HB

301

SFIN FILE

SENATE FINANCE COMMITTEE REPORT

DATE: 5/5/94 FURTHER:

DATE TURNED INTO OFFICE: 5-7-94

The Finance Committee considered CS SSHB 301(L&C)

"An Act prohibiting the sale of certain studded tires or the sale of certain studs to be installed in tires; and providing for an effective date."

and recommends:

[ ] replace with ______ CS ________________ ________(FINANCE)

or [ ] adopt previous_____ CS ___________ ________(________)

[ ] attaches amendment(s)

[ ] same title
[ ] new title
[ ] technical title change (HB only)

[ ] adopts ____________________________Letter of Intent

[ ] further referral to the ____________________________

[✓] do pass

[ ] do not pass

[ ] no recommendation

[ ] individual recommendations

NEW FISCAL NOTES

Department	Date	Zero	Fiscal

PREVIOUS FISCAL NOTES

Department	Date	Zero	Fiscal
DOTPF	4/11/94	-0-	

[ ] Appropriation No Fiscal Note

DO PASS:

Tim Kelly

Steve F.

Bert Sharp

OTHER RECOMMENDATIONS:

Gary Wilken

[illegible] NO Rec

1. ______________________________
Co-Chair: Signature/Recommendation

2. [illegible] - 10 [illegible]
Co-Chair: Signature/Recommendation

No. 2
Bill Version: CSSSHB 301(L&C)
(H) Publish Date: 4/11/94

STATE OF ALASKA
1994 LEGISLATIVE SESSION

FISCAL NOTE

Revision Date:
Title: Ban Sale of Some Studded Tires and Studs
Department Affected: DOT&PF
BRU:

Sponsor: Hanley
Requestor:
Component:
Component Serial Number:

EXPENDITURES/REVENUES: (Thousands of Dollars)

OPERATING	FY95	FY96	FY97	FY98	FY99	FY00
PERSONAL SERVICES	0	0	0	0	0	0
TRAVEL	0	0	0	0	0	0
CONTRACTUAL	0	0	0	<1,000.0>	<2,000.0>	<2,000.0>
SUPPLIES	0	0	0	0	0	0
EQUIPMENT	0	0	0	0	0	0
LAND & STRUCTURES	0	0	0	0	0	0
GRANTS, CLAIMS	0	0	0	0	0	0
MISCELLANEOUS	0	0	0	0	0	0
TOTAL OPERATING:	0	0	0	<1,000.0>	<2,000.0>	<2,000.0>

CAPITAL	0	0	0	0	0	0

REVENUE FUND SOURCE	0	0	0	0	0	0

FUNDING: (Thousands of Dollars)

1002 FEDERAL RECEIPTS	0	0	0	<900.0>	<1,800.0>	<1,800.0>
1003 GF MATCH	0	0	0	<100.0>	<200.0>	<200.0>
1004 GF	0	0	0	0	0	0
1005 GF/PROGRAM RECEIPTS	0	0	0	0	0	0
1006 GF/MHTIA	0	0	0	0	0	0
OTHER	0	0	0	0	0	0
TOTAL FUNDING:	0	0	0	<1,000.0>	<2,000.0>	<2,000.0>

POSITIONS

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

Estimate of current year (FY94) impact: 0

ANALYSIS: (Attach a separate page if necessary)

DOT&PF estimates that stud wear of highway pavements creates annual pavement replacement or repair costs of approximately $4,000,000. While not providing additional funding to DOT&PF, the bill will allow better use of existing Federal Aid Highway funds, by reducing rut repair costs by 50% annually once the bill is in effect.

Prepared by: Schuyler J. Stevens, P.E. Phone: 465-6977

Division: Chief State Engineer Date: April 8, 1994

Approved by Commissioner: B.A. Campbell Phone: 465-3901

Agency: Department of Transportation and Public Facilities Date: April 11, 1994

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COMMITTEE COPY

Representative Mark Hanley
Alaska State Legislature

SPONSOR STATEMENT

CSSSHB 301 (L&C) would require the sale of lightweight studs in Alaska starting in 1997. Use of lightweight studs could reduce pavement wear by 50% without compromising the performance benefits of studded tires. This is a "win-win" situation.

Studded tires have a negative side effect on our roads in the form of increased pavement wear, which compromises safety and increases the need for road maintenance. Studs currently used in Alaska cause between $133 and $266 in pavement damage per vehicle, per 40,000 miles of travel. Grooves worn in pavement create the potential for vehicle loss of control, especially during wet or icy conditions.

The direct value of the pavement worn away amounts from $10 to $15 per studded tire. Repairing ruts normally requires that the pavement across the lane from the ruts be extracted. This increases the repair costs to about $40 to $50 per studded tire.

Lightweight studs are sold in the U.S. and are available on a large scale. As a marketing tool, Johnson Tire Service of Anchorage will use the lightweight studs in their 1994 winter tires.

Lightweight studs are now being used in Northern Europe and are expected to cut pavement wear rates in half. The lightweight studs compare favorably in performance tests against standard studs and consist of tungsten steel tips seated in aluminum or plastic bodies. I believe Alaska should move in this direction.

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ENGINEERING & OPERATIONS STANDARDS

August 3, 1993

Representative Mark Hanley
716 West 4th Avenue
Anchorage, Alaska 99501

Attn: Kip Knutson

Subject: Studded Tires & Stud Types

File: 2552

AUG 09 1993

Dear Mr. Knutson:

I am responding to your call and our discussion on July 21st regarding the advisability of requiring a tire stud type with a hardness of 6.5 on the Moh hardness scale. You should be aware that the Moh scale is intended only for scratch hardnesses of crystals of minerals and not for metals. As such, it was constructed by determining what mineral would scratch other minerals. I understand that typical steels range from about 5.5 to 6.5. However, tire studs require a carbide center pin which is probably around 7 or 8 on the Moh scale. Studs of only steel would wear quickly and not work as ice gripping studs at all; I doubt that any such are even manufactured. The alternative I suggest for reducing pavement wear is the use of lightweight studs, as are now being required in Northern Europe. Mr. Bo Simonson of Sweden's Road and Traffic Research Institute advised that use of aluminum or plastic bodied studs will be expected to cut pavement wear rates in half. Samples of lightweight European type studs are enclosed, along with typical steel studs from a local tire shop. Legislation requiring such lightweight studs would require that the maximum stud weight be set at 1.3 grams for cars and at about 2.0 grams for large trucks (tire rim sizes of 17" or greater).

As we discussed, our pavement rut measurements from start to end of the winter seasons have shown a pavement wear rate of 0.1 to 0.2 inches per million studded tire passes. The direct value of the pavement worn away amounts to $10 to $15 per studded tire during it's useful life. However, repairing the ruts normally requires that we mill or remove and replace the pavement across the entire lane to the bottom of the ruts. This increases the pavement repair costs to about $40 to $50 per studded tire. These costs may substantially reduced by lightweight studs.

25A-T34LH

The best wear data we have from pavement rut measurements is from Juneau. It is summarized by my memo of 6/13/91 (copy enclosed). However, in the Anchorage area good data comes from our pavement study site on the Glenn Highway just north of Eagle River. At that location the maximum rut depth is now about 0.9" after 10 years of service. The wear rate has been about 0.10" per million studded tire passes and the pavement loss from wear has been 19 tons per lane per mile per million passes.

As a final comment, the few studded tire use counts we made this past winter indicated large increases in studded tire use over the 1990 levels, which is disturbing from a pavement life standpoint. Juneau studded tire usage levels in March were 35% higher than in 1990, while Anchorage usage was up by 55%.

I hope that these figures will be of help to you. Also, we are just initiating a study of the comparative wear resistance of our different paving mix types. Within the next few months we hope to have some additional information from the wear testing machine being developed under that study. If you need further information on our rutting research work, please call me at 465-6956.

Sincerely,

David Esch
Research Applications Engineer

Enclosures

cc: R. D. Shumway, Chief Engineer
Eric Johnson, Pavement Management Engineer, Stwd. Materials

Washington lawmakers seek a $25-per-tire fee on studs

By JOSEPH TURNER
McClatchy News Service

NORTHWEST

TACOMA, Wash. — State lawmakers have tried to outlaw road-damaging studded tires for most of the past 20 years, and they came close a few years ago.

But on the day the ban came up for a vote in the state House, fate intervened. It snowed.

And as supporters of the ban drove down the freeway from Seattle to the state capital in Olympia — slipping and sliding along the way — they started changing their minds.

"The gods were trying to tell us something," said George Walk, who sponsored the bill as chairman of the House Transportation Committee in the late 1980s. "It was going to be a close vote anyway. So when it started snowing outside, we were ready to give up."

Walk let the bill die without a vote.

This year lawmakers are taking a different tack. Instead of trying to ban studded tires, they want to impose a tax of $25 per tire.

Senate Transportation Committee members approved the special stud tax in Senate Bill 5151 last week; the full Senate is expected to vote on the bill this week.

"We might not have to raise the gas tax so much if we'd do something about studded tires," said Rep. Shirley Winsley, R-Fircrest, this year's bill sponsor. "If people are going to insist on using studded tires, they should be willing to pay a small fee."

Small fee?

"Oh, jeez," said Richard Nordness, director of the Washington State Tire Dealers Association. "People can't afford to put that much money into tires.

"A good snow tire costs $50 to $60. Most dealers charge $9 or $10, plus labor, to put the studs on. With a $25 tax ... you're talking pretty close to $100.

"It's insane, really," he said. "Putting such a high tariff on them has the same effect as a ban."

That's the point, said Sen. Larry Vognild, chairman of the Senate Transportation Committee.

Highway officials estimate studded tires cause about $25 million damage a year to the highway system. The studs gouge into asphalt and concrete roadways. Pavement supposed to last 14 years gets chewed up years earlier.

Historically, the studded tire debate has pitted Western Washington lawmakers against their Eastern Washington counterparts. It's a question of differing climates.

In the slushy snows west of the Cascades, a studded tire is no help. And on wet or dry pavement, studs can radically reduce traction, said Ron Maulsby, public affairs manager for Goodyear Tire and Rubber Co. in Akron, Ohio.

"The only time we recommend a studded tire is where you're in part of the country where ice is covering the road for days or for months at a time," Maulsby said. "Metal studded tires will provide 40 percent better traction on compact snow and ice."

Nordness disputes the amount of damage caused by studded tires, especially since they've been equipped with a softer metal stud.

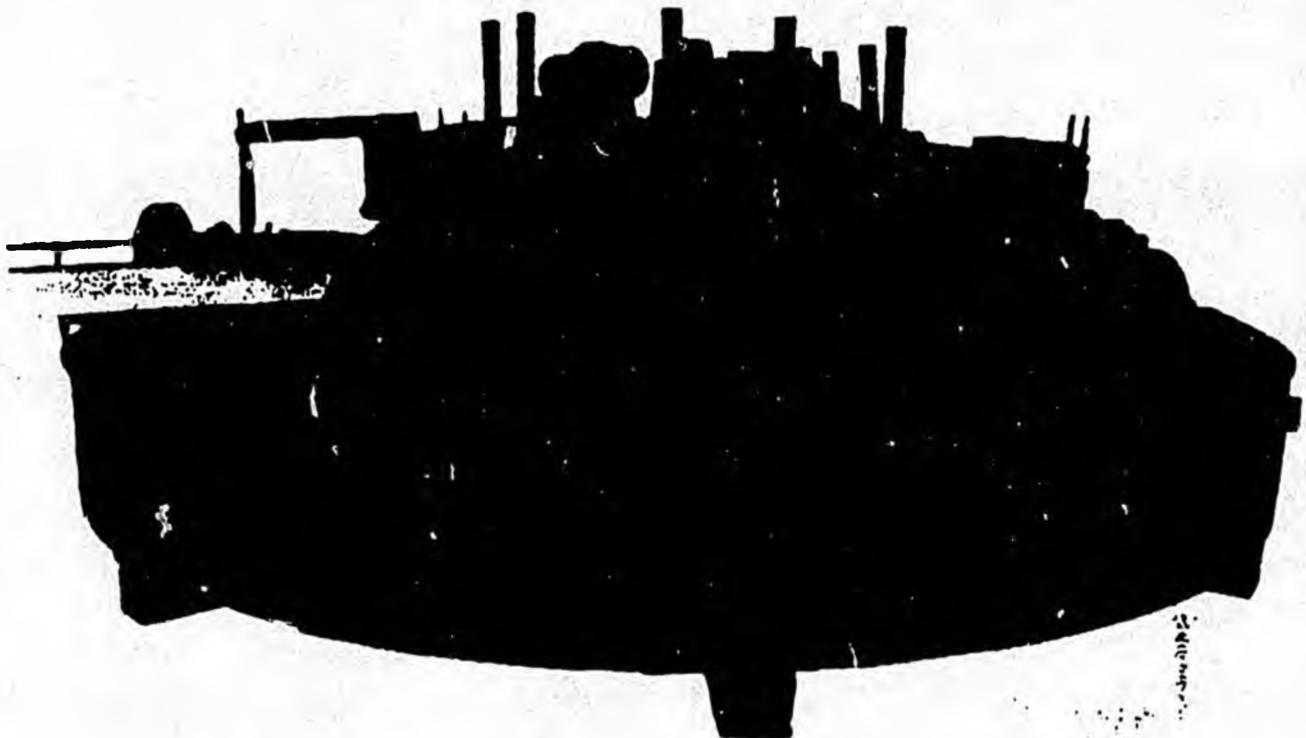
"It has not been proven that studded tires do that much damage to the road," he said. "Those same kinds of ruts show up in Florida and other states where studs are outlawed.

Heavy trucks get some of the blame for rutted highways.

"If we have to go back to the old days of using chains, we're going to see a lot more damage," Nordness said.

Studs have worn through the top pavement layer (2"±) along lines spaced equally with car wheels.

Pavement (2"±) on bridge has been stud worn to concrete.



VTI ROAD SIMULATOR

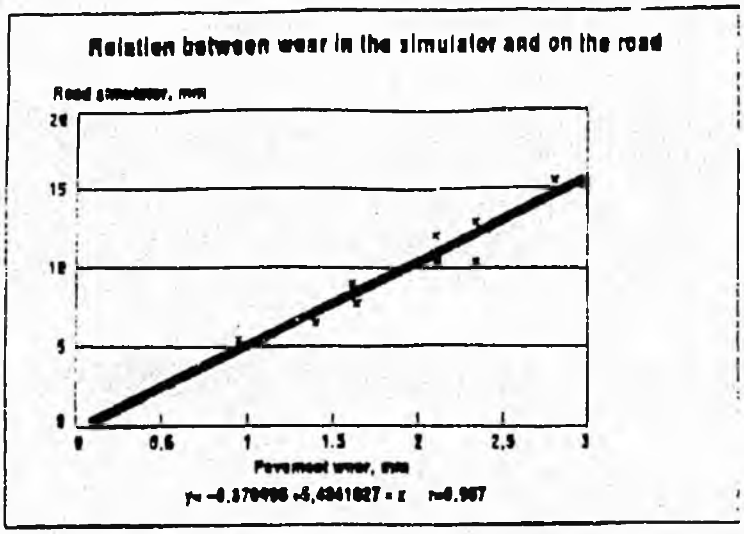
The VTI Road Simulator is a machine for accelerated testing of tyre influence on pavements under controlled conditions.

The machine has six wheels rotating on a circular track covered with the pavement material. A separate motor drives each wheel. The diameter of the track is 5.25 m, giving a mean lap length of 16.5 m. The maximum width of the track is 0.85 m.

The wheels can be fitted at various radial distances from the centre of the machine and the machine's axis can be slowly moved laterally while running by means of an eccentric device. This enables all wheels to be moved in and out a total of 60 mm. The lateral movement is especially important when using studded tyres, which would otherwise produce narrow ruts after each line of studs.

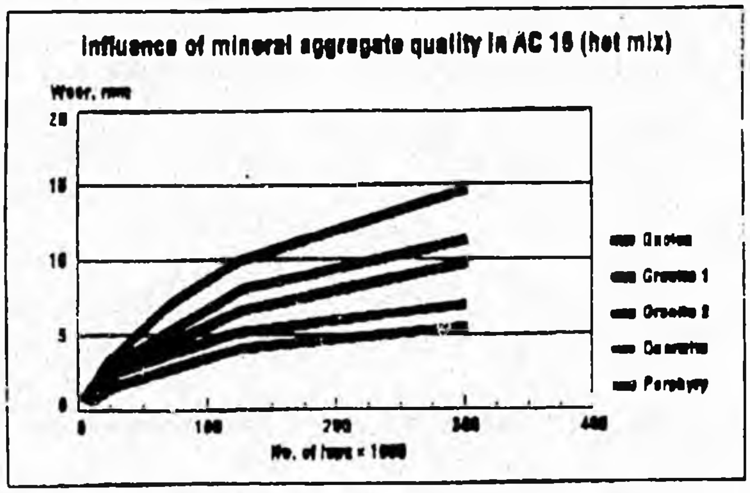
The pavement of the machine can be sprayed with water and the hall in which the machine stands can be cooled to −20°C. The speed of the machine can be varied, but the maximum speed is limited according to the wheel load. With the present design, the maximum speed is 85 km/h for a wheel load of 5 kN. Truck or car tyres with conical or conventional treads can be used. Normally, the machine is run with conventionally studded car tyres, size 185/70 R14.

Determination of wear is performed from cross-sections recorded perpendicularly to the direction of travel. Measurements ...



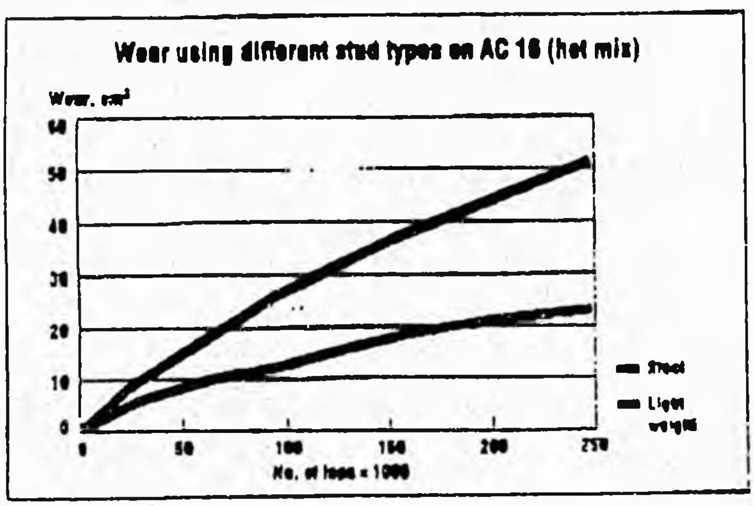
RELATION BETWEEN SIMULATOR AND FIELD TESTS

The simulator has shown excellent correlation with pavement wear in the field. The diagram indicates the relation between the wear on test slabs laid on the road and in the simulator. Pavement type AC 12 and 16 (hot mix).



STUDIES OF PAVEMENT MATERIAL

In studies of resistance of pavements to studded tyres, laboratory rolled slabs with known compaction and composition were tested. The parameters that can be studied include the effect of pavement type, binder, mineral aggregate quality, particle size etc.



STUDDED TYRE TESTS

The development of studs for car tyres has resulted in a steady reduction of stud mass. Among new studs on the market are types with plastic or alloy mantle surrounding a hard metal pin. Tests with these lightweight studs have been performed in the road simulator. The results show that the lightweight studs produce considerably less wear on the pavement than the heavier conventional steel studs.

Examples of other applications

- *testing traffic count cables*
- *testing wear on surface condition sensors*

Publisher:

Swedish Road and Traffic Research Institute

Swedish Road and Traffic Research Institute • S-581 01 Linköping Sweden

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Published: 1992

Project code: 43361-5

Project: Tests with lightweight tyre studs in the VTI's pavement testing machine

Author:

Kent Gustafson

Sponsor:

Swedish National Road Administration

Title:

Tests with lightweight tyre studs in the VTI's pavement testing machine

Abstract (background, aims, methods, results) max 200 words:

The use of studded tyres, while having a direct effect on traffic safety, gives rise to a number of problems and increased costs, especially on roads with high traffic volumes. The wear from studs contributes to rutting and shorter pavement life. In the latest investigation of studded tyres, carried out in 1989, the cost of pavement wear from studded tyres was estimated at SEK 250—-300 million per year for the Swedish road network. In recent years, new types of lightweight studs have appeared on the market, which may reduce pavement wear and consequent expense

At the VTI, a special machine for accelerated testing of pavement wear is being used to perform investigations under controlled conditions. Using the machine, a study has now been completed on two types of lightweight studs, one with a plastic body and the other of light metal.

Tests using plastic studs have been performed at two speeds, 60 and 85 km/h, while the light metal stud has been tested only at the higher speed. With the exception of one case, the test runs have been made on an dense asphalt concrete (AC) pavement with normal wear resistance. In one run, plastic studs were also tested on Stone Mastic Asphalt (SMA) pavements with high wear resistance.

On both the highly wear-resistant and normally wear-resistant pavements, abrasion from the lightweight plastic studs was generally about half that from corresponding steel studs. However, the absolute wear level naturally differed according to the wear resistance of the particular pavement. For example, the most wear-resistant pavements in the tests, SMA pavements with very high quality aggregate demonstrated 3-5 times less abrasion than the "normal pavement" with locally obtained aggregate. Also abrasion from the light metal studs was considerably lower than from the conventional steel studs and even lower than from the somewhat lighter plastic studs. Light metal studs produced only about one third, 35 %, as much wear as steel studs. The corresponding ratio between plastic and steel was 44 %.

The tests showed that speed is of great significance for pavement wear. Abrasion increased significantly at higher speed. Steel studs gave almost the double amount of wear at 85 km/h compared to 60 km/h.

To obtain an idea of the wear-resistance of the studs, stud protrusion has also been measured. The decrease in protrusion was of the same order of size for plastic studs as for light metal and steel studs. Thus, the results do not indicate any significant difference in wear resistance between the various types of stud.

The conclusion from the investigation is that the lightweight studs that have been tested reduce pavement wear by about half. The calculated cost of this wear could thereby be halved within a few years when these studs have replaced the conventional steel stud.

Keywords:

ISSN: | Language: | No of pages:

Tests with lightweight tyre studs
in the VTI's pavement testing machine

by Kent Gustafson
Swedish Road and Traffic Research Institute (VTI)
S-581 01 Linköping
Sweden

Summary

The use of studded tyres, while having a direct effect on traffic safety, has also had certain negative effects. Perhaps the most tangible of these pavement wear, contributing to rutting and shortened life of the wearing course, especially on roads with heavy traffic volumes. In the latest Swedish investigation of studded tyres, conducted in 1989, the cost of pavement wear as a direct result of studded tyres was estimated at SEK 250—300 million per year for the Swedish road network as a whole.

The extent of the wear caused by studded tyres depends on a number of factors, as stated in the report. One critical factor is the design and weight of studs. For many years, the basic principle of the tyre stud for passenger cars has been a hard metal pin enclosed in a mantle of steel, the whole stud having a weight of about 2 g. In recent years, however, several tyre and stud manufacturers have carried out intensive development to find a stud that is less aggressive to pavements. This work has resulted in studs of new design and/or weight, which are expected to reduce pavement wear.

At the VTI, a special machine for accelerated testing of pavement wear is being used to perform investigations under controlled conditions. Within a relatively short time, the machine produces a rut depth which is comparable to many years pavement wear on a road with large traffic volumes. In this study, the machine has been used to investigate pavement wear from tyres fitted with lightweight studs.

Tests have been conducted with the two types of lightweight studs which have so far captured a certain share of the Swedish market, in addition to conventional steel studs. One of the lightweight studs, "BETEK", has a body of plastic and weighs 0.7 g. These studs were fitted to Gislaved "Nord Frost" tyres. The other type of lightweight stud, "Eurometec", is made of light metal and weighs 0.95 g. These were fitted to Goodyear "Ultra Grip" tyres

All test runs except one took place on a pavement of normal wear resistance, asphalt concrete (AC). In addition, one run was made on pavements with very good wear resistance, having asphalt wearing courses of high aggregate content and the best abrasion resistance, so called Stone Mastic Asphalt (SMA). The aim of the runs on wear-resistant pavements was to study whether the results obtained on a normal pavement also applied to these types of asphalt concrete.

The tests comprised a total of four types:

- Wear from plastic studs and steel studs at 60 km/h
- Wear from plastic studs and steel studs at 85 km/h
- Wear from plastic studs and steel studs at 85 km/h on highly wear-resistant pavements
- Wear from light metal studs and steel studs at 85 km/h

In the first two runs, with both plastic studs and steel studs, the speed was 60 km/h and the AC pavement with locally produced aggregate. The test comprised a total of 150,000 rotations in ecah case and the rut depth was about 10-15 mm at the end of the run. The result showed that pavement wear from the lightweight plastic stud was considerably less than that from the conventional steel stud. After the run, pavement wear from the lightweight stud was found to be 65 % of that from the steel stud at this speed, 65 km/h.

Three runs were performed at 85 km/h, two with steel studs and one with a lightweight plastic stud. Two somewhat different steel studs were tested, a single-shouldered stud weighing 1.6 g and a double-shouldered stud weighing 2.1 g. Despite some variation in design and weight, the difference in pavement wear between these two types of stud was very marginal The small difference between the two runs also shows that the reproducibility of the tests is fairly good.

As in the runs at lower speed, the difference in abrasion between the lightweight plastic stud and the conventional steel stud in runs was relatively great also in this case. After 150,000 rotations, the lightweight stud had caused abrasion equal to only 44 % and 47 % of that from the single-shouldered and double-shouldered types respectively, compared to the steel stud. At 250,000 rotations, the plastic stud had caused wear equal to only 44 % of that from the double-shouldered steel stud at this speed, 85 km/h. The large difference in wear also appeared in the maximum rut depth measured in the pavements. After 250,000 rotations, rut depth was about 15 mm for plastic studs and about double, 30 mm, for steel studs.

The tests on pavements of varying wear-resistance showed that abrasion in absolute levels differs greatly between pavement types. Particularly large was the difference between, on the one hand, the conventional pavement with normally wear-resistant aggregate and, on the other hand, the highly wear-resistant pavements with good quality aggregate and generally a high content of coarse material. The highly wear-resistant pavements showed abrasion usually only one fifth to one third of that on the conventional AC pavement with local aggregate.

However, the difference between the wear from lightweight plastic studs and conventional steel studs changed very little among the pavement types. The smallest difference was found for an AC (with maximum 20 mm aggregate) pavement, where the abrasion from plastic studs was 57 % of that from steel studs, and the largets difference was found on an SMA (with maximum 16 mm aggregate) pavement, where the corresponding figure was 37 %.

Summing up, the difference in wear between the new lightweight studs with a body of plastic and conventional steel studs is relatively constant for different pavement types On both highly wear-resistant and normally wear-reistant pavements, abrasion from the lightweight studs is generally about half the corresponding abrasion from steel studs.

However, the absolute wear level naturally depends on the wear resistance of the particular pavement. For example, the most wear-reistant pavements in the tests, SMA pavements with very good quality aggregate (porphyry) showed 3-5 times less abrasion than the "normal pavement", AC with local aggregate.

Tests similar to those above have also been conducted with light metal studs. The speed was 85 km/h and the pavement was of the same type as previously: AC with local aggregate. The run with light metal studs was continued until 300,000 rotations had been completed. The same number of rotations had earlier been made with plastic studs and somewhat fewer, 250,000 rotations, with steel studs on a similar pavement, thereby allowing a comparison to be made.

The abrasion from the light metal studs was considerably less than that from the conventional steel studs and even lower than that from the somewhat lighter plastic studs. After 250,000 rotations, the ratio between light metal and steel was only 35 %, i.e light metal studs produced wear that was only about one third of that from the steel studs. The corresponding ratio between plastic and steel was 44 %. The reason for this difference between the two types of stud can only be surmised, but may be due to differences in stud design, pressure or wear during the run. Otherwise, it would be natural for the lightweight plastic stud to produce less wear than the light metal stud.

The tests on the effects of steel studs and plastic studs on asphalt pavements have been performed at two speeds, 60 and 85 km/h, and it is therefore possible to study the effect of speed on abrasion and whether the various types of stud are similar in this respect.

This study, like many others, has shown that speed is of great significance in regard to pavement wear Abrasion increases considerably when speed increases. For steel studs, abrasion after 150,000 rotations at 85 km/h was 86 % greater than at 60 km/h. After a smaller number of rotations, the increase was even greater, so that the increase from 60 to 85 km/h led to an overall increase of appr. 100 % in pavement wear for conventional steel studs

In the case of plastic studs, speed does not have fully the same influence on abrasion. A speed increase from 60 to 85 km/h increased wear by 44 % after 150.000 rotations. The fact that speed has a lesser influence in the case of the lightweight plastic stud compare to the conventional steel stud is probably because the former is in itself less aggressive to the pavement owing to its lower weight. The influcence on pavement wear from both speed and stud weight is probably exponential, i.e. the increase in wear becomes higher at higher speed and higher stud weight respectively.

The pavement testing machine is primarily designed for investigations of the effects of tyres on road surfaces, in particular pavement wear. However, wear on tyres and studs is somewhat different to that in normal traffic, where there is a combination of acceleration, braking, cornering, etc. Since the tyres in the pavement testing machine rotate constantly in a very tight circle, the wear on the studs is much heavier. To obtain a certain idea of the wear resistance of the studs being tested, the stud protrusion has been recorded. However, it must be emphasised that the protrusion observed cannot be compared in absolute terms with protrusion in normal conditions, but only against other measurements made in the same context.

Stud protrusion was recorded in most cases after 500 kilometres ("zero" measurement) and after each 50.000 rotations. However, there were deviations from this routine. The results of the stud protrusion measurements when running at 60 km/h showed that protrusion was almost constant for the steel studs, while the plastic studs showed reduced protrusion. A comparison between the two types of stud shows that the plastic studs had somewhat greater wear in this case.

The results for the three runs, one with plastic studs and two with steel studs, at 85 km/h showed that the difference in protrusion was relatively great, even for new tyres. The plastic studs had the smallest protrusion, an average of 1.13 mm, while the steel studs had a protrusion of 1.32 mm (single shoulder) and 1.59 mm (double shoulder). A comparison of the wear resistance of the studs thus refers to the decrease in protrusion and not the absolute protrusion. A comparison between plastic studs and single shoulder steel studs after 150.000

rotations showed that the decrease in protrusion was very similar. For both types, the decrease was 0.4 mm. In this case, the plastic studs had a wear resistance comparable to steel studs. The same applies even in a comparison with the other steel stud, the double shoulder type. For this steel stud, protrusion decreased from 1.59 mm to 0.60 mm, i.e. about 1 mm, after 250,000 rotations, while the decrease in protrusion of the plastic stud was about 0.6 mm, from 1.13 mm to 0.50 mm, after 300,000 rotations.

A third comparison of stud protrusion for lightweight plastic studs and conventional steel studs was performed in the run on wear-resistant pavements. Neither in this case did the results reveal any difference in wear resistance between the two types of stud compared, the decrease in protrusion being of the same order of size. In general, the lightweight type of stud had similar wear resistance compared to the conventional steel stud in the reported tests.

The change in stud protrusion in tests with light metal studs has been investigated in the same way as above. The protrusion of the light metal stud was recorded both on new tyres and after 150,000 and 300,000 rotations. From the beginning, the light metal studs had the smallest average protrusion of the types tested, about 1 mm. By the and of the run, the protrusion had decreased to 0.60 mm. This decrease is smaller than that of the other two types of stud after the same number of rotations. As with the plastic studs, the result therefore indicates no reason to fear that the wear resistance of these studs is poorer than that of conventional studs.

The conclusion from the reported investigations is that, given full market coverage, the lightweight types of stud of plastic and light metal will reduce pavement wear from tyre studs by about half within a few years. This means a cost saving of SEK 125-150 million according to the calculations in the latest investigation on studded tyres. Reduced pavement wear naturally also means other positive effects for the environment.

A number of other factors concerning the extent of pavement wear have also changed since the latest investigation on studded tyres. The use of highly wear-resistant SMA pavements has increased in recent years and has spread to other roads and streets besides those with the heaviest traffic. SPS (Specific wear = pavement wear in gram per km of road and vehicle with studded tyres) ratios under 10 are not uncommon for this type of pavement and the average SPS ratio for the Swedish road network in 1989 (calculated at 30 in the investigation) should therefore have fallen somewhat. A further decrease is expected since this type of pavement is being laid to a greater extent than before.

Another factor that may be assumed to have a positive influence in reducing pavement wear is the change in painted lane markings now being introduced on a wider scale. Today, 13 metre roads are in some cases being painted with lanes 5.5 metres wide. The traffic is thereby distributed more evenly across the road and pavement wear is thereby less concentrated. Moving the markings laterally on motorways is another alternative that also leads to less concentrated rutting, according to initial experiments.

In general, the use of lightweight studs. together with the other factors mentioned above, may contribute to a decrease in pavement wear from studded tyres to about half the present level within a few years. This means that the cost of pavement wear from studded tyres could be reduced to a figure in the region of SEK 100 million per year, a relatively modes level in relation to the positive effect on road safety resulting from the use of studded tyres. Results so far also show that these new lightweight studs have the same road grip and wear reistance as the conventional steel studs. The positive effect on traffic safety with these new studs would therefore be of the same order of size as earlier.

WHEEL TRACK RUTTING DUE TO STUDDED TIRES

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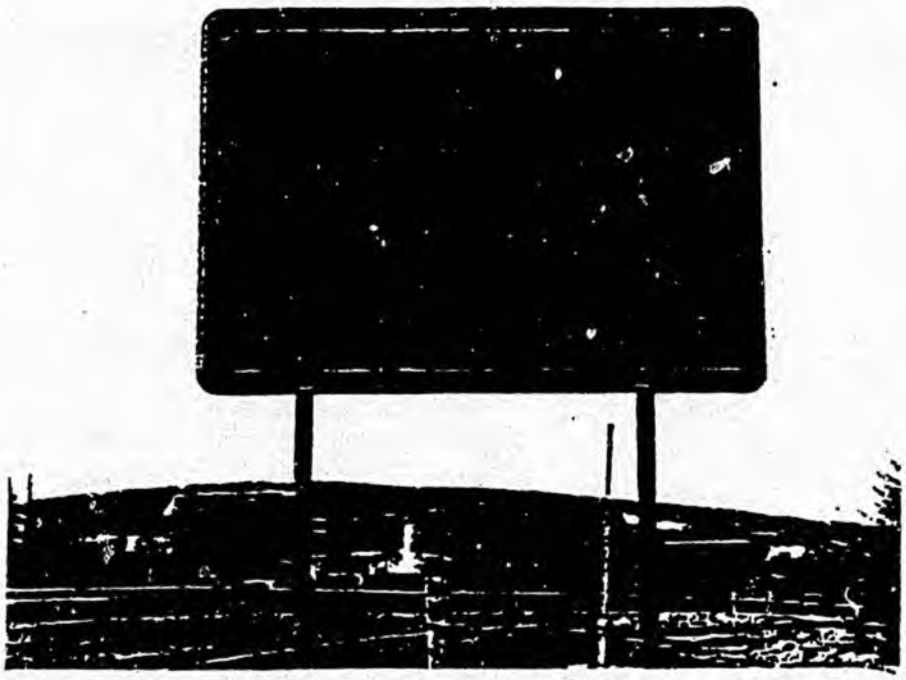

STATEWIDE DOT&PF RESEARCH

Wheel Track Rutting Due to Studded Tires

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16. Abstract

This is the second of a series of reports which deals with wheel track rutting in asphalt pavements. Specifically, this report is concerned with the extent of rutting due to studded tires. Significant findings include:

1) Very little research has been done since 1980 in this area, with the exception of work in the Scandinavian countries.

2) Many agencies continue to prohibit or restrict the use of studded tires.

3) Very little new information on percent of vehicles using studded tires or on tire wear studies was available.

4) Factors affecting wear rates were defined.

5) The consequences and benefits of using studded tires were identified.

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Studded tires, flexible pavements, wheel track rutting	Unrestricted

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1.0 INTRODUCTION

1.1 Background

The use of studded tires has long been recognized as improving traction in highways during the winter months when the roads are often icy. However, they also have been shown to increase road wear on both asphalt and portland cement concrete pavements. This report has been prepared to document the use and effects of studded tires, particularly in terms of producing wheel track ruts.

1.2 Objectives

Specific objectives of this report are to:

1) Quantify the use of studded tires in countries throughout the world. This includes data on

   - Percent of vehicles using studded tires
   - Characteristics of the studs (size and number)
   - Time periods that studded tires are permitted

   This information is summarized in Chapter 2.

2) Summarize the results of road wear studies (field and test track) in each of the following areas

   - Mechanism of pavement wear
   - Rate of pavement wear
   - Factors affecting the wear rate

   These results are presented in Chapter 3.

3) Identify the consequences/benefits of using studded tires such as

   - Increased pavement maintenance to repair ruts, etc.
   - Increased safety problems due to splash and spray

   These results are presented in Chapter 4.

1.3 Scope of Work

In order to accomplish the stated objectives, two major work activities were undertaken. These included:

1) A computer literature search (TRIS). Many of these publications were reviewed and evaluated in the preparation of this report.

2) A survey of agency practices. A survey form (see Appendix A) was developed and mailed to 30 highway agencies, 11 Canadian provinces and territories, and 4 foreign countries (Norway, Sweden, Finland, and West Germany). The responses to the survey are given in Appendix B.

3) A telephone survey of selected tire manufacturers to identify the types and number of studs currently being used. These results are summarized in Appendix D.

2.0 STUDDED TIRES PRACTICES

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

2.1 Use of Studded Tires

The results of the survey were used to provide an indication of use of studded tires throughout the United States, Canada and abroad. The results indicate the following agencies permit their use:

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

It should also be noted that in all cases where studs are permitted, so are chains.

2.2 Percent of Vehicles With Studs

The results of the survey did not provide much useful recent information on use of studded tires. In fact, only a few agencies provided an estimate for current usage. Therefore, heavy reliance was placed on results from the literature (pre-1980) since the actual usage rates are virtually unknown in the USA and Canada.

Historical data on the percent usage by vehicle type (cars and trucks) of studded tires in the United States and abroad is given in Table 2.1. As noted, many states do not allow studded tire use, while usages as high as 60% or more have been reported by the states of Alaska, Montana, and Vermont (TRB, 1975).

Sweden reports that 60% of all vehicles use studs, while 90-95% of cars and 30-60% of trucks use studded tires in Finland (Huhtala, 1978). Provinces in Canada reported usage rates on cars as low as 20-25% and as high as over 50% (Smith & Schonfeld, 1971).

The percentages of use on two versus all four wheels are generally unknown except for Scandinavia and Alaska. In certain countries, the use is mandated on all four wheels if studs are used on any wheel. This is to increase safety as well as acceleration.

A recent survey of studded tire usage in Alaska is given in Table 2.2. As indicated, studded tire usage varies seasonally as well as between years and locations. However, it can be seen that wintertime usage (through March) by light vehicles is between 20 and 35% with roughly one-third of these vehicles being four-wheel drive.

2.3 Characteristics of Studded Tires

As indicated in Figure 2.1, a typical studded tire is essentially a normal winter or all-season tire with studs embedded in the tread. Typical specifications for passenger car studded tires are given in Table 2.3.

Although there were many types of studs found in the literature, all have similar components. These consist of a pin (typically tungsten carbide) surrounded by the stud housing or body (typically steel), which has a flange at its base to hold the stud in the tire tread. Figure 2.2 illustrates the four basic stud types that have been used in the past, while Table 2.4 summarizes the characteristics of each type. Conversations with tire manufacturer/distributor personnel revealed that only the Controlled Protrusion (Type I) stud is currently used in the U.S. The principal reason is that as the stud housing or body wears, coinciding with the tread

Table 2.1. Historical data on the use of studded tires.

Agency		% of Vehicles with Studs	Reference
Canada	Ontario	32	Smith, 1971
	Manitoba	20-25	Smith, 1970
	Quebec	50	Smith, 1970
	Maritime Provinces	50 +	Smith, 1970
	Ottawa	48	Smith, 1971
United States	Alabama	1	NCHRP Syn. 32
	Alaska	61	
	Arizona	1	
	Arkansas	1	
	California	NA	
	Colorado	30	
	Connecticut	25	
	Delaware	18	
	Florida	NA	
	Georgia	NA	
	Idaho	27	
	Illinois	12	
	Indiana	10	
	Iowa	25	
	Kansas	7	
	Kentucky	12	
	Maine	NA	
	Maryland	NA	
	Massachusetts	32	
	Michigan	12	
	Missouri	14	
	Montana	60	
	Nebraska	38	
	Nevada	6	
	New Hampshire	30	
	New Jersey	20	
	New Mexico	NA	
	New York	30	
	North Carolina	2	
	North Dakota	32	
	Ohio	20	
	Oklahoma	1	
	Oregon	10	
	Pennsylvania	28	
	Rhode Island	NA	
	South Carolina	3	
	South Dakota	40	
	Tennessee	NA	
	Texas	0	
	Vermont	60	
	Virginia	10	
	Washington	35	
	West Virginia	10	
	Wisconsin	20	
	Wyoming	35	
Finland		Cars: 90-98	Lampinen, 1988
		Trucks: 40	Huhtala, 1978
Sweden		60	Keyser, 1970

Table 2.2. Recent counts of studded tire usage in Alaska

Survey Date	Total Vehicles	Studded Tires (one side)	Studs per Vehicle Pass	% Vehicles w/Studs On Some Tires	% Vehicles w/Studs On All Tires	% 4WD Vehicles
a) Fairbanks						
4/18/89	250	81	0.324	28.0	12.4	24.8
5/22/89	319	23	0.072	6.6	0.63	24.0
3/2/90	583	182	0.312	20.4	10.8	34.1
5/7/90	820	121	0.148	11.0	4.10	33.2
7/16/90	1228	101	0.082	5.45	2.77	35.4
1/23/91	1385	402	0.290	19.3	9.75	43.4
b) Anchorage						
5/17/89	1766	143	0.081	6.4	1.7	—
8/21/89	1892	63	0.033	2.9	0.4	—
11/16/89	2361	1142	0.484	36.8	11.5	—
2/14/90	2076	1043	0.502	35.0	14.4	—
8/20/90	2339	112	0.048	3.8	0.9	24.3
c) Juneau						
4/12/89	993	348	0.350	24.8	9.3	32.5
8/1/89	352	28	0.080	6.2	1.7	30.0
3/15/90	1187	512	0.431	30.8	12.1	32.7
6/25/90	1119	40	0.036	2.9	0.45	35.3
1/25/91	650	345	0.531	40.8	16.9	40.6

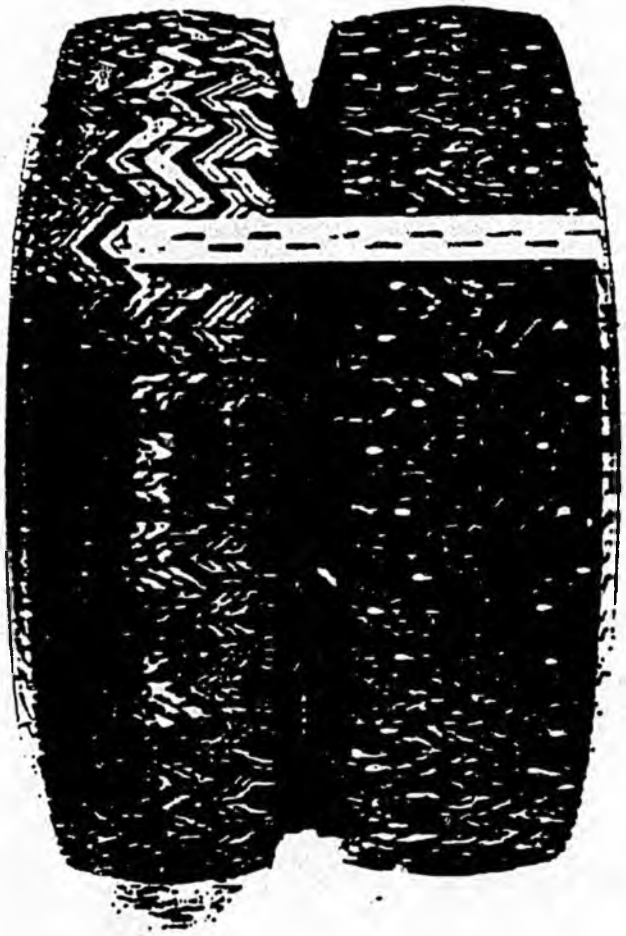


Figure 2.1. G78x14 studded (R) and unstudded passenger tires (Krukar & Cook, 1972).

Table 2.3. Typical cross-sectional area specifications (NCHRP Syn. 32).

Nominal Car Size	Tire Data		Tire Stud Data		
	Nominal Size	Typical Tread Surface Area (sq. in.)	Typical Maximum Number of Studs	Typical Cross-Sectional Area (sq. in.)	Percent of Tread Surface Area
Compact	E78x13	250	96	.0314	1.25
Intermediate	F78x14	270	96	.0314	1.10
Full Size	H78x15	312	96	.0314	1.00

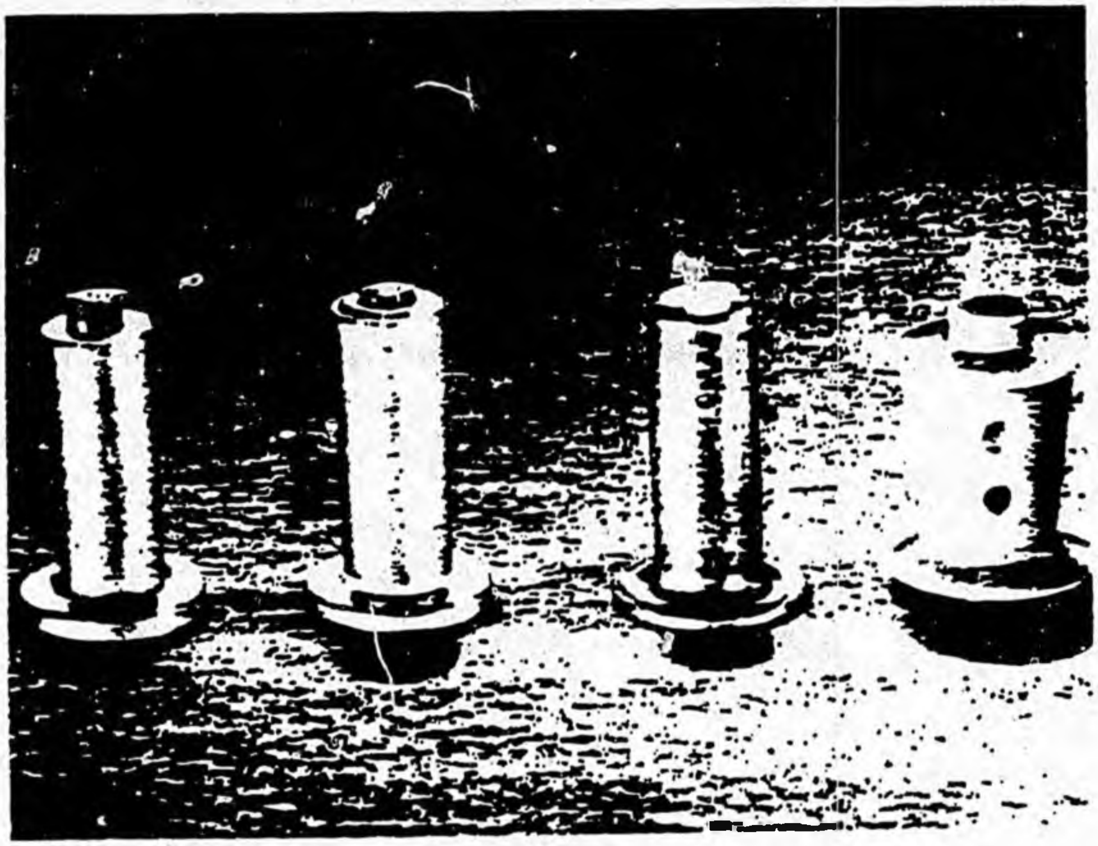


Figure 2.2 Four basic stud types. Left to right: Type III or CV Stud; Type I or CP Stud; Type II or PT Stud; and Type IV or FS Stud (Krukar & Cook, 1973).

Table 2.4. Characteristics of studs (Krukar & Cook, 1972).

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

wear, the tungsten carbide pin is pushed deeper into the stud housing providing a uniform protrusion length throughout the life of the stud. This benefit is not fully realized with the other stud types since the protrusion length of the stud can vary over time. Figure 2.3 gives the dimensions for the Controlled Protrusion Stud (see Appendix C for further details), while Figure 2.4 illustrates a fifth type of stud which was listed in the literature as being considered for manufacture. The number of studs/tire range from 64 to 120 (see Table D1).

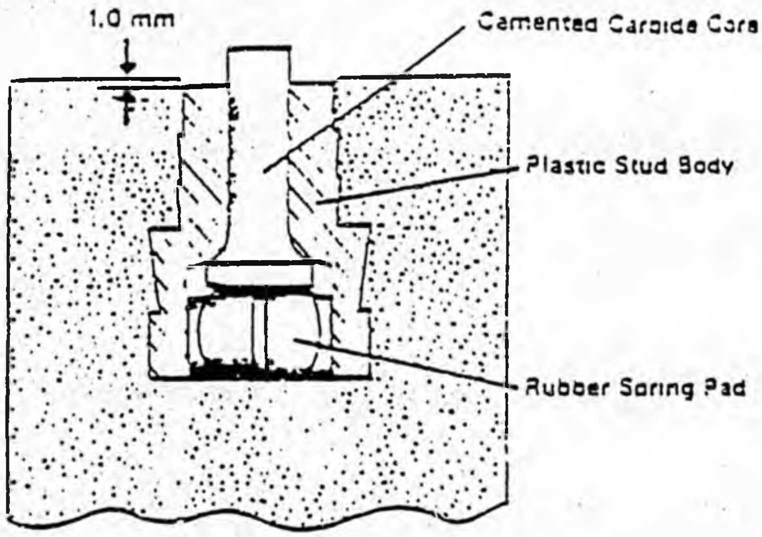
In Sweden, it has been long recognized that the conventional studs cause excessive tire wear. They have therefore developed a new low-noise, reduced road wear ice-stud. It weighs only 0.7 gram, yet reportedly retains ice grip and durability. The reduction in weight is possible due to the use of a new polymer in the stud body (Simonsson, 1990).

2.4 Permitted Use Periods

Based on the results of the literature review the periods of the year to which studded tire use is restricted in the United State and Canadian Provinces is shown in Figure 2.5 (TRB, 1975). Note that in the 1970's 14 states and two provinces had no restrictions and that nine states and one province prohibited the use of studded tires. The remaining states and provinces allow use of studded tires only during the fall, winter, and spring months. The results of the 1990 survey (Table 2.5) showed, for North America, that only three agencies had no restrictions, 25 states/provinces restrict stud use to a given time period, and eight agencies prohibit their use. For those agencies restricting the use of studs to a specific time period, most restrict their use to the period from October through April. Similar results for the European countries surveyed are given in Table 2.6.

2.5 Enforcement

The results of the survey (see Appendix B, Question 7) also investigated the role of enforcement during prohibited periods. Generally, the risk of getting caught is considered low to moderate. Only South Dakota, Washington, Illinois, Minnesota, Nevada, Ontario, and Quebec indicated a high risk. The cost of being cited also varies considerably, with ranges in fines from <$25 to $500 plus vehicle impoundment.



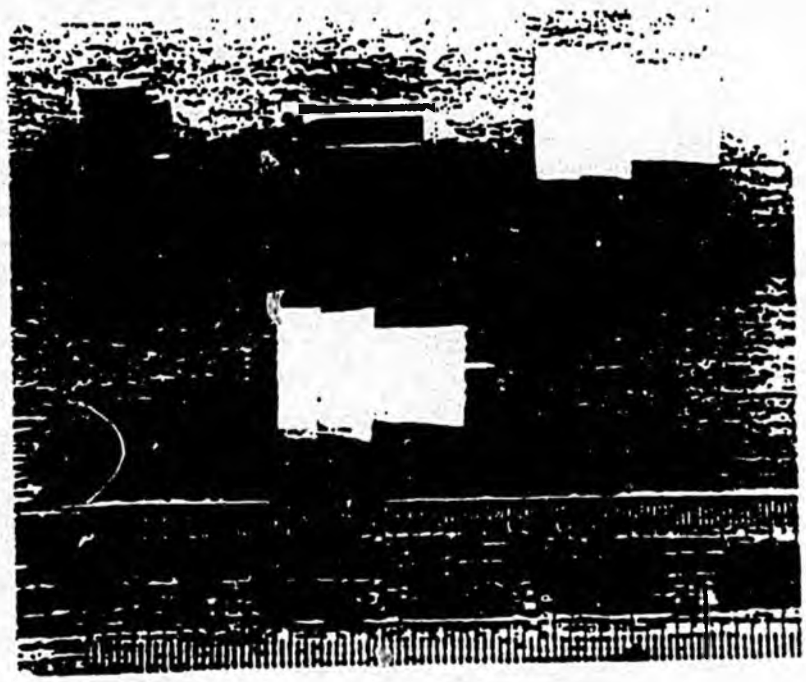


Figure 2.4. Spring-action stud (Fagersta Steels Limited) (NCHRP Syn. 32).

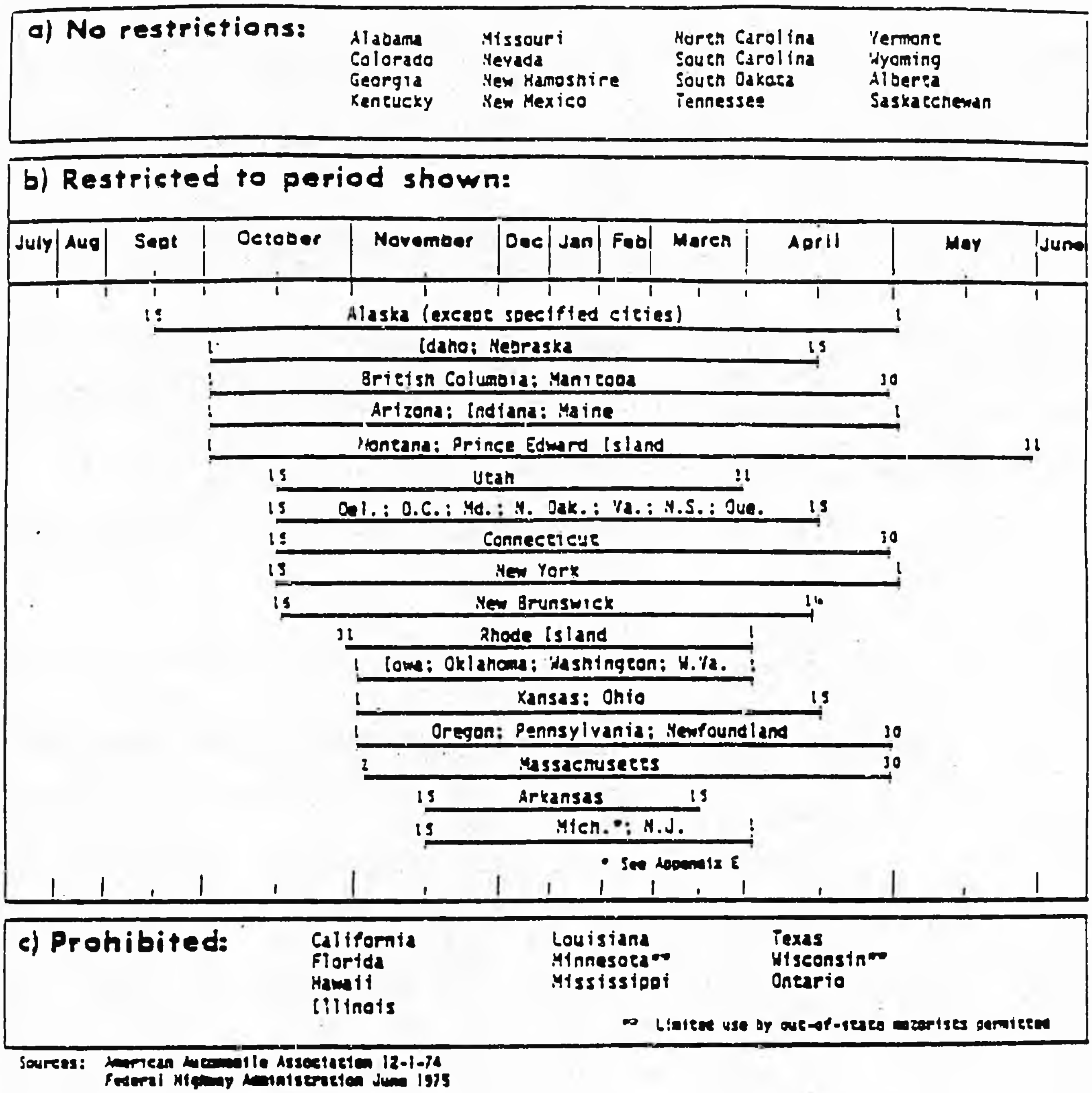


Figure 2.5. Legal restrictions on use of studded tires (NCHRP Syn. 32).

Table 2.5. Restrictions on use of studded tires in the U.S., Canada (August 1990).

a) No restrictions	Colorado Vermont Saskatchewan	
b) Restricted to time period shown	Alaska	Sept. 15 - April 30 (north of latitude 60°N) October 1 - April 14 (south of latitude 60°N)
	Connecticut	November 15 - April 30
	Iowa	November 1 - April 1
	Kansas	November 1 - April 5
	Maine	October 1 - May 1
	Nevada	October 1 - April 30th
	New Jersey	November 1 - April 1
	New York	October 15 - May 1
	Rhode Island	November 15 - April 1
	Utah	October 15 - March 15
c) Restricted (period unreported)	California Delaware Idaho Indiana Montana Nebraska North Dakota Oregon Pennsylvania South Dakota Washington Wyoming New Brunswick Nova Scotia Quebec	
d) Prohibited	Arizona Illinois Maryland Michigan Minnesota Alberta Northwest Territories Ontario	

Table 2.6. Restrictions on use of studded tires in Scandinavia (August 1990).

a) No restrictions	
b) Restricted	Sweden - 31 October to Easter Finland - 1 November to 31 March
c) Prohibited	Germany

3.0 ROAD WEAR STUDIES

This chapter summarizes, based on the literature, the results of studies from throughout the world to identify the cause (mechanism) of pavement wear owing to studded tires, the rate of pavement wear, and factors which affect the rate.

3.1 Cause of Pavement Wear

The results of the literature review indicated that the mechanism of wear is primarily by abrasive action. Nieme (1978) has summarized the mechanism best, as shown in Table 3.1. Which of the four possible cases is most important is still open to debate. In Alaska, it is generally felt that the primary mechanism of studded tire wear is by scraping off the mastic and abrasion of the aggregate.

3.2 Factors Affecting Wear Rate

Several factors have been identified as affecting the pavement wear rate. Keyser (1970) has prepared (in Table 3.2) an excellent summary of these factors. In addition, Keyser (1972) stated the most important factors to be wheel load, stud protrusion, temperature, and humidity.

Figure 3.1 shows the effect of pavement type on wear rate. The "regular" bituminous pavements consisted of fine-graded mixtures for thin overlays with 85-100 penetration asphalts while the "high type" bituminous pavements contained either rubber or asbestos admixtures and 85-100 asphalts. The "regular" pavements contained a filler while no filler was present in the "high type" pavements. For both tests (on a test track and typical highway pavements), the wear rate was considerably greater for asphalt concrete compared with portland cement concrete pavements. Aggregate type also had an effect for the portland cement concrete pavements. Other factors, as shown in Table 3.3, can also affect the wear rate. In addition, as shown in Figure 3.2, the wear rate in acceleration can be 2 1/2 times the wear rate in deceleration.

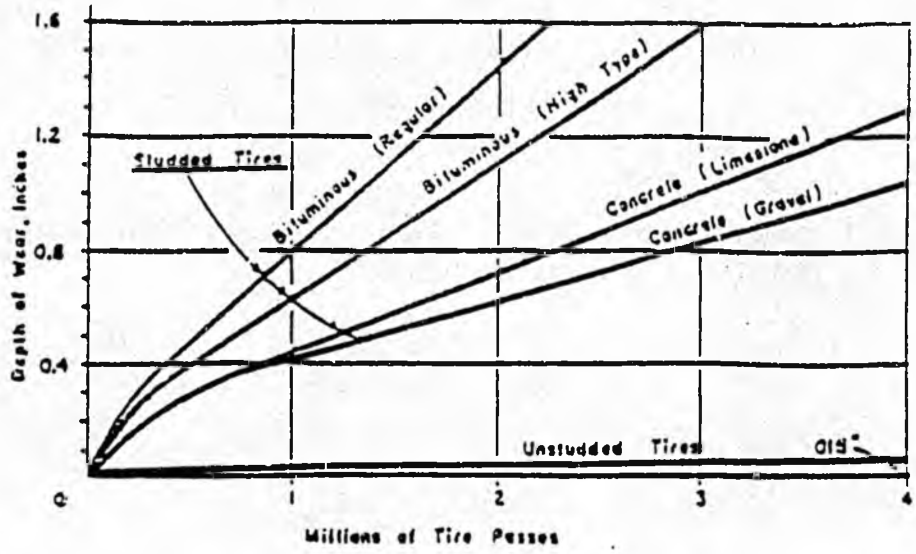
Figure 3.3 shows the effect of stud type on the average rate of wear on a test track under 542,000 wheel passes. In all cases, the wear rate was greatest during the initial 160,000 wheel passes. Wear rates then decreased to only 11 to 31% of the initial rates during the final 220,000 wheel passes. Type I and III studs caused much greater wear than type II studs.

Table 3.1. Cause of pavement wear under studded tires (after Niemi, 1978).

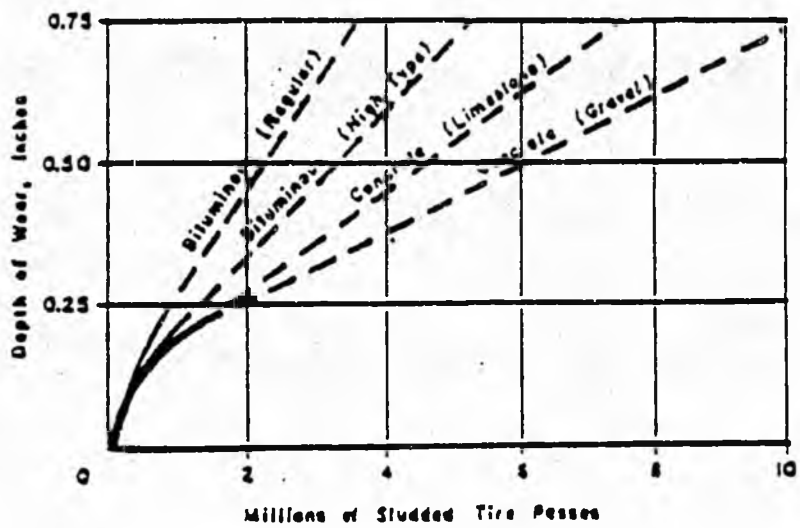
Cause	Description
1	The scraping action of the stud produces marks of wear on the mastic formed by the binder and the fine-grained aggregate.
2	The aggregate works loose from the pavement surface as a result of scraping by studs.
3	Scraping by the stud produces marks of wear on stones. Only in very soft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

Table 3.2. Factors affecting pavement wear (Keyser, HRR 331, 1970).

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



a) Wear rates of pavement specimens at test track



b) Wear rates of pavements of typical Minnesota highways

Figure 3.1. Relationship of studded tire induced wear vs. pavement type; Minnesota research (Keyser, HRR 352, 1971).

Table 3.3. Effect of Factors on Resistance of Asphalt Pavement to Wear by Studded Tires (Keyser, HRR 352, 1971).

Factors	Influence on Wear	Wear Ratio
Penetration of bitumen[a] 60 vs 300	Significant	1:1.3
Bitumen content[a] 5 vs 7 percent (opt. at 7 percent)	Very significant	1:1.8
Type of aggregate[b] Lamprophyre vs limestone	Very significant	1:1.6
Mix type[b] Special mix vs sheet	Very significant	1:1.8
Voids in mix[a] 3 vs 7 percent	Significant	1:1.4
Uniformity[a] Asphalt concrete variation	Variation	X ± 42 percent
Vehicle Speed[a] 60 to 80 km/hr	Not significant	–
Vehicle Weight[a] Car vs truck	Very significant	1:1.9
Tire pressure[a]	Not significant	–
Temperature[c] 37 ± vs 50 F	Very significant	1:1.5

[a]Data taken from Norwegian studies
[b]Data taken from Keyser's work
[c]Data taken from Finnish studies

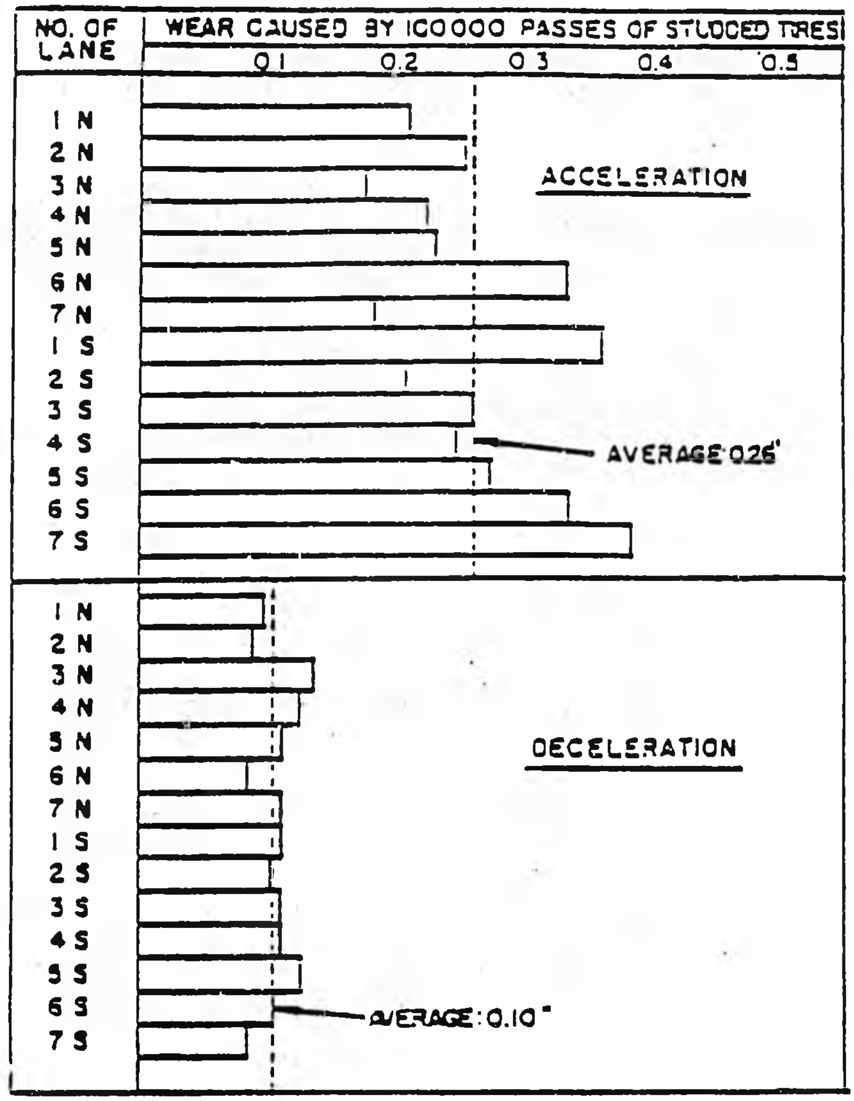
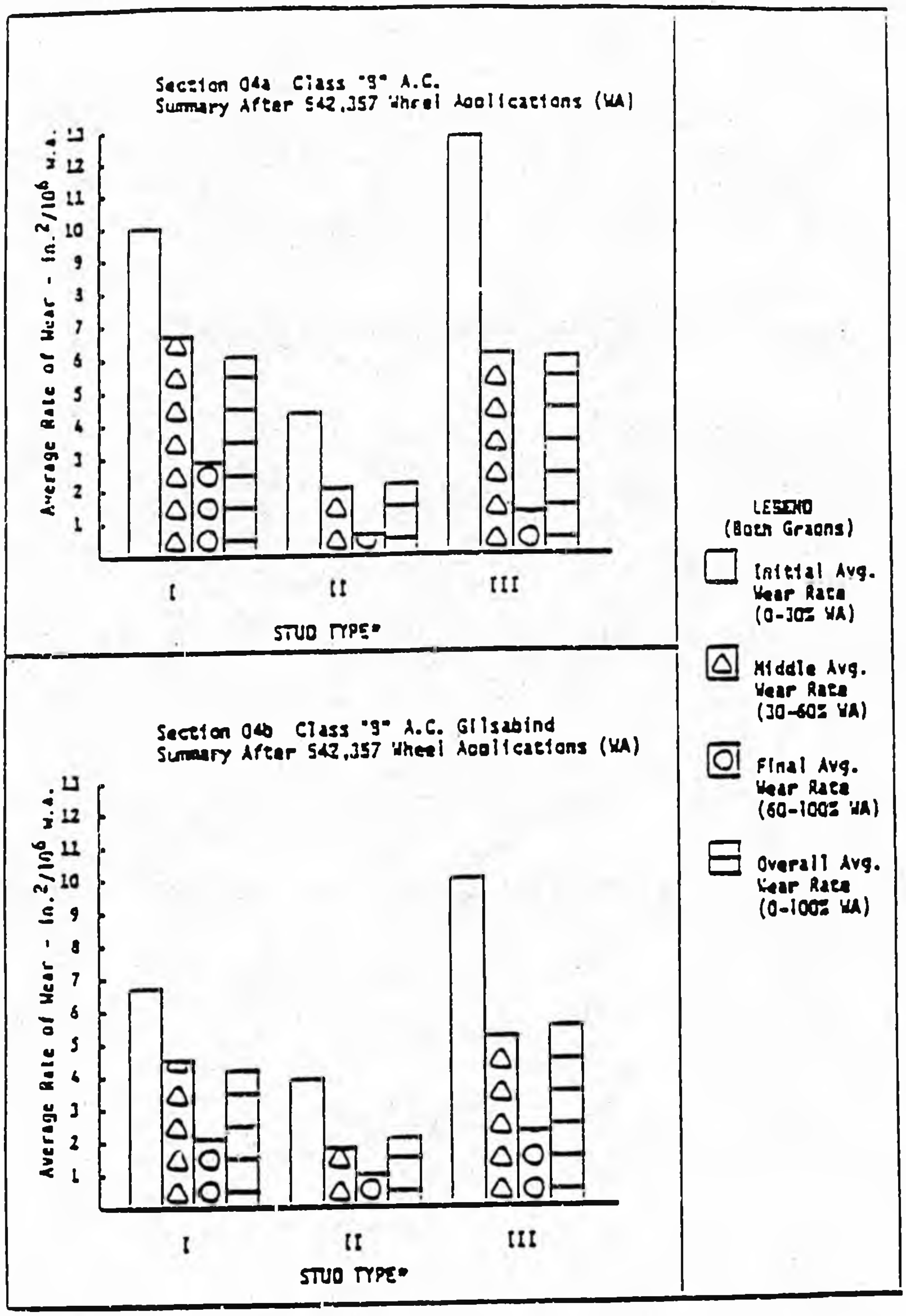


Figure 3.2. Relationship between acceleration and deceleration on portland cement concrete (Keyser, HRR 352, 1971).



* Wear Rate Due to Unstudded Tires Insignificant or Immeasurable.

Figure 3.3. Effect of Stud Type on Wear for Asphalt Concrete Pavements (Krukar and Cook, 1972).

Finally, temperature affects wear rates for asphalt concrete. The work by Krukar and Cook (1973) shows the lowest wear rate at or near 0°C. Increases in pavement wear as pavement temperatures go below 0°C are reportedly associated with increased tire hardness and pavement stiffness. As temperature decreases, pavement stiffness increases, as does the force required to push the stud into the tire so that tire so that it is flush with the pavement surface. Thus, at low temperatures, the combination of high stud force and increased pavement brittleness may result in increased wear rate. However, in Alaska it has been observed that wintertime frost and ice formation on roadways in colder cities such as Fairbanks can provide a protective surface coating and greatly reduce the low temperature wear rates.

The rate of wear reportedly increases when the pavement is wet (Keyser, 1970).

3.3 Pavement Wear Studies

The number of pavement wear studies is quite limited. However, both the literature review and survey did yield some basic information as shown in Table 3.4. In general, these results indicate:

1) Reported wear rates vary considerably between agencies. This likely is due to differences in percentages of vehicles with studded tires, and to materials differences.

2) Pavement type has a great effect on pavement wear. Asphalt surfaces wear at a faster rate than portland cement concrete.

3) In areas of acceleration and deceleration, pavement wear increases substantially.

4) Mixes with larger, more durable aggregates wear less.

In addition, other factors were shown to influence the wear rate. These are given in Table 3.5.

a) Literature

Reference		Rate of Wear (in./passes)	Avg. Rate/ 100,000 passes
Quebec (1967)		0.25/100,000	0.25
Quebec (1970)	Acceleration	0.36-0.44/100,000	0.40
	Deceleration	0.18-0.20/100,000	0.19
	Normal	0.11/100,000	0.11
Germany (19XX)		0.11/120,000	0.09
Finland (1988)		.15-.2/10,000 AADT	
Sweden (Keyser, 1970)		0.5/40,000 AADT	
Maryland		0.28-1.07/100,000	0.7
Minnesota		1.5/4,000,000	0.04
Oregon (ODOT, 1974)	Concrete	0.028/100,000	0.03
	Asphalt	0.066/100,000	0.07

b) Survey

Reference	Rate of Wear (in./passes)	Avg. Rate/ 100,000 passes
California	0.0005-0.0018/1000	0.12
Connecticut	0.08/1,000,000	0.01
Maryland	0.028-0.107/10,000	0.68
New Jersey	0.05 per year for 5400 AADT per lane	
New York	0.009-0.016/year PCC pavements 0.022-0.025/year ACC pavements	
Oregon	0.032/100,000 PCC pavements 0.073/100,000 ACC pavements	.03 .07
Norway	SPS*: AC = 25, Topeka = 15, Mastic stone = 10-15, PCC = 10	
Sweden	35 g/vehicle (4 studded tires)/km driven	

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

Table 3.5. Factors affecting studded tire wear.

Factor	Variable	Comments
Traffic (ADOT)	Normal	Standard wear
	Acceleration	Increases wear rate by 300%
	Deceleration	Increases wear rate by 200%
Surface Type (ADOT)	Bare pavement	Increases wear rate*
	Snow pack	No wear

*Amount not reported.

4.0 IMPACTS OF STUDDED TIRE USE

The impacts of studded tire usage are twofold: 1) increased costs to the agencies through accelerated pavement wear as well as through safety problems created by the wheel track ruts and 2) benefits derived through increased traction during icy conditions which either improve safety or allow increased speeds. The use of studded tires is somewhat dependent on the agency's ice control practices. For example, heavy salt use for a "bare pavement" policy reduces icy road concerns in exchange for increased vehicle and bridge corrosion effects. This section of the report discusses each of these impacts, and is based on the results of the literature review and of the survey of agencies.

4.1 Economic Impacts

The survey of agencies clearly indicated that increased pavement wear was the major concern of most agencies. Safety problems due to increased wear of pavement markings were another concern. However, in most cases the improved stopping distance and/or maneuverability associated with studded tire use generally offset any negative impacts.

Though costs were not requested in the survey, the literature has some data which is useful in defining the economic impacts (Table 4.1). Though most of this information is from Scandinavia, it clearly indicates substantial costs associated with pavement wear, but a potential benefit due to improved (not reduced) safety and reduced winter maintenance (e.g., sanding) costs.

Table 4.2 also provides information on the additional costs associated with the continued use of studded tires on municipal roads and streets in Ontario. As indicated, not only does the cost for pavement maintenance increase, but significant costs can be realized in replacing traffic markings.

Table 4.3 summarizes the impacts of studded tire usage. Clearly the primary reason people use studded tires is for improved maneuverability and control under icy conditions.

4.2 Benefits of Studded Tires

Clearly the primary benefit of studded tires is improved traction (apparent) and hence improved safety. This is noted in the survey of agencies; however, little documentation was provided to substantiate the benefits.

Table 4.1. Annual cost effects of studded tires on pavement wear and safety (for a ban on studded tires).

Agency	Pavement Wear Costs	Winter Maintenance Costs	Accident Costs
Oregon DOT (1974)	+1.1 million	NA	NA
Finland (Pelkonen, 1978)	+175 to 250 million mks	-44 million mks	-0 to 190 million mks
Sweden (VTI - 1988/89)	+160 to 250 million SEK (national roads)	NA	-560 to 1160 million SEK (switch to snow tires)
	+95 to 150 million SEK (municipal roads)	NA	-1230 to 2590 million SEK (switch to summer tires)

Notes:

6 SEK = 1 U.S. dollar
4 mks = 1 U.S. dollar

+ Increase in costs
- Decrease in costs

NA = Not available

Table 4.2. Estimate of additional agency costs in Ontario due to the continued use of studded tires (Smith and Schonfeld, HRR 331, 1970).

Financial Year	Department of Highways				Municipalities				Grand Total
	New Pavement Construction[a]	Resurfacing and Patching[b]	Traffic Marking[c]	Total	New Pavement Construction[d]	Resurfacing and Patching[e]	Traffic Marking[f]	Total	
1970-71	608,000	589,000	1,078,000	2,276,000	458,000	470,000	1,078,000	2,006,000	4,281,000
1971-72	625,000	1,533,000	902,000	3,060,000	469,000	1,226,000	902,000	2,597,000	5,657,000
1972-73	855,000	4,298,000	778,000	5,931,000	641,000	3,438,000	778,000	4,857,000	10,788,000
1973-74	683,000	5,769,000	302,000	6,754,000	512,000	4,615,000	302,000	5,429,000	12,183,000
1974-75	625,000[g]	5,960,000[g]	325,000[g]	6,910,000	469,000	4,768,000	325,000	5,562,000	12,472,000
1975-76	625,000[g]	2,250,000[g]	1,325,000[g]	4,200,000	469,000	1,800,000	1,325,000	3,594,000	7,794,000
1976-77	625,000[g]	8,569,000[g]	1,325,000[g]	10,519,000	469,000	6,855,000	1,325,000	8,649,000	19,168,000
1977-78	625,000[g]	18,607,000[g]	1,325,000[g]	20,557,000	469,000	14,886,000	1,325,000	16,680,000	37,237,000
1978-79	625,000[g]	8,578,000[g]	325,000[g]	9,528,000	469,000	6,860,000	325,000	7,654,000	17,182,000
Total	5,896,000	56,153,000	7,685,000	69,734,000	4,425,000	44,918,000	7,685,000	57,028,000	126,762,000

[a]Costs include both concrete and bituminous pavements.
[b]Costs include additional costs of providing more wear-resistant surfaces for the normal resurfacing program.
[c]Additional cost of providing more permanent traffic markings for both new pavements and existing ones.
[d]Taken as 75 percent of corresponding King's Highway figures.
[e]Taken as 80 percent of corresponding King's Highway figures.
[f]Taken as 100 percent of corresponding King's Highway figures.
[g]Estimated figure based on continuance of department's construction and resurfacing program at about the level of preceding years.

Table 4.3. Impacts of studded tire usage.

a) Consequences

Factor	Consequences
Effect on Safety	• Increased rutting, ponding and hydroplaning • Increased splash and spray
Effect on Pavement	• Destruction of pavement markings • Increased rutting • Build up of snow and ice in ruts

b) Benefits

Factor	Benefit
Effect on safety	• Improved stopping distance on ice • Improved maneuverability on ice
Effect on pavement	• None identified

The literature review shows mixed results. Smith et al. (1971) shows a minor benefit in terms of stopping distance on asphalt pavements and mixed benefits on concrete pavements (Table 4.4). This is also shown in Figures 4.1 and 4.2 for wet and dry pavements. However, Figure 4.3 clearly indicates the benefits of studded tires on ice (i.e., significantly improved stopping distances). Finally, it is clear from Figure 4.4 this decrease in stopping distance is not due to increased pavement skid resistance. Work by Smith et al. (published in HRR 352) shows that in most cases the skid resistance decreases with increasing use of studded tires.

Results of a recent skid survey done in Alaska in the summer of 1987 indicated that higher traffic areas were more polished and had lower skid numbers by late summer. However, pavement age was not a factor, so total number of stud passes were not a factor. The conclusion was that studs roughen the pavement and that normal tires polish the pavement (Ryer, 1988).

Table 4.4. Stopping distances from report for the Canadian Safety Council (Smith et al., HRR 352, 1971).

Stopping Distances from 50 miles per hour (in feet) Under Various Road Conditions	Dry Asphalt	Wet Asphalt	Dry Concrete	Wet Concrete	Glare Ice 0°C
Highway tread on 4 wheels	121	151	105	154	640'
Snow tire tread on rear wheels	118	148	106	165	620'
Studded snow tire on rear wheels	117	142	115	177	580'
Studded snow tire on 4 wheels	116	149	122	195	500'

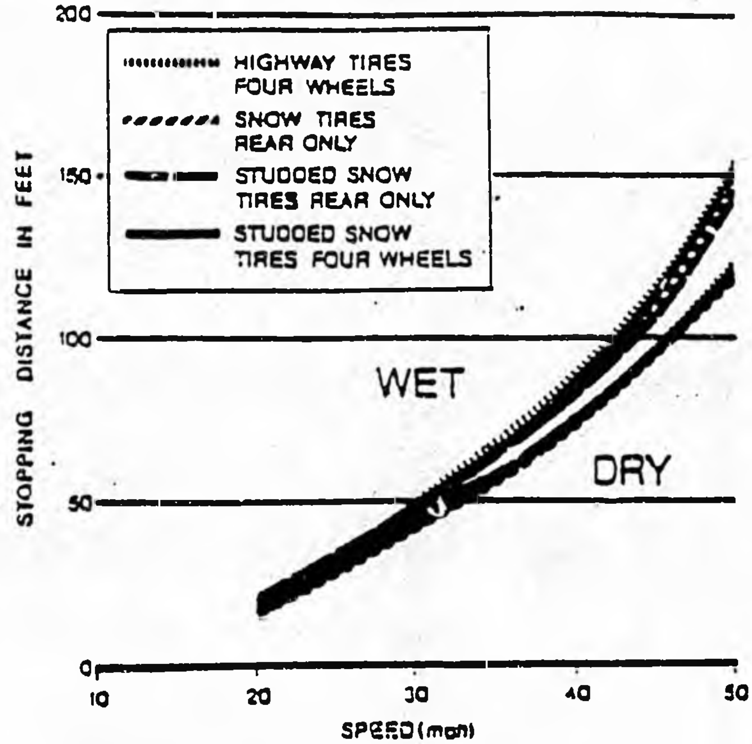


Figure 4.1. Stopping distance versus speed for cars traveling on asphalt pavement (Smith, et al., HRR 352, 1971).

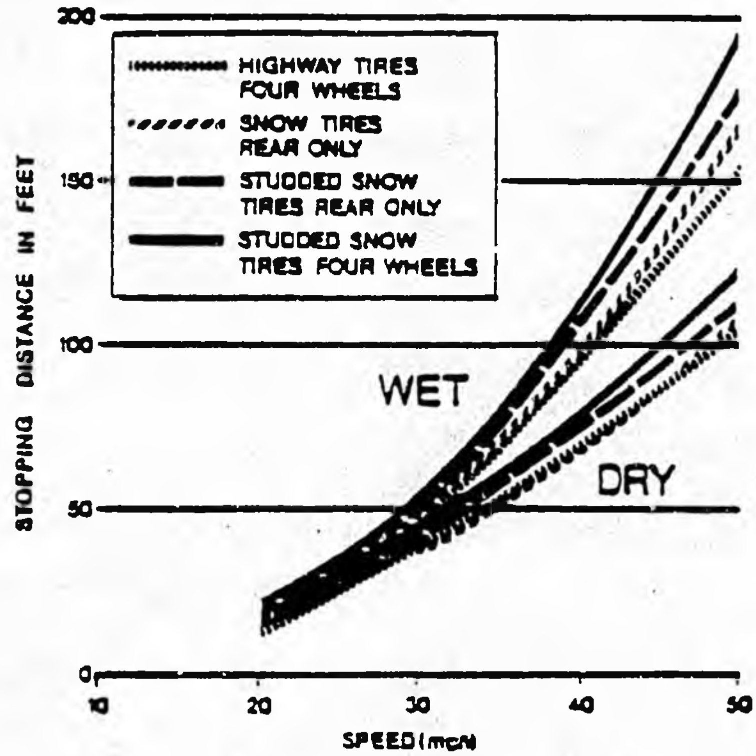


Figure 4.2. Stopping distance versus speed for cars traveling on concrete pavement (Smith, et al., HRR 352, 1971).

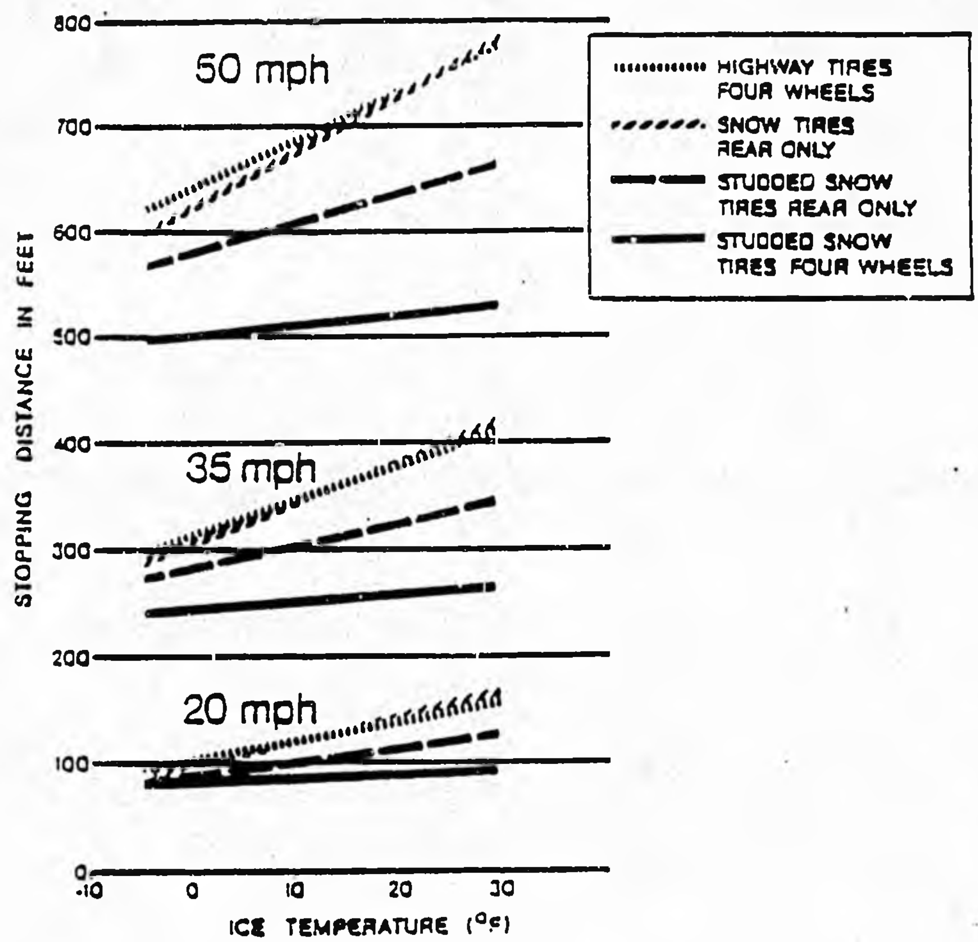


Figure 4.3. Stopping distance versus ice temperature for four cars traveling at 20, 35, and 50 mph (Smith et al., HRR 352, 1971).

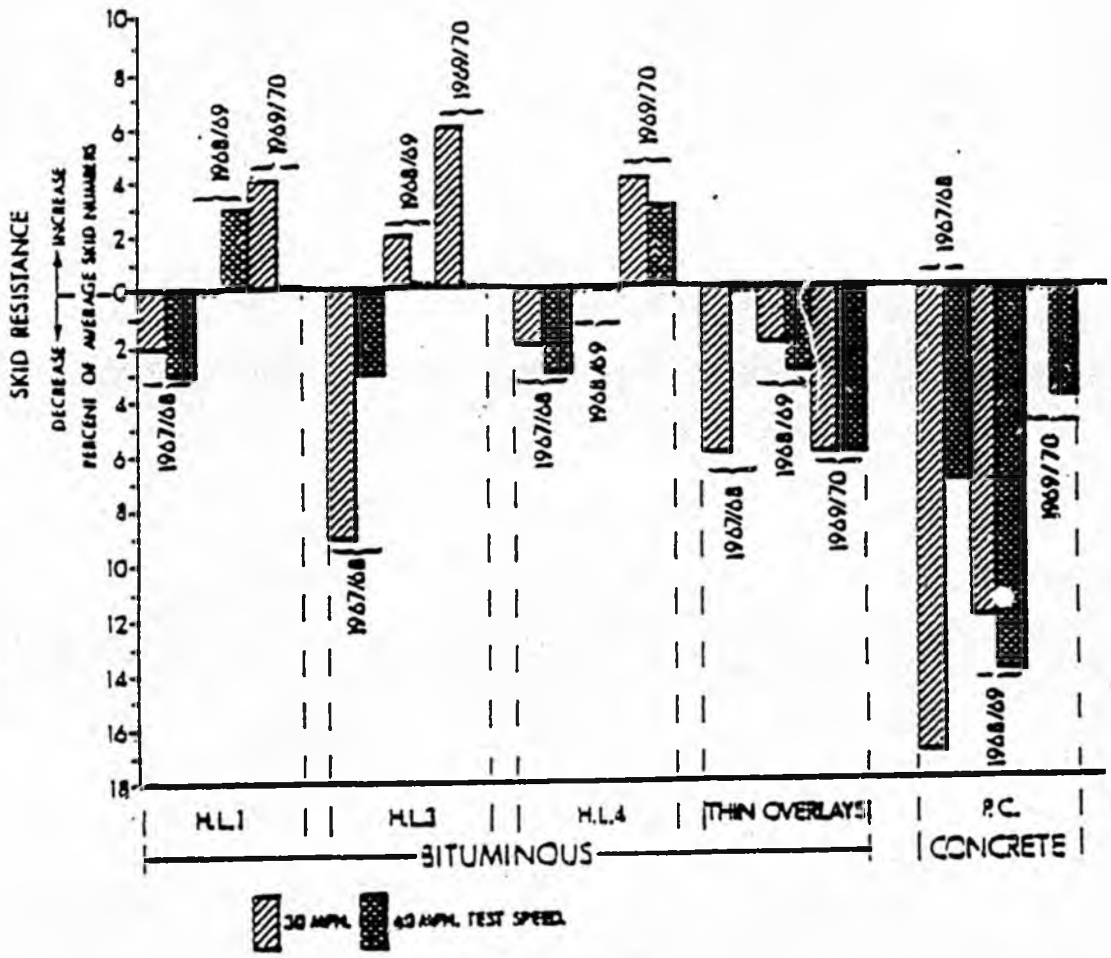


Figure 4.4. Changes in skid resistance of some pavements in Ontario with increasing use of studded tires (Smith and Schonfeld, HRR 352, 1971).

5.0 SUMMARY

This report presented a summary of the results of a literature review and survey of agencies on the use and effects of studded tires. Significant findings include the following facts:

1) Very little research has been done since 1975 in this area, with the exception of the Scandinavian countries.

2) Many agencies continue to prohibit or restrict the use of studded tires.

3) Very little new information on percent of vehicles using studded tires or on tire wear studies was available. Agencies basically do not know the rates of stud use.

4) Factors affecting wear rates were defined (e.g., pavement type, temperature, acceleration and deceleration areas).

5) The consequences and benefits of using studded tires were identified, but remain largely unquantified.

6) Telephone conversations with the manufacturers/distributors revealed that only the controlled protrusion type stud is currently used in the U.S.

Car owners continue to spend millions each year on studded tires for perceived or real benefits. Benefits associated with new tire types, radials instead of bias-ply tires, all-season treads vs. the older summer and winter treads, have not been evaluated in the USA. The shift from rear axle to front axle drive would also increase the effectiveness of studs on the drive axles, since the front axles perform much of the braking work. Therefore the above conclusions may no longer be valid.

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