AFTER STUDS IN MINNESOTA

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After six winters of legalized use in Minnesota (1965 to 1971), studded tires were prohibited during the winters of 1971-72 and 1972-73. Comparisons are made in this report of the effects observed after 1 year without studs as against the previous 6-year period with studs. Observations were made over several winters on various types of roads and streets to ascertain the proportion of time that icy cover conditions prevailed when studded tires could have some beneficial effect. Up to 44,000 such observations were made in the winter of 1971-72. Icy conditions prevailed no more than 1 percent of the time in the metropolitan area on predominantly high-volume and high-speed roads. On low-volume and low-speed roads and streets, icy conditions occurred much more frequently. Traffic accident data were assembled and analyzed by the Minnesota Department of Public Safety comparing the records for the 1971-72 winter without studs against the preceding three winters with studs. For snowy or icy roads, the winter without studs compared favorably with the previous winters with studs. All things considered, there was no appreciable increase in traffic accidents because of discontinuance of studded tires. Noise level measurements indicated that pavements badly worn by studded tires and having coarse aggregate particles exposed could yield noise levels almost twice as high as the original surface texture might produce.

•FOR the second winter season, Minnesota resident motorists are now driving without studded tires after previously having experienced six winters, from 1965 to 1971, during which the use of studs was permitted. The 1971 legislature did not legalize studded tires for Minnesota residents for the 1971-73 biennium. This situation has therefore provided a rather unique opportunity to compare observations and recorded data from last winter when studded tires were not used against the records for the previous winters when studs were in use. This report will present comparisons on pavement surface wear, studded-tire use in Minnesota, winter road cover conditions, traffic accident data, and pavement surface effect on traffic noise.

PAVEMENT SURFACE WEAR

Since studded tires were first legally introduced in Minnesota in 1965, the Minnesota Department of Highways has made field observations and measurements on pavement surfaces to determine the degree of wear that was associated with the use of studs. Initially only six wear measurement sites were established, but this was increased to 85 sites that were distributed about all regions of the state to obtain representation of various pavements, traffic volumes, and geographic locations.

The measurements were in all cases obtained from dial gauge readings taken at 1-in. intervals across the wheelpath from a frame set on metal plugs embedded in the pavement surface. From these measurements there was established, for each of several pavement types, a relation between the rate of wear and the number of studded-tire applications.

Following the ban on studded tires, the pavement wear measurements were continued on the previously established test points. In addition, a number of new test points were established on several new pavement sections that had never been subjected to the previous volumes of studded-tire traffic. The measurements, therefore, on the new pavements following the winter of 1971-72 represent the wear induced by

normal traffic with sand and salt applications but with virtually no studded tires.

The annual and cumulative depths of surface wear that occurred at a number of typical measurement points are given in Table 1. From these data, it is evident that, after the winter of 1971-72 and with the ban in effect, pavement wear was reduced to virtually nil. Similarly, on the other test points the results were the same, thus confirming the conclusions of all our previous studies that the pavement wear was unquestionably related to the studded-tire applications.

STUDDED-TIRE USE

The proportion of passenger vehicles in the state that were equipped with studded tires was determined by making a series of wintertime surveys at various locations throughout the state. It was found that the percentage had increased from about 3½ in the first winter to approximately 40 in the winter of 1969-70 and somewhat less in the winter of 1970-71.

As a follow-up to the ban on studs, another statewide survey of the extent of their use was conducted last winter. This was of particular interest because the 1971 law permitted limited use of studded tires in Minnesota by nonresidents, up to a maximum of 30 calendar days in a year. This survey was made by checking on nearly 4,000 parked cars, a large portion of which were in a number of cities located fairly close to the borders of adjacent states that did not ban studs.

The out-of-state vehicles composed less than 8 percent of all vehicles checked, varying from about 4 percent in the metropolitan Minneapolis-St. Paul area to about 12 percent in communities in southeast Minnesota, including Rochester, the medical mecca. Of the out-of-state vehicles, less than 11 percent were equipped with studded tires. Therefore, less than 1 percent of all vehicles had studded tires, even in the areas where out-of-state cars were most numerous and studded-tire concentration might be expected to be greatest.

Only 3 Minnesota-licensed vehicles out of the 4,000 checked were found to have studs, indicating a high degree of compliance on the part of Minnesota residents.

ROAD COVER CONDITIONS

The road cover conditions existing day by day on the streets and roads were observed and recorded during each of the winters of 1969-70, 1970-71, and 1971-72. The cover conditions were classified into three categories: bare pavement, loose snow or slush, and ice or hard-packed snow. Six types of roadways were observed. The proportion of time that each of the cover conditions occurred on each type of road was computed.

For the first 2 years, about 18,000 observations were made each winter on representative thoroughfares in the Twin Cities metropolitan area, including adjacent rural areas. In the 1971-72 winter, however, the observations were extended to represent all areas of the state, and more than 44,000 recordings were noted. Observations were made in both the morning and afternoon of each workday from October 15 to April 30, covering the calendar period in which studs were allowed until the time of the ban.

The indications from the 1971-72 survey suggested that, for the purpose of summarizing the data, the state could be divided into three regions: north, south, and metropolitan. Accordingly, the data given in Table 2 indicate the percentage of time during the winter driving season that each cover condition prevailed on each type of road in each of the three regions.

It is evident that, for all types of roads, the pavements are for most of the winter season either bare or covered with loose snow or slush. Under such conditions it then follows that, for the majority of the time, studded tires offer no potential stopping advantage and may at times display a small disadvantage.

For condition 3 (ice and hard-packed snow), where studs have been shown to provide a stopping advantage, the data show that such conditions prevail from 1 to 33 percent of the winter driving season, with the higher proportion being on roads and streets carrying low traffic volumes and generally at lower speeds. On the state trunk highways where traffic volumes and maintenance are typically at higher levels, the icy occurrence is 4 percent or less. Icy conditions occur less than one-sixth of the time on

arterial streets and county roads. Only on township roads and on residential streets in out-state areas, where traffic volumes and speeds are lowest, do the icy conditions prevail up to one-third of the wintertime. These findings substantially corroborate those reported from the earlier surveys.

TRAFFIC ACCIDENT DATA

The 1971 report that the Department submitted to the legislature on studded-tire effects concluded that "if studded tires were discontinued there would be little appreciable change in traffic safety in Minnesota." Statistics covering accidents during the winter of 1971-72 when studs were banned have been compared with the records for previous years when studs were in use. Data compiled by the Minnesota Department of Public Safety are summarized in Tables 3 and 4.

The numbers of accidents vary considerably from year to year, and even more so from month to month and day to day, depending greatly on road conditions. The apparent small increases in accidents in each of the past 2 years are within the variation that might be expected from winter to winter with the normal increase in traffic of about 5 percent per year.

Considering the data given in Table 3 on all winter accidents, the record for the 1971-72 winter without studs compares favorably with the preceding winter with studs and even more so with the averages for the three preceding winters when studs were used. Indeed, in terms of fatal accidents, the studless winter was 15 percent lower than the winter before with studs. Although the total number of accidents last winter was slightly higher than the winter before (by only 3 percent), it was nevertheless lower than the average for the three preceding winters.

The data given in Table 4 for accidents that occurred on snowy or icy roads—where studded tires should have provided their greatest advantage—show that the record for 1971-72 without studs again compares quite favorably with the previous winters when studs were used, notwithstanding the slightly higher number of fatal accidents. However, the fatal accidents are so relatively few in number that chance influences the statistics to a much greater degree than it does for property damage accidents. Some of the apparent small increase in police-reported fatalities may be due to administrative changes in the Minnesota Highway Patrol accident reporting procedures in which some accidents in 1969-70 were not coded as to road conditions.

Traffic volumes were about the same for the three winters preceding the winter of 1971-72. Data for 1972 are not yet available. The snowfall average statewide was slightly less in the early months of last winter, but the total (52.6 in.) was about average for the past three winters. In general, the weather last winter was not substantially different from previous winters.

All things considered, it can be concluded that there has been no appreciable increase in traffic accidents in Minnesota because of the discontinuance of studded tires.

The accident study conducted by Cornell Aeronautical Laboratory, Inc., for the Minnesota Department of Highways and reported to the 1971 legislature showed a slight benefit for studded tires in accidents involving sliding on icy or snowy road surfaces. Following that study, the Highway Research Board under the National Cooperative Highway Research Program contracted with Cornell Aeronautical Laboratory, Inc., for further studies including a "before-and-after" study in Minnesota and a before study in Michigan. The statistical analysis of the Minnesota data is not complete, and the findings are not expected until late winter or spring of 1973. Details of more than 18,000 accident situations for both the before and after conditions are available for analysis.

PAVEMENT SURFACE EFFECT ON NOISE

One effect that studded tires have indirectly produced but that has not received much attention is the increase in traffic noise level caused by stud-roughened pavements. Inside a car, the sound often becomes a noisy rumble when traveling over rough, stud-worn wheelpaths. Outside the vehicles, a rough road surface texture such as produced by studded tires accentuates the noise generated by tire-pavement interaction.

In an attempt to quantify the differences in noise level produced by various pavement

Table 1. Depth of pavement surface wear at typical test points (in inches).

Winter	TP 6[a]		TP 33[b]		TP 32[c]		TP 83[d]	
	Yearly	Cumulative	Yearly	Cumulative	Yearly	Cumulative	Yearly	Cumulative
1966-67	0.04	0.04						
1967-68	0.07	0.11						
1968-69	0.07	0.18	0.09	0.09	0.10	0.10		
1969-70	0.05	0.23	0.07	0.16	0.03	0.13	0.08	0.08
1970-71	0.05	0.28	0.06	0.22	0.07	0.20	0.07	0.15
1971-72	0.00	0.28	0.00	0.22	0.00	0.20	0.01	0.16

[a]Test point 6, portland cement concrete, gravel aggregate.
[b]Test point 33, portland cement concrete, limestone aggregate.
[c]Test point 32, asphaltic concrete, high type.
[d]Test point 83, bituminous, intermediate type.

Table 2. Road cover conditions, winter 1971-72 (percentage of time prevailing).

Type of Road	Condition 1, Bare			Condition 2, Loose Snow or Slush			Condition 3, Ice or Hard-Packed Snow		
	North	Metropolitan	South	North	Metropolitan	South	North	Metropolitan	South
Divided highway	87	92	91	9	7	5	4	1	3
Undivided highway	87	91	91	10	8	5	4	1	4
County road	69	83	82	16	14	9	15	2	10
Township road	52	59	62	18	34	9	29	7	29
Arterial street	68	79	73	16	17	13	16	4	14
Residential street	49	51	59	18	36	12	33	12	28

Table 3. Accidents on all roads, November through April.

Type of Accident	1968-69	1969-70	1970-71	3WA[a]	1971-72
Fatal	332	320	334	329	284
Personal injury	11,747	11,402	11,148	11,432	11,507
Property damage only	49,074	41,978	43,405	44,819	44,762
Total	61,153	53,700	54,887	56,580	56,553

[a]3WA = 3-winter average; studs in use.

Table 4. Accidents on snowy or icy roads, November through April.

Type of Accident	1968-69	1969-70	1970-71	3WA[a]	1971-72
Fatal	78	69	78	75	82
Personal injury	4,372	3,246	3,865	3,828	4,078
Property damage only	19,374	11,081	12,150	14,202	12,730
Total	23,824	14,396	16,093	18,105	16,890

[a]3WA = 3-winter average; studs in use.

surfaces, a limited study of preliminary nature was conducted last fall in which noise measurements were taken on a series of five bituminous pavements and five portland cement concrete pavements located in the Twin Cities metropolitan area. Each of the two types of pavements included surfaces that were classified as smooth and others that were rough-textured in varying degrees.

The noise level intensity was measured with a standard B&K sound meter, model 2204, mounted on a tripod 4 ft above pavement level and set at a distance of 25 ft from the edge of the pavement. A 1970 Ford 4-door sedan was driven past the meter at constant speed of 45 mph, with the motor running but under no acceleration while passing. Care was taken to avoid any noise interference from other vehicles in the vicinity. All tests were made with a windscreen attached to the microphone and only when wind velocity was under 15 mph.

The smoothest one of the bituminous pavements, constructed in 1972 and not exposed to studded tires, produced a sound level of 72 dBA. The reading on another bituminous surface abraded by 7 years of moderate traffic, including 6 years of studded tires, reached a level of 78 dBA. Other surfaces that have been more severely roughened by much higher traffic volumes would obviously produce even higher noise levels. Unfortunately, it was not possible to obtain readings on any such section because of extremely heavy traffic and time limitations during the period of the survey. Therefore, the difference in noise level between the smoothest and roughest bituminous surfaces in this area would be well in excess of the 6 dBA.

Of the portland cement concrete pavements, the lowest noise level was 73 dBA on a slab constructed in 1966 but not opened to traffic. The highest reading, 82 dBA, was recorded at a section of Interstate highway that has been under extremely heavy traffic for 14 years including 6 years with studded tires. The difference of 9 dBA from the lowest to the highest in this instance would represent almost a doubling of the perceived loudness because of the studded-tire wear.

The results of these tests, though very preliminary, indicate that the surface texture and composition of both types of pavements have a significant influence on the noise level that emanates from the roadway surface.

Because of public complaint over traffic noise in an urban residential area traversed by an Interstate route carrying more than 100,000 vehicles per day, an experimental section of asphaltic concrete overlay was placed in 1971 over the portland cement concrete pavement that had been moderately roughened by studded tires. The noise reduction achieved in that case measured about 3 dBA. Though seemingly this is not a great reduction by itself, this amount together with that expected on completion of erection of a noise barrier consisting of an earth mound surmounted by a timber wall will go a long way toward alleviating the noise problem for the residents adjacent to this area.

The public reaction to this project, where the pavement roughness was relatively moderate, has been generally favorable. It led, in fact, to placement of a similar overlay on a section of a nearby county expressway that had been more severely roughened by studded tires. This overlay reportedly reduced the neighborhood noise levels by 6 dBA, and the effect has been acclaimed by residents.

As a result of these trial projects, others are being planned to cover pavements that have suffered severe abrasion from studs. It seems likely that, in the future, as vehicle mechanical noise emissions are reduced through regulatory restrictions, pavement-generated tire noise will become the more prominent source of traffic noise. If severe pavement wear, as from studded tires, is expected in noise-sensitive areas, pavement compositions will apparently have to be designed to more effectively resist or compensate for such roughening effects.