IOWA'S EXPERIENCE WITH SPRINKLE TREATMENT OF ASPHALT PAVEMENTS

**Progress Report
for
Project HR-199**

**Submitted for Presentation
at the 62nd Annual Meeting
of the**

TRANSPORTATION RESEARCH BOARD
Washington, D.C.

Iowa Department
of Transportation

Highway Division
July 1982

PROGRESS REPORT
FOR
PROJECT HR-199

IOWA'S EXPERIENCE WITH SPRINKLE TREATMENT OF ASPHALT PAVEMENTS

BY

ROBERT A. SHELQUIST
BITUMINOUS ENGINEER
515/239-1003

AND

CHARLES L. HUISMAN
MATERIALS ENGINEER
515/239-1452

OFFICE OF MATERIALS
HIGHWAY DIVISION
IOWA DEPARTMENT OF TRANSPORTATION
AMES, IOWA 50010

JULY, 1982

ABSTRACT

The practice of sprinkle treating asphalt surfaces with high-quality aggregate to provide improved frictional characteristics has been used in Europe since the 1960s. Use of sprinkle treatments on asphalt mixtures produced with locally available aggregates has economic potential while conserving high-quality aggregate resources. Iowa's first sprinkle treatment effort was in 1975 with a truck-mounted dual spinner, tailgate spreader. English-built Bristowes chipping spreaders have been used for uniform distribution of all Iowa sprinkle treatments since 1977.

The objective of this paper is to relate Iowa's experiences in improving frictional characteristics using sprinkle treatments.

A 5.3-mile (8.5-km) research project was constructed in 1978 to evaluate sprinkle treatment surfaces. Six different sprinkle aggregates were rolled into three standard mixes used for asphalt surface courses. The sprinkle aggregates were quartzite, crushed gravel, granite, expanded shale lightweight aggregate, dolomite, and a limestone-dolomite mixture.

Precoating of the chips is one of the most important aspects of successful sprinkle treatments. Poorly coated chips result in substantial losses of sprinkle aggregate from the finished surface. Lowering temperatures after drying the sprinkle aggregate yields better coating. Manipulation of coated chips in small piles with a light sprinkling with water just prior to use reduces congealment problems.

Friction testing has shown the greatest improvement from quartzite and expanded shale, with 8- to 10-point higher friction numbers when compared to the nonsprinkled sections. Sprinkle treatments also yield greater macrotexture.

INTRODUCTION

In recent years, much emphasis has been placed on highway safety through geometric design factors, the diligent use and placement of manufactured materials such as guardrails, and the use of quality natural resource materials. In addition, conservation of natural resources and escalating cost factors are concerns which have been addressed in some form in many conference programs and/or papers.

This paper will discuss a method Iowa is using as a means of treating the surface of asphalt pavements to increase texture characteristics and at the same time conserve our supply of high-quality, non-polishing aggregates.

Open graded friction courses have been used extensively as a means of improving frictional characteristics of asphalt pavements. Iowa has constructed three experimental projects using this concept but was disappointed in the results. Some of the conclusions which came from these projects were:

1. They quickly became impermeable due to dirt being deposited on the pavement and they lacked the edge drainage which is needed but often requires an edge drop off, a factor that is also recognized as a hazard.
2. They spalled excessively at reflected cracks.
3. They required a minimum of 60 pounds (27 Kg) of high-quality aggregate per square yard.

Sprinkle treating or "chipping" is a process of spreading quality coarse aggregate (chips) on both bituminous and portland cement concrete pavements to provide improved frictional characteristics. This process has been used in

Europe since the early 1960s. Experimental projects utilizing this process were first constructed in Virginia (1) in 1969 and in Texas (2) in 1972.

IOWA'S EXPERIENCE

Emphasis on skid resistant, non-polishing highway surfaces and the monitoring of them precipitated an in-house "Skid Review Committee" in late 1972. Since that time, increased emphasis in design of asphalt mixes and aggregate selection of durable, non-polishing materials has generated costly restrictions on the use of local materials, even to the point of importing trap rock and quartzite from Wisconsin, Minnesota and South Dakota.

In 1975, with the cooperation of the Office of Maintenance, Iowa made its first attempt at sprinkle treatment. A dual spinner, tailgate spreader was mounted on a standard dump truck for use in sprinkle treating a new asphalt surface. The dump truck equipment was marginally satisfactory since the lug tires of the truck left marks in the finished pavement, the uneven distribution of chips caused depressions in the surface, and the surface texture was not uniform. Results of this experimental work did demonstrate increased surface texture and durability.

In 1976 a new dump truck was modified with an auxiliary transmission and a set of slick-surfaced tires. The dual spinner spreader was mounted to again attempt surface sprinkle treatment. Precoated chips were scheduled to be put on a test section but because of lateness of the season and unusually cold fall weather, the project was delayed until 1977.

The test section placed with this unit in early 1977 again did not produce desirable results. The distribution of the chips was somewhat uneven and the tire marks still reflected even though no depressions were evident.

In June of 1977 the Iowa DOT was advised by the E.D. Etnyre Company that they had a Bristowes model Mark V hydrostatic chipping spreader manufactured in Middlesex, England and that it would be made available to the Iowa DOT through their distributor. In addition, the Bristowes Company advised that their assistant plant manager from England would spend two or three weeks to assist in the procedures and usage of the spreader.

The Iowa DOT was eager to pursue the evaluation of sprinkle treatment further and immediately began the process of developing a specification for aggregates to be used, gradation limits, and coating and application procedures.

A total of 10 projects at various locations in the state were selected. Projects selected for sprinkle treatment were rural two-lane roadways with speed limits exceeding 40 mph (64 km/hr) and traffic volumes in excess of 2,000 vpd. All of the projects had been let without sprinkle treatment so it was necessary to develop extra work order details and costs, as well as construction timing to best utilize the one available spreader. Eight of the projects were 1-1/2" (38 mm) to 2" (51 mm) thick single course resurfacing projects with 1/2" (13 mm) size mixes. The other two projects utilized the Cutler repaving procedure and the addition of 100 pounds (45 kg) of new 3/8" (10 mm) size mix per square yard.

Aggregates selected for sprinkle evaluation consisted of imported quartzite and granite and locally available dolomite, limestone and crushed gravel. Also selected was "Haydite", a manufactured, expanded shale lightweight aggregate. Tests were performed in the central Materials laboratory to determine the asphalt required to obtain a suitable asphalt coating. This was determined to be in the range of 1% to 1.5% for conventional aggregate to 2% for

Haydite. The aggregate was coated in a conventional plant using the same asphalt used in the mix. It was necessary to store it in a clean place and cover the stockpile.

In placing the chips with the spreader, several minor problems were recognized. The spreader had a span of 14 feet (4.3 m) and a clearance of only 5 inches (127 mm) above the roadway surface. Any significant edge drop would, therefore, cause the machine to scalp the fresh AC surface. Also, keeping the outer wheel close to the roadway edge would cause encroachment into the opposing traffic lane. Refilling the spreader hopper presented a problem on roads with narrow shoulders and it became necessary to use the traffic side for the nurse truck and charging loader.

Some problems were encountered in maintaining a uniform chip application rate. It was found that a buildup of asphalt cement and fines in the drum flutes caused this problem. During extremely hot weather the chips would occasionally congeal and clog the distributor hopper. Wetting of the chips in the stockpile or as they were loaded minimized this problem.

Retention of the sprinkle aggregate caused some concern. Loss of the aggregate seemed to range from very little to 50 to 60 percent. Investigation indicated some loss was occurring due to traffic pickup, believed to be from opening the new surface to traffic too soon. Some losses were attributed to excessive fine material causing minor chip concentration or "clumping" which prevented proper imbedment of each individual chip. Additional losses may have occurred from attempting to imbed the sprinkle aggregate into a coarse mix that did not provide sufficient matrix to hold it in place. The most significant loss was attributed to attempting to place sprinkle aggregate with ambient temperatures below 50°F (10°C).

Results of the 40 mph (64 km/hr) friction tests performed on these projects yielded friction numbers ranging from 47 to 54 for the sprinkle sections and 29 to 42 for non-sprinkled control sections.

Another group of 12 projects was selected for further evaluation in 1978. The only change in the specifications was a gradation change to reduce the percentage of aggregate passing the #4 screen from a maximum of 10% to a maximum of 5%.

RESEARCH PROJECT

Surface courses on high-traffic roads in Iowa have historically been a Type "A" 1/2" topsize dense graded mix with a minimum of 65% crushed particles to provide good stability. Aggregates specified are to be non-polishing types.

Since one of the benefits of sprinkle treatment is to provide good frictional characteristics by reducing the amount of high-quality aggregates required, it was acknowledged that a research project would be desirable. The road selected for this research project was a 5.3-mile (8.5-km) section of old U.S. Highway 30 from just east of Ames to Nevada. It was originally paved 18' (5.5 m) wide in 1929. It was widened to 24' (7.3 m) in 1953 and resurfaced with 3" (76 mm) of asphalt concrete in 1956. This was followed by an inverted penetration chip seal in 1974. The average daily traffic for the highway exceeds 4,000 vehicles per day.

The project was developed by dividing the 5.3 miles (8.5 km) into three mix type sections to provide a comparison of the three surface textures normal to Iowa's dense graded mixes. The mixes designed for this project were: (1) a Type B 1/2" (13 mm) topsize dense graded mix composed of 70% pit run gravel and 30% crushed gravel with 5.75% AC-20 grade asphalt cement; (2) a Type B

3/8" (10 mm) topsize dense graded mix composed of 55% crushed limestone and 45% natural sand with 6.25% AC-20 grade asphalt cement; (3) an asphalt-sand surface course composed of 90% clean concrete sand and 10% limestone screenings with 8.0% AC-20 grade asphalt cement. Surface course thicknesses were 1-1/2" (38 mm) for the 1/2" (13 mm) mix size and 1" (25 mm) for the others.

The three sections were each divided into seven sub-sections to provide for control sections and a test section for each of six sprinkle aggregates. Aggregates were to represent a cross-section of readily available types from sources which have been classified as to friction resistance type. Iowa's rating system (3) classifies aggregates on the basis of Mohs' hardness and grain size. Type 1 would be composed of very hard-grained particles (Mohs' 7 to 9) bonded together by a slightly softer matrix. Type 2 has a hardness range of 5 to 7. Type 3 would consist of crushed traprock, gravel and dolomites with a hardness range of 3.5 to 4 and 80% or more of the grains having diameters of 120 microns or larger. Type 4 would have a hardness range of 3 to 4 with 80% of the grains at 30 microns or larger. Type 5 would be lithographic and sublithographic in nature with grain sizes below 30 microns. Aggregates selected were as follows:

Aggregate	Source	Iowa Skid Resistance Rating*
Quartzite	New Ulm, Minnesota	2
Crushed gravel	Hallett Construction Co. Pit Boone, Iowa	3
Granite	St. Cloud, Minnesota	2
Expanded shale	Carter-Waters Plant Centerville, Iowa	3

Aggregate	Source	Iowa Skid Resistance Rating*
Dolomite	Quimby Quarry Mason City, Iowa	4
Limestone/ Dolomite	Ferguson Quarry LeGrand, Iowa	4

* 1 - good 5 - poor

This project was let May 23, 1978 and the contract was awarded to the Iowa Road Builders Company of Des Moines, Iowa.

CONSTRUCTION

Surface Preparation

Surface preparation work was started on July 12, 1978. Areas requiring full depth patches were identified. Removal of the deteriorated material was accomplished by use of a "ditch witch" type pavement cutter to saw the extreme limits of the patch, followed by the use of a jack hammer and end loader to remove the broken material. Asphalt concrete was used as a patching material. Full depth asphalt, properly placed, provides some pressure relief and reduces the problem of pavement blowups. Bulges created in the full depth asphalt by pressure can be trimmed to restore a smooth surface. This, in turn, reduces the amount of patching required in future maintenance.

Surface patching was routine and consisted of chipping out the fractured asphalt material along cracks and joints and backfilling with new asphalt concrete material.

Precoating of Sprinkle Aggregate

Precoating the sprinkle treatment aggregate is the most important, but the most tedious, part of the sprinkle treatment process. Observation of the previous years' work had indicated considerable loss of the sprinkle aggregate on two projects. This was traced to a probable lack of coating or film thickness.

To aid in determining the maximum amount of asphalt needed to completely coat each aggregate, samples were coated in the laboratory. The method used was by a visual observation of three samples coated at different asphalt percentages. The recommended asphalt was generally in the range of from 1% to 1.5% for natural aggregates and 2% for the lightweight aggregate.

A batch type plant was used to precoat the aggregate. Initially, small quantities of each aggregate were coated. The recommended amount of asphalt was used and the coating was observed. If it appeared inadequate (less than 99% coated), additional asphalt was added. The additional asphalt was often required to obtain complete coating. This was attributed to some degradation of the aggregate and some increase in minus #200 material (finer than 0.075 mm) while passing through the dryer.

Congealing during stockpiling and cooling of the precoated aggregate was a problem which had to be dealt with. A suggestion had been made that applying cold water to the hot precoated aggregate would set the asphalt and make congealing less of a problem. It appeared this approach was at least worth consideration so the first load of each aggregate coated was sprayed with water as it was dumped. The cooling process was expedited by manipulation with an end loader. The following morning it was noted some stripping of the asphalt had occurred on several of the aggregates. It was concluded the stripping, while not critical, could not be tolerated. Further experimentation has shown that by placing the freshly coated aggregate in small piles (4' (1.2 m) or less in height) and manipulating it slightly with an end loader, congealment is minimal. Light sprinkling of the aggregate with water at the time it was loaded for use eliminated most lumps by the time the load arrived at the spreader.

Stockpiles should be placed on a clean, hard platform and kept covered if there is any chance of becoming contaminated with fugitive dust, rain or other foreign material. Because of the need for small stockpiles, the fear of congealment and limited paved areas for storing precoated aggregate, precoating was limited to about a two-day supply.

Laydown Operation

Placement of the mat itself was routine as far as equipment and method are concerned. Mix temperatures of the material as it was produced ranged from 275°F to 320°F (135°C to 160°C) for the 1/2" (13 mm) and 3/8" (10 mm) mix. The sand mix was from 265°F to 290°F (129°C to 143°C). At the time of compaction the 3/8" (10 mm) and 1/2" (13 mm) mixes ranged from 250°F to 290°F (121°C to 143°C), while the sand mix ranged from 250°F to 275°F (121°C to 135°C). These temperatures are quite normal for work being done when ambient temperatures are 70 to 80°F (21 to 27°C). Some slowing of production was experienced due to the methods used to charge the spreader.

The spreader is manufactured in England. It is diesel powered, hydrostatically driven and has dual controls to permit operation from either side. The shuttle hopper is mounted on a track and oscillates to distribute the chips evenly in a shallow trough. The opening in the trough is adjusted and controlled by a gate setting mechanism. There is an agitator above the gate opening and mechanical hammers on the front of the trough to keep the chips flowing. The chips are picked up on the top of a fluted drum and delivered over the rear. The chips are dropped to the mat as the flutes reach a downward position.

The spreader distributes the chip uniformly, however, on occasion, a rippled appearance in the mat surface has been noted. This has been traced to the spreader and it was concluded that as the drive chains tend to loosen, the rotation of the drum becomes erratic, causing an uneven distribution of chips. By keeping the drive chains tight and by keeping a uniform speed which will keep the spreader at the desired proximity to the paver, this problem has been minimized.

Sprinkle Aggregate Application

The application rate of the sprinkle aggregate is controlled by the gate adjustment previously described. It is recommended the gate be initially set slightly wider than the maximum size aggregate. It can then be adjusted during operation to obtain the desired coverage, which for this project was 5 lbs. per square yard (2.7 kg/sq. m) of lightweight aggregate (Sp.Gr. = 2.2) and 7 lbs. per square yard (3.8 kg/sq. m) of the natural aggregate (Sp.Gr. = 2.6).

To prevent aggregate overlap at the beginning of each section, a canvas was spread under the spreader and the hopper was emptied. As each new section was begun, the gates had to be readjusted because of the differences in particle size and shape. To expedite the adjustment and to check on the application rate, a 3' x 3' (0.9 m x 0.9 m) canvas was placed ahead of the spreader to collect one square yard of chip application and the collected material was weighed on a scale. This was followed by rate determination and the gates readjusted as required. This process was repeated until the proper application rate was reached. Appearance was also used as a factor in determining and adjusting to the best application rate since the difference in aggregate gradation has an effect on the results, i.e. chips with near maximum percentages passing the 3/8" (10 mm) screen have more of a tendency to pile up, giving the appearance of insufficient coverage. Also, smaller particles are often not imbedded deep enough to be permanently retained. Both conditions have resulted in some loss of sprinkle aggregate. For these reasons, we changed our specifications for future work. Commencing in 1979 a single size aggregate meeting the following gradation was required:

Sieve Size	Percent Passing Minimum	Percent Passing Maximum
3/4" (19.0 mm)	100	
3/8" (9.5 mm)	0	15
No. 4 (4.75 mm)	0	5
No. 200 (0.075 mm)		1.5

A cubical aggregate shape is more desirable than slivered particles.

Compaction

Compaction of the sprinkled surface was routine. Minor delay was experienced because of some difficulty in charging the shuttle hopper. Some contractors are experimenting with methods to develop a rapid charging method. Once this is perfected, the sprinkle treatment and roller operations can closely follow the paver.

The need to delay the opening of sprinkle treated surfaces to traffic in order to reduce the potential of dislodging the sprinkle aggregate was to be considered as part of this research project. However, since progress was slowed somewhat because of the need to change sprinkle aggregates every 1,200 feet (366 m), it was impossible to determine a reasonable minimum time. Project records indicate that traffic was kept off the fresh surface from two to seven hours with the two-hour period being at the end of the day. No dislodging of the sprinkle aggregate by traffic was noted on this project.

FRICTION TESTING

Friction tests have been made several times since completion of the project. The first test was made on August 10, 1978 just after the project was completed. Subsequent tests were made on August 28, September 15 and October 18, 1978, May 15, 1979 and at least once a year since. Tests were made at 40 mph in accordance with ASTM E-274 using an ASTM E-501 standard tread tire.

Graphs have been prepared to illustrate how frictional characteristics are affected by sprinkle treatment. Figure 1 depicts the effects on the 1/2" (13 mm) mix size. Friction numbers are higher on all sprinkled sections except for the one where a coarse grained dolomite was used. Granite, limestone/dolomite and crushed gravel have improved friction numbers by 3 to 5 points; while quartzite and expanded shale produce numbers which run consistently 8 to 10 points higher than the non-sprinkled section.

Figure 2 indicates friction numbers for the control section using a 3/8" (10 mm) Type B mix are about 4 points higher than the 1/2" (13 mm) mix size control section. Coarse grained dolomite and the limestone/dolomite blend have consistently failed to improve the friction numbers. Crushed gravel and granite show a slight benefit with quartzite and expanded shale indicating 8 to 10 points better.

Figure 3 is for the asphalt-sand surface. Friction numbers for the control section are continually in the 47 to 52 range. Quartzite and expanded shale are the only two aggregates which improved the friction numbers.

Considering the combined results shown in the three figures for the control sections, the friction numbers increase as the mix gradations become finer (1/2" or 13 mm to 3/8" or 10 mm to sand). This would seem to indicate that friction numbers are a function of the surface micro texture. However, when considering the friction numbers for the sprinkle treated sections, there is an indication that the friction numbers become more a function of the aggregates, i.e. limestone and dolomites in the lower range, granite and crushed gravel in the mid range, and expanded shale and quartzite performing the best.

The next three figures show the most significant indication of the benefits of sprinkle treatment. In 1982 we began testing with a smooth tread tire (ASTM E 524-76). To show this graphically, results from all of the sprinkle treated sections have been averaged and compared to the control sections. Here again, it is noted that with the smooth tire, friction numbers for the control increases as the surface macro texture (mix size) decreases. It can also be noted that the range in the control sections are uniformly wide (17 to 23 points) but when the sprinkle treated sections are compared, the band is narrowed significantly (9 to 12 points).

TEXTURE

Surface texture measurements using the "silly putty" method (4) were made immediately following the completion of the project. Follow-up measurements were made in April 1979. From this test a very significant improvement in average texture depth is noted (figure 7). Measurements on 1/2" (13 mm) mix non-sprinkled sections show a texture depth of 0.011 inches (0.27 mm), while sprinkle treated sections averaged 0.036 inches (0.91 mm) or 303% greater. The texture depth of the 3/8" (10 mm) mix non-sprinkled sections averaged 0.005 inches (0.12 mm) and sprinkle treated sections averaged 0.036 inches (0.91 mm) or 761% greater. The texture depth of the non-sprinkled sand asphalt section was 0.003 inches (0.07 mm) with sprinkle treated sections averaging 0.016 inches (0.42 mm) or 607% greater.

POST-CONSTRUCTION PERFORMANCE

The initial, and perhaps one of the more significant, difference which has been noticed in comparing the sprinkle treated surface to a non-treated surface is that during a rainstorm the splash or spray from tires of oncoming vehicles is considerably less from the treated surface. It is also noted that at night, headlight glare from a wet surface is significantly less from the treated surface.

The winter following construction was severe, with above normal snow and ice and below normal temperatures. Maintenance reports on road condition variability during inclement weather indicate that snow and ice are inclined to adhere to the sprinkle treated surface quicker than to an untreated surface. This is reported as being a problem with both salted and non-salted roads. There have, however, been incidents reported where, because of a retained brine on a treated section, the snow or ice melted quicker than on an untreated section. This is, however, a condition which can generally be anticipated when a good macro texture has been obtained.

ECONOMIC BENEFIT

The cost savings using sprinkle treatments are dependent on the proximity of the project to non-polishing aggregate.

A project in southwest Iowa, where non-polishing aggregate is non-existent, that would require either 35% of the aggregate in a 1-1/2 inch (38 mm) surface course be non-polishing or the surface be sprinkle treated is presented below as an illustration of the possible savings.

Assuming that the non-polishing aggregate for the sprinkle treatment is quartzite from Del Rapids, South Dakota, the following comparisons can be made.

One mile (1.6 km) of 1-1/2 inch (38 mm) surface course requires 1,042 tons (945 t) of aggregate. If the surface course used 100% local limestone at $4.95 per ton ($5.45 per t) and 53 tons (48 t) of quartzite sprinkle treatment costing $5.50 per ton ($6.06 per t) plus $0.10 per ton mile ($0.07 per t km) for 190 miles (306 km), plus $40 per ton ($44 per t) to coat and spread, the cost would be $8,576 per mile ($5,328 per km). Costs for the same mile using 677 tons (614 t) of limestone and 365 tons (331 t) of quartzite in the surface course would be $3,351 for limestone and $8,942.50 for quartzite, for a total of $12,293 per mile ($7,638 per km). The savings realized by using the sprinkle treatment would be $3,717 per mile ($2,310 per km). Significant savings in haul costs alone could be realized soon after the haul exceeds 70 miles (113 km), which would not be uncommon in many areas.

In addition to the savings in the cost of aggregate, natural resources which include the high quality aggregate and gasoline for transporting that aggregate, would be conserved.

CONCLUSIONS

The following conclusions were derived from this research project:

1. Hard, durable stone which resists polishing should be used for sprinkle treatment of paved surfaces.

2. A single size aggregate should be used for best results. A 3/4" x 1/2" (19 mm x 13 mm) size is most appropriate for the type of spreader currently being used.

3. A heavy coating of asphalt can be applied to the aggregate without fear of congealment if stockpiles are kept small and are manipulated carefully during the cooling process.

4. A small amount of water added just before application will aid in keeping the aggregate friable and freeflowing. It will also aid in reducing the amount of asphalt build-up on the spreader flutes.

5. Sprinkle treated surfaces result in an improvement of the friction numbers of asphalt pavement.

6. Sprinkle treatment increases the surface macro texture significantly.

7. Sprinkle treatment tends to reduce the amount of vehicle tire spray during wet weather.

8. Sprinkle treatment tends to reduce headlight glare from wet pavements at night when the surface is wet.

9. Under some conditions, snow and ice removal may be more difficult on sprinkle treated sections.

SUMMARY

The Iowa Department of Transportation has been impressed by the results of sprinkle treatment to the extent that it is considered as a surface course treatment on resurfacing of two-lane highways where traffic exceeds 2,000 vehicles per day, and when geometrics or aggregates available indicate it may be a cost effective safety measure. Iowa has been sprinkle treating approximately 100 miles per year, and as of 1981 had approximately 420 miles of sprinkle treated surfaces. Approximately 150 miles were sprinkle treated in 1982. This total includes 13 miles of the eastbound lanes of I-80 in west-central Iowa. Traffic volumes in this area exceed 10,000 vehicles per day.

One technique not noted in our research effort is that chips will coat better at low temperatures (240°F to 250°F). This can be accomplished by slowing the drying process, holding the hot chips in a batch bin until they have cooled some, or by predrying and rerunning them through the plant with little or no heat. As indicated previously, stockpiles must be kept small and shallow until the asphalt has set. Water can be used after the asphalt

has cooled considerably as a means of preventing congealing. Water is also needed at the time chips are used to reduce the tendency for sticking in the chip spreader.

Iowa contractors have tried numerous schemes for charging the chip spreader. None have yet developed a means which is suitable or desirable for all situations since shoulder width and traffic conditions vary considerably from job to job. Most of the contractors use end loaders, but some have modified Flow-boy trucks and concrete dumpsters with augers or conveyors for a satisfactory job.

ACKNOWLEDGEMENT

Research project HR-199, "Sprinkle Treatment of Asphalt Surfaces" was sponsored by the Iowa Highway Research Board and partially funded by the Federal Highway Administration.

The authors wish to extend appreciation to Messrs. L. Zearley, D. Jordison, Duane Smith, C. Manchester, K. Meeks, and V. Marks of the Highway Division of the Iowa Department of Transportation. Their assistance and cooperation contributed greatly to this product. Special recognition and gratitude is extended to Richard Smith of the Office of Materials who assisted in the development of this report.

REFERENCES

1. Dillard, J.H. and Maupin, G.W., Jr. "Use of Sprinkle Treatment to Provide Skid Resistant Pavements", Association of Asphalt Paving Technologists, February 1971.

2. Tyler, R.L. and Kennedy, T.R. "Sprinkle Treatment for Achieving Skid Resistant Pavements in Texas", Texas Highway Department, Special Study No. 20.0, August 1974.

3. Iowa Department of Transportation "General Aggregate Source Information", Materials I.M. T-203.

4. Stephens, Dr. Jack E., "Symposium - Compaction of Asphalt Concrete" Proceedings, The Association of Asphalt Paving Technologists, Vol. 36, Pages 357-367 (1967).

LIST OF FIGURES

Figure 1: Friction Number of Sprinkle Treatments on the Type B ½" (13 MM) Mix Four Years After Construction

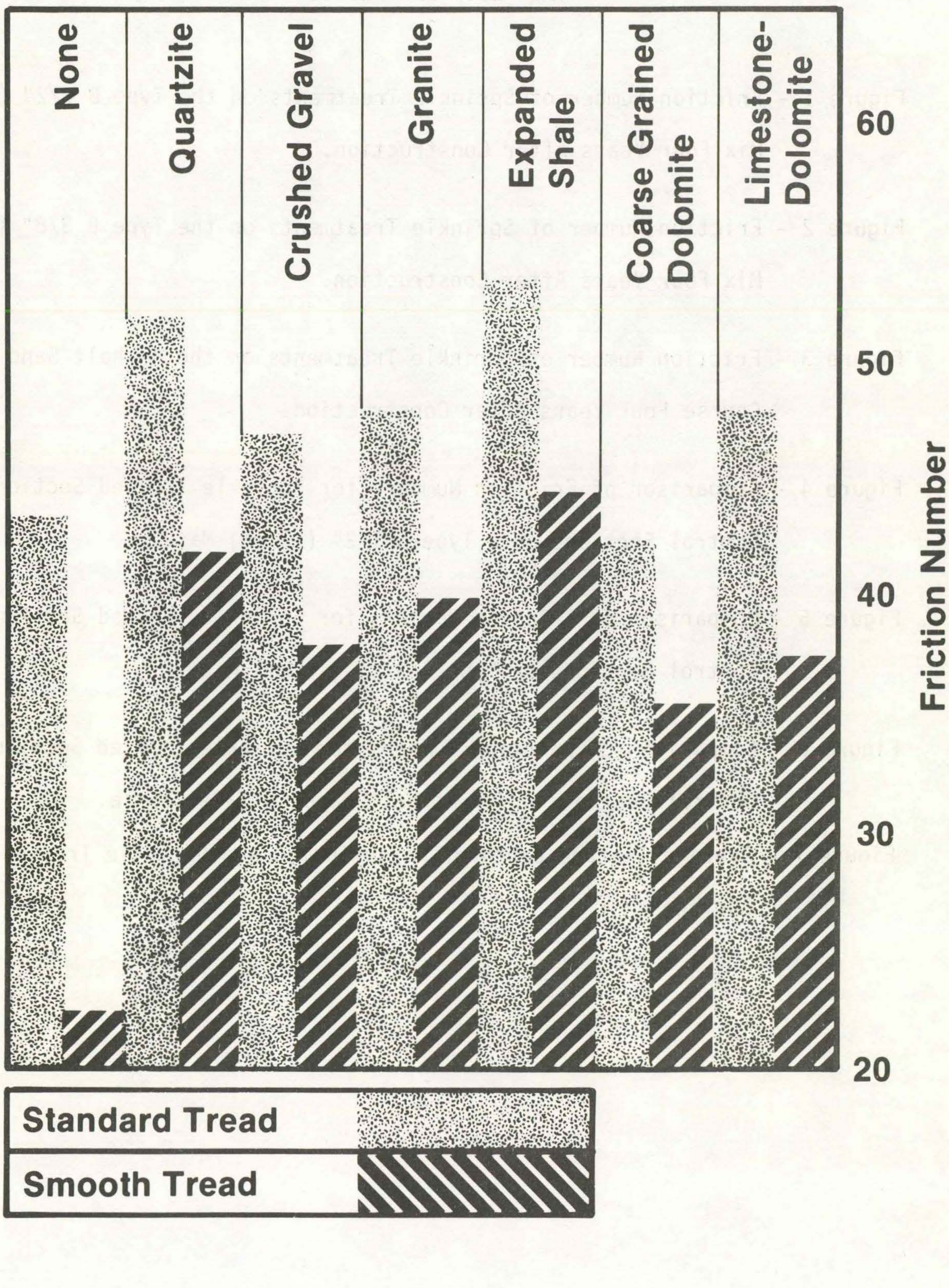


Figure 2: Friction Number of Sprinkle Treatments on the Type B 3/8" (10 MM) Mix Four Years After Construction

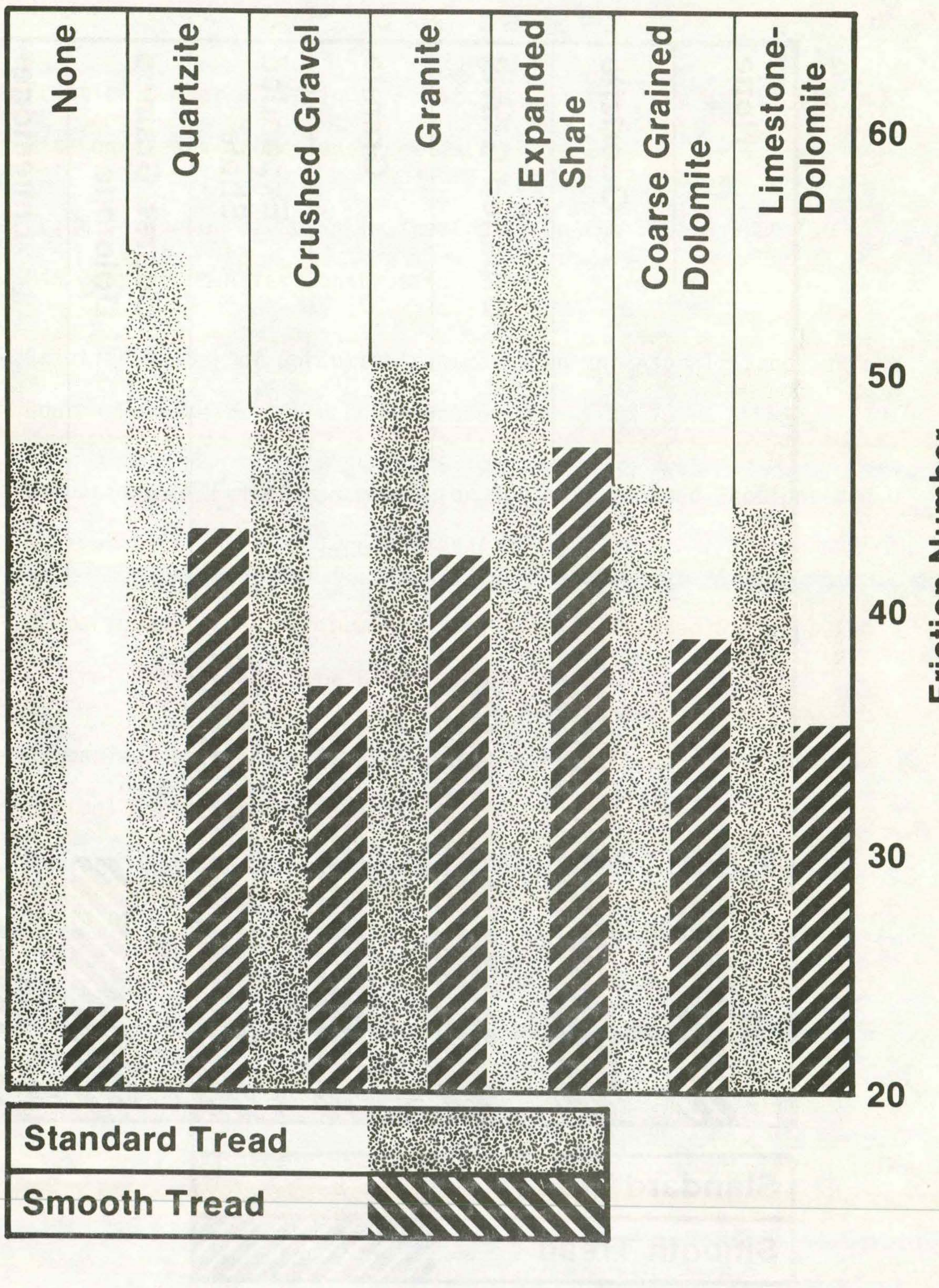


Figure 3: Friction Number of Sprinkle Treatments on the Asphalt Sand Surface Course Four Years After Construction

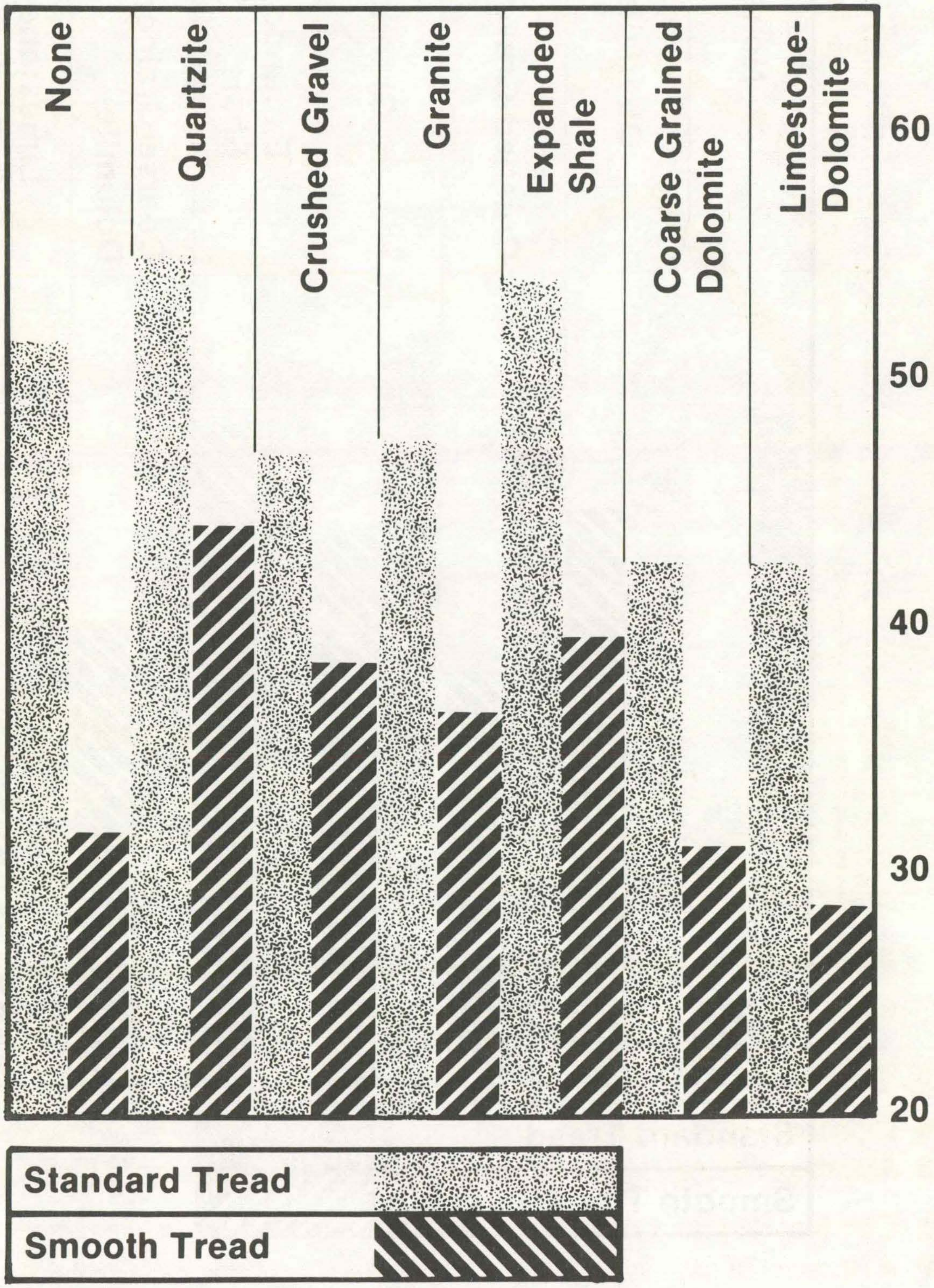
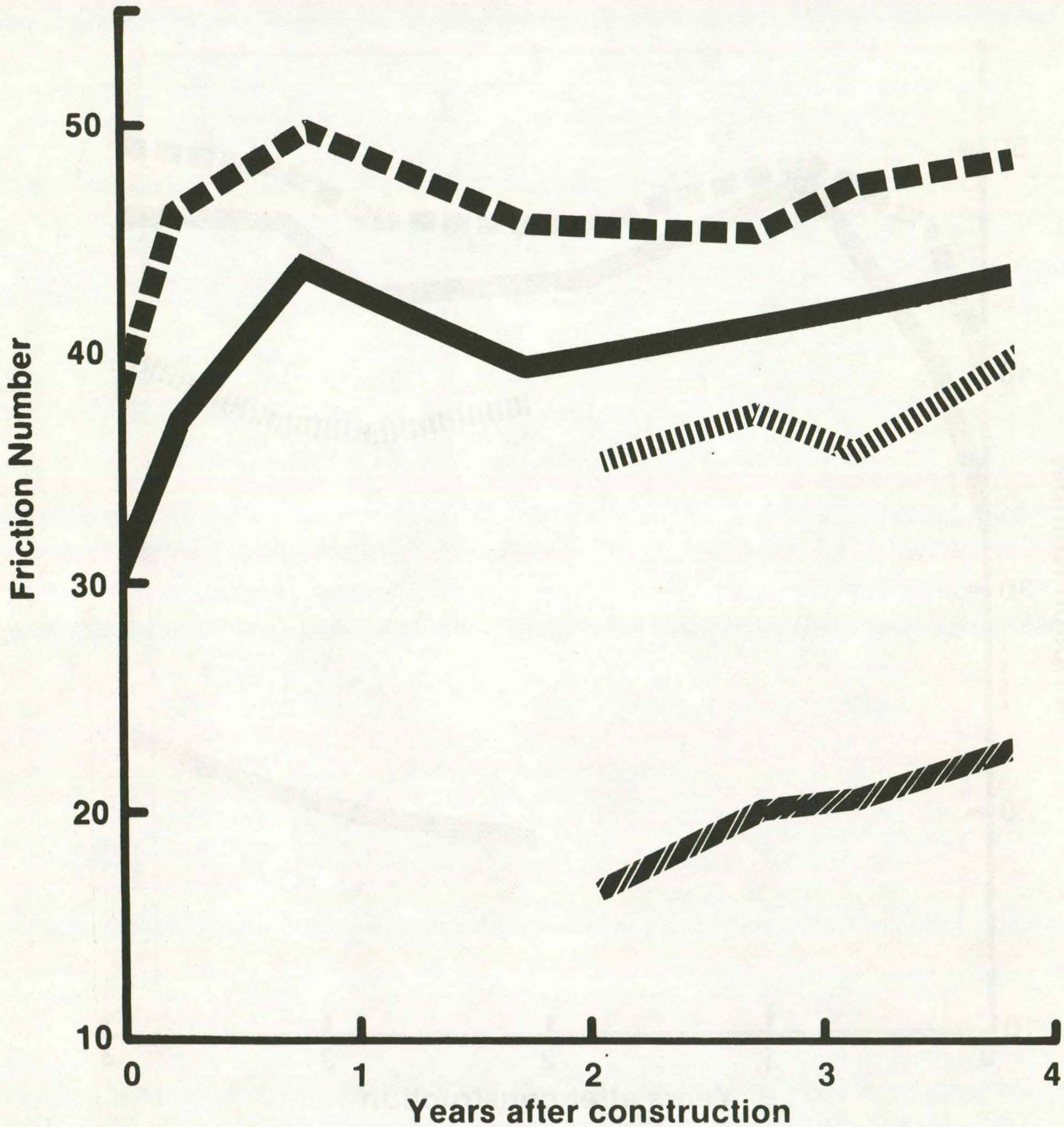


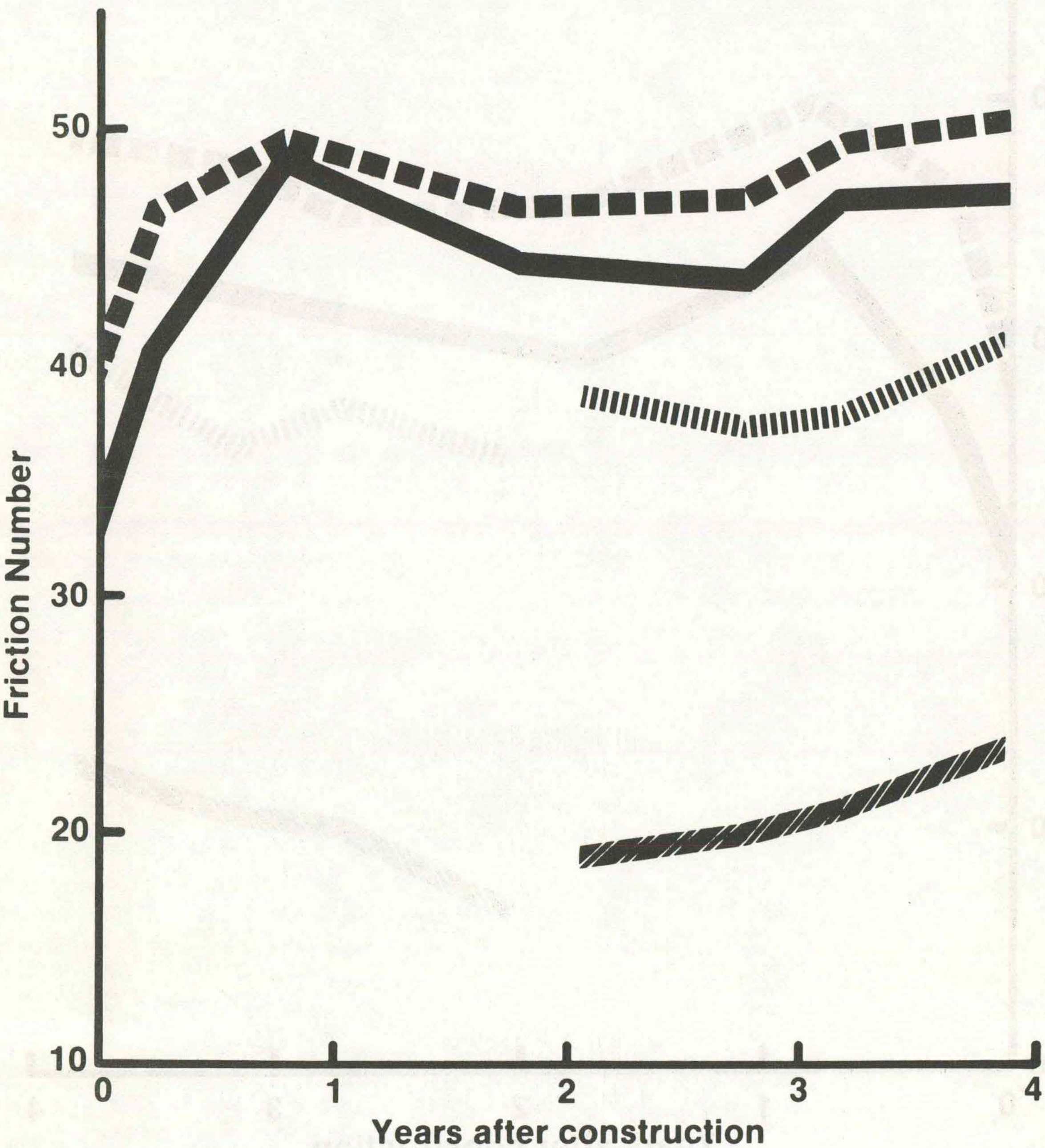
Figure 4: Comparison of Friction Numbers for Sprinkle Treated Sections and Control Sections on a Type B ½" (13 MM) Mix



Legend

- Control - Standard Tire
- Average all Sprinkle Treated Sections-Standard Tire
- Control - Non Treaded Smooth Tire
- Average of all Sprinkle Treated Sections-Nontreaded Smooth Tire

Figure 5: Comparison of Friction Numbers for Sprinkle Treated Sections and Control Sections on Type B 3/8″ (10 MM) Mix



Legend

- Control - Standard Tire
- Average all sprinkle treated Sections-Standard Tire
- Control - Non Treaded Smooth Tire
- Average of all Sprinkle Treated Sections-Nontreaded Smooth Tire

Figure 6: Comparison of Friction Numbers for Sprinkle Treated Sections and Control Sections on an Asphalt Sand Surface Course

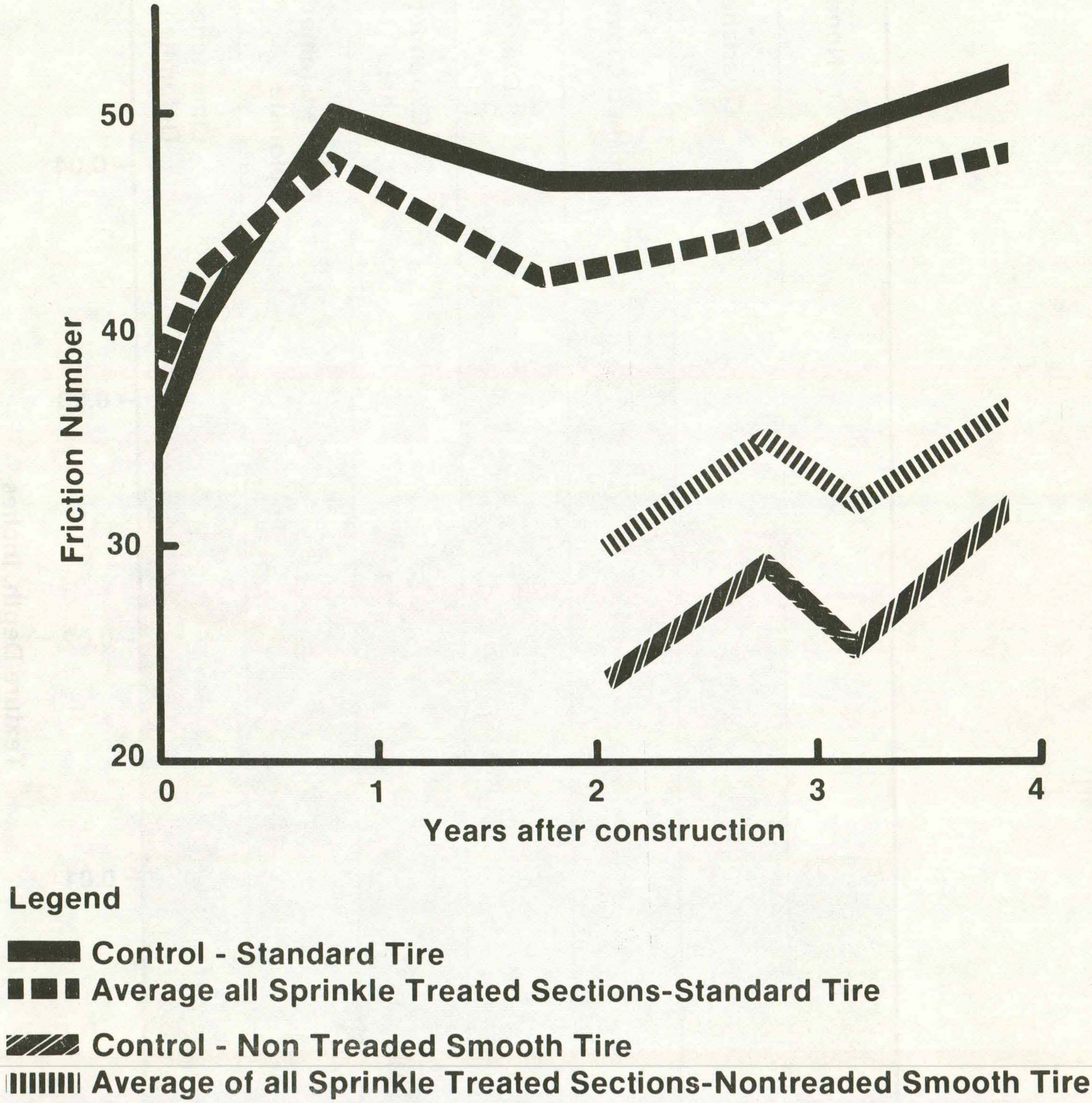


Figure 7: Average Texture Depth of Nonsprinkled and Sprinkle Treated Surfaces