

cc: Senator Jerry Ward, Chair, Senate Transportation

ROAD WEAR RELATED TO USE OF STUDDED TIRES

2 January 1997

The use of studded tires and their relationship to road wear is a subject of comprehensive international interest.

The State of Alaska Department of Transportation and Public Facilities is interested in opportunities which decrease the amount of Capital and Operating funding spent on roads in the state.

The department recognizes that accelerated pavement wear is not confined to the effects of studded tire use. In fact, rutting and other forms of pavement wear result from a combination of the following factors:

1. Use of studded tires
2. Traffic conditions (i.e. - traffic volume, average speed, vehicle weight, amount of braking, acceleration and turning)
3. Pavement Materials (i.e. - quality, gradation, fraction and hardness of aggregate)
4. Pavement Composition (i.e. - mixture characteristics of the pavement material)

The department estimates that road wear related to use of studded tires costs the state up to $5 million per year

BACKGROUND

Studded tires were first developed and used in Finland in 1959. By the winter of 1963, studded tires were in use on roads in the United States.

As early as 1972, the State of Alaska Department of Highways released a report outlining the problems of studded tire use on Alaskan roads.

Rutting on Alaskan roads is a severe problem. Estimates place the annual cost due to wear associated with studded tires at approximately $5 million. Studies show that pavement displacement is not a significant factor in rutting on Alaska roads.

Use of studded tires during the summer months accounts for approximately 20% of the studded tire related wear to Alaska's road system.

FINDINGS

Use of lightweight studs can decrease pavement wear by up to 50%.

Use of Stone Mastic Asphalt (SMA) can reduce pavement wear by up to 30%.

Use of better quality aggregates can extend pavement life.

Lightweight studs are equal in cost and in some cases superior in wear characteristics when compared to heavyweight studs.

RECOMMENDATIONS

1. Continue road testing of Stone Mastic Asphalt for cost effectiveness.
2. Continue research to locate better aggregate material for use in pavement.
3. Introduce legislation allowing the sale of only those studded tires with lightweight studs (studs weighing less than 1.3 grams). Permit the use of heavier (up to 3 grams) studs in commercial vehicles and buses.
4. Initiate a pubic information campaign to provide consumers with information on the benefits of switching to lightweight studs on their studded tires.

Department of Transportation and Public Facilities
Statewide Materials

Memorandum State of Alaska

TO: Distribution

DATE: April 25, 1996

TELEPHONE NO: 269-6242

FROM: Eric G. Johnson EGJ
Engineer of Tests

SUBJECT: Scandinavian Studded Tire Trip Report

I have attached a copy of a report entitled "Studded Tire Research in Norway, Finland and Sweden." The report summarizes the findings of Tony Barter, State Materials Engineer, David Sterley, Regional Materials Coordinator, Southeastern Region, and myself on a trip to Scandinavia in June, 1995. It will be published in the proceedings of the 8th International Specialty Conference on Cold Regions Engineering to be held in Fairbanks, August 12-17, 1996. The report has been reviewed by several of the Scandinavian researchers we visited.

Distribution:

2500 Joseph Perkins, Commissioner
Bo Brownfield, Deputy Commissioner
Loren Rasmussen, Acting Director of E. & O.
Scott Gartin, PMS Engineer
Tony Barter, State Materials Engineer
Matt Reckard, Research Engineer, Headquarters
John Horn, Regional Director, Central Region
Keith Morberg, Chief of Design, Central Region
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Studded Tire Research in Norway, Finland and Sweden

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ABSTRACT

In June of 1995, engineers for the Alaska Department of Transportation and Public Facilities journeyed to Norway, Sweden and Finland to investigate Scandinavian research into reducing the effects of studded tires on pavements. Many northern tier states in the United States have banned studded tires; since the 1970's, little research has been done in North America. The road administrations, road institutes, and tire manufacturers of Norway, Sweden and Finland have continued to do extensive research on studded tires. To solve the problem of stud damage to pavements the three countries researched stud design, tire traction, driver behavior, aggregates, asphalt concrete, and asphalt mix designs. The solution to studded tire wear involved a three pronged approach. First, the countries legislated the use of lightweight studs: studs that weigh less than 1.1 grams. The core of the stud is tungsten carbide steel, but the lightweight sleeve is either plastic or aluminum oxide. This stud reduced pavement wear rates by 50 percent. Second, they used a Stone Mastic Asphalt (SMA) concrete mix for surface courses. This mix contains up to 70 percent coarse aggregate. The use of SMA can reduce pavement wear rates from 25 to 50 percent. Third, they found hard durable aggregates that resist studded tire wear better than aggregates from local material sources. They developed tests such as the Ball Mill Test, SRK Test and the Point Load Test. Their research showed that the commonly used wear and degradation tests do not correlate to pavement wear due to studded tires. The harder aggregates that resist

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studded tire wear are fine grained metamorphic and volcanic rocks and make up only 2 to 4 percent of the rock in Scandinavia. They have hauled this rock up to 300 kilometers for a wearing course. The use of these harder aggregates can reduce wear rates by a factor of three to five compared to using local aggregates.

INTRODUCTION

In June of 1995, the Alaska Department of Transportation and Public Facilities sent a team to Scandinavian to learn first hand how to combat studded tire wear in their asphalt concrete pavements. Alaska spends approximately $5 million annually to repair studded tire wear. In the early 1970's, much research was done on studded tires in Europe[1]. Based on this research, most countries in Europe except Norway, Finland and Sweden have banned studded tires. These three countries have continued to do research in this field for twenty-five years. This paper summarizes what the department's team learned about how Norway, Finland and Sweden have solved studded tire wear.

In Norway, the Alaska team visited the Norwegian Public Roads Institute in Oslo. In Finland, the Alaskan engineers visited the Road Engineering and Geotechnical Laboratory of the Technical Research Centre of Finland (VTT) in Espoo and the Finnish Public Roads Administration (FinnRa) in Helsinki. In Sweden, the team visited the Swedish Road and Transport Research Institute (VTI) in Linkoping.

In each country, various researchers investigated a specific topic that provided part of the solution to studded tire wear. The various subject areas included: stud design and installation; traction testing; asphalt concrete and aggregate testing; social aspects of studded tire usage; and field performance of asphalt concrete mixtures. By combining the results of the research in these areas a comprehensive solution to the wear of pavements due to studded tires was arrived at.

STUDDED TIRE USAGE

In Norway, studded tire usage has reached as high as 92 percent of the passenger vehicles, while Finland reported 97 percent usage. Sweden reported 50 percent usage in southern Sweden which has dropped to 30 percent and 90 percent in the north. Most of Sweden's traffic is in the southern part of the country.[2]

STUD DESIGN, MANUFACTURE AND INSTALLATION

In Finland the Alaska team met with a studded tire manufacturer. Only five studded tire manufacturers exist worldwide in 1995: two in Finland, two in Germany, and one in France. In Sweden the team met with one of the tire manufacturers.

A tire stud consists of two components. The inner pin is usually made of tungsten carbide steel. The outer sleeve can be composed of several different kinds of materials. Heavier studs have a steel sleeve and weigh 1.8 grams or more. A stud with an aluminum oxide sleeve weighs approximately 0.95 grams and a composite stud with a plastic sleeve weighs about 0.7 grams. All studs with a tungsten carbide pin have almost the same stopping distance, though the sleeve may be a different material. Sweden said that they are experimenting with a ceramic pin in hopes of reducing the weight of the stud even further. (The tungsten carbide pin weighs 0.6 grams). The aluminum oxide stud is recommended for police and emergency vehicles. A 3 gram steel sleeved stud is recommended for buses and commercial trucks.

The sleeve material must be designed so that it wears at the same rate as the rubber on the tire. The sleeve must be designed to keep the stud from moving laterally in the tire. Pure aluminum sleeves wear laterally allowing the stud to lean over in the socket. This reduces the stopping ability and leads to a loss of stud retention. Aluminum oxide added to the aluminum prevents this problem. Studs have been designed with a widened portion at the top of the sleeve to make the stud more stable within the stud socket.

The dynamics of stud action include three phases. As the tire and stud move over the pavement, there are measurable "spikes" in the force at the beginning and end of contact. Between spikes, the studs apply a static force to the pavement. During the initial contact the energy spikes, the studs have a "punching" action that breaks up aggregate and picks out asphalt. During the second energy spike at the end of the contact with pavement, the studs scratch the pavement (See Figure 1).[3]

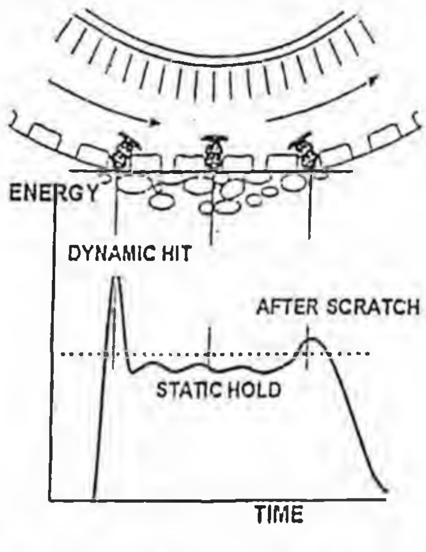

Figure 1 - Kinetic forces of Studs on Pavement

Research in these Scandinavian countries on pavement wear rates with different kinds of studs, shows that the rate of wear varies directly with the weight of the stud.[4] Because of this, Norway, Finland and Sweden have passed laws limiting stud weights to 1.1 grams for passenger vehicles. This has reduced the pavement wear rates by 50 percent or more.[2]

TRACTION TESTS

Finland and Sweden have a long history of friction testing of studded and studless tires. Traction was not discussed with the Nowegian researchers.

Sweden: Sweden has been testing traction and friction on tires for many years at the Swedish Road and Transport Research Institute (VTI). VTI has built a moving flat bed test track system that tests up to truck size tires. The facility includes a stationary test rig with a tire and suspension system. The tire can be rotated up to 90 degrees for testing sideways skidding. A 55 meter long moving steel beam test track is moved at speeds up to 40 kilometers per hour under the stationary tire. The system includes an ice laying machine that places a uniform ice thickness over the steel beam to simulate wintertime conditions. The testing system can control the slip from full slip to a fully locked wheel configuration.[5]

VTI tested stopping distance on ice for forty-nine different tire types, including studded and unstudded tires. All the studded tires showed better traction than the unstudded tires. The unstudded silica modified tires also showed better traction than the other unstudded tires. The unstudded silica modified tire had better friction than three of the fifteen studded tires tested. All other studded tires were significantly better than the silica modified tire and other unstudded tires. A siped was also tested. Siping a tire involves placing 6 mm cuts into the surface of the tire. The siped tire test results should stopping distances just below the studded tires, and better than regular tires. Other friction tires showed mixed results compared with regular tires.[6]

Tests on a bare pavement showed that studded tires showed a slight reduction in friction, but that it was less than the difference in friction between brands of unstudded tires. Tests also showed that on stud roughened ice, unstudded tires have a significant higher friction than on smooth ice.

Sideways control upon skidding is considered by Norway, Finland and Sweden to be more important than straight ahead stopping distances for safety. On wet ice, only the studded tires provided sideways control at lower speeds. Also, tests showed that if studded tires were installed only on the front or back tires, the vehicle could lose control when attempting to stop on ice.[2] Because of these considerations Norway, Finland and

Sweden require studs on all four tires by law. In general, Norway, Finland and Sweden have not been able to document hydroplaning accidents from police reports.[2]

Finland: The Finnish Road Administration (FinnRa) completed a multiyear research project on traction and driver response. Stopping distance tests were done on lake ice with studless and studded tires. Cars with studded tires stopped sooner than those without studs. Testing on snow showed no difference in stopping distance between studded and studless tires. Friction tests were performed at 5000 kilometer intervals. As part of the project, FinnRa placed video cameras in vehicles to monitor driver performance. Drivers without studs were found to drive more carefully than those with studs. The changes were not sufficient to keep the risk at the same level as drivers with studded tires. The drivers stated that they would rather drive with studs than not.[7]

TESTING PROCEDURES

The procedures for testing aggregates and asphalt concrete for resistance to studded tire wear in Norway, Finland and Sweden have evolved over the last thirty years. They started with an evaluation standard quality tests for aggregate such as the Los Angeles Wear, Sulphate Soundness, and so forth. These tests were found to have no correlation with studded tire wear, as they were developed for nonstudded tire loadings. Following is a description of each test they developed in order ending with the Scandinavian's recommendation for the best tests for studded tire wear. The tests fall into two categories: aggregate testing and asphalt concrete testing.[2]

Aggregate Testing

Abrasion Test - This test consists of gluing 16 pieces of 8 mm aggregate to a card (75mm x 75 mm). The card is placed on a circular table and a steel abrader is rotated over the sample in the presence of grit. After a specified number of revolutions the weight loss of the aggregate is measured. This test correlates well with studded tire wear but has poor repeatability, especially when a mixture of aggregate types is used. The stronger aggregates may protect the weaker aggregates. All three countries visited are moving away from using this test and replacing it with the Ball Mill Test.

Impact Test - This test was first developed in Britain. It consists of placing a uniform sized (8 mm) crushed aggregate in a steel box. A 14 kg weight is dropped 25 cm 20 times. The percent loss is then measured. Only Norway uses this test with the Abrasion Test to predict studded tire wear. This test exhibits some of the same problems with Los Angeles Wear Test in that the abraded particles cushion the larger aggregate on some samples. Norway is moving away from using this test and relying on the Ball Mill Test.

Flakiness - This test measures the geometrical properties of the crushed aggregate. This test measures the percent of elongated aggregates. The aggregate is sieved and the material retained on each sieve is reseived through a slotted screen. The slots have half the width of the next higher sieve. Finland specifies the Flakiness Index for two sieves: 12.5 to 20 mm and 8 to 12.5 mm. The specification ensures uniformity and particle interlock within the asphalt mixture. Aggregate that is too flaky can break during compaction or stud impact.

Ball Mill - A single size crushed aggregate sample (11.2 to 16.0 mm) is placed in a rotating steel drum with 2 liters of water and 7 kg of steel balls. There are three ribs on the interior of the 219 mm diameter 335 mm length drum to improve the mixing. After 5400 revolutions, the amount of abraded aggregate less than 2 mm in size is measured and the percent loss is calculated. This is repeatable and shows an excellent correlation with studded tire wear. Research in Finland showed the Los Angeles Wear test does not predict studded tire wear because being run dry, the fine particles can cushion the aggregate. Finnish tests show that on some aggregates can have a low Los Angeles Wear loss (lower is better) and have a high Ball Mill loss. Sweden, Finland and Norway are specifying the Ball Mill Test for their paving aggregate to resist studded tire wear.

Point Load - Finland has developed this test to estimate the durability of rock material for paving aggregate. (It is different from the hardness test usually done in the United States). A rock core having a diameter of 32 to 62 mm is placed diametrically between two hard metal points. The geometry for these points was developed specifically for this test. The load is increased until the specimen fails. Finland showed in their ASTO road test data, that this test improves the accuracy of the Ball Mill prediction on a few of the aggregates. Only Finland uses this test.

Asphalt Concrete Testing

Troeger - This test was developed in Germany. It rapidly presses many metal needles into the surface of a pavement core. The percent weight lost for a specified number of presses is then calculated. This test correlates well to studded tire wear but has poor repeatability. The Troeger Test is no longer used regularly in Scandinavia. This test is also used to measure the durability of pavement markings.

Test Slabs in Roadway - Slabs 47.5 mm by 75 mm are compacted in the laboratory and placed in the wheelpath of a roadway. Pavement wear and deformation are measured with a laser profiler beam with feet on each end placed on recessed reference points. This test is used extensively in Sweden. A few slabs have been placed recently in Norway. Th s test gives actual field wear and deformation measurements. Traffic data must be known to calculate wear rates.

Road Simulator - This test applies multiple passes of a full scale tire (with or without studs) to a pavement sample. All three countries have circular machines. Sweden's includes a full suspension system for each tire. Finland also has a simulator that is unidirectional with the tire raised and returned to the start at the end of each pass. Samples are compacted in trays using rolling compactors. Sweden uses a small field rolling compactor to compact the samples. Norway runs its test at just above and just below freezing. Finland runs theirs at 30 degrees C when testing without studs and five degrees C with studs. Sweden runs their test at plus or minus 5 degrees C. The road simulator has a very high correlation with the field wear values.

SRK - This test is run only in Finland. Three studded rubber wheels are run around the outside of an asphaltic concrete core. After a specified number of revolutions the percent weight loss is calculated. This test correlates very well with studded tire wear in the field. The test is run at five degrees C. Finland specifies various levels of test values for mix design for different levels of traffic.

STUDDED TIRE WEAR RESISTANT AGGREGATES

Studded tire resistant aggregates in Scandinavia are typically heavily metamorphosed and found around the edges volcanic intrusions. These sources only make up 2 to 4 percent of all rock in Scandinavia. Desirable aggregates typically exhibit a fine grained matrix indicative of a fairly rapid cooling which prohibits the growth of a larger crystalline matrix. Because of the larger grains, granites usually do not possess the necessary "rut resistance." The rock type does not guaranty a rut resistant aggregate. An aggregate must be tested because the intergranular strength can vary and the mix of minerals can change.[8] Almost all the aggregates are produced from quarries and some have been hauled up to 300 kilometers. Because of the cost, the Scandinavians have used mixtures of the hard aggregate and softer local aggregates for lower volume roads.

Rock Descriptions:

Following are the descriptions of each country's aggregate used to resist studded tire wear as translated by Scandinavian geologists:

Norway: They generally describe their best aggregates as fine grained rocks without any foliation or mineral orientation. In the Oslo region the best aggregates are hornfels, porphyritic basalt and syntectic volcanics. The latter may be porphyritic as for instance rombe porphyry with alkaline feldspars as 2-3 cm phenocrysts. In the south west of Norway there is a fine grained "quartz-diorite - consisting of plagioclase and quartz.

The producer calls it Durasplitt. They have also used some gabbroes and amphilbolites. Norway also uses some quartzite.

Sweden: They like to use a rheolitic porphyry as their best aggregate. They have used traprock, diabases, and amphibolites. Sweden has also used a lot of quartzite.

Finland: Finland performed a large research project called the ASTO Test Road. In this project, 35 different aggregate types were tested for studded tire wear in the field. The following aggregates were found to resist studded tire wear the best. Their best aggregates were the following: Diabase (53% plagioclase, 17% amphibole, 26% pyroxene), Greenstone (Heavily metamorphosed)(30% plagioclase and quartz, 60% amphibole) intermediate volcanite (55% plagioclase and quartz, 40% amphibole, 5% OP), Acid volcanite (32% quartz, 57% plagioclase, 7% Biotite), Acid volcanite (36% quartz, 51% plagioclase, 9% Amphibole), Acid volcanite (47% quartz, 43% plagioclase, 7% Biotite). Finland has also used a lot of quartzite.

Field Performance

Norway, Finland and Sweden all showed significant reductions in the studded tire wear of pavements by using the more resistant aggregates. Figure 2 shows the results of a large field study performed in Sweden by Törbjorn Jacobson.[9] The results compare the wear on asphalt concrete composed of local aggregates versus a wear resistant aggregate. The use of these aggregates reduced wear by a factor of 3 to 5.

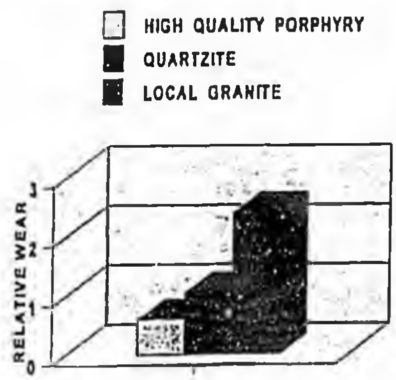

Figure 2 - Relative Studded Tire Wear of High Quality Versus Local Aggregates. Reference 9.

MIX DESIGN CONSIDERATIONS

Mixture Composition

Pavement mixture composition (mix design) appears to significantly influence wear resistance to tire studs. In terms of pavement wear, mix composition is of secondary importance when compared with aggregate quality and the use of lightweight studs. However, it has been proven that given a studded tire wear resistant aggregate, a pavement will perform better if it is "loaded" with coarse aggregate. The conventional name for this type of mix is Stone Mastic Asphalt (SMA). It contains approximately 70 percent coarse aggregate and has a relatively high amount of voids. The asphalt is stabilized with cellulose or polyethylene fibers to increase binder viscosity to help prevent asphalt draindown. The mixture also contains mineral fillers. The use of SMA reduces studded tire rates by approximately 30 to 50 percent (See Figure 3).[9] All three countries recommend constructing SMA mixes at just under 3 percent voids to reduce the initial compaction due to traffic loads.

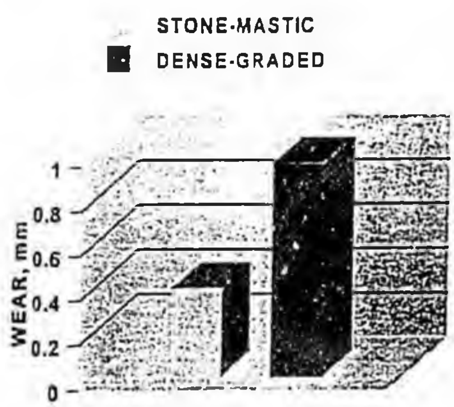

Figure 3 - Studded Tire Wear on Stone-mastic Asphalt Mix Versus Dense Graded Mix. Reference 9.

If the traffic volumes are 5000 ADT or greater, SMA is placed as a surface course to resist studded tire wear. SMA is not a structural material and does not resist fatigue that occurs at the bottom of the asphalt layer. The lift thickness and the maximum aggregate size are varied based on traffic speed as shown in Table 1. Wear rates due to studded tires increase with increasing speed.[2]

Table 1
Versus Traffic Speed

Lift Thickness (mm)	Maximum Agg. Size (mm)	Speed (km/hr)
15	8	50
20	12	70
25	16	90
35	16	Freeway

Asphalt Binder

Wear

In the large multi year ASTO research project, Finnish researcher Asko Saarela found that the asphalt binder only contributed 15 percent to the affect on wear. Additives only showed a 5 percent affect on wear. In contrast the aggregate type contributed 60 percent to the affect on wear and the gradation contributed 20 percent (See Figure 4).[10]

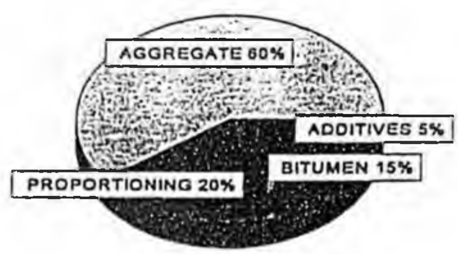

Figure 4 - The Most Important Factors Affecting Studded Tire Wear In Asphalt. Mixes. Reference 10.

Deformation

Finland: Asphalt binder contributed 30 percent to pavement deformation, with additives accounting to 40 percent of the effect. The gradation of the aggregate amounted for 40 percent of the effect on deformation (See Figure 5).[10] The softening point was found by

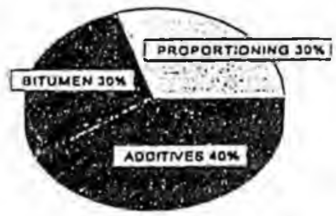

Figure 5 - The Most Important Factors Affecting Deformation. Reference 10.

the Finnish to be a major characteristic of the binder that affected deformation. For their climatic conditions, the softening point should be more than 50 degrees C. Deformation was found to occur in the first and second year after construction. Except for thermal cracking, the Finnish researchers did not consider asphalt modifiers cost effective.

Sweden: In their large field and laboratory study, Torbjörn Jacobson found that in Stone Mastic Asphalt polymer additives did not change the wear rates. He stated in his report that, "Concerning stone-mastic, wear is not influenced by binder type."[9] Wear was 20 to 40 percent less for conventional hot-mix asphalt test sections containing polymer modified binder versus test sections with conventional binder. The Swedish research did not separate out initial deformation from wear.

Norway: Norwegian engineers stated that they do not vary the binder for studded tire wear. For deformation, they like to use binder that is as hard as possible, provided thermal cracking is not a problem. For Stone Mastic Asphalt they thought SBS polymer modified asphalt may be able to replace the need for cellulose fibers.[2]

Field Review of Projects

Fourteen projects were visited in Norway, Finland and Sweden. Most of these projects were constructed with a Stone Mastic Asphalt (SMA) surface layer. The layer thicknesses varied from 15 mm (0.60 inches) to 50 mm (2.0 inches). The maximum size of the aggregate in the SMA varied from 8 mm (0.32 inches) to 16 mm (0.64). On higher volume routes (greater than about 5000 ADT per lane) 100 percent of the hardest rut resistance aggregate was used. Below this level various mixtures of the harder aggregate and weaker local aggregate were used. Below 2000 ADT per lane, SMAs with local granite have been used. On lift thicknesses less than 40 mm (1.6 inches) propane heaters were used to preheat the pavement, to prevent rapid loss of heat before compaction. All projects investigated showed little wear.[2]

Norway:

1) This project is located European Road 18 at National Road 165 to the west of Oslo. The surface had been milled and a layer of a Modified Topeka mix was placed in 1993. A Topeka mix has essentially a gap grading. The aggregate does not interlock, but sits independently in a matrix. The asphalt for a Topeka mix is usually stabilized to retain the aggregate. This mix is not usually used by Norway. After two years, this mix showed little rutting.

2) This project is also located on European Road 18 using a French mix used for microsurfacing called Novacip. This mix used a hornfelz aggregate. The original surface was milled and a 25 mm overlay was placed. For thin overlays 25 mm or less the surface is preheated with propane burners before placing the overlay. This is to prevent the effects of rapid heat loss on thin lifts on compaction. The project was constructed in 1992. In 1994 the rutting measured 10 and 11.5 mm.

3) On a bridge to the east of the city of Drammen on European Road 18, a 25 mm (1 inch) overlay had been placed in 1991. This project required a guaranty of less than 15 mm rutting in six years by the contractor. The contractor provided a mix design for 15,000 ADT. The normal guaranty in Norway is two years. The contractor chose a Stone Mastic Asphalt mix using a blend of hornfelz and local aggregates with 5 percent SBS modified binder. Only minimal rutting was noticed after four years.

4) In the city of Drammen, a project had been constructed with red asphalt with red aggregate on National Road 11. To make the asphalt all the asphaltenes were removed and replaced with Fe_2O_3.

5) Although not on our schedule, south of Drammen an active highway project was being constructed. The bound layer consisted of three layers. The first 63 mm layer was called a gravel asphalt, that appeared comparable to our stabilized base with a higher asphalt content. The next 31mm layer was conventional hot mix and the top 31 mm layer was Stone Mastic Asphalt.

6) This test site consisted of six test plates placed in the wheelpath of a road with 7500 ADT (RV 11 and RV 289 at Buskerud). Each plate contained a different mix design. Each plate was 75 cm by 50 cm by 5 cm. The plates were compacted in the laboratory then glued into sawed pavement cutouts. This procedure had been developed in Sweden. This test site was the first of two installed in Norway. The first plate contained a reference asphalt mix from Sweden. The other plates had various Stone Mastic Asphalt mixes with various aggregates. The mixes had been placed in November of 1994 and showed very little wear.

Finland:

1) The asphalt plant, owned by the Finnish Road Administration (FinnRa), is located south and west of Helsinki, near Maantiekyla. The automatic batch plant was constructed in 1996 and had processed a total of seven million metric tons. Two hundred and fifty thousand metric tons had been produced so far in 1995, of which 100,000 metric tons was Stone Mastic Asphalt. The plant uses five separate stockpiles for its aggregate. (Finnish research showed that Stone Mastic Asphalt can be made from three stockpiles, but that five allowed for greater control). The harder aggregate is hauled from 70 kilometers away. The plant was equiped with an automatic conveyor belt for the bags of cellulose fiber. The fiber came from Germany. The bitumen was not supplied by the contractor. FinnRa owns two asphalt plants. The plant batches 4 metric tons at a time with a 160 metric ton silo. All dust is recycled back through the plant. The plant had separate silos for fly-ash.

2) The team sited a low volume paving project 40 kilometers southwest of Helsinki. All of the paving crew and equipment except for the trucks belonged to FinnRa. A 3 cm (1.2 inch) fine conventional hotmix (AB 12) was placed over an existing surface with an emulsion tack coat. Density was monitored with nuclear gauges. Cores were taken for acceptance. The paver was equiped with circular brushes on the side at the back to adjust the height of the asphalt mat at the joint. The brushes provided a better joint than hand raking. Both the sides of the truck beds and the paver hopper boxes were curved (instead of square cornered) to reduce the asphalt mix segregation.

Sweden:

1) This project was located on Vistvagen (Vist Street), a two lane street with 6000 ADT, in Linkoping. A 15 mm (0.60 inches) layer of SMA8 (maximum aggregate size 8 mm [0.3 inches]) containing 50 percent porphyry and 50 percent granite had been placed. After four years little rutting was noticed.

2) This project was located on Landerydsvagen (Landeryds Street), a two lane street

with 4000 ADT, in Linkoping. A 40 mm (1.60 inches) layer of SMA16 (maximum aggregate size 16 mm [0.64 inches]) containing 100 percent granite had been placed. After four years little rutting was noticed.

3) On Norrkopingsvagen (Norrkopings Street), in Linkoping, a 35 mm (1.40 inches) layer of SMA12 (maximum aggregate size 12 mm [0.5 inches]) containing 80 percent quartzite and 20 percent granite had been placed. Norrkopingsvagen is a four lane street with 12000 ADT. After four years little rutting was noticed.

4) This project was located on Rv(Route) 215, a two lane highway with 3000 ADT, outside of Linkoping. A 15 mm (0.60 inches) layer of SMA8 (maximum aggregate size 8 mm [0.3 inches]) containing 100 percent granite had been placed. After one year little rutting was noticed.

5) On Rv(Route) 215 outside of Linkoping, a 20 mm (0.80 inches) layer of SMA12 (maximum aggregate size 12 mm [0.5 inches]) containing 100 percent granite had been placed. RV 215 is a two lane highway with 4000 ADT at this site. After one year little rutting was noticed.

6) This project was located on Rv(Route) 22, a two lane highway with 12,000 ADT, outside Linkoping. A bituminous base and 25 mm (1.0 inch) layer of SMA16 (maximum aggregate size 16 mm [0.64 inches]) containing 100 percent porphyry had been placed. The project was recently constructed and no rutting was noticed.

CONCLUSIONS

All three countries performed economic analyses combining all the research done in the various subject areas concerning studded tires and pavement wear. These analyses estimated the costs of increased accidents if studs were banned. Their research showed that the number of fatalities did not increase, but that the non-fatal accidents increased 30 percent.[11] All three countries have concluded that for safety and the environment the use of studded tires is cost effective taking into account all costs.[2] They are currently researching the amount and health risk of airborne particulate that is generated from the wear of pavements.

SUMMARY

Norway, Finland and Sweden have mitigated the studded tire wear problem by reducing the wear rates so that the magnitude of the problem is the same or less than other modes of distress. They have done this by three actions:

(1) Mandating by legislation the use of lightweight studs, which provide the same stopping distance as heavier studs, but reduce the wear rates in direct proportion to the weight.

(2) Using Stone Mastic Asphalt for a wearing course. The maximum aggregate size can be varied with the traffic speed. Lower speeds can use smaller aggregate.

(3) Using more stud wear resistant aggregates as determined by the Ball Mill, Point Load and SRK tests. These aggregates make up only 2 to 4 percent of the available aggregate in Norway, Finland and Sweden.

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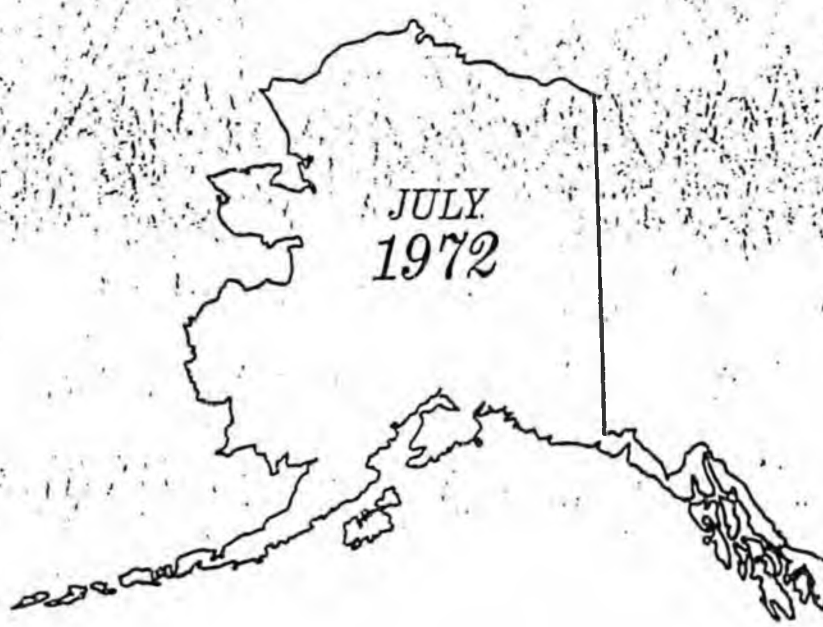
REPORT ON

ALASKA STUDDED TIRE STUDY



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DEPARTMENT OF HIGHWAYS

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INTRODUCTION

During the past year the Alaska Department of Highways has conducted an extensive investigation including field research and a literature survey on the subject of studded tires.

Main purpose of the work was to establish reliable conclusions concerning advantages and possible disadvantages of studded tires by evaluating their performance characteristics in a wide range of driving, weather and road surface conditions.

Also sought was accurate information concerning road surface wear caused by the studs.

At the time of this writing studded snow tires have been banned by legislation in Hawaii, Louisinana, Minnesota, Mississippi, Utah, and the Province of Ontario in Canada. The matter is under consideration in a number of other states. During the past year field observations of highway pavements in Alaska have shown a marked deterioration in many localities. Both the type and timing of the deterioration indicate that the major contributing factor is recent increased use of studded snow tires in the State.

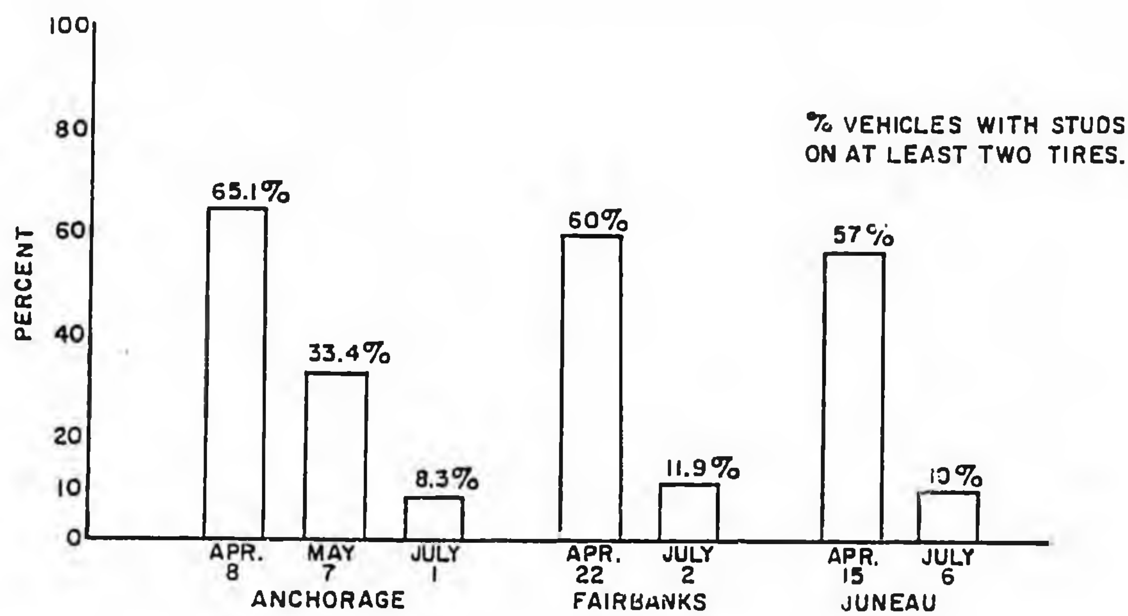
A comprehensive film on an extensive research project conducted in Ontario which led to the banning of studs in that province was released in early 1971 and provided a very graphic and dramatic portrayal of relationships between studded snow tires, vehicles, and roadway surfaces. This film and its accompanying report documented pavement wear caused by studs. Because of the conculusions of the Canadian research, the concern expressed by other states, and initial physical observation of Alaska's highway pavement, an extensive literature search was undertaken which led to the conclusion that uncontrolled use of studded snow tires causes a great amount of economic loss through pavement wear without providing offsetting economic or safety benefits. Based on these findings the Commissioner of Highways on April 9, 1971, issued an order banning the use of studded tires from May 1 to September 15.

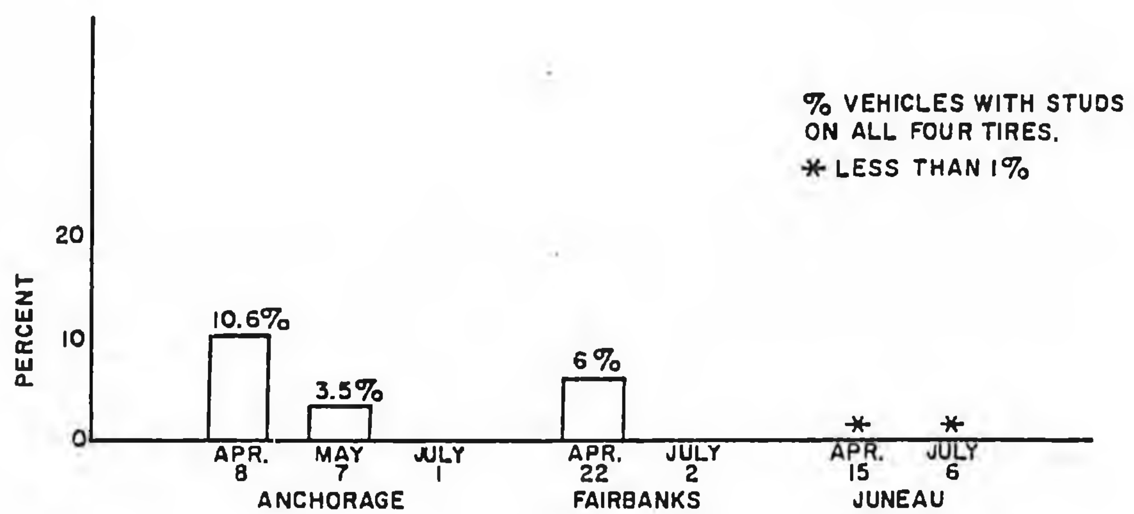
Subsequently, a more exhaustive search of published literature was undertaken and more detailed field observations and measurements were made to further document the earlier conclusions. This report summarizes the data collected, analysis, evaluation and findings of other states' research, and field data gathered directly in the State of Alaska.

PRESENT SITUATION

Tire studs are tungsten carbide tips anchored in snow tire treads which protrude from the surface. This material is one of the hardest substances known to man. They were first developed and used in Finland in 1959. The primary purpose for their development was to increase the traction of ordinary snow tires. By 1961 they were in wide use throughout Europe and were introduced to the United States and Canada in the winter of 1963-1964. Since that time, their use has steadily increased in North America. Ontario reported that 32 percent of vehicles within that Province used

ALASKA STUDDED TIRE USAGE 1971





This figure illustrates that approximately 60-65% of all vehicles utilize at least two studded tires during the winter months. Approximately 10% continued the use of studded tires through the summer, even though they were prohibited.

Exhibit 1

SUMMARY OF LEGAL TIME RESTRICTIONS ON STUDDED TIRES

State	Legal Restriction	Period of Restriction
Alabama	No	
Alaska	Yes	May 1-Sept. 15
Arizona	Yes	May 1-Oct. 1
Arkansas	Yes	Mar. 15-Nov. 15
California	Yes	May 1-Oct. 1
Colorado	No	
Connecticut	Yes	Apr. 30-Oct. 15
Deleware	Yes	Apr. 15-Oct. 15
Washington, D. C.	No	
Florida	No	
Georgia	No	
Hawaii	Yes	Ban-All Year
Idaho	Yes	Apr. 15-Oct. 1
Illinois	Yes	May 1-Oct. 1
Indiana	Yes	May 1-Oct. 1
Iowa	Yes	Apr. 15-Nov. 1
Kansas	Yes	Apr. 16-Oct. 31
Kentucky	No	
Louisiana	Yes	Ban-All Year
Maine	No	
Maryland	Yes	Apr. 15-Oct. 15
Massachusetts	Yes	May 1-Nov. 1
Michigan	Yes	May 1-Nov. 1
Minnesota	Yes	Ban-All Year
Mississippi	Yes	Ban-All Year
Missouri	No	
Montana	Yes	May 31-Oct. 1
Nebraska	Yes	Apr. 15-Oct. 1
Nevada	No	
New Hampshire	No	
New Jersey	Yes	Apr. 1-Nov. 15
New Mexico	No	
New York	Yes	May 1-Oct. 15
North Carolina	No	
North Dakota	Yes	Apr. 15-Oct. 15
Ohio	No	
Oklahoma	Yes	Apr. 1-Nov. 1
Oregon	Yes	May 1-Oct. 31
Pennsylvania	No	
Rhode Island	Yes	Apr. 1-Oct. 31
South Carolina	No	
South Dakota	No	
Tennessee	No	
Texas	No	
Utah	Yes	Ban-All Year
Vermont	No	
Virginia	Yes	Apr. 1-Nov. 1
Washington	Yes	Mar. 31-Nov. 1
West Virginia	Yes	Apr. 16-Nov. 1
Wisconsin	Yes	Mar. 15-Nov. 10
Wyoming	No	

studded tires in the winter of 1969 and 1970 and a sampling in Minnesota indicated 40 percent usage in that state at the same time. In Europe common paractice is to use studs on all four tires while in the United States the rear wheels only are usually so equipped.

Surveys conducted in Alaska during late spring and mid-summer of 1971 indicated that between 57 percent and 65 percent of vehicles within the State were equipped with studded tires during the winter months. Approximately 10 percent of all vehicles continued their use during the summer of 1971 even though their use had been banned. No records exist showing the use of studded tires during the summer months prior to the ban. It was undoubtedly considerably higher. Exhibit 1 portrays the results of these surveys.

In order to determine the status of control exercised over the use of studded tires the Alaska Department of Highways initiated questionnaires to all states in June of 1972. Results of this survey, indicated that 31 states incorporate some form of restriction on the use of studs. A summary is shown in Exhibit 2.

RESEARCH PERFORMED TO DATE

ONTARIO. The most extensive studded tire performance tests to date are those done by Damas and Smith Consulting Engineers for the Canadian Safety Council. These tests were conducted during the winters of 1969-70 and 1970-71.

The purpose of the 1969-70 test was to compare the stopping effectiveness of automobiles equipped with (1) four highway tread tires, (2) highway tread front tires and snow tread rear tires, (3) highway tread front tires and studded snow tread rear tires and, (4) four studded snow tread tires. The automobiles, driven by members of the Ontario Provincial Police, were tested on wet and dry asphalt pavement, wet and dry concrete pavement and glare ice. Stops were made from speeds of 20, 35, and 50 m.p.h. The air temperature varied from -5 to +30 degrees F. over the test period.

During the second winter Damas and Smith extended the data from the previous year's tests. The tests included the use of other traction aids such as natural rubber tires, controlled protrusion studs, reinforced steel tire chains, and elastomeric tire chains. The automobiles were again driven by the Provincial Police. In addition to the types of stopping surfaces used in the previous years's tests, sanded ice and packed snow were used. Starting traction and maneuvering tests were also carried out to increase the scope of performance knowledge.

MINNESOTA. In 1971 the Minnesota Department of Highways released the results of a two-year study of the effects of studded tires on pavements. Studded and non-studded tires were mounted on a circular track test machine. The machine was operated continuously so the accelerated wear could be observed. The tires were run on concrete pavement and asphalt pavement both with and without salt and sand. Following the laboratory testing, field investigations were carried out to compare and correlate results. The field investigations consisted of actual measurement of wear rates on Minnesota's highway system.

OTHER. Other research efforts have been carried out regarding studded tires. The New York Department of Public Works and the Ontario Provincial Police have both conducted limited stopping tests on packed snow. In addition, the Department of Roads in Quebec and the Ontario Department of Highways have conducted separate tests concerning the effects of studded tires on accident rates. The statistics and analyses however, were limited in both cases. A more extensive investigation was that made by the Cornell Aeronautical Laboratories for the Minnesota Department of Highways. The study included the examination of 4,500 winter accidents and resulted in several significant observations.

EFFECT OF STUDS ON VEHICLE

STOPPING DISTANCES. The Damas and Smith tests used locked brakes with the combinations of studded and regular snow tires, variations in weather and surface conditions and speed ranges described above.

Exhibit 3 presents data obtained by the Canadian Safety Council in its 1971 tests illustrating the effects on stopping distances of various tire combinations on clear ice at 0 and 30 degrees F. From these tests the following conclusions were made:

1. Snow tires gave no consistent improvement over highway treaded tires on glare ice.

2. On glare ice, studded tires on the rear wheels gave a significant reduction in stopping distance at 30 degrees F.

3. On glare ice at 30 degrees F., four studded tires provided more than double the braking provided by only two studded tires.

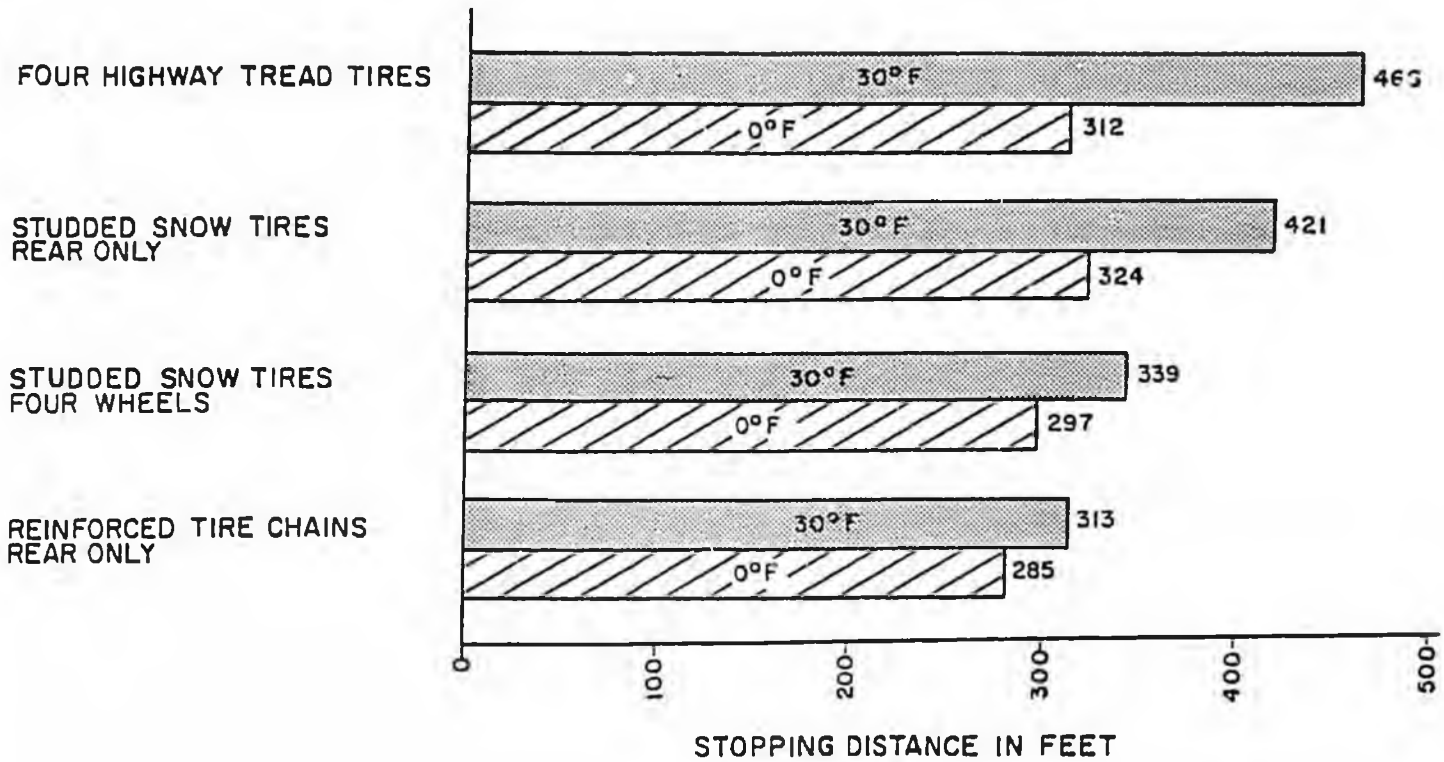
4. There is a definite relationship between temperature and stopping distances on glare ice. The greatest improvement in stopping distances with studded snow tires existed at near-freezing temperatures. At lower speeds, essentially all advantage was lost at 0 degrees F. At high speeds, the improvement was still significant at -5 degrees F.

5. On either wet or dry asphalt pavement the type of tire and the presence or absence of studs made little difference in stopping distance.

6. Small increases in stopping distances were found on either wet or dry concrete pavement when using studded tires. Stopping distances were somewhat greater with four studded tires than with two under these conditions.

Exhibits 4 and 4A illustrate that, with only slight reductions in speed, equivalent stopping distances may be obtained with various tire combinations on ice. For example, at 40 m.p.h. with highway tires or at 44 m.p.h. with studded tires on the rear only the required stopping distance is the same as with four studded tires at 50 m.p.h. It is also shown that, to insure the same stopping distance as with highway tires at 50 m.p.h. on bare pavement, speed must be reduced to approximately 23 m.p.h. with four studded

MEAN STOPPING DISTANCE
ON GLARE ICE
35 MPH



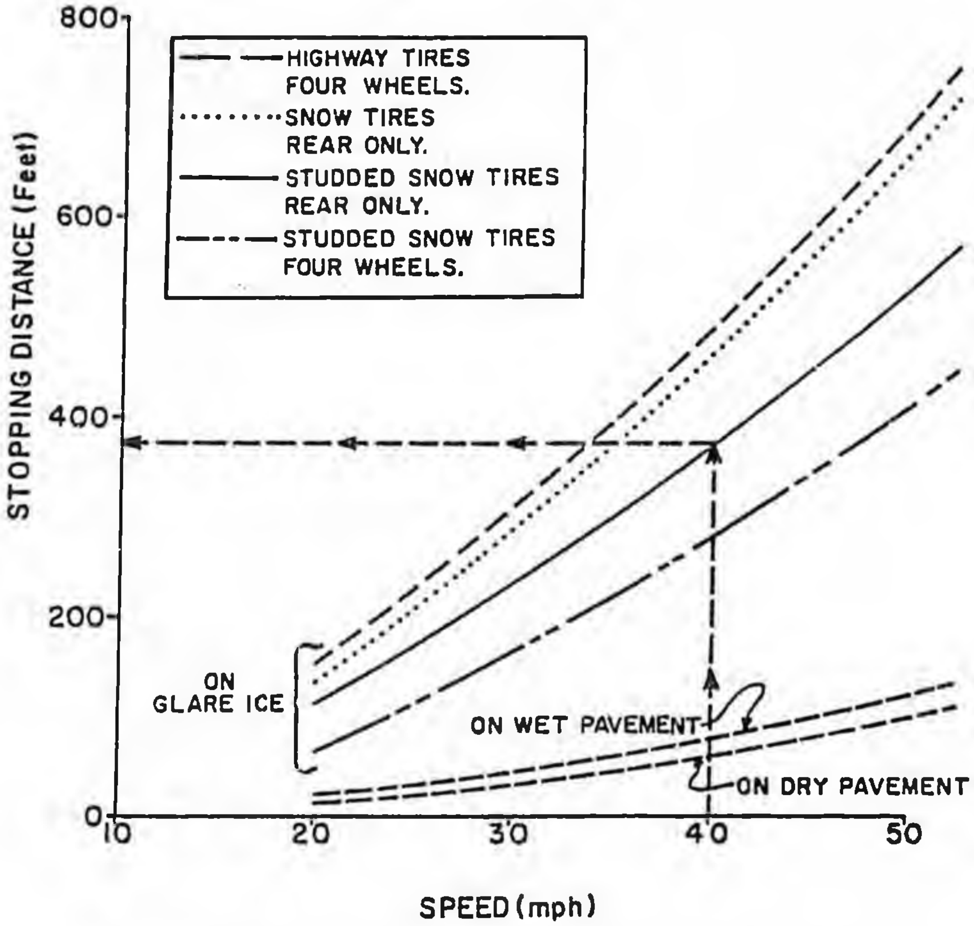
NOTE: DATA FROM CANADIAN SAFETY COUNCIL.

The type of tires used has a significant effect on stopping distances on glare ice at near-freezing temperatures. At colder temperatures the advantage of one tire type over another essentially disappears. This figure illustrates that while a vehicle with two studded tires stops in approximately 10% less distance than one with all highway tires at 30°F, it actually requires about 4% greater distance to stop with 2 studded tires than with 4 highway tires at 0°F.

Exhibit 3

STOPPING DISTANCE
VERSUS SPEED

GLARE ICE @30°F
AND BARE PAVEMENT



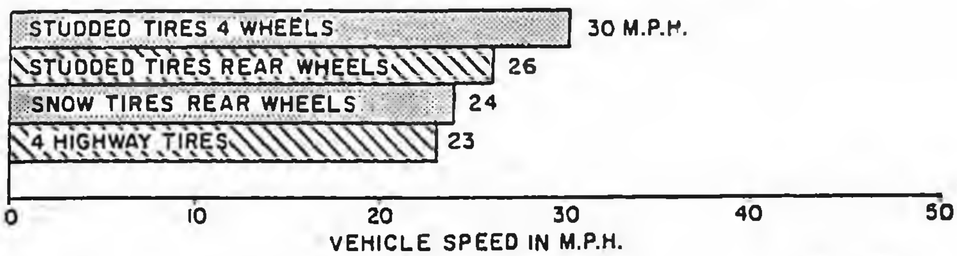
NOTE: DATA FROM CANADIAN SAFETY COUNCIL.

Stopping distance vs vehicle speed for various tire combinations on glare ice and on wet and dry asphalt pavement. Example illustrates that vehicle with studded snow tires on rear wheels requires 340 feet to stop from 40 mph on glare ice at 30°F.

Exhibit 4

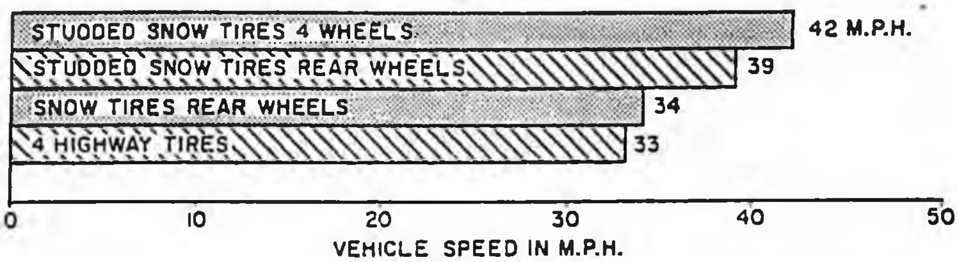
VEHICLE SPEEDS TO PERMIT EQUAL STOPPING DISTANCES WITH VARIOUS TIRE COMBINATIONS

GLARE ICE AT 30°F
STOP IN 200'



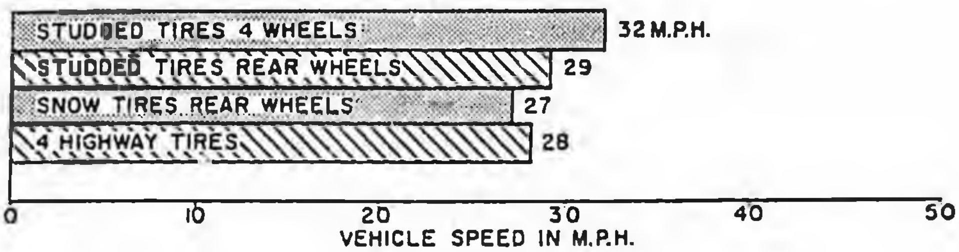
Maximum speed at which vehicle with various tire combinations can be driven to assure stopping in 200 feet. Note a 2 M.P.H. difference exists between studded tires and snow tires on rear wheels only. (26 M.P.H. vs 24 M.P.H.)

GLARE ICE AT 30°F
STOP IN 400'

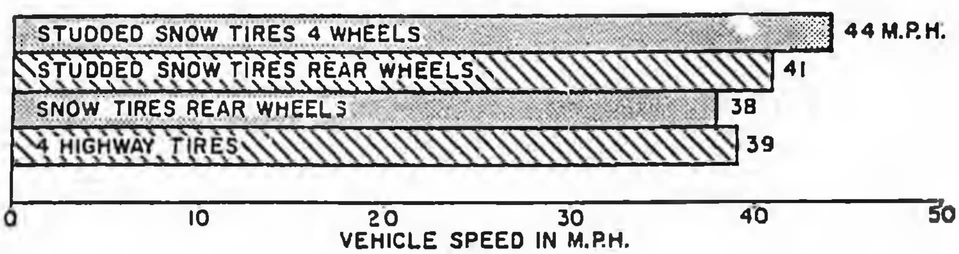


Mamimum speed at which vehicle with various tire combinations can be driven to assure stopping in 400 feet.

GLARE ICE AT 0°F
STOP IN 200'



GLARE ICE AT 0°F



Note that difference in speeds for equal stopping distances between studded tires on rear wheels and conventional highway tires virtually disappears at 0°F.

The above graphs illustrate that only a very small miles per hour increase in speed when using studded tires eliminates the advantage in stopping distance.

Exhibit 4A

tires, 19 m.p.h. with two studded tires, and 14 m.p.h. with highway tires when driving on glare ice at 30 degrees F.

Results of the Canadian Safety Council tests on sanded ice are presented in Exhibit 5. Tests were performed under the same conditions as the glare ice tests and with the same equipment, but with an application of clean sand to the ice surface. It is seen that sanding is far more effective in reducing stopping distances than any tire combination tested. At 30 degrees F. regular highway tread tires on sanded ice are approximately 50% more effective than chains or studded tires on glare ice. Tests showed that the advantage of using sand is largely lost at 0 degrees F.; its effectiveness at lower temperatures can be increased, however, by the addition of chemicals.

Tests on packed snow are limited and yield contradictory results. The New York Department of Public Works showed a 9% reduction in stopping distance by using studded tires, while the Ontario Provincial Police reported a 5 to 11% increase in stopping distances.

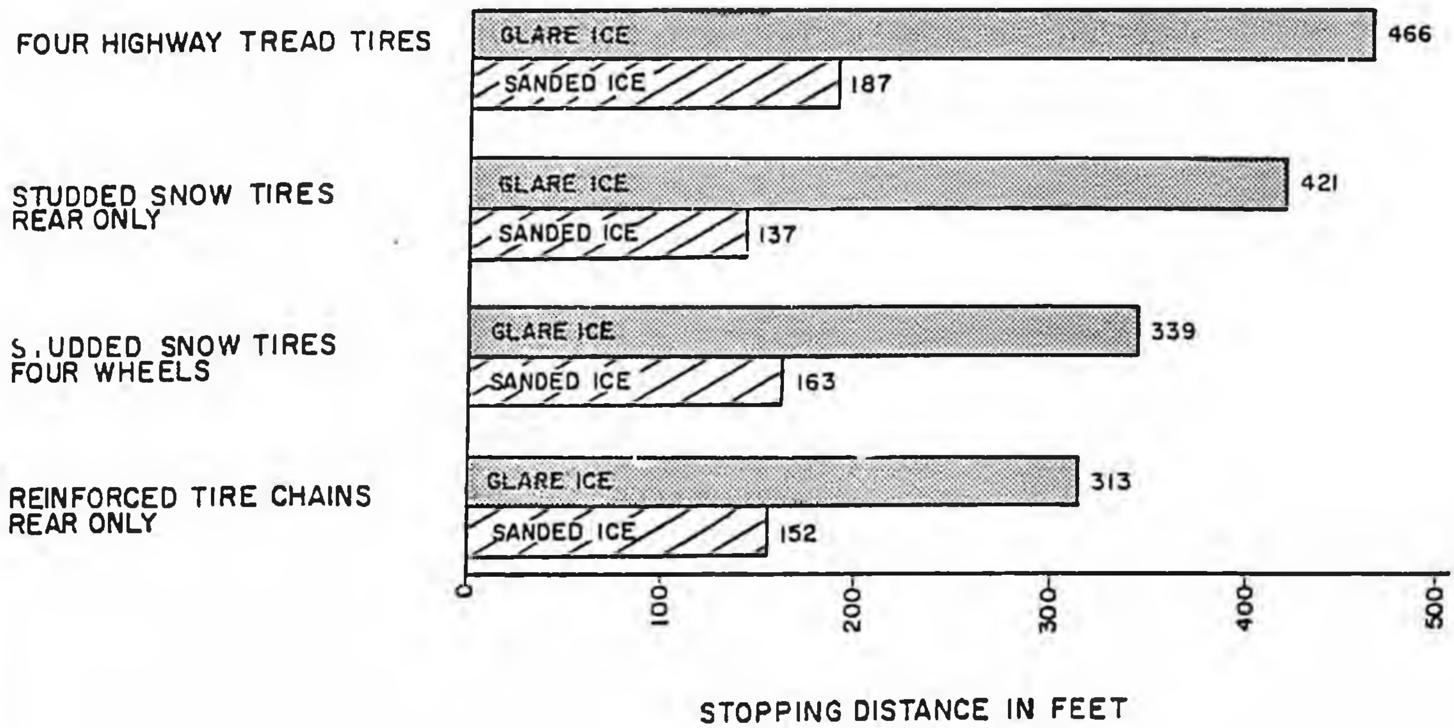
MANEUVERABILITY. Tests were also conducted in Ontario to determine maneuverability of cars equipped with studded and unstudded tires on glare ice. A short radius serpentine course was set up for this purpose. The same cars used in the stopping distance tests were run through the course at various speeds, increasing the speed each time until the car could not stay on the course. It was found that the breakaway speed of a car with unstudded tires and the one with studded tires only on the rear were the same. Maneuverability was not increased until four studded tires were used. The only difference between a car with unstudded tires and one with studded tires on the rear was the method of breakaway. The cars without studs spun around while leaving the course and the cars with two studded tires broke out by sliding tangentially when trying to negotiate the first curve. It was calculated that at 32 degrees F. a vehicle with 4 studded tires could negotiate a curve at 40 m.p.h. but with normal highway treads or with studded tires on rear wheels only it would break away and skid at 30 m.p.h.

TRACTION. Probably the greatest benefit of studded tires is the convenience of improved traction for starting, acceleration, and hill climbing (the purpose for which they were originally designed). The fact that most users have utilized studded tires primarily for this aspect is evidenced by the fact that more than 80% of the vehicles with studded tires have them on the rear wheels only; if stopping or maneuverability were the primary consideration and only two studded tires were used, better performance would be achieved by placing them on the front wheels. On glare ice, vehicle starting traction is improved up to 30%, while hill climbing ability is improved by as much as 50% by the use of studded tires. Exhibit 6 presents data obtained by the Canadian Safety Council in 1971 comparing starting traction on glare ice and packed snow for highway tires, studded snow tires, and reinforced steel tire chains. These data indicate that studded tires provide some advantage over regular highway tires and chains on clear ice. Tire chains, however, provided a 20% advantage over studded snow tires in packed snow.

THE EFFECT OF STUDDED TIRES ON ACCIDENT RATES

There have been three major reports dealing with the effect of studded tires on accident rates. The first was published by the Department of Roads of

COMPARISON OF STOPPING DISTANCE
GLARE ICE vs SANDED ICE
35MPH, 30°F

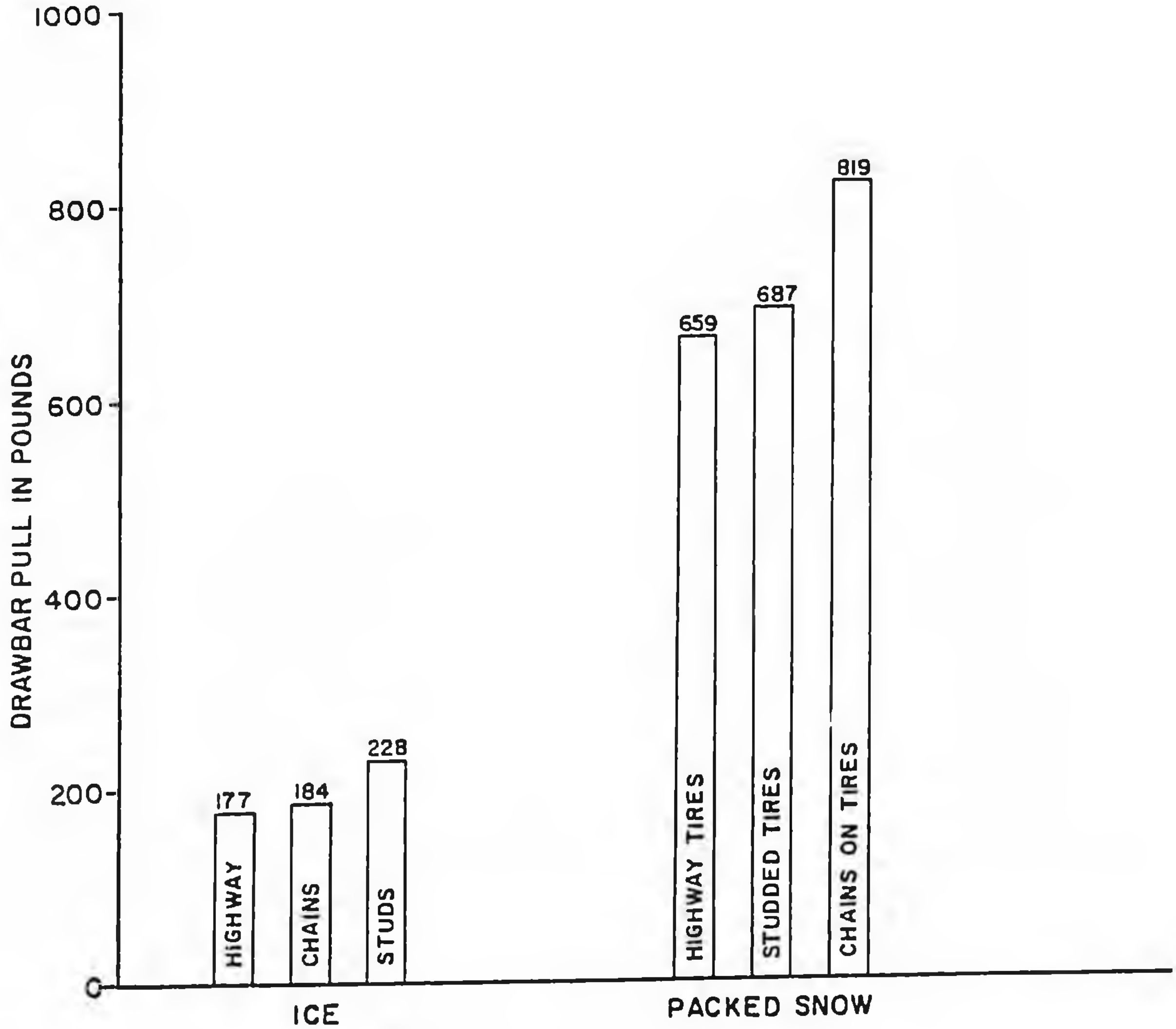


NOTE: DATA FROM CANADIAN SAFETY COUNCIL.

This graph shows conclusively that sanding is the most effective method of improving traction on glare ice. Even regular highway tires on sanded ice provide much better stopping traction than either studded tires or tire chains on unsanded glare ice.

Exhibit 5

STARTING TRACTION ON CLEAR ICE AT 30°F AND ON PACKED SNOW



NOTE: DATA FROM CANADIAN SAFETY COUNCIL.

The greatest advantages of studded tires are in starting, accelerating, and climbing hills. This figure illustrates that studded tires provide better starting traction than either highway tires or reinforced tire chains on glare ice; however, the tire chains show a distinct advantage over the studded tires on packed snow.

Exhibit 6

Quebec and entitled ''The Influence of Studded Tires on Winter Driving Safety in Quebec City''. It was concluded in this report that, ''the use of studded tires does not seem to have improved the accident record of the users''. It also says that due to the many variables and limited statistics it was ''impossible to determine from the statistics whether or not studded tires provided increased safety in driving''. A limited winter accident analysis was also conducted by the Ontario Department of Highways. The resulting report stated that the limited analysis failed to show any significant reduction in the severity or chance of an accident on icy roads by use of studded tires.

The first extensive analysis of winter accidents was that by the Cornell Aeronautical Laboratories under contract with the Minnesota Department of Highways. In this study 4,500 winter accidents were examined and a number of observations were made:

1. Of all autos in accidents, 14% were said to have been associated with slippery winter road surfaces; 21% of all accidents were precipitated by vehicles sliding on ice or snow and 30% of the single vehicle accidents were precipitated by sliding.

2. Accidents caused by sliding were, on the average, less severe than others, as measured by the degree of injury and by depth of penetration of the vehicle upon impact.

3. The probability of causing an accident due to sliding (that is, on roads with some degree of snow or ice cover) was least for studded tire vehicles, followed by snow tire vehicles, then regular tire vehicles.

4. Accident rates which showed advantages for studded tire vehicles even on roads that were primarily bare suggest that there are extraneous effects that influence the results. Adjustments were made to correct for these extraneous effects. The adjusted sliding accident rates showed a slight advantage for studded tires over snow tires, with both the studded and snow tires outperforming regular tires.

5. In accidents attributed to sliding, the most frequent preimpact behavior was loss of directional control. Of all trigger vehicles (those causing accidents) that were involved due to sliding, 69% were considered to be associated with loss of directional control, 28% were associated with prolonged stopping distance and only 3% with reduced acceleration. Stopping distance is therefore seen to be of less significance than generally supposed.

6. On dry roads, regular tires performed best with regard to preimpact rotation (spinning), and studded tires were poorer than both regular and snow tires. On wet surfaces there was little difference in preimpact rota-

tion among the three tire types. On snow-covered roads both snow tires and studded tires were better than regular tires, and on ice-covered roads the studded tires were superior with respect to preimpact rotation.

7. For vehicles that precipitated accidents because of sliding, studded tire vehicles usually performed better than regular snow tire vehicles, and snow tires were usually better than regular tires in terms of reduced impact speed and preimpact spin. For driver injury, studded tire vehicles had an apparent advantage, with little difference between snow tire vehicles and those with regular tires. These tire effects were most evident in single vehicle accidents.

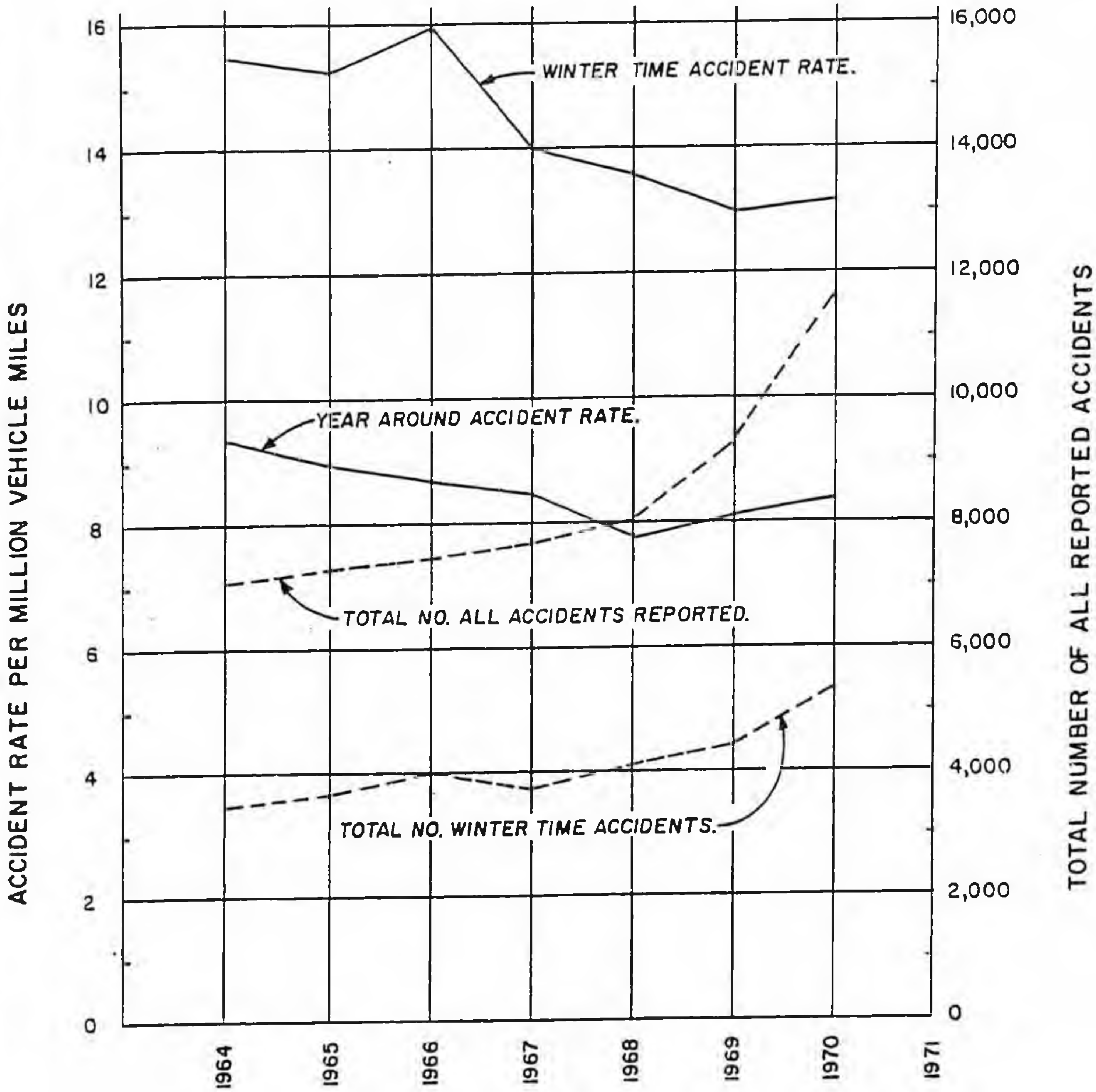
The conclusion reached by the Cornell Aeronautical Laboratory was that on icy or snowy roads, the use of studded tires provided some observable, though slight, advantages over other tires in terms of accident precipitation, vehicle behavior in emergencies, and driver injury. Results reflecting sliding accident rates, when corrected for extraneous effects, showed studded tires to have "a mild advantage over snow tires during the winter months".

The fact that winter accident rates for those drivers using studded tires have not decreased in proportion to their increased capabilities on icy roads is apparently due to increased driving speeds caused by the confidence of the studded tire user. It has been previously shown that a car with studded tires on the rear wheels only will stop from 44 m.p.h. in the same distance as one without studded tires requires from 40 m.p.h. Thus, if the driver with two studded tires increases his speed by only 4 m.p.h. over that at which he would drive with regular tires all stopping advantage of the studded tires is lost.

There has been no detailed analysis of the effects of studded tires on accident rates in Alaska. Exhibit 7 illustrates that there has been a slight decrease in winter accident rates since 1964 when studded tires first came into use; however, a similar decrease is also present in the summertime accident rate. While some of the decrease in the winter accident rate may be due to the use of studded tires it is apparent that higher design standards, the increased use of sand and deicing chemicals, and increased highway department stress on the elimination of hazardous conditions have had significant effects on the accident rate.

Prior to 1971 no detailed records were kept of the daily conditions of the highways throughout the State. During the winter of 1971-72 a program was initiated in which each of 36 maintenance stations reported the daily road surface condition. A summary tabulation of this data is presented in Table 6 in the appendix, and indicates that from October 1, 1971 through April 30, 1972 over the 1,820 miles of highway surveyed, icy conitions prevailed an average of 10% of the time, snow or packed snow 24% of the time, and bare conditions 66% of the time. Analysis of travel performed during the same period indicates the amount of travel performed over these routes under icy surface conditions was less than 8% of the total. From this information, it can be concluded that the typical motorist in Alaska can expect some advantage to be gained in stopping distances an average of not more than 8% of the time in winter months, and no advantage in summer months from the use of studded snow tires.

ACCIDENT RATE FOR ALASKA



NOTE: WINTER ACCIDENTS RUN DEC. THRU MARCH.

Exhibit 7

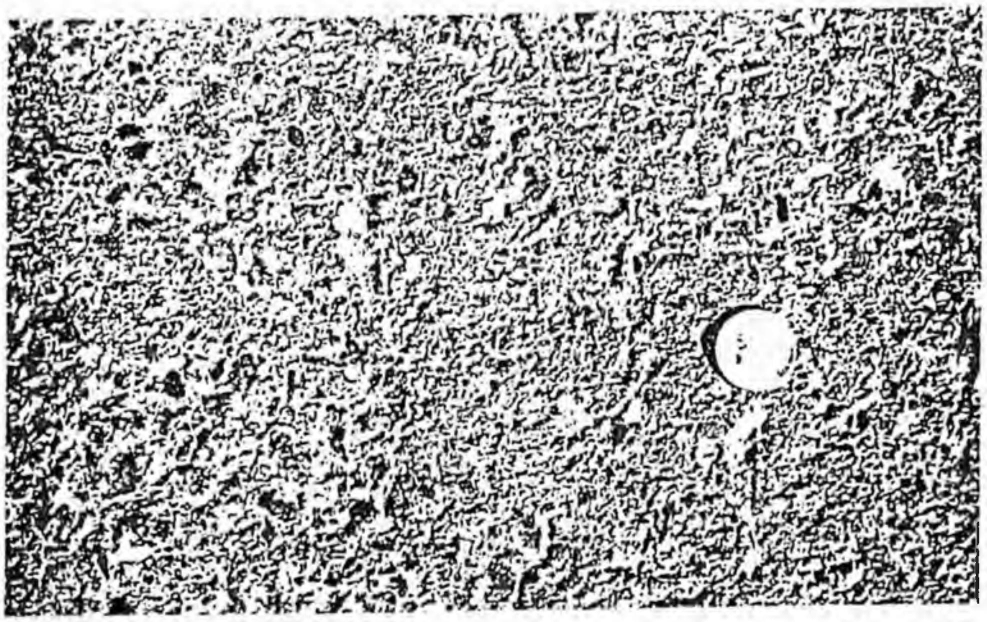
EFFECT OF STUDS ON ROADWAY SURFACES - OTHER RESEARCH FINDINGS

As indicated earlier, research on pavement wear due to studded tires has been conducted extensively, both in the field and in laboratories. The field investigations generally consisted of taking periodic cross sections at designated test locations and computing the wear. Laboratory research consisted of attempting to duplicate field conditions while controlling variables. Most traffic-simulating testing devices today consist of a circular machine that runs a series of tires continuously around a test track, thus allowing a large number of wheel passes to be run over the same point in a relatively short period of time. Several different pavements can be tested simultaneously with this arrangement. As stated before, the most recent testing of pavement wear rates due to studded tires has been published by the Minnesota Highway Department in cooperation with the American Oil Company.

The results of these tests indicate that there are basically three different asphalt pavement wear rates, depending upon the relative age of the pavement. The first rate is the rapid depletion of the asphalt and fine aggregate mixture on the surface of new pavement. The second rate is slower. Here the asphalt is worn from the spaces between the large aggregates in the pavement. (See Exhibit 8) The last rate is the actual wearing of the large aggregates. It is during this stage that pronounced deterioration of surface conditions occurs and subsequent discussion will be concerned with this rate.

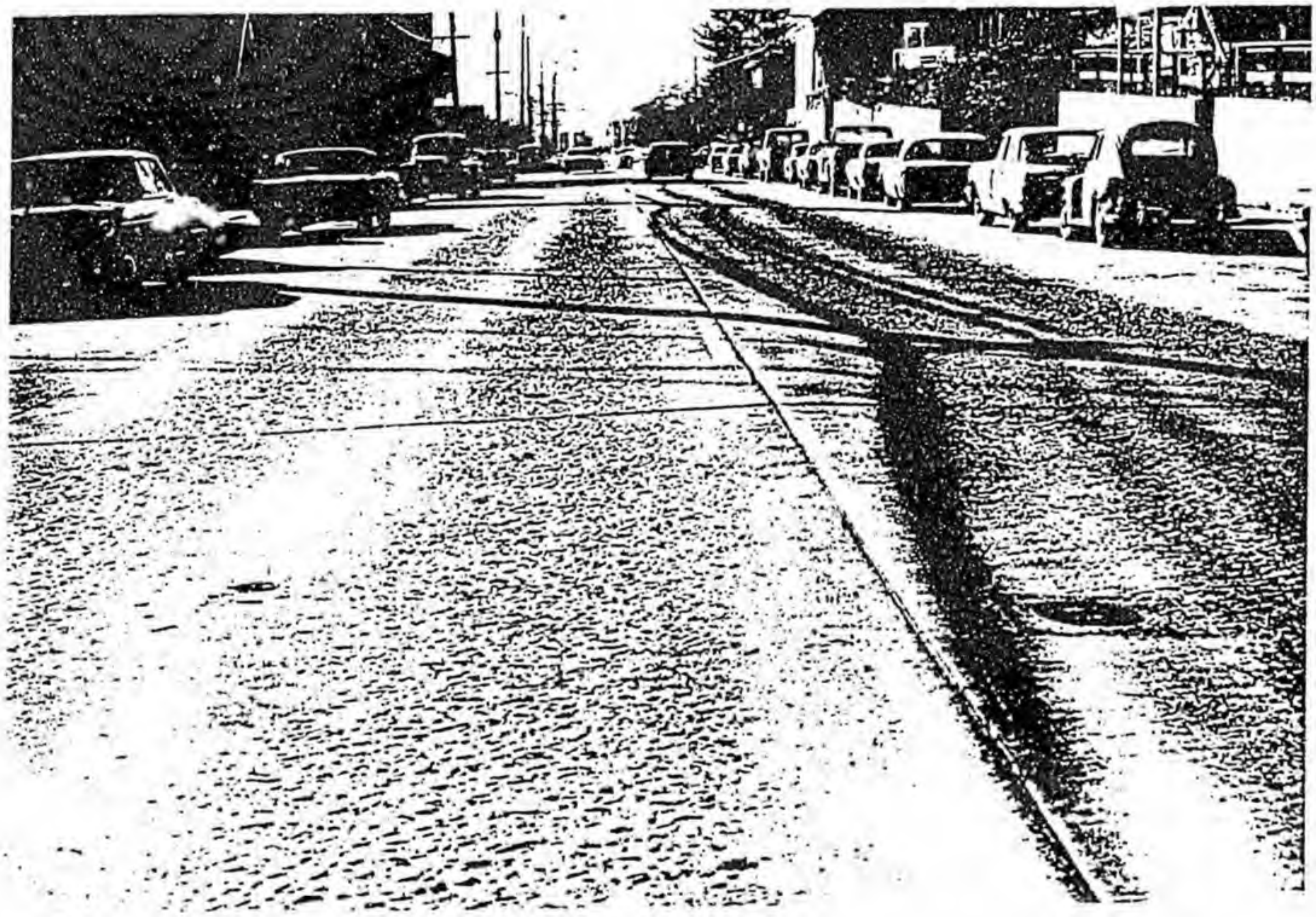
Measurements have shown an average third stage wear rate with studded tires, for conventional asphaltic surfaces, to range from 0.75 to 0.91 inch per million tire passes. For concrete pavement, the range is between 0.30 and 0.47 inch per million tire passes. (See Exhibit 9) Nonstudded tires produce a wear on asphalt pavement of 0.0027 inch per million tire passes indicating that the studded tire wear is from 100 to 300 times that caused by nonstudded tires. These tests also indicate that with studded tires salt and sand contribute significantly to total wear; with nonstudded tires alone they produce a measurable but insignificant increase in the amount of wear.

The Minnesota Department of Highways also conducted field investigations to determine pavement field conditions and to compare the lab test results (see Exhibit 10) to actual pavement wear. These investigations, and those carried out at the time that studs were first used, disclosed that ''pavement wear measurements show that pronounced wheel path wear was virtually non-existent on high-type roadways prior to the introduction of studded tires in 1965''. The department appeared before the Congressional Subcommittee on Investigations and Oversight of the Committee on Public Works on May 19, 1971, and presented a series of slides illustrating this point. First a picture of a section of concrete pavement that was five years old in 1966 was shown. In Minnesota at this time a very small number of studded tires were being used and the concrete pavement looked practically new, with the upper layer of fines and cement still intact. The next series of slides portrayed the pavement condition for each succeeding year. Between 1966 and 1967 a significant difference in the amount of wear was shown; the large aggregate in the concrete was severely exposed. All the wear in the previous five years had not equalled that experienced during 1966 and 1967. By 1971 the maximum depth of wear was 0.4'' after six seasons of exposure of studded tires.



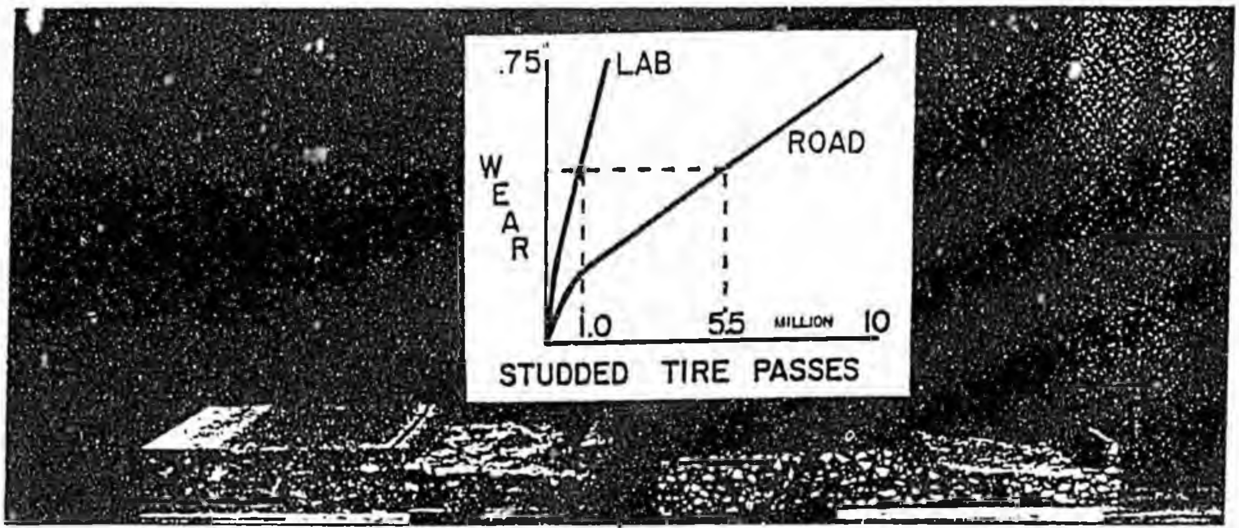
Intersection of Minnesota Drive and International Airport Road in Anchorage. (See Exhibit 14 for location.)
Top: Little used lane; note fines still visible in the surface.
Lower: Heavily used lane; note larger aggregate visible.

Exhibit 8



This photo, taken on Tongass Avenue near Madison Street in Ketchikan, illustrates the severe wear experienced on concrete pavements and bridge decks. Photo taken 8-9-71.

Exhibit 9



CONCRETE		BITUMINOUS	
SAND & SALT	BOTH PATHS	SAND & SALT	BOTH PATHS
NON STUDDED	STUDDED	NON STUDDED	STUDDED
4 MILLION PASSES	4 MILLION PASSES	4 MILLION PASSES	2.8 MILLION PASSES
.006" WEAR	1.23" WEAR	.008" WEAR	1.60" WEAR

This photograph shows samples of both asphalt and concrete pavements which were subjected to wear by studded and non-studded tires during tests for the Minnesota Department of Highways. Regular tires produced essentially no wear, while studded tires resulted in severe wear on both concrete and asphalt pavements.

Exhibit 10

When comparing rates obtained by laboratory testing to actual pavement wear, it was found that there was a 5.5 to 1 ratio between laboratory rates vs. those measured by Minnesota on its roads. The reason for this was that in the tests, the studded tires were run virtually over the same point while a driver is not confined to one certain track on the road. This same ratio also exists between the width of a wheeltrack in the in the field and the width of a tire.

Studies conducted by the Norwegian State Road Laboratory resulted in a report which stated, ''It appears that the wear due to spiked chains is about 7-10 times the wear due to ordinary studs while the wear caused by ordinary chains and truck studs are about the same''. The report went on to say that major wear was caused by studs, rather than chains, because chains were used only under special weather conditions, and are removed as soon as road conditions improve.

Pavement wear is affected by several variables, the major one being the exposure rate, or traffic volume. Because of this fact the higher volume urban and suburban roads are usually affected more than the lower volume rural roads. Minnesota reported that studded tires normally will not cause pavement on rural roads to wear out before the normal life.

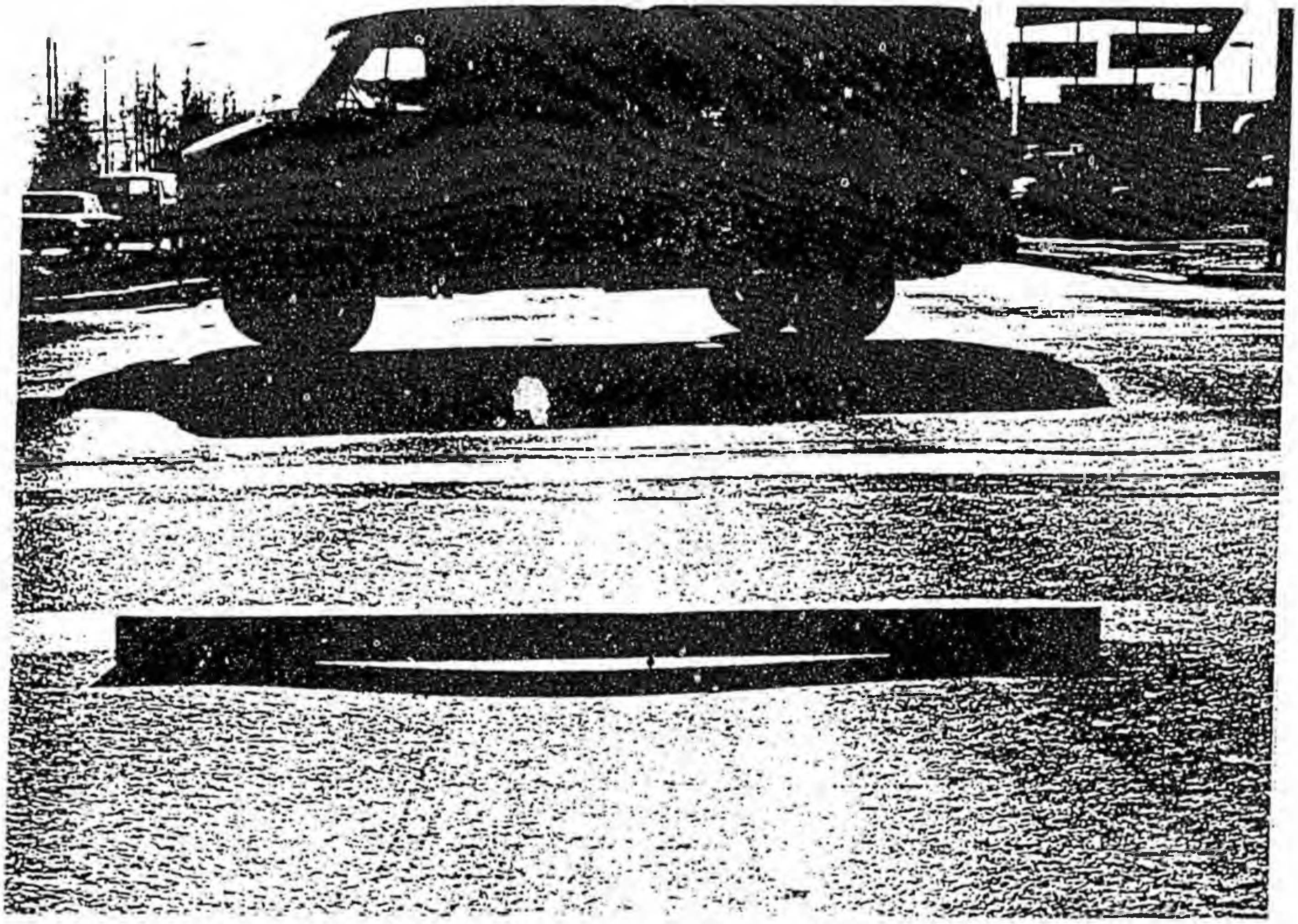
Another variable that affects pavement wear rates is the cross section geometry of the roadway. On tangents or ''straightaways'' the depth of the wheel tracks is affected by the lane width; the narrower the lane, the deeper the wheeltracks. Various figures have also been published on the effects of curves, acceleration and deceleration on pavement wear rates. In each the wear is greater than for straight ahead and level constant speed driving. In Montreal the wear ratios compared to level straightaway sections, were reported for curves 1:1.1; for acceleration 1:2.8; and deceleration 1:1.4. Here the greatest wear was in areas of acceleration. In studies made by Wehner in Germany the respective ratios were reported at curves 1:1.1; acceleration 1:1.3; and deceleration 1:2.6. The greatest wear here was found to be at points of deceleration. The difference was attributed to the fact that almost all of the cars in Europe are equipped with four studded tires, rather than two as is common in North America. In braking, all four tires produced relatively high wear; while accelerating only two tires produced higher wear.

Temperature is another important parameter. M. Huhtula of the State Institute of Technical Research in Finland stated that pavement wear was about 50 percent greater at 50 than at 37 degrees F. The National Road Research Institute of Sweden also found that pavement wear was much greater at temperatures above 32 degrees F. than below 32 degrees F. No extensive work has been done to determine pavement wear at all temperatures.

OBSERVATIONS IN ALASKA. The method used to measure pavement wear in Alaska was to place a straightedge across the wheel path and measure the maximum depth of the wheel track. For these tests a standard ten foot steel straightedge or screed was used throughout most of the survey. (See Exhibits 11 and 12) A small portion was tested with a six foot length of angle iron. A scale graduated in 50ths of an inch was used and measurements reported in hundredths of an inch. For this survey the depth was taken to the top of the exposed aggregate as this was assumed to be the riding surface.

This photograph was taken in July, 1971 at the intersection of East 5th Avenue and Bragaw Street in Anchorage and shows typical wheelpath wear caused by studded tires. Note the dime in the wheelpath under the straightedge.

Exhibit 11



This photo taken on the Seward Highway at the Fireweed Lane intersection in Anchorage shows typical wheelpath wear at a heavily traveled intersection. Note the dime in the wheelpath under the straightedge.

Exhibit 12

This study was confined to the State maintained highway system. Many city streets and off-system roads experience snow or ice conditions during most of the winter months, as compared to the frequent bare pavement conditions found on main highways. Some city streets, however, are maintained in a bare pavement condition and are subjected to wear by studded tires similar to that experienced on the State system.

In choosing Alaska test sections, several characteristics were considered. According to work done in Ontario by the Highway Department, ''results show that significant wear can occur on both bituminous and concrete paved lanes where the Average Annual Daily Traffic (AADT) is as low as 2,000 passenger cars per day, with probably no more than 20 percent of these vehicles equipped with studded tires''. Because of this, the test sections were chosen to have an AADT of greater than 2,000 wherever possible. Another consideration used in choosing test sections was the condition of the roadway foundation, accomplished by using data from the Rural Area Sufficiency Rating Report prepared by the Alaska Department of Highways, Planning and Research Division, in 1969. In selecting test locations, only sections rated as sufficient in structure and foundation were used.

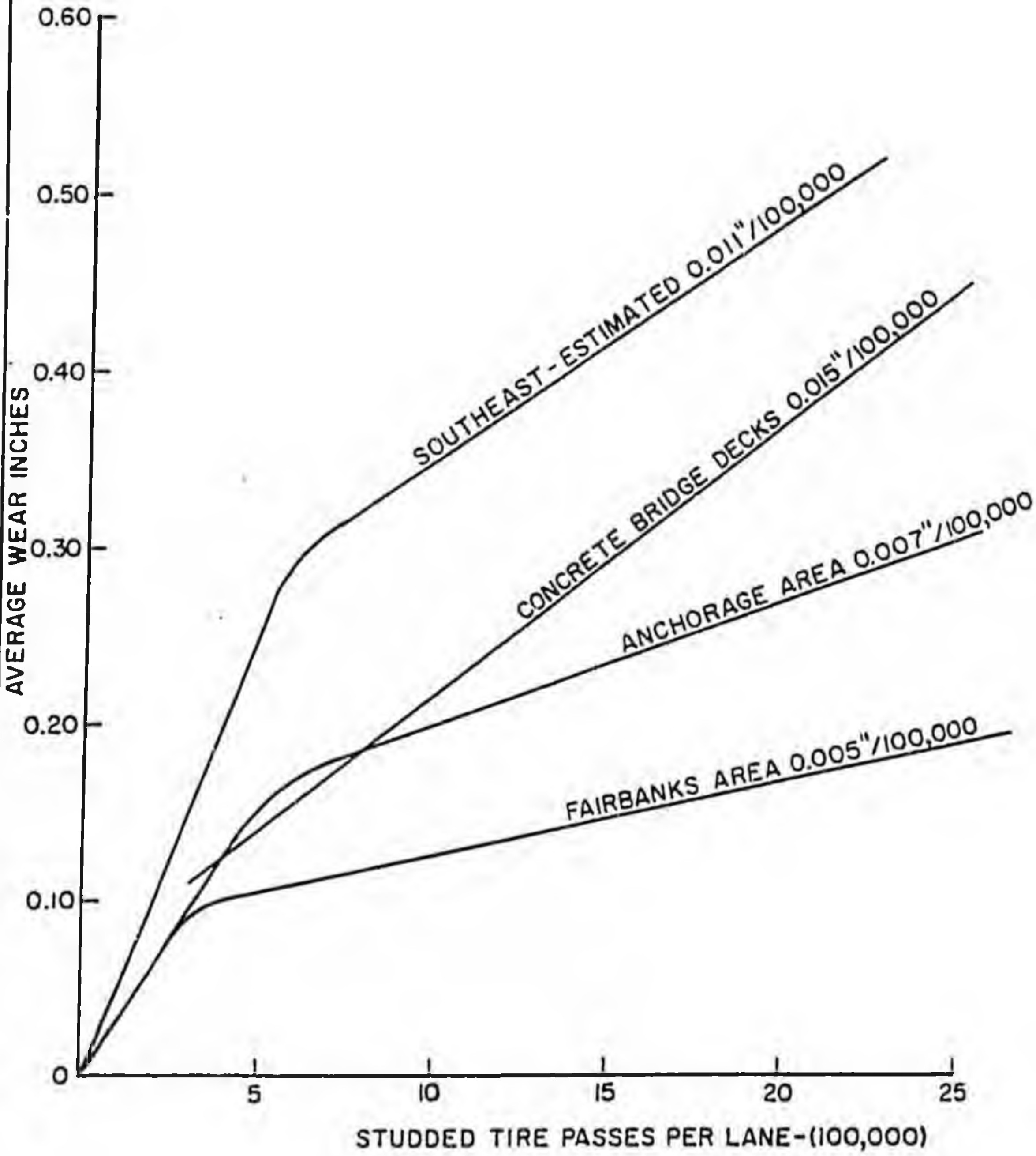
The actual recording of the data was accomplished by taking readings at segments evenly spaced along a test section. Because of the fact that the wear was greater at the intersections than on the normal ''straightaway'', care was taken to properly weigh the intersections to ensure reliable averages for each segment. To accomplish this, more readings were taken on test sections with, than without intersections. To be sure that true measurements of wear were taken, sections with frost heaves, settlements and pavement joints were omitted. A total of 36 test sections throughout the State were investigated and are itemized in Tables 2 through 5 in the Appendix. Both asphalt and concrete pavements were investigated.

After each section was measured, and the average depth computed, traffic counts and construction history were gathered. Next, the percentage of vehicles employing studded tires was estimated by sampling as many as 1,000 cars in various parking lots in Anchorage, Fairbanks and Juneau. These counts, taken from the first part of April to the first part of July, were analyzed to estimate the percentage of vehicles using studs each month.

When all data had been gathered, computations were made to determine the total number of studded tire passes, per lane, for each test section. Studded tires were first introduced in Alaska during the winter of 1963-64. A straight line growth rate for studded tire use was assumed. As shown by laboratory tests in the Minnesota report, the overall pavement wear rate is a composite of initial, intermediate and terminal wear rates. To determine an average terminal wear rate for each district, the average wear for each section was plotted as opposed to the total studded tire passes per lane as shown in Exhibit 13.

These graphs show the fast initial wearing of the top layer of fine aggregates and asphalt. Also included in this part of the graph is any settlement in wheeltracks caused by traffic. Most of the settlement in a roadway occurs during the first spring after the highway is constructed and terminal wear rate is affected very little by initial settlement. The intermediate pavement wear rate occurs somewhere in the curved portion of

PAVEMENT WEAR DUE TO STUDDED TIRES IN ALASKA



This graph illustrates the very rapid studded tire wear in all areas of Southeast Alaska and particularly on concrete bridge decks throughout the State. Wear rates are lower in Anchorage, but with the higher traffic volumes experienced, pavement wear is severe.

Exhibit 13

the graph but is difficult to determine from the data. The slope of the final straight portion of the curves is the terminal wear rate. From the graphs the terminal wear rates for the different districts are:

Asphalt Pavement
- Anchorage - 0.007''/100,000 studded tire passes
- Fairbanks - 0.005''/100,000 studded tire passes
- Southeast - 0.011''/100,000 studded tire passes (estimated)

Concrete
- All Districts- 0.015''/100,000 studded tire passes

The Anchorage data correlate very well. A definite upward trend in the wear rate can be seen. The variation in the data points at the up r end of the graph is probably caused by the varying effects of snow cover, temperature and initial settlement. The Fairbanks data does not cover as large a range as the Anchorage data does, but a definite trend can be also seen. Southeast's data is rather sketchy. The overlaid and seal coated sections do not seem to follow any pattern; but, by interpolating from the Anchorage and Fairbanks data a rate can be estimated from the sections which were not overlaid.

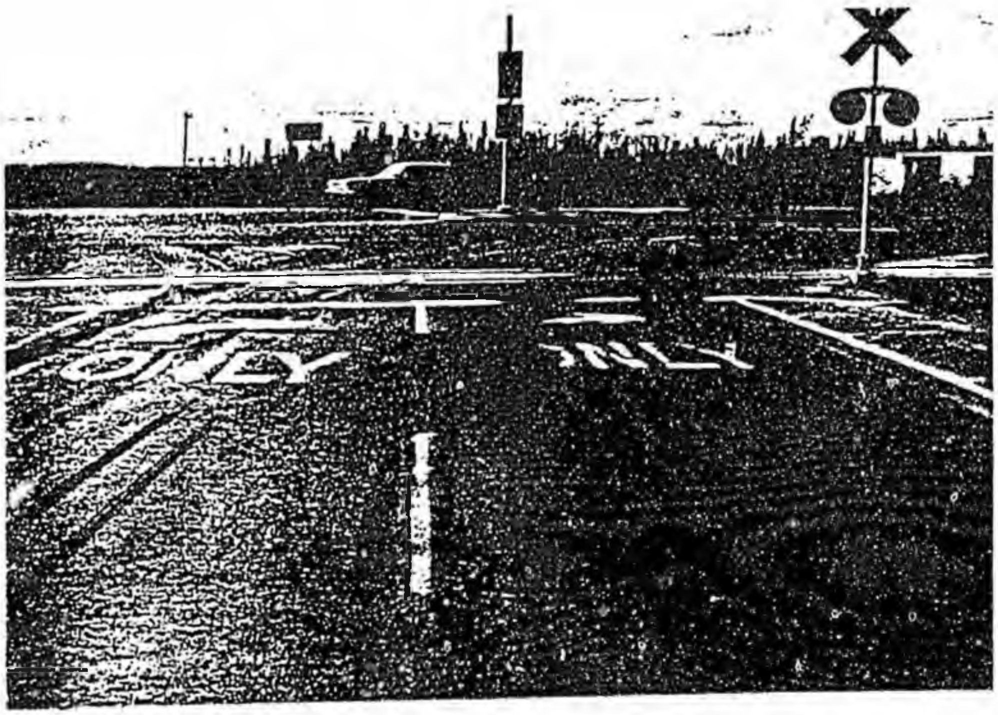
The concrete data are sparse but those given correlate extremely well.

In the course of investigations it was found that sealcoats wear at a faster rate than the original pavement. Asphalt overlays quickly assumed the configuration of the original pavement in the wheeltracks, but probably actually wear at a rate close to that of the original pavement.

A series of pavement core samples were cut to determine if there was any compaction of the pavement in the wheeltracks. Cores were cut in the wheeltracks, between the wheeltracks, and on the shoulder of the road. The density of each sample was measured and results indicated that there was no significant difference between samples at any one cross section.

A section of the Old Glenn Highway south of Eagle River, abandoned before the use of studded tires, was investigated. The original pavement was still in place, although a lower section was severely cracked. The upper section was examined to determine whether any settlement in the wheeltracks was measurable and it was found that the average depth of the wheeltracks was 0.09''. The texture of the pavement was uniform over the whole pavement and showed that there was no wear in the wheeltracks. The aggregate was exposed slightly and the fines were still in the aggregate and had not been worn away. The surface was smooth, compared to the rough, exposed aggregate surface of the studded tire worn pavement. These results show that when measuring the depth of the wheeltracks, some settlement is included. Examination of this section indicates conclusively that the wear now being experienced on the State's paved highways is the result of studded tires.

The most conspicuous element of pavement wear is that of traffic marking paint. The first paint to be worn away is the crosswalk paint which is worn first in the wheeltracks. (See Exhibit 14) This is most severe at intersections. Here stop and start action of the traffic accelerates wear. Also worn at the intersections are the directional arrows and correspond-



Intersection of Minnesota Drive and International Airport Road in Anchorage. Note the differential paint and pavement wear. Almost all traffic uses the right lane.

Exhibit 14

ing word messages. Center striping lasts longer than crosswalks because it is not in the driving path. Accelerated striping wear can be seen on the lane striping of four-lane roads with narrow lanes, apparently due to weaving maneuvers between lanes. (See Exhibit 15) Another example of such accelerated wear is edge striping on the insides of curves.

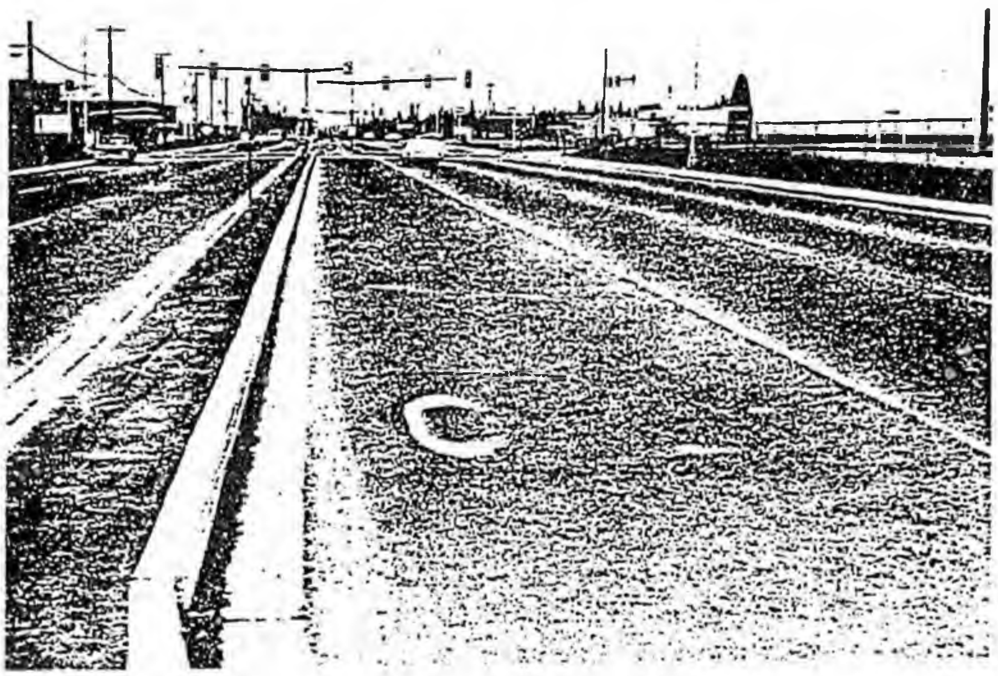
Tests have been conducted in Alaska by the Department of Highways Materials Division on paint wear. The first test was conducted by the State Materials Laboratory at College and was designed to determine paint wear rates and compare various grades of traffic marking paint. Three test sites were set up in June 1970, one each in Fairbanks, Anchorage and in Juneau and consisted of a series of transverse test stripes. Each stripe in the series was a different type of paint. The stripes were painted with a thickness of 8 mils rather than the normal 15 mils, with poorest material lasting 60 days. From these figures a crosswalk, painted with the normal 15 mils thickness, would have lasted approximately four to six months with normal summer driving conditions.

The second test was conducted by the Materials Division of the Central District. They tested a ''hot-extruded'' (hot melted) thermo-plastic traffic striping material which was advertised to last five years. The striping material is extruded hot into a groove in the pavement and solidifies in minutes and may be exposed to traffic much sooner than conventional paint stripes. These were put down during the summer of 1970 on the Spenard Thruway in Anchorage. A section was painted with a conventional paint for comparison and during April of 1971 the paint was investigated and was rated on appearance, durability, night visibility and reflectivity.

The ''thermoplastic'' traffic markings were found to be highly satisfactory on lane, center and edge markings. However, the crosswalks did not resist stop and go traffic and were completely worn through in the wheeltracks. Virtually no conventional paint markings north of the Northern Lights Intersection were retained; although south of the intersection unusually high retention was observed. The night visibility of the thermoplastic markings was somewhat higher than that of the paint but not as bright as fresh paint. One crosswalk paint stripe which was poured into a prepared groove in the pavement showed a much higher retention than other crosswalk stripes.

HAZARDOUS SECONDARY EFFECTS OF PAVEMENT WEAR. Studded tire wear causes safety hazards, such as the loss of pavement marking and adverse steering conditions caused by ruts in the wheeltracks. Obliteration of lane and directional markings can lead to driver confusion and improper vehicle location with respect to adjacent vehicles. The importance of roadway striping is indicated by the results of a recent study in New Jersey, which showed a reduction of approximately 40% in accidents when striping was applied to a previously unmarked roadway.

Studded tire-induced ruts also impede surface drainage by collecting water in the wheeltracks. This water causes spray from tires which decreases visibility and may result in ''hydroplaning'', where a vehicle's tires ride on a cushion of water with a resultant loss of steering control. To avoid this water, vehicle operators tend to drive to one side



Intersection of Minnesota Drive and 26th Avenue in Anchorage. Note "ONLY" and turn arrow worn away in top photo. This section was painted in the summer of 1970; the photo was taken 8-18-71. Crosswalk has been repainted in top photo.

Exhibit 15

or the other of a lane which increases the accident potential. In the winter these ruts result in areas of glare ice on an otherwise dry pavement thereby presenting unexpected and dangerous surface conditions to the motorist.

EFFECT ON STUDS ON TRAVEL ON BARE PAVEMENT

The statement has been made by a number of persons corresponding with the Department that they cannot afford to buy additional tires to replace their studded tires during the summer months. Data presented in the following table shows that if any significant benefit is to be obtained from the use of studded tires they must be removed during the summer months to preserve their traction characteristics.

Loss of Increased Effectiveness of Studded Snow Tires Compared to Snow Tires After 5,000 Miles

Number of Studs	Loss	
48	100%	These data are from
72	67%	20 MPH Stopping Test
144	23%	on Ice

ECONOMIC EFFECTS OF THE USE OF STUDS

Continued use of studded tires will undoubtedly cause accelerated wear on Alaska's highways. This part of the report illustrates the estimated cost of the resulting maintenance and repair, based on five assumptions:

1. The use of studded tires will continue at present rates, i.e. 57-65% in the winter and 8-12% in the summer. The use of four studded tires will not increase.

2. Asphalt pavement will require repair when wheeltrack depths reach .75 inch.

3. Bridge decks and concrete pavement will require repair when the depth of the wheeltracks reaches .50 inch.

4. The normal life of full-depth asphalt pavement will be 20 years.

5. The normal life of concrete will be 35 years without any major surface rehabilitation.

Some of the foregoing criteria are self-explanatory, but others require further explanation.

Engineers in Minnesota expect that a wheeltrack depth of .75 inch will produce adverse steering characteristics and cause water to pond or flow within the wheeltracks. A wear depth of .50 inch for bridge decks was chosen because most existing bridge decks in Alaska have 1.5 inches of cover over the steel. A .50 inch loss is considered critical in reducing protection over the steel and contributes to corrosion of the steel which leads to wear.

From the wear rates measured on Alaska's pavements and presented in a preceeding section the number of studded tire passes required to produce .75 inch of wear on asphalt pavement and .50 inch on concrete pavement is as follows:

Fairbanks	12,400,000	studded tire passes
Anchorage	8,890,000	studded tire passes
Southeast	3,710,000	studded tire passes
Concrete	2,850,000	studded tire passes

There have been no wear rates of traffic paint due to studded tires reported. For the purposes of this study the following assumptions for paint wear due to studded tires were made:

1. Paint wear due to studded tires was considered negligible in rural areas. Rural roads are considered to be those with an AADT volume of less than 5000.

2. Studded tires cause sufficient wear in urban areas that an extra painting is required each year.

3. In urban areas lane stripes on undivided four-lane highways and all crosswalk stripes will require two paintings.

Based on the above assumptions, the estimated cost to local governments and the State of Alaska for repair and replacement of facilities damaged by studded tires ranges from $5,000,000 to $15,000,000 annually.

It was previously shown that, on a statewide average, approximately 8% of highway travel is on ice-covered highways during the winter months. Thus, this is the direct cost for the convenience of using studded tires which are effective only 8% of the time during the winter months and are completely ineffective during the remainder of the year.

No cost can be assigned the inconvenience to the public due to closing or restriction of traffic at intersections and on bridges during periods when repair of worn pavement is being accomplished.

SUMMARY

1. Studded tires are used primarily for convenience and not safety. Most motorists apparently increase driving speeds enough to cancel any safety benefits that might be provided by studded tires.

2. Studded tires provide a definite advantage in traction for starting, hill climbing, and acceleration on icy roads.

3. Other than traction convenience studded tires offer no advantages over regular tires equipped with reinforced steel tire chains.

4. The unrestricted use of studded tires on bare pavement causes significant wear of pavement and pavement markings, which introduces detrimental effects on the safety of highways due to ponding of water, hydroplaning, and improper vehicle placement because of lack of lane markings.

5. The severity of pavement surface wear is directly proportional to the amount of studded tire traffic.

6. The rate of asphalt pavement wear increases significantly as temperature increases; wear at 50 degrees F. has been found to be approximately 50% greater than at 37 degrees F. Wear rate at 75 degrees F. is double that at 32 degrees F.

7. The use of studded tires on bare pavement provides no benefit to the motorists.

8. The unrestricted use of studded tires would result in extra costs to State and local governments.

CONCLUSIONS

All studies to date have shown conclusively that the use of studded tires during the summer months is of no benefit and in some circumstances is detrimental to the performance of the vehicle. It has also been shown that pavement wear due to studded tires is much greater at higher temperatures.

The use of studded tires which have been driven through the summer months may very well introduce a serious safety hazard when a driver is relying on benefits which no longer exist or are greatly diminished. Most studded tires in use in North America have approximately 5,000 miles of effective use. The effectiveness of the studs is then reduced to only half that of new studded tires.

The advantage of studded tires over steel tire chains is primarily convenience. Tests indicate that under all ice and snow conditions regular tires with reinforced steel chains are equal or superior to studded tires. However, chains must be put on the vehicle and removed each time roadway conditions require their use -- a time-consuming and unpleasant task. For this reason, chains are frequently not utilized until roads become extremely hazardous or even impassible without their use. Chains are almost always removed immediately when no longer required, because of the uncomfortable ride, the restriction on driving speed, and the rapid rate at which they wear out on bare pavement.

Even though tire chains result in equal or greater pavement wear per wheel pass pavement wear would be practically eliminated if studded tires were completely banned and motorists relied on snow tires and tire chains.

The estimated yearly cost of between $5,000,000 and $15,000,000 apparently far outweights the minor advantages of using studded tires, these advantages being largely psychological during most of the time spent in travel. The heavy yearly cost to state and local governments would if spent in sanding provide a much safer and more convenient solution to the problems associated with winter driving.

Positive control of studded tires is an indicated necessity.

RECOMMENDATIONS

Positive action to control the use of studded tires should be taken immediately to prevent the high rate of pavement wear being experienced on the State's highway system and city streets in Alaska. The Ketchikan, Juneau, and Anchorage areas in particular should receive urgent attention because of the exceptional degree of deterioration noted.

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APPENDIX

Tables 2 through 5

Pavement Wear Data

Table 6

Winter Road Condition Data

TABLE 2

ASPHALT PAVEMENT DATA

Anchorage Area

Test Location	Construction Date	No. of Studded Tire Passes/Lane	Average Wear	Composite Wear Rate Per 100,000 Passes
E. 5th (Bragow to McCrarry)	1965	1,933,157	0.28"	0.015"
E. 5th (Airport Heights to Bragow)	1965	1,978,259	0.31"	0.016"
Spenard I (15th to N. Lights)	1969	1,304,489	0.20"	0.015"
Spenard II (N. Lights to Spenard Rd.)	1970	452,430	0.13"	0.029"
Spenard II (Spenard Rd. to International)	1970	289,511	0.12"	0.041"
Gambel (15th to Fireweed)	1967	2,314,564	0.22"	0.0095"
Ingra (15th to Fireweed)	1967	2,310,702	0.24"	0.010"
Northern Lights (Seward Hwy. to "C" St.)	1970	769,067	0.18"	0.024"
Glenn Hwy. (Gate 1 N. 2 miles)	1954	2,298,356	0.34"	0.015"
Jewel Lake Rd. (International to 4 Corners)	1965	2,185,508	0.26"	0.012"
"C" Street (Diamond to International)	1969	911,428	0.20"	0.022"
O'Malley Road	1963	628,813	0.15"	0.024"
*International Airport Road (Seward Hwy. to "C" Street)	1970	488,619	0.22"	0.045"
*Lake Otis (Dowling to 88th)	1970	391,615	0.14"	0.036"

*Asphalt Overlays

TABLE 3

ASPHALT PAVEMENT DATA

Fairbanks Area

Test Location	Construction Date	No. of Studded Tire Passes/Lane	Average Wear	Composite Wear Rate per 100,000 passes
Airport (Cowles to Lathrop St.)	1968	1,002,268	0.11"	0.011"
Airport Way (Lathrop to Wilbur St.)	1968	826,644	0.13"	0.016"
irport Way (Wilbur to Peger Rd.)	1968	838,984	0.12"	0.014"
Airport Way (Peger Rd. to University Ave.)	1968	765,482	0.12"	0.016"
University Ave. (Airport Way to Geist Rd.)	1965	775,202	0.17"	0.022"
University Ave. (Geist Rd. to College Rd.)	1965	742,810	0.10"	0.013"
College Rd. (University Ave. to Jade Shop)	1969	423,785	0.10"	0.024"
College Rd. (Jade Shop to Aurora)	1969	392,473	0.12	0.031"
College Rd. (Illinois to Steese Hwy.)	1969	351,744	0.09"	0.026"
Richardson (4 Lane I) (Old Richardson Intersection to Wainwright Gate)	1966	939,371	0.21"	0.022"

TABLE 4

ASPHALT PAVEMENT DATA

Southeastern District

Test Location	Construction Date	No. of Studded Tire Passes/Lane	Average Wear	Composite Wear Rate per 100,000 passes
Juneau				
Outer Drive (Glacier Ave. to 12th Ave.)	1969	390,122	0.20"	0.051"
[1]Glacier Highway (M.P. 2)	1967	909,492	0.51"	0.056"
[2]Glacier Highway (Sunny Point Non Overlaid)	1968	823,486	0.35"	0.042"
Glacier Highway (Sunny Point Overlaid)	1968	823,486	0.44"	0.053"
Glacier Highway (N. of Brotherhood Bridge)	1965	659,682	0.33"	0.050"
[3]South Douglas Highway (Lawson Creek South)	1967	552,152	0.40"	0.072"
[4]Mendenhall Loop (South End)	1963	691,283	0.41"	0.059"
Ketchikan				
North Tongass Highway (Above Pulp Mill)	1954	360,839	0.19"	0.052"
[5]South Tongass Highway (Off End of Concrete)	1970	187,944	0.24"	0.128"

[1]Seal coated 8/25/70
[2]One lane overlaid with a mixture of fines and asphalt
[3]Asphalt overlay 9/27/67 and seal coat 6/27/68
[4]Seal coated July 1968
[5]Asphalt overlay