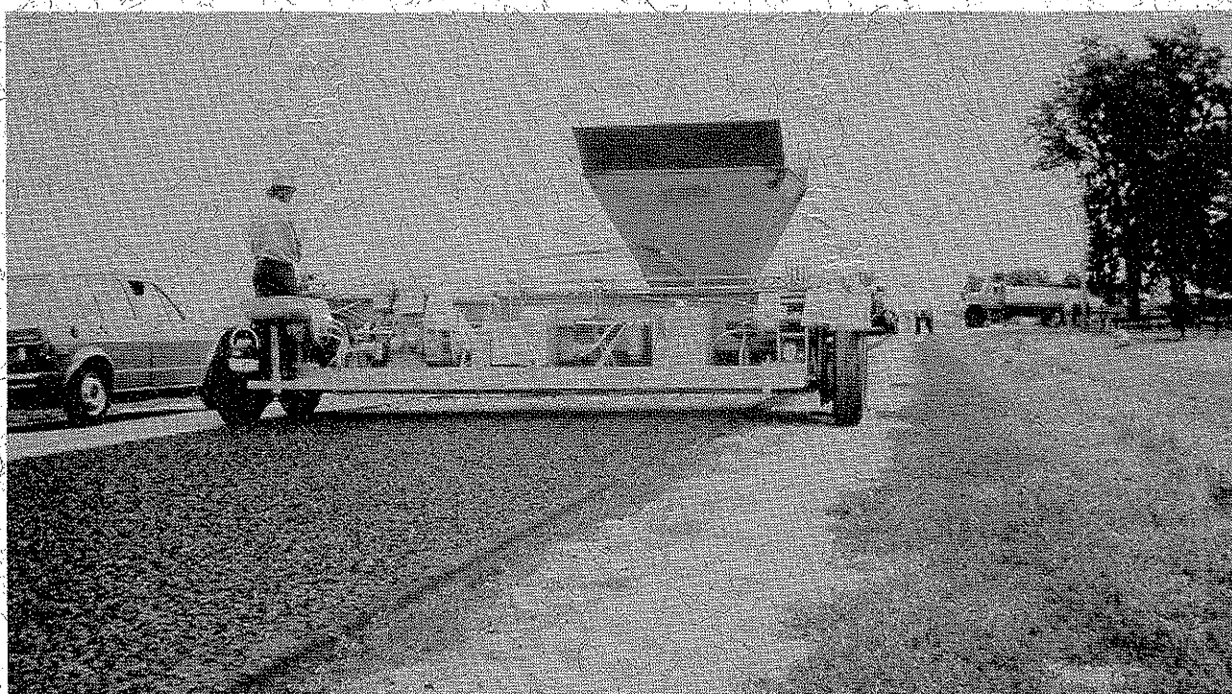
SPRINKLE TREATMENT OF ASPHALT SURFACES



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Iowa Highway Research Board
Project HR-199

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FINAL REPORT
IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-199

U.S. DEPARTMENT OF TRANSPORTATION
CONTRACT NO. DOT-FH-15-295

SPRINKLE TREATMENT OF ASPHALT SURFACES

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TABLE OF CONTENTS

SPRINKLE TREATMENT OF ASPHALT SURFACES

SCOPE AND PURPOSE

The purpose of this research is to evaluate the use of sprinkle treatment to provide asphalt surfaces with durable frictional characteristics.

CONCLUSIONS

The following conclusions have been 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" (19m x 13m) 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 pavements.

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 during nighttime or wet surface driving periods.

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

10. "Overflex MS" did not retard or reduce crack reflection as had been anticipated.

UPGRADING ASPHALT SURFACE FRICTION

BY

AGGREGATE SPRINKLE TREATMENTS

ABSTRACT

Methods of improving highway safety are of major concern to everyone involved in the planning, development and construction of improvements of our vast highway network. Other major concerns are the conservation of our rapidly disappearing sources of energy and quality building materials.

This research is devoted to further exploration of a process which will: 1) help preserve higher quality aggregates; and, 2) improve the frictional characteristics and surface texture of asphalt pavement surfaces.

Sprinkle treatment of asphalt concrete pavement surfaces with a non-polishing aggregate, a procedure which was developed in Europe, is one method which has shown promise in accomplishing the above listed objectives.

Iowa began experimenting with sprinkle treatment in 1974 by using a dump truck with a dual spinner tailgate spreader to apply the precoated aggregate. After several modifications, it was concluded that the desired results were still not obtained. Marks left by the truck tires reflected in the surface and the application of the aggregate was not uniform.

In June of 1977 it was learned that a spreader designed for the placement of precoated aggregate was available. With renewed interest, Iowa went about the task of putting down several demonstration sections in different areas of the state. The results were quite satisfactory, however, it was felt that further research was needed in several areas.

This research seeks to explore the feasibility and cost effectiveness of using standard asphalt mixtures of local, less expensive aggregates for surface courses followed by a surface sprinkle treatment of a hard, durable, non-polishing layer of precoated chips to produce a durable, non-skid pavement surface for safe highway travel.

Three standard mixture types were evaluated for aggregate retention characteristics and six sprinkle aggregates were evaluated for durability, polishing and friction characteristics. In addition, measurements of the surface texture by the silicone putty method were made.

Another feature of this research was the evaluation of a rubberized asphalt material called Overflex MS as a crack filler. It has been reported that the material could be beneficial in reducing reflective cracking.

The project was begun in July of 1978 and was completed in August. It was determined from slide photos taken after construction and annually through 1983, that aggregate retention was very good. However, many cracks had reflected indicating that the Overflex MS had not been effective. Follow-up friction test results and texture analysis were also very good. The results of these tests are shown in Appendix A.

INTRODUCTION

The Iowa Department of Transportation (Iowa DOT) made its first attempts at sprinkle treatment of fresh asphalts in 1974 subsequent to a presentation made at the annual meeting of the Association of Asphalt Paving Technologists at Oklahoma City in February, 1971.

Continued emphasis on skid resistant non-polishing highway surfaces and the monitoring thereof precipitated an in-house "Skid Review Committee" in late 1972. Since that time increased emphasis in design of asphalt mixes and surface. Stockpiling methods which minimize segregation shall be used. Provisions should be made for manipulation or wetting of the coated aggregate if crusting of the aggregate occurs. No water shall be applied to the freshly coated aggregate until it has cooled sufficiently to prevent the possibility of stripping. The engineer may require the stockpile to be covered.

At the option of the contractor, precoated aggregate remaining at the completion of the work will be purchased and paid for by the contracting authority. The precoated aggregate shall be hauled and stockpiled at a site designated by the engineer. The haul may be as far as the nearest maintenance garage of the contracting authority. The engineer may limit the quantity of aggregate to be precoated to assure this quantity is reasonable.

847.05 CONSTRUCTION. The precoated aggregate may be spread hot or cold. It shall be uniformly applied to the surface of the asphalt surface course as soon as possible after laydown and before initial rolling of the surface. The spreader shall span the lane to be spread. Provisions should be made for wetting the coated aggregate if crusting or unusual adherence of aggregate particles occurs.

The precoated aggregate shall be applied to the surface at a target rate of 7 1/2 pounds per square yard when crushed stone or gravel is used or at a target rate of 5 pounds per square yard when lightweight aggregate is used. These target rates may be adjusted by the engineer to insure proper coverage of the surface area.

Rolling shall commence immediately after the coated aggregate is applied unless otherwise directed by the engineer. The initial rolling shall be done with a steel roller. Compaction shall be in accordance with the requirements for the type of surface course being laid. Pneumatic-tired rollers, when used for intermediate compaction, shall not be used if tire pick up of sprinkle aggregate is encountered.

Any nonuniform distribution of coated aggregate shall be corrected with lutes or brooms before initial rolling.

Traffic will not be permitted on the finished surface until the pavement has cooled to such a level that the coated aggregate will not pick up under the tires. Sprinkling the pavement surface with water may be required, as directed by the engineer, to promote cooling of the pavement prior to opening the roadway to traffic.

847.06 LIMITATIONS. Sprinkle treatment of asphalt cement concrete surfaces shall not be placed after October 1 except by authorization of the Construction Engineer.

847.07 METHOD OF MEASUREMENT. The quantity of Aggregate for Sprinkle Treatment will be computed from weights of precoated aggregate that is applied to the asphalt surface course, in accordance with appropriate requirements of 2303.19A.

When payment is to be made for precoated aggregate remaining at the completion of the work, precoated aggregate will be measured separately in the same manner.

847.08 BASIS OF PAYMENT. For the number of tons of Aggregate for Sprinkle Treatment, satisfactorily applied to the asphalt surface course and measured as provided above, the contractor will be paid the contract price therefor. The contract price will be based on one of two alternates, as follows:

1. Crushed gravel or crushed stone.
2. Lightweight aggregate.

For the number of tons of precoated aggregate remaining at the completion of the work and hauled and stockpiled according to 847.04, the contractor will be paid 25 percent of the contract price for Aggregate for Sprinkle Treatment.

These payments shall be full compensation for furnishing, precoating, and applying the precoated aggregate to the asphalt surface course and for furnishing, precoating, hauling, and stockpiling the precoated aggregate remaining at the completion of the work. Asphalt cement used for precoating will be considered incidental.

Water, when required, will be considered incidental.

56 all

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/or quartzite from Minnesota, Wisconsin and South Dakota.

During the summer of 1975, with the cooperation of the Office of Maintenance, a dual spinner tailgate spreader was mounted on a standard dump truck to attempt additional sprinkle treatment. The dump truck equipment was marginally satisfactory since the lug tires of the truck left marks in the finished pavement and the uneven distribution of chips caused depressions in the surface and non-uniform surface texture. Results of this experimental work demonstrated increased surface texture and durability.

During 1976 a new, current order 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 ordered onto a test section, but because of lateness of the season and unseasonably cold fall weather, the project was delayed until 1977.

The test section placed in early 1977 with this unit again did not produce the desired 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 on board ship 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, we were advised that the Bristowes Company was sending their assistant plant manager from England to 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 was selected. Projects selected for sprinkle treatment were rural two-lane roadways with speed limits exceeding 40 MPH 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" (38mm) and 2" (51mm) thick single course resurfacing projects with 1/2" (13mm) size mixes. The other two projects utilized the Cutler repaving procedure and the addition of 100 lbs (45.4 kg) of new 3/8" (10mm) 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 film thickness. This was determined to be in the range of 1% to 1.5% for conventional aggregate to 2% for the Haydite. The aggregate was coated in a conventional plant using the same asphalt used in the mix. It was required that it be stored in a clean place and that the stockpile be covered.

In placing the chips with the Bristowes spreader, several minor problems were recognized. The spreader had a span of 14 feet (14.3m) and a clearance of only five inches (13cm) 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 of the spreader hopper presented a problem on roads with narrow shoulders as 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 build-up of asphalt cement and fines in the drum flutes caused this problem. During extremely hot weather, the chips would occasionally congeal and clog the distributing hopper. Wetting of the chips in the stockpile or as they were loaded minimized this problem.

Results of the sprinkle aggregate retention evaluation 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 which "piggy-backed" and did not become adequately imbedded. 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^{o}F (10^{o}C).

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

Another group of twelve 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 (4.76mm) screen from a maximum of 10% to a maximum of 5%. This has been changed to a coarser "one size" 3/4" x 1/2" (19mm x 13mm) for future work.

PROJECT SELECTION AND DEVELOPMENT

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 (Figure 1). It was originally paved 18' (5.5m) wide in 1929. It was widened to 24' (7.3m) in 1953 and resurfaced with 3" (7.6cm) of asphalt concrete in 1956. This was followed by an inverted penetration seal coat in 1974. The average daily traffic for the highway exceeds 4,000 VPD.

On October 21, 1977, a project proposal was submitted to the Iowa Highway Research Board. Approval was received on December 31, 1977. A contract was subsequently negotiated with the Federal Highway Administration to include this research project as a part of the Federal Demonstration Program. The contract (Appendix B) was approved on July 6, 1978.

The project was developed by dividing the 5.3 miles (8.5 km) into three mix type sections. This was to provide for the utilization of a Type "B" 1/2" (13mm) mix size, a Type "B" 3/8" (10mm) mix size and an asphalt sand surface course. Type "B" mixes require a minimum of 30 percent crushed particles. Asphalt sand surface courses are a combination of sand with crushed limestone or mineral filler with either an asphalt emulsion or an AC-20 asphalt cement. Surface course thicknesses selected were 1-1/2" (3.8cm) for the 1/2" (13mm) mix size and 1" (2.5cm) 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 the six sprinkle aggregates selected for evaluation (Figure 2).

BOP 104 + 50

EOP 374 + 54

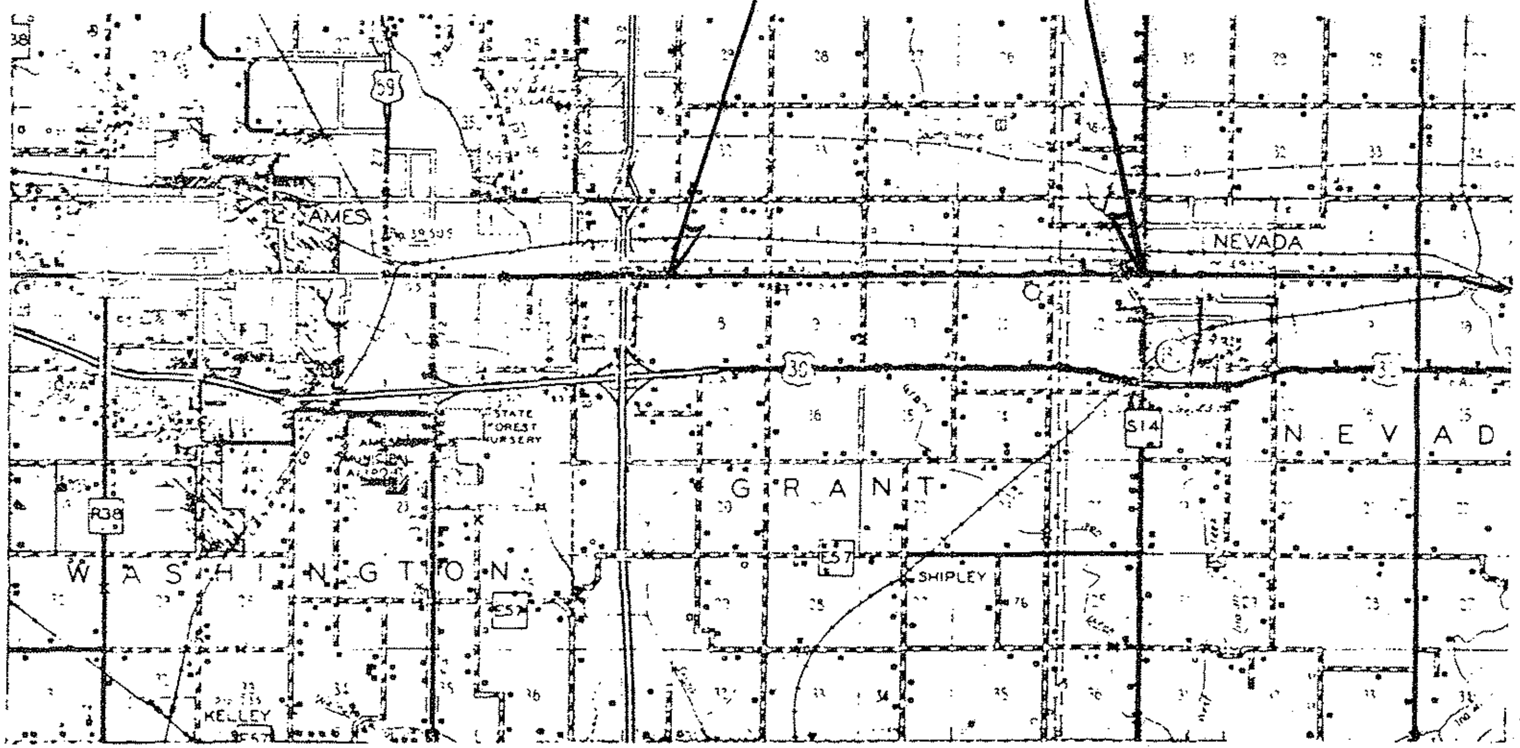


Figure 1: Project Location

16

1/2" Asphalt Mix

A 1	A 2	A 3	A 4	A 5	A 6	A 7
Control	Quartzite	Crushed Gravel	Granite	Expanded Shale	Coarse Grained Dolomite	Limestone & Dolomite

104+50 116+00 128+00 139+00 151+00 162+32 176+00 189+00

3/8" Asphalt Mix

B 1	B 2	B 3	B 4	B 5	B 6	B 7
Control	Quartzite	Crushed Gravel	Granite	Expanded Shale	Coarse Grained Dolomite	Limestone & Dolomite

189+00 202+00 215+20 229+00 242+00 255+00 268+30 282+00

Sand Asphalt Mix

C 1	C 2	C 3	C 4	C 5	C 6	C 7
Control	Quartzite	Crushed Gravel	Granite	Expanded Shale	Coarse Grained Dolomite	Limestone & Dolomite

282+00 295+00 308+00 321+72 335+00 348+00 360+36 374+54

Figure 2: Sprinkle Treatment Test Area

Aggregates selected for evaluation and their sources are as follows:

Aggregate	Source	Skid Resistance Type
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
Dolomite	Quimby Quarry Mason City, Iowa	4
Limestone & Dolomite	Ferguson Quarry LeGrand, Iowa	4

Aggregate skid resistance types are defined in Materials I.M. T-203 (Appendix C).

Specifications for the sprinkle aggregate may be found in Appendix D.

The project was let May 23, 1978, and the contract was awarded to the Iowa Road Builders Company of Des Moines, Iowa, (Bid Tabulation - Appendix E). The Iowa DOT Resident Engineer was Duane Smith, P.E.

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 (Figure 3) to saw the extreme limits of the patch followed by the use of a jack hammer and end loader to remove the remaining material. Asphalt concrete was used as a patching material. We have found full depth asphalt, properly placed, provides some pressure relief and reduces the problem of pavement blow-ups. 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 asphalt concrete material.

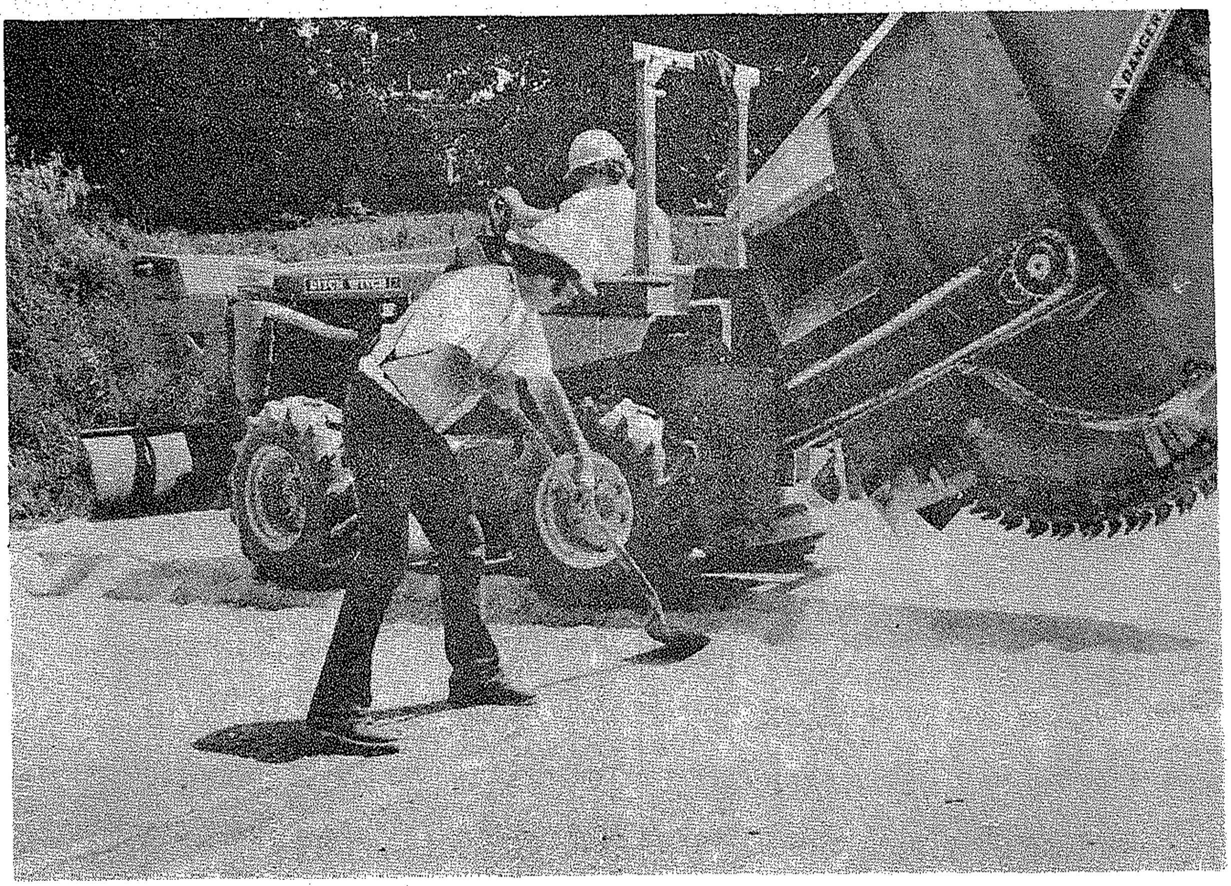


Figure 3 - Preparing Patch Area

The crack sealing was sub-contracted to Asphalt Surfacing Company of Sioux Falls, South Dakota. Preparation for crack sealing was accomplished by loosening the dirt in the cracks to a depth of about 1" (2.5mm) and blowing them clean with compressed air. The "Overflex MS" rubberized asphalt material was heated in a distributor especially designed for this product (Figure 4) (Appendix F for special provisions).

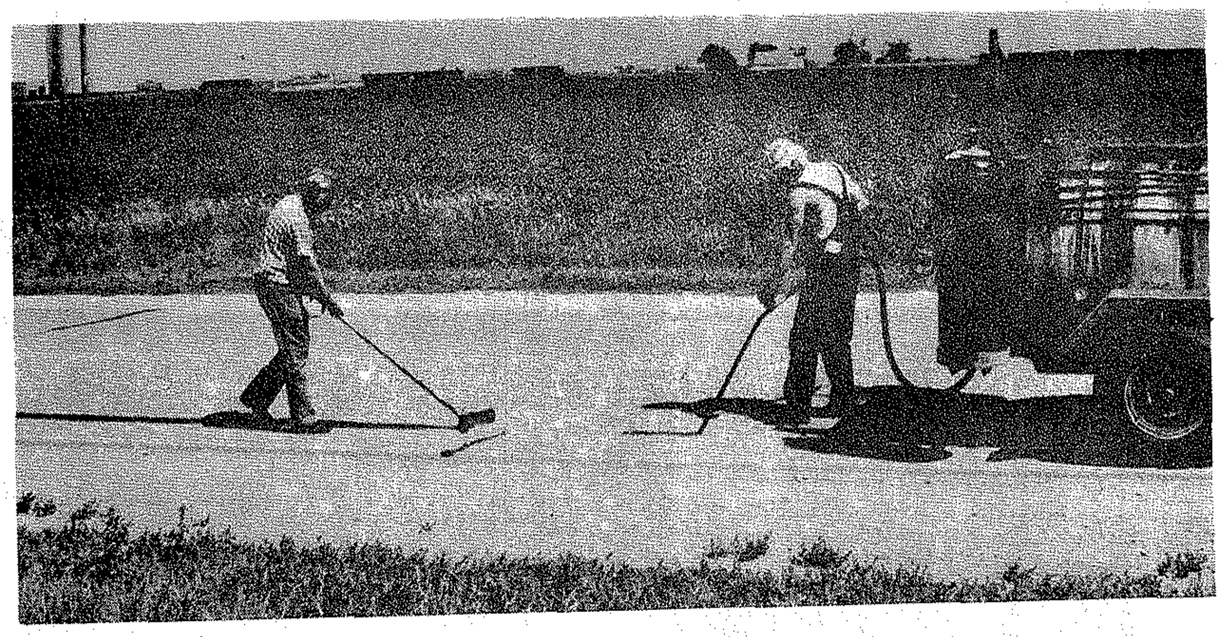


Figure 4 - Filling Cracks with Overflex MS

Upon the initial application of the rubber asphalt material, it could be seen that because of the high viscosity, the material was not flowing into the cracks. The sub-contractor acknowledged that the cracks were too narrow and that ideally, the material should be placed in the winter. Best results are obtained when cracks are routed to a 1/2" (13mm) width. Rather than going to the added expense of routing the cracks, it was decided to proceed with the work by spreading the material over the cracks with a squeegee, hopefully forcing some material into the wider ones. It was felt some benefits might be obtained by this procedure since some success has been reported where rubber asphalt has been used as a stress-absorbing membrane interlayer.

Precoating of Sprinkle Aggregate

Precoating the sprinkle treatment aggregate is the most important and yet the most tedious part of the sprinkle treatment process. Observation of the previous year's 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 reduce the coating problem, samples of the aggregates were coated in the laboratory and a film thickness was calculated to determine the basic asphalt requirement for each aggregate. The recommended asphalt was generally in the area of from 1% to 2% for natural aggregates.

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, an additional 1/4 to 1/2% 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 (0.074mm) material in the drying process.

Congelation 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 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 that some stripping of the asphalt had occurred on several of the aggregates. It was concluded that the stripping, while not critical, would not be tolerated. Further experimentation has shown that by placing the freshly coated aggregate in small piles (4' (1.2m) or less in height) and with slight manipulation with an end loader, congealment is minimal. Light sprinkling of the aggregate with water at the time it is loaded for use reduces lumps by the time it gets to 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 two days needs.

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" (13mm) and 3/8" (10mm) mix. The sand mix was from 265°F to 290°F (130°C to 143°C). At the time of compaction, the 3/8" (10mm) and 1/2" (13mm) mix ranged from 250°F to 290°F (120°C to 143°C) while the sand mix ranged from 250°F to 275°F (120°C to 135°C). These temperatures are quite normal for work being done when ambient temperatures are in the 70s and 80s (21°C to 27°C). Some slowing of production was experienced due to the methods used to charge the Bristowes Spreader (Figure 5).

The Bristowes 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 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.

Figure 5 - Charging the Bristowes Spreader

The spreader distributes the chips uniformly (Figures 6 and 7). However, on occasion, we have noticed a rippled appearance in the mat surface. We have traced this to the spreader and have 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, we have minimized this problem.

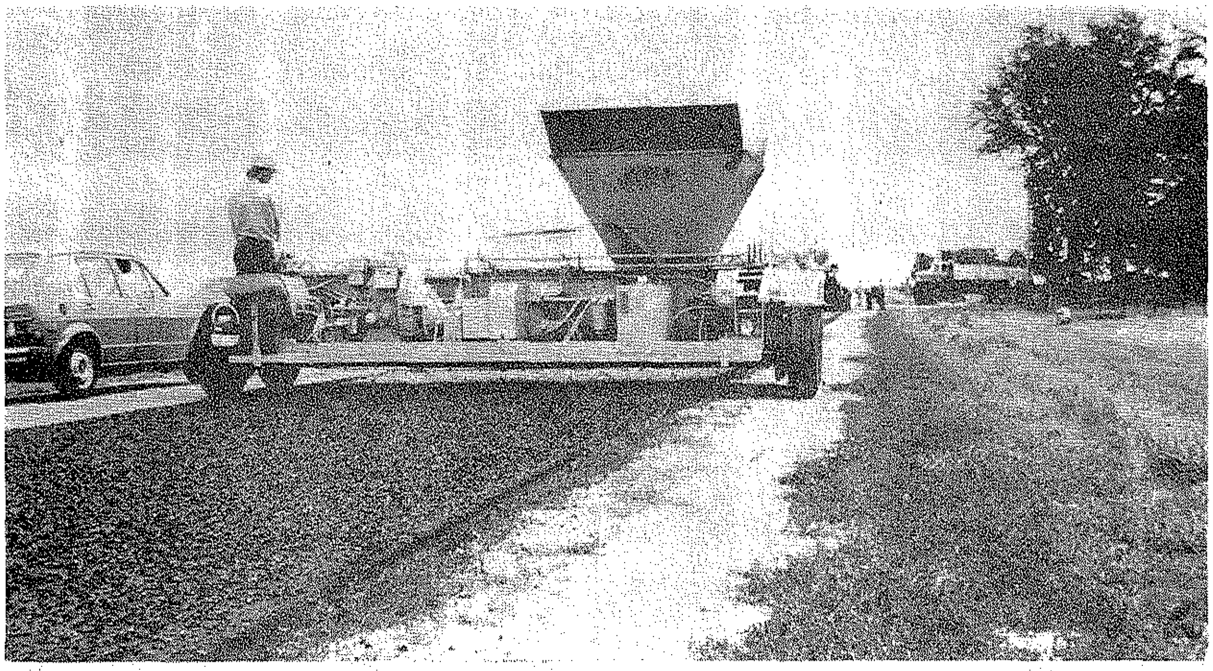


Figure 6 - Spreading Sprinkle Aggregate

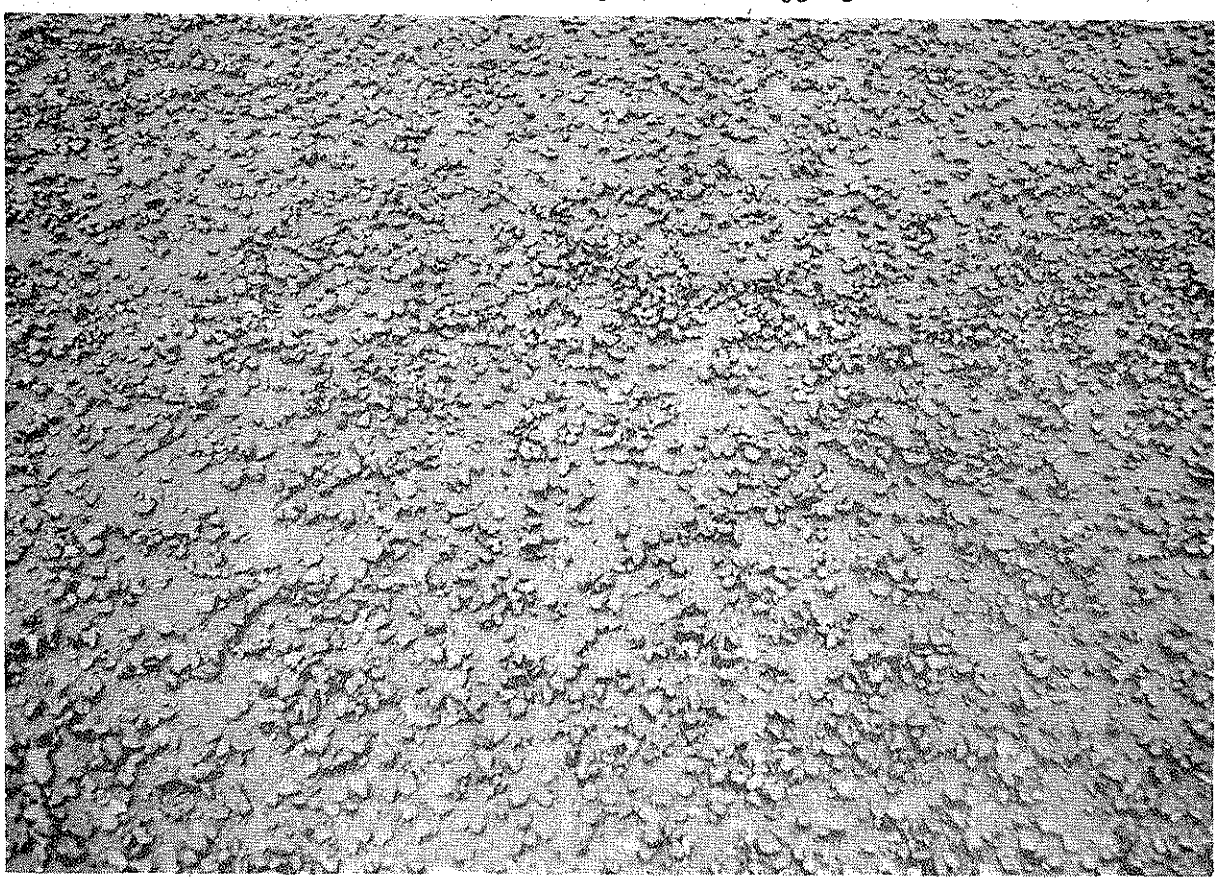


Figure 7 - Sprinkled Aggregate Before Rolling

Sprinkle Aggregate Application

The application rate of the sprinkle aggregate is controlled by the gate adjustment previously mentioned. It is recommended that the gate initially be 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/sq yd (3.75 kg/sq m) of lightweight aggregate (Sp Gr = 2.2) and 7 lbs/sq yd (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 (Figure 8). 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' (0.9m x 0.9m) canvas was placed ahead of the spreader to collect one sq yd (0.8 sq m) of chip application (Figure 9) and the collected material was weighed on a scale (Figure 10).

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" screen have more of a tendency to "piggy back" or 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.

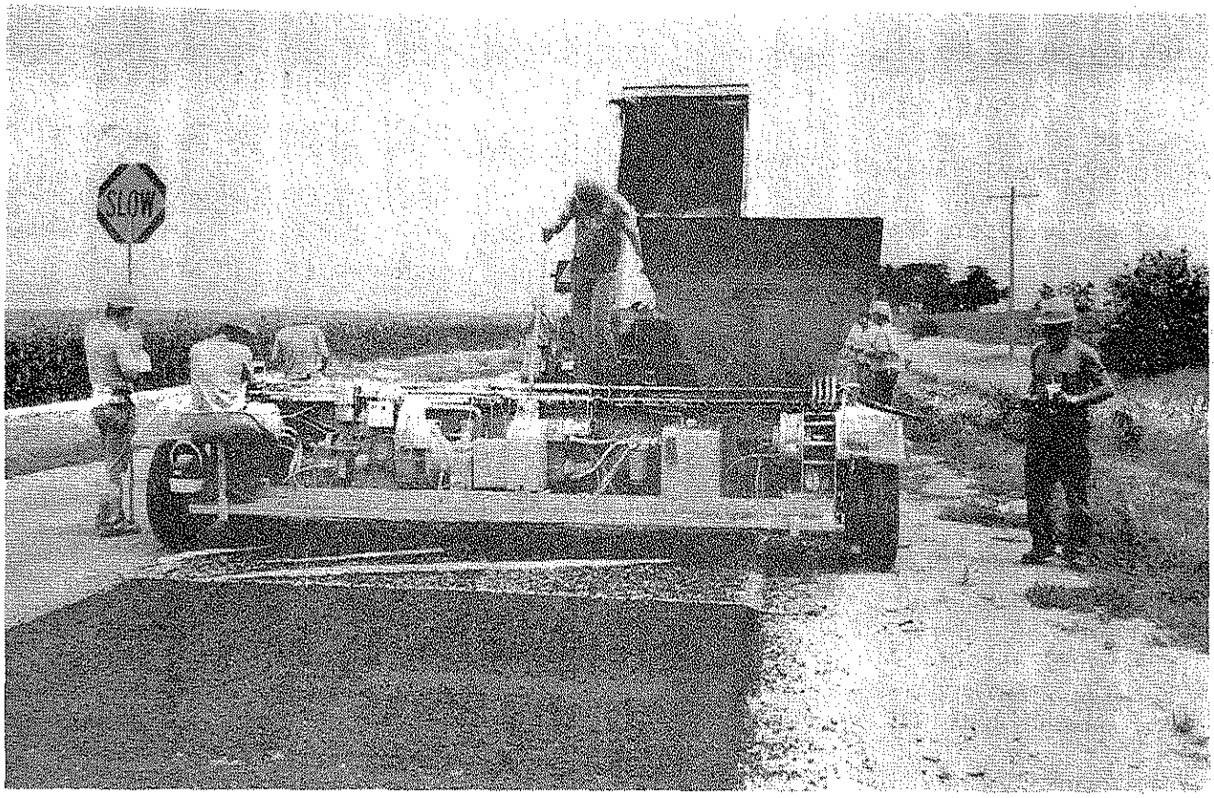


Figure 8 - Canvas for Preventing Aggregate Overlap

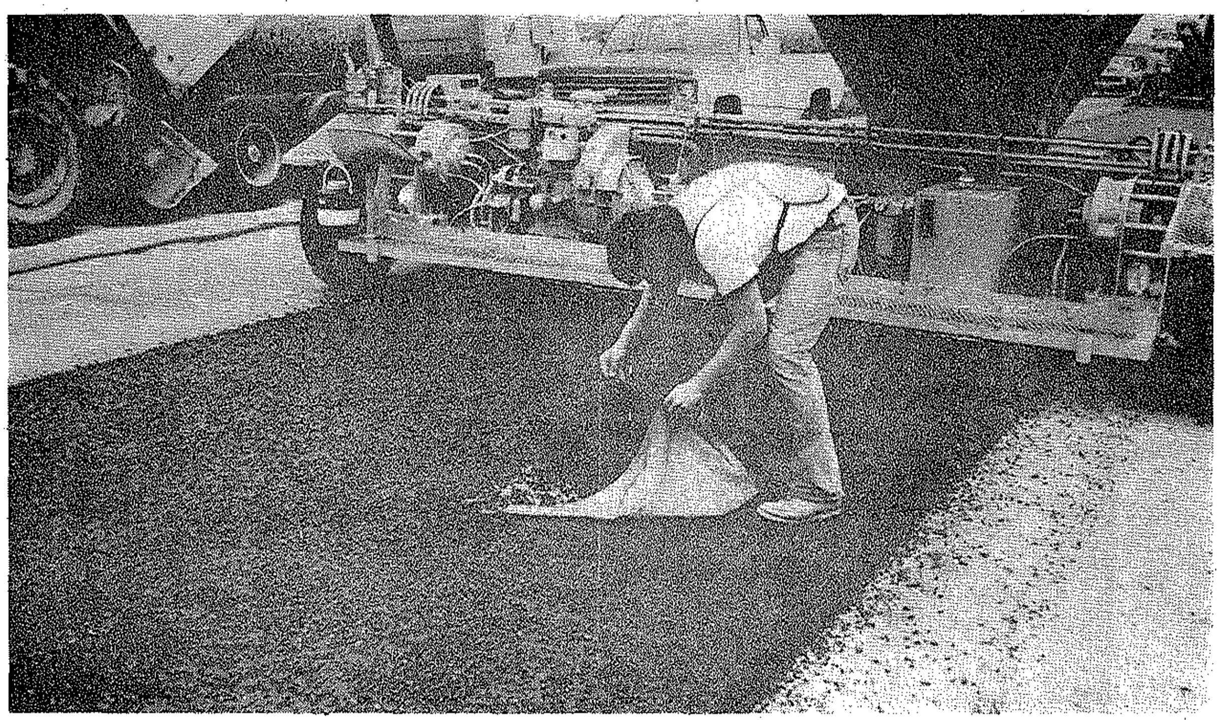


Figure 9 - Collecting Sample for Application Rate Check

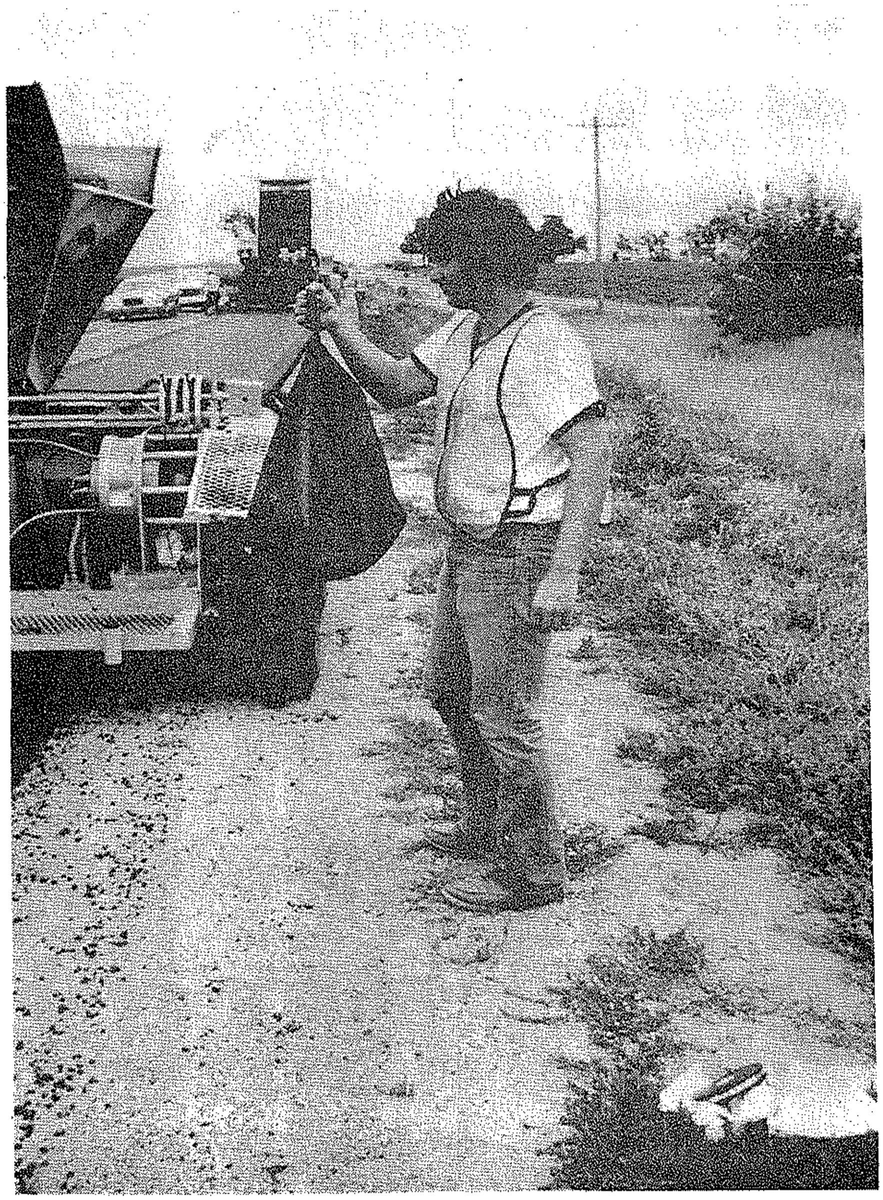


Figure 10 - Weighing Sample to Check Application Rate

For these reasons, we changed our specifications for future work. Commencing in 1979, we require a single size 3/4" x 1/2" (19mm x 13mm) aggregate (Appendix G). Cubical aggregate shape is more desirable than slivered particles.

Compaction

Compaction of the sprinkled surface was routine. Minor delay was experienced because of 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 to reduce the potential of dislodging the sprinkle aggregate was to be addressed as part of this research project. However, since progress was slowed somewhat because of the need to change sprinkle aggregates every 1,200 feet (365 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.

POST CONSTRUCTION PERFORMANCE

The initial and perhaps one of the more significant differences 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 nonsalted 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.

Reflective cracking does not appear to be significantly retarded by the use of the "Overflex" material as a crack sealer. The cracks on this project were mostly thermal and any movement can be expected to cause reflection.

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 (Appendix A). Tests were made at 40 MPH in accordance with ASTM E-274 using an ASTM E-501 standard tread tire and beginning in 1980, with a smooth tread tire (ASTM E-524-76).

Graphs have been prepared to illustrate how frictional characteristics are affected by sprinkle treatment. Figure 11 depicts the effects on the 1/2" (13mm) 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 numbers; while quartzite and expanded shale produce friction numbers which run consistently 8 to 10 numbers higher than the non-sprinkled section.

Figure 12 indicates friction numbers for the control section using a 3/8" (10mm) Type B mix are about 4 numbers higher than the 1/2" (13mm) mix size control section. Coarse grained dolomite and the limestone/dolomite blend consistently failed to improve the friction numbers. Crushed gravel and granite show a slight benefit with quartzite and expanded shale indicating 8 to 10 numbers higher.

Figure 13 illustrates friction values for the asphalt-sand surface course. Friction numbers for the control section are consistently in the 47 to 52 range. Quartzite and expanded shale are the only 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 13mm to 3/8" or 10mm 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.

Figures 14, 15, and 16 show the most significant indication of the benefits of sprinkle treatment. To illustrate 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 is uniformly wide (17 to 23 numbers) but when the sprinkle treated sections are compared, the band is narrowed significantly (9 to 12 numbers).

Texture

Surface texture measurements using the "silly putty" method were made immediately following the completion of the project. Measurements were also made in April, 1979, (after eight months of traffic) with the following results:

The 1/2" (13mm) mix nonsprinkled sections show a texture depth of 0.012 inches (0.30mm), while sprinkle treated sections averaged 0.026 inches (0.66mm). The texture depth of the 3/8" (10mm) mix nonsprinkled sections averaged 0.007 inches (0.18mm) and sprinkle treated sections averaged 0.031 inches (0.79mm). The texture depth of the nonsprinkled sand asphalt section was 0.014 inches (0.36mm) with sprinkle treated sections averaging 0.026 inches (0.66mm).

The texture depths from the 1/2" (13mm) mix, the 3/8" (10mm) mix and the sand asphalt were averaged for each sprinkle aggregate (Figure 17) to graphically show the significant texture depth improvement. The average texture depth of the nonsprinkled sections was 0.011 inches with the average of all sprinkle treated sections averaging 0.028 inches (0.70mm).

Final texture measurements were taken in the summer of 1983 (Appendix A-3). It was noted that texture depths had increased significantly. At first it was felt this may be attributed to a loss of sprinkle aggregate. From close observation of the roadway, the loss appeared to be very insignificant. The minor loss of sprinkle aggregates can be further confirmed by comparing the average texture depth differences as plotted in Figure 17. By comparing the averages of the various sections, it can be noted the increase in average depth changes is as significant on the control sections as it is in the sprinkled sections. This seems to indicate the texture depth increase is due to weather and traffic abrasion and a loss of some surface matrix.

Figure 11: Friction Number of Sprinkle Treatments on the Type B ½" (13 MM) Mix Five Years After Construction

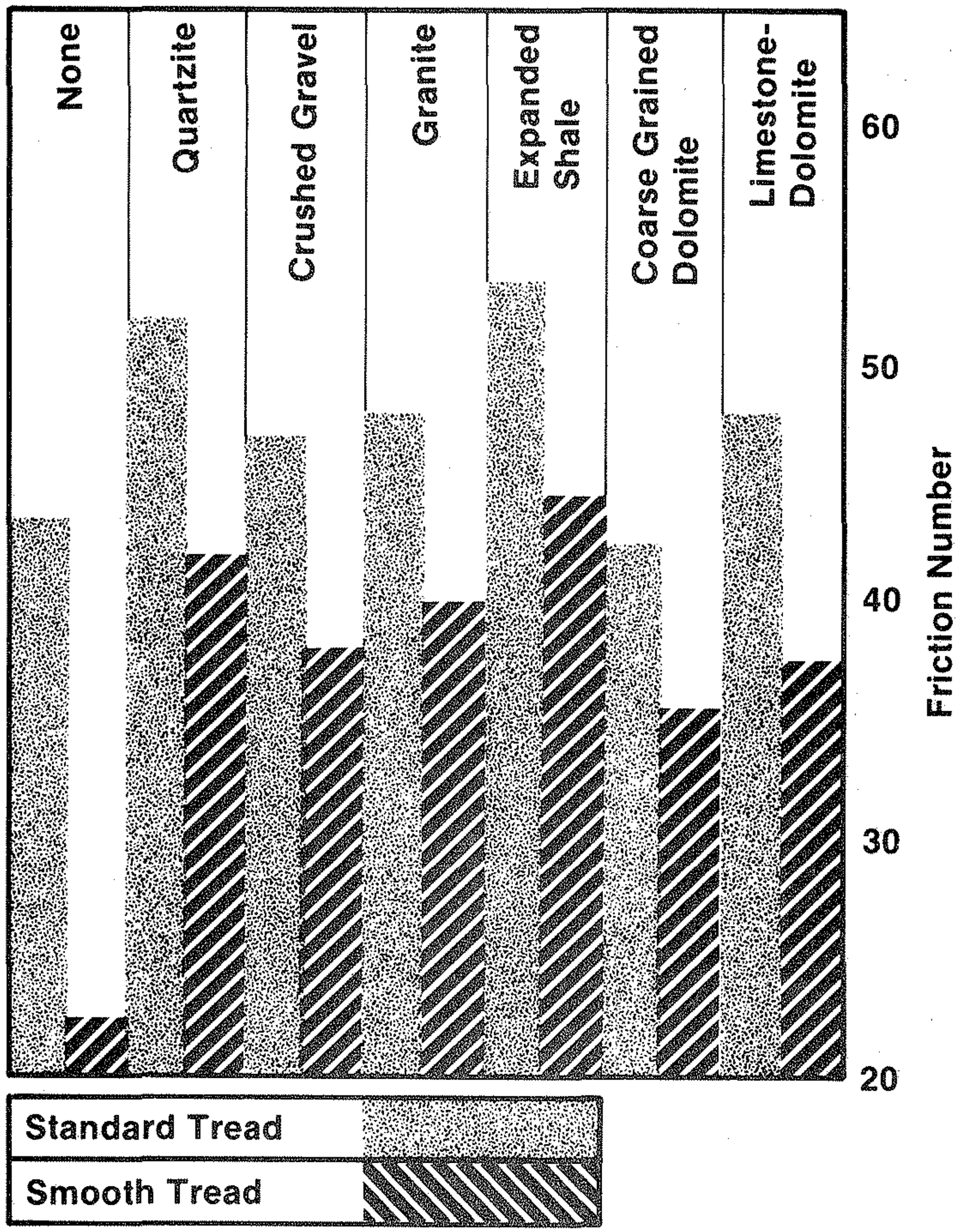


Figure 12: Friction Number of Sprinkle Treatments on the Type B 3/8" (10 MM) Mix Five Years After Construction

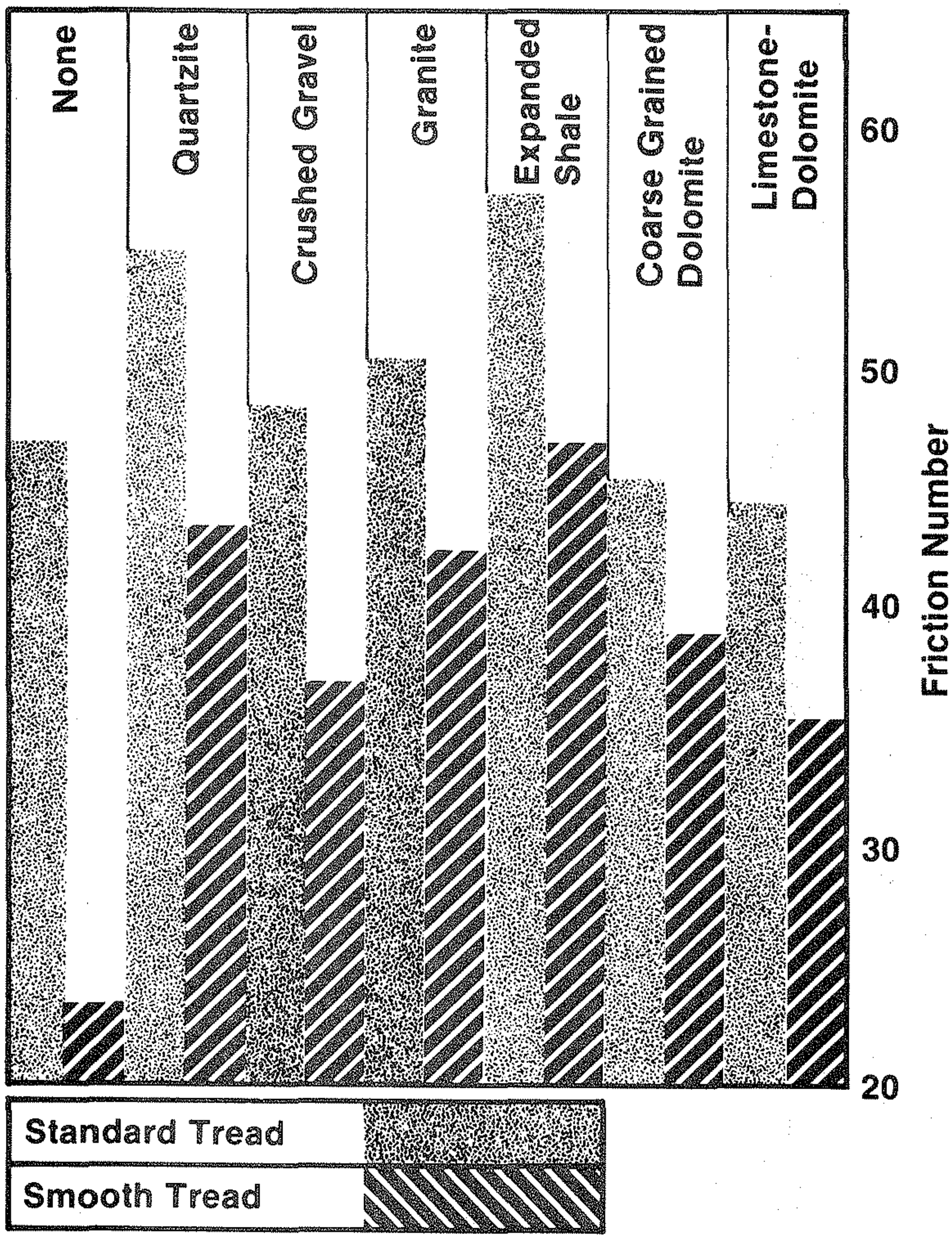


Figure 13: Friction Number of Sprinkle Treatments on the Asphalt Sand Surface Course Five Years After Construction

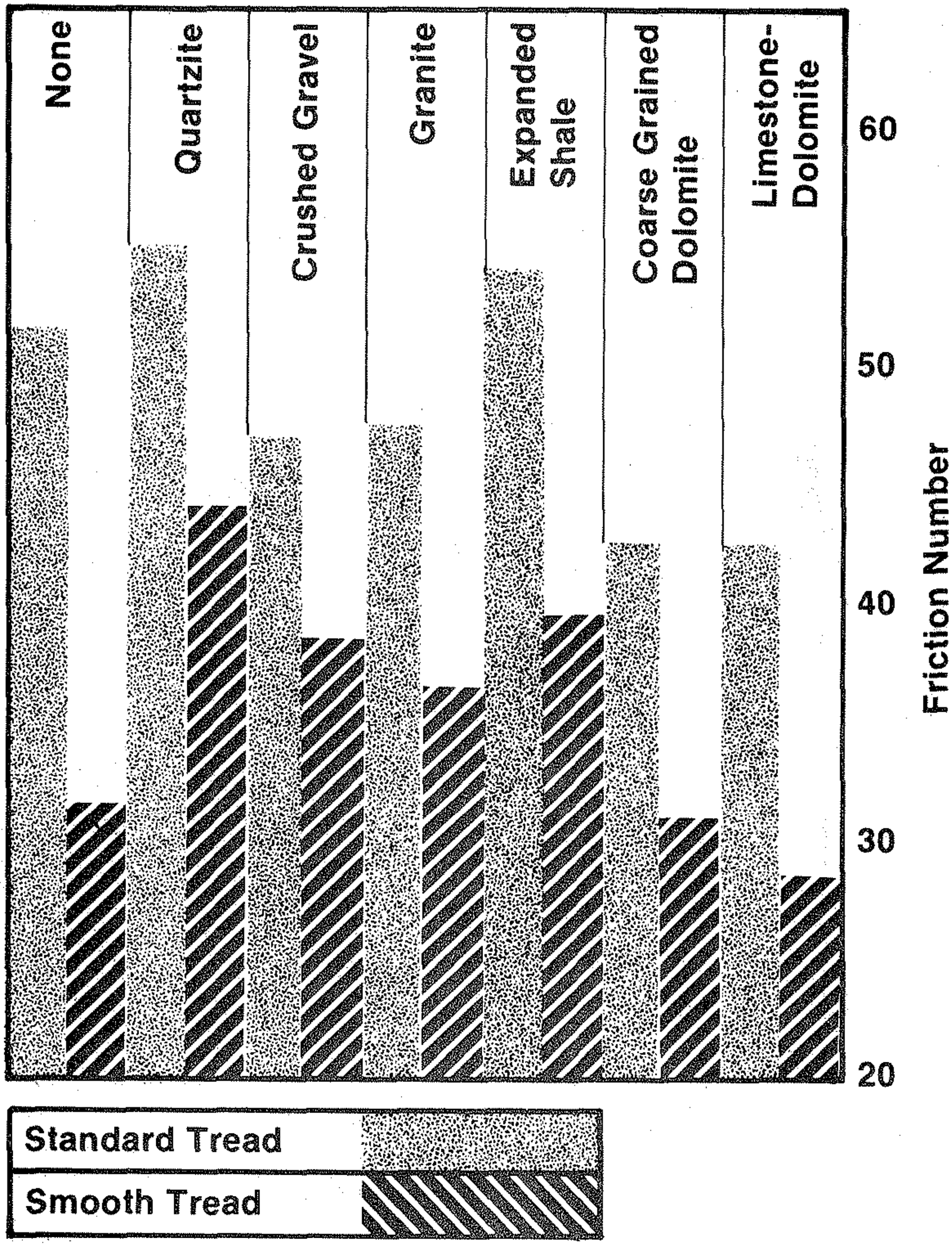
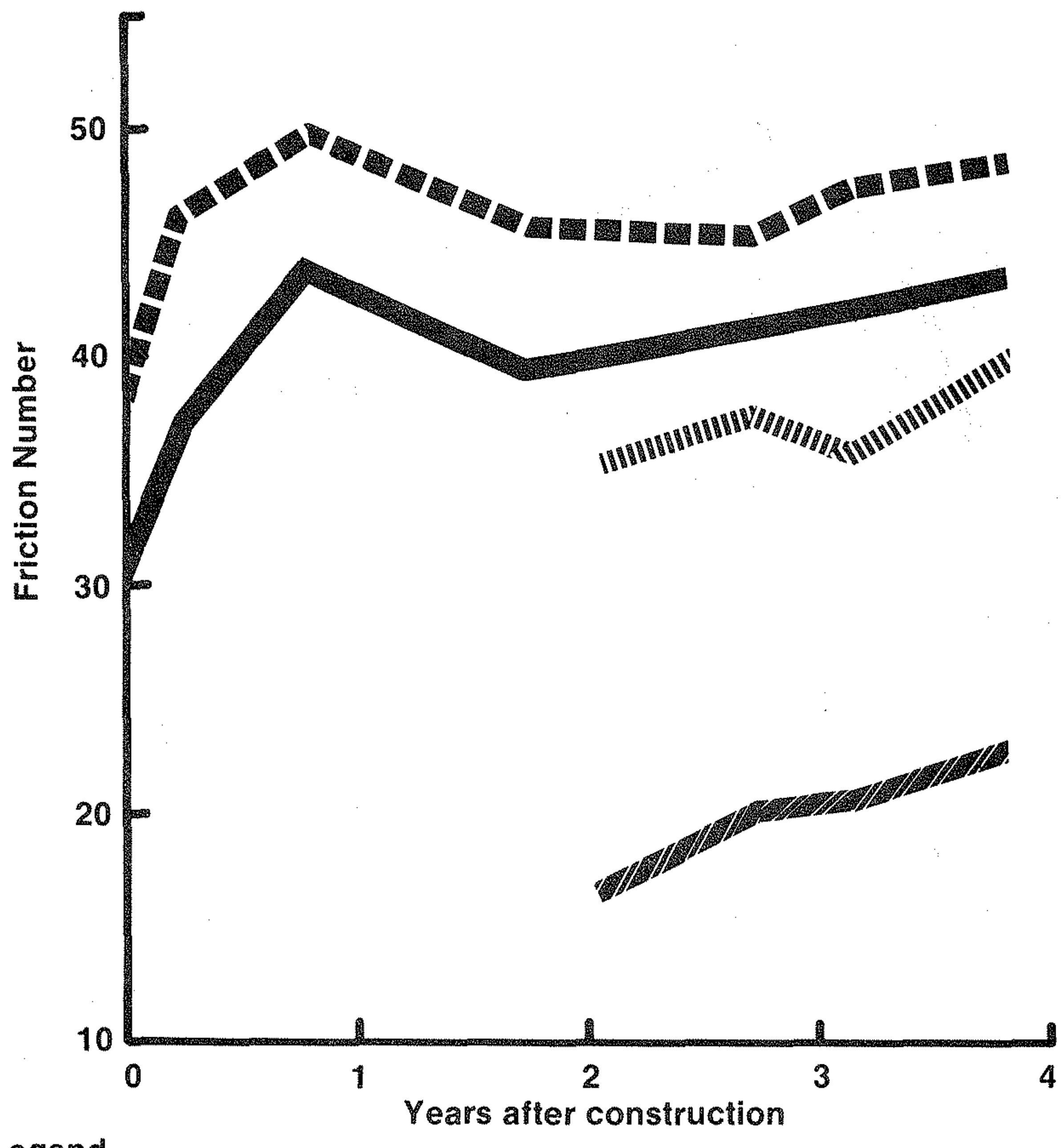


Figure 14: Comparison of Friction Numbers for Sprinkle Treated Sections and Control Sections on a Type B ½" (13 MM) Mix



Legend

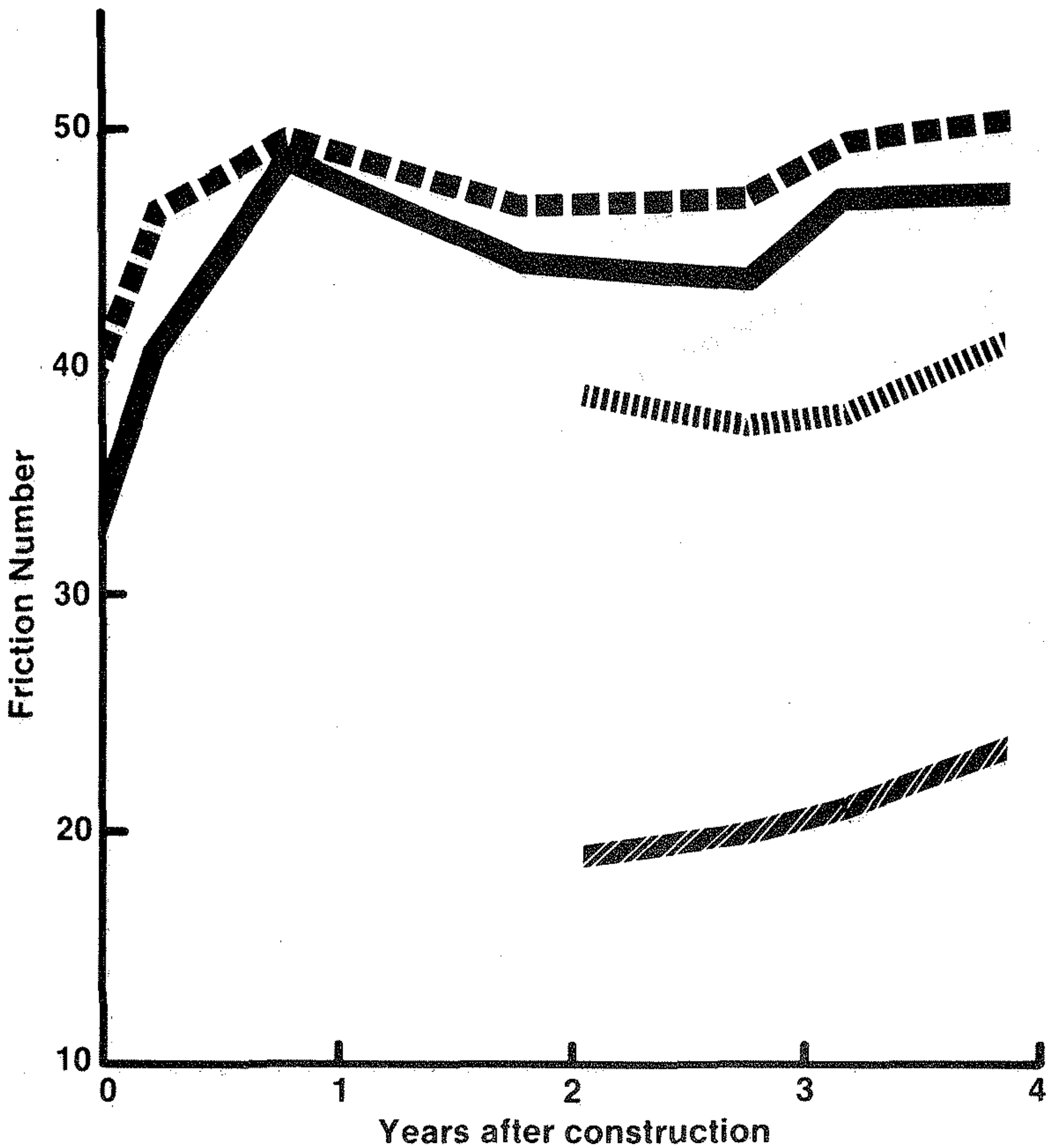
Control - Standard Tire

Average all Sprinkle Treated Sections-Standard Tire

Control - Non Treaded Smooth Tire

Average of all Sprinkle Treated Sections-Nontreaded Smooth Tire

Figure 15: Comparison of Friction Numbers for Sprinkle Treated Sections and Control Sections on Type B 3/8" (10 MM) Mix

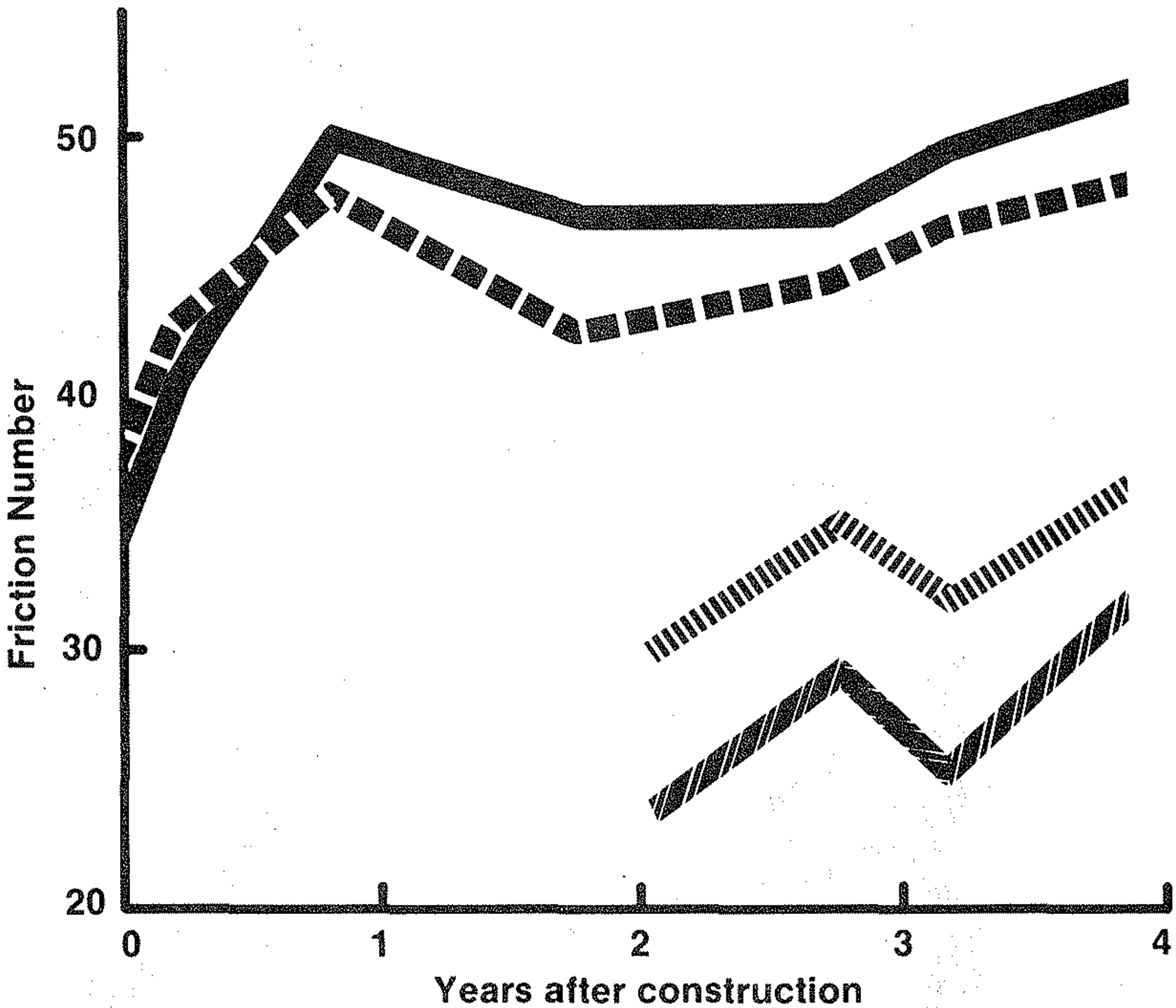


Legend

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

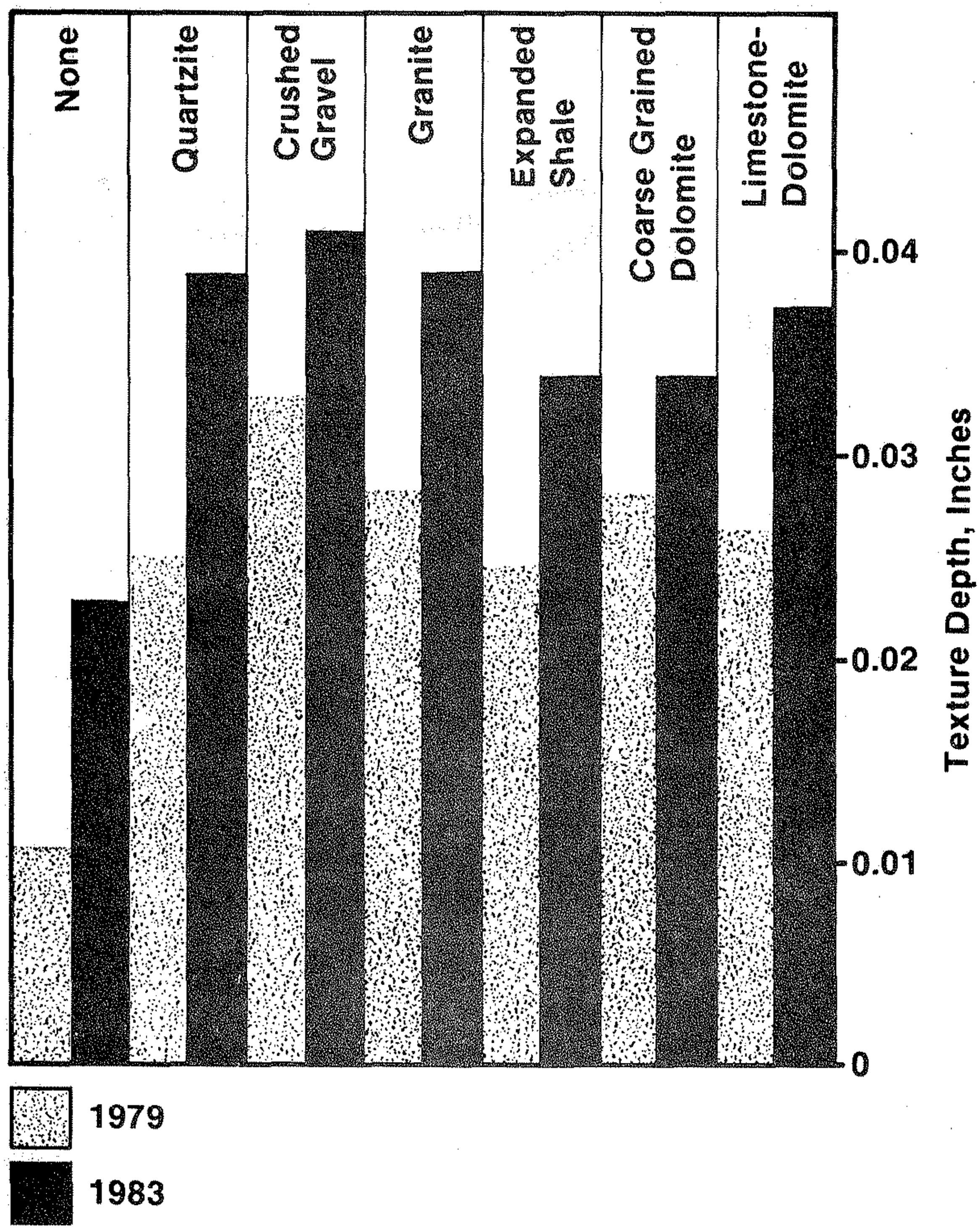


Legend

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 17: Average Texture Depth of Nonsprinkled and Sprinkle Treated Surfaces



ECONOMIC BENEFIT

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

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

Assuming that the nonpolishing 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" (38mm) 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.

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 (161 km) per year, and as of 1981 had approximately 420 miles (675 km) of sprinkle treated surfaces. Approximately 150 miles (240 km) were sprinkle treated in 1982. This total includes 13 miles (21 km) of the eastbound lanes of I-80 in west-central Iowa. Traffic volumes in this area exceed 10,000 VPD.

One technique not noted in our research effort is that chips will coat better at low temperatures ($240^{\circ}F$ to $250^{\circ}F$ or $115^{\circ}C$ to $120^{\circ}C$). 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 Flowboy trucks and concrete dumpsters with augers or conveyors for a satisfactory job.

ACKNOWLEDGEMENT

Research Project HR-199 was sponsored by the Iowa Highway Research Board, the Highway Division of the Iowa Department of Transportation and the Federal Highway Administration.

The author wishes to extend appreciation to Messrs. R. H. Given, C. L. Huisman, 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.

APPENDICES

Appendix A-1

FRICTION TEST DATA

40 MPH

Standard Tread

1/2" Mix	Control A 1		Quartzite A 2		Cr.Gravel A 3		Granite A 4		Exp.Shale A 5		CG Dolomite A 6		Lmst Dolo. A 7	
Date	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
08-10-78	30	33	39	35	41	34	38	35	39	43	36	37	45	38
08-28-78	33	39	44	42	46	42	45	41	45	49	41	44	48	46
09-15-78	30	39	47	45	48	43	46	43	49	51	41	45	49	47
10-18-78	33	41	46	46	46	44	46	44	49	51	43	46	48	47
05-15-79	42	46	54	51	48	47	50	46	54	54	48	48	50	47
04-29-80	39	40	51	50	47	43	47	44	53	47	39	41	44	43
05-05-81	37	46	47	51	43	43	44	46	51	52	36	44	42	45
10-01-81	42	42	51	49	46	43	48	46	55	50	40	44	47	48
06-01-82	43	44	51	53	47	47	50	46	55	52	39	46	47	49
08-19-82	41	45	53	52	47	46	47	46	61	50	39	47	44	49
06-01-83	46	49	57	58	52	51	54	50	61	58	46	59	51	52
09-06-83	42	50	54	55	48	48	48	49	58	53	40	49	46	52

3/8" Mix	B1		B2		B3		B4		B5		B6		B7	
Date														
08-10-78	38	32	42	35	42	38	37	38	45	43	44	39	40	41
08-28-78	41	38	47	44	43	44	44	45	51	51	46	42	45	45
09-15-78	41	40	47	45	46	46	46	47	52	52	46	43	47	49
10-18-78	41	40	49	45	46	43	46	46	53	51	45	40	42	47
05-15-79	50	48	55	51	49	48	49	48	55	56	40	45	47	47
04-29-80	46	43	51	47	46	44	48	46	57	54	49	37	40	40
05-05-81	42	45	51	50	43	46	46	47	54	56	44	42	38	44
10-01-81	48	46	54	50	52	46	50	47	57	54	48	42	44	46
06-01-82	47	47	57	53	49	48	50	51	58	57	48	43	43	46
08-19-82	47	48	56	52	46	49	48	49	60	58	49	42	41	46
06-01-83	51	52	58	58	52	51	55	53	64	64	52	45	44	50
09-06-83	48	50	56	56	48	50	50	51	57	57	48	44	46	48

Sand	C1		C2		C3		C4		C5		C6		C7	
Date														
08-10-78	36	35	39	37	38	40	37	38	39	37	36	37	39	43
08-28-78	40	38	43	42	42	42	42	42	46	43	39	37	40	41
09-15-78	41	41	45	42	44	43	42	42	47	44	41	38	42	38
10-18-78	40	41	45	45	44	42	42	42	46	45	41	38	42	38
05-15-79	51	49	53	52	46	47	47	47	54	54	48	42	44	38
04-29-80	47	47	52	47	46	40	41	43	51	47	40	33	38	32
05-05-81	47	47	51	50	44	43	42	44	55	51	40	37	39	34
10-01-81	50	49	55	51	49	44	43	45	53	50	46	39	47	36
06-01-82	51	52	56	54	47	47	47	48	54	54	45	40	46	39
08-19-82	51	49	57	54	49	45	44	46	58	55	42	37	44	38
06-01-83	58	55	61	59	52	47	48	51	52	58	48	43	48	44
09-06-83	50	50	54	52	49	46	42	48	56	55	45	42	46	38

Appendix A-2

FRICTION TEST DATA
40 MPH

Smooth Tread

	Control		Quartzite		Cr.Gravel		Granite		Exp.Shale		CG Dolomite		Lmst Dolo.	
1/2" Mix	A 1		A 2		A 3		A 4		A 5		A 6		A 7	
Date	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
08-21-80	15	18	37	37	32	35	37	38	35	40	28	35	33	35
05-05-81	19	21	38	37	36	34	41	39	43	40	31	36	36	37
10-01-81	18	21	40	36	36	34	34	36	39	37	34	35	31	35
06-01-82	20	25	42	42	38	38	41	39	48	41	32	39	36	39
08-19-82	19	22	43	38	38	36	39	37	39	38	26	38	34	37
06-01-83	26	28	45	45	43	40	44	44	46	44	32	39	36	40
09-06-83	24	26	44	43	42	41	44	44	44	44	34	39	38	42
3/8" Mix														
Date	B 1		B 2		B 3		B 4		B 5		B 6		B 7	
08-21-80	18	20	42	37	35	36	43	41	42	46	39	34	36	33
05-05-81	19	21	38	37	36	34	41	39	43	40	31	36	36	37
10-01-81	21	21	44	36	34	34	42	40	40	46	37	35	33	34
06-01-82	24	23	44	43	37	37	42	43	46	48	42	36	34	37
08-19-82	23	23	44	38	37	37	43	41	49	44	37	30	33	32
06-01-83	25	27	49	46	41	42	46	44	47	48	43	36	34	36
09-06-83	28	30	46	46	40	41	47	46	47	49	40	38	36	36
Sand	C 1		C 2		C 3		C 4		C 5		C 6		C 7	
Date														
08-21-80	25	23	39	35	36	29	31	30	34	33	26	23	23	20
05-05-81	31	27	44	37	40	33	35	33	46	37	32	27	30	23
10-01-81	26	25	41	33	37	34	32	32	38	32	31	25	27	24
06-01-82	32	31	42	46	40	37	37	36	42	37	34	28	32	25
08-19-82	29	26	47	36	38	31	34	33	45	36	31	23	28	22
06-01-83	35	33	46	46	44	30	42	41	46	41	36	30	34	28
09-06-83	34	28	48	42	43	36	35	36	51	38	32	30	34	25

AVERAGE TEXTURE DEPTH
Silly Putty Method

Section 1/2"Mix	1978 (in.)	1979 (in.)	1983 (in.)
A1	0.0107	0.0120	0.023
A2	0.0251	0.0270	0.036
A3	0.0355	0.0278	0.039
A4	0.0390	0.0317	0.036
A5	0.0295	0.0194	0.036
A6	0.0312	0.0258	0.033
A7	0.0347	0.0255	0.040
3/8"Mix			
B1	0.0047	0.0066	0.017
B2	0.0288	0.0210	0.037
B3	0.0367	0.0326	0.040
B4	0.0324	0.0266	0.040
B5	0.0360	0.0314	0.037
B6	0.0423	0.0361	0.041
B7	0.0363	0.0361	0.044
Sandmix			
C1	0.0027	0.0139	0.029
C2	0.0145	0.0272	0.044
C3	0.0233	0.0379	0.043
C4	0.0217	0.0263	0.042
C5	0.0118	0.0233	0.029
C6	0.0097	0.0229	0.027
C7	-	0.0179	0.027

Type of Stone		1978	1979	1983
Control	1	0.0060	0.0108	0.023
Quartzite	2	0.0228	0.0251	0.039
Gravel	3	0.0318	0.0328	0.041
Granite	4	0.0310	0.0282	0.039
Haydite	5	0.0258	0.0247	0.034
Dolomite	6	0.0277	0.0283	0.034
Limestone & Dolomite	7	0.0355	0.0265	0.037

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

NEGOTIATED CONTRACT

PAGE 1 OF 47 PAGES

EFFECTIVE DATE

REQ. NO. OR OTHER PURCHASE AUTH.	NEGOTIATED PURSUANT TO	CONTRACT NO.
Demonstration Projects Division	Titles 41 USC §252(c)(15) 23 USC §307(a)	DOT-FH-15-295

ISSUED BY:	MAIL INVOICES TO:
DEPARTMENT OF TRANSPORTATION FEDERAL HIGHWAY ADMINISTRATION Region 15 1000 North Glebe Road Arlington, Virginia 22201	U.S. Department of Transportation Federal Highway Administration Region 15 1000 North Glebe Road Arlington, Virginia 22201

CONTRACTOR *(Name and address)*	PAYMENT WILL BE MADE BY:
Iowa Department of Transportation State Capitol Des Moines, Iowa 50319	Federal Highway Administration Region 15, Finance Office 1000 North Glebe Road Arlington, Virginia 22201

OFFICE OF TECHNICAL ADMINISTRATION AND NAME OF CONTRACT MANAGER	COMPLETION DATE OR PERIOD OF PERFORMANCE
Mr. Douglas Bernard Federal Highway Administration Region 15, Demonstration Projects Division 1000 North Glebe Road Arlington, Virginia 22201	See ARTICLE V - PERIOD OF PERFORMANCE

ACCOUNTING AND APPROPRIATION DATA

958-15-78-1C-1060-0050

The contractor agrees to perform all the services set forth in the attached schedule, for the consideration stated therein. The rights and obligations of the parties to this contract shall be subject to and governed by the schedule and the general provisions. To the extent of any inconsistency between the schedule or the general provisions and any specifications or other provisions which are made a part of this contract, by reference or otherwise, the schedule and the general provisions shall control; to the extent of any inconsistency between the schedule and the general provisions, the schedule shall control.

THE TOTAL AMOUNT OF THIS CONTRACT IS $ NTE $15,000

NAME OF CONTRACTOR	
Iowa Department of Transportation	UNITED STATES OF AMERICA DEPARTMENT OF TRANSPORTATION FEDERAL HIGHWAY ADMINISTRATION

BY *(Signature of authorized individual)*	DATE	BY *(Signature of contracting officer)*	DATE
	6-23-78		

TYPED NAME	TYPED NAME OF CONTRACTING OFFICER
	Thomas O. Edick
TITLE	**TITLE**
	Regional Engineer and Contracting Officer

Form FHWA-1232 (Rev. 4-72) Previous edition [illegible]

O.S.O. 43   44+

Highway Division

OFFICE OF MATERIALS — INSTRUCTIONAL MEMORANDUM

GENERAL AGGREGATE SOURCE INFORMATION

GENERAL

Only those aggregate sources which have been sampled or tested within the last ten years are listed. This listing additionally ranks sources in accordance with a skid resistance classification as defined herein for aggregates used in asphalt construction. The rankings are based on the ledges used in the past for asphalt aggregates. Upon request, new sources or different combinations of beds within an existing source will be evaluated as to their skid resistance classification. This ranking refers only to the skid resistant properties and does not waive the normal quality requirements for the particular type of aggregate indicated in the contract documents.

One or more skid classification types may be specified on asphalt surface courses.

PORTLAND CEMENT CONCRETE AGGREGATES

Aggregates shall be produced from sources approved in accordance with the requirements of Materials I.M. Numbers 410, 415, and 417.

All aggregates produced and inspected for intended use in contracts under Iowa Department of Transportation Specifications shall be stored in identifiable stockpiles unless they are being delivered as produced.

Scalping of some portion of the coarser fraction may be approved by the engineer. The engineer may consider the results of laboratory freezing and thawing tests, behavior in concrete in which the aggregate or petrological similar aggregates have been used, physical, chemical and petrographic analyses, coating characteristics or other characteristics in making this determination.

SKID RESISTANCE CLASSIFICATION OF AGGREGATE

When Type 1 through Type 5 skid resistant aggregates are specified for construction, a source approval including bed limitations, is required for each project. Tentative bed limitations are shown in the listing.

Aggregates have been classified into five functional types in accordance with their characteristics as related to skid resistance. One or more of the four higher type skid resistant aggregates may be specified for use in pavement surface courses. If a type is not specified in the contract documents, Type 5 or better will be acceptable.

The five skid resistant types are listed and defined in order of descending quality as follows.

Type 1
Aggregates which are generally a heterogeneous combination of minerals with coarse grained microstructure of very hard particles (Generally a Mohs Hardness range of 7 to 9) bonded together by a slightly softer matrix.

These aggregates are typified by those developed for and used by the grinding-wheel industry such as calcined bauxite (synthetic) and emery (natural). They normally are not available from Iowa sources. Due to the high cost, these aggregates would be specified only for extremely critical situations.

Type 2
Natural aggregates in this class are crushed quartzite and granites. The mineral grains in these materials generally have a Mohs hardness range of 5 to 7.

Synthetic aggregates in this class are some aircooled steel furnace slags and others with similar characteristics.

Type 3
Natural aggregates in this class are crushed traprocks, crushed gravels or those crushed from dolomitic ledges in which 80 percent or more of the grains have diameters of 120 microns or larger. The mineral grains in the approved dolomitic ledges generally have a Mohs hardness range of 3.5 to 4. The crushed gravels shall not contain more than 30 percent of carbonate stone as defined in the Type 5 classification.

Synthetic aggregates in this class are the expanded shales with a Los Angeles abrasion loss less than 35 percent.

Type 4
Aggregates crushed from dolomitic or limestone ledges in which 80 percent of the grains are 30 microns or larger. The mineral grains in the approved ledges for this classification generally have a Mohs hardness range of 3 to 4. The gravels shall not contain more than 60 percent of carbonate stone as defined in the Type 5 classification.

Type 5
Aggregates crushed from lithographic and sublithographic limestone ledges and natural gravels containing more than 60 percent lithographic and sublithographic limestone particles. Grain sizes will predominately be below 30 microns for the crushed stone.

LISTING

The following sheet explains the code used in the listing.

The bed numbers shown for concrete aggregate are those on the formal approval letter for the source. The beds shown for asphalt sources are those which have been used or have a potential for use and are of the designated skid resistance type. The beds listed may not include all of those normally worked.

Asphaltic Concrete - Type B

Asphaltic Concrete - Type A

Portland Cement Concrete - Fine Aggregate

Portland Cement Concrete - Coarse Aggregate

Skid resistance classification for asphalt use

Concrete Durability Class
Class 2 sources with a bar over the numeral ($\overline{2}$) are approved for bridge deck repair aggregate.
A (V) indicates Class 5 aggregate.

Specific Gravity

Denotes that the source has the potential to make the kind of aggregate designated.

			SpGr	PCC CA	PCC FA	AC 'A'	AC 'B'	BEDS
CEDAR COUNTY	CRUSHED STONE	LOCATION						
Alpha Cr Stone	Hunt	SW 10-81-04		2		4	4	1
Wendling Quarries	Schneckloth	NW 04-81-01	2.66	2				1
Wendling Quarries	Schneckloth	NW 04-81-01				4	4	1-3
Alpha Cr Stone	McGuire	SE 14-80-03	2.72	2				1-4
Alpha Cr Stone	McGuire	SE 14-80-03				4	4	4
B L Anderson	Lime City	NE 16-79-02		2		4	4	2
Martin Marietta	Peden	NE 09-79-03				5	5	
	SAND & GRAVEL							
Wendling Quarries	S. Rochester	NW 12-79-03	2.65		X	4	4	
Wendling Quarries	Massillon	SE 11-82-01					4	
CERRO GORDO COUNTY	CRUSHED STONE							
P & M Stone	Wepking	NW 15-97-21	2.77	2				4-5
P & M Stone	Wepking	NW 15-97-21				4	4	2-5
• Weaver Const.	Quimby	NW 27-97-20	2.77	2		5	5	4-10
Weaver Const.	Quimby	NW 27-97-20				4	4	8-10
Welp & McCarten	Kohler	NE 19-96-19	2.77	2		5	5	1-8
Welp & McCarten	Kohler	NE 19-96-19				4	4	4-8
Greene Ls. Co.	McEachran	NW 20-96-19	2.77	2		5	5	1-8
Greene Ls. Co.	McEachran	NW 20-96-19				4	4	4-8
Weaver Const.	Lillybridge	SW 26-94-20		X		5	5	
Welp & McCarten	Swaledale	SW 10-94-21					5	
Welp & McCarten	Rock Falls	NE 16-97-19					5	

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IOWA DEPARTMENT OF TRANSPORTATION

Ames, Iowa

Supplemental Specification

for

SPRINKLE TREATMENT OF ASPHALT CEMENT CONCRETE SURFACES

February 28, 1978

THE STANDARD SPECIFICATIONS, SERIES OF 1977, ARE AMENDED BY THE FOLLOWING ADDITIONS. THESE ARE SUPPLEMENTAL SPECIFICATIONS, AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

824.01 DESCRIPTION. Sprinkle Treatment shall consist of properly graded aggregate, precoated with asphalt cement and applied to the surface of hot-mix asphalt cement concrete pavement as designated in these specifications and elsewhere in the contract documents.

824.02 MATERIALS. The materials used in sprinkle treatments of asphalt cement concrete surfaces shall meet the following requirements.

A. Aggregate shall be composed of a Type III crushed gravel or a Type IV crushed stone as classified in Materials Instructional Memorandum T-203 or lightweight aggregate (expanded shales).
Crushed gravel shall be produced as a separate operation by crushing gravel to the extent that 100 percent will pass the 3/4-inch sieve; the aggregate shall be prescreened prior to crushing on a screen at least 1/4 inch larger. The prescreen size shall be adjusted to compensate for screening efficiency, material variability, and carryover.
All limestone and gravel aggregates shall be washed products.
All aggregate sources and production procedures shall be subject to approval of the engineer, and the aggregate shall meet the following requirements.

1. Freezing-and-Thawing Test. The freezing-and-thawing test loss, when tested according to Laboratory Test Method 211, Method A, shall not exceed 10 percent.
2. Abrasion Loss. The percentage of wear, as determined by AASHTO T 96, shall not exceed 40.
3. Size of Particles. When tested by means of laboratory sieves, the aggregate shall meet the following limits. The percentage passing the No. 200 sieve shall be determined by washing followed by dry sieving. Any mudballs present shall be completely broken up and dissolved.

Sieve Size	Percent Passing
3/4	100
3/8	20 - 55
No. 4	0 - 5
No. 200	- 1.5

B. Asphalt. The asphalt cement used to coat the aggregate shall be the grade used in the asphalt surface course.

C. Aggregate Coating. Aggregates to be used for sprinkle treatment shall be submitted to the Central Laboratory prior to precoating. The Laboratory will designate the proper coating, and this may be modified by the engineer. The designated coating will be between 0.75 percent and 2.0 percent, expressed as percent by weight of asphalt cement in the total mixture. The designated coating shall be considered a target value.

824.03 EQUIPMENT. The equipment used for spreading the precoated aggregate shall be a Bristowes Chip Spreader. An equivalent spreader may be approved by the engineer.
Initial rolling shall be with a self-propelled, smooth, steel-tired roller meeting requirements of 2001.05B.

824.04 PRECOATED AGGREGATE. The equipment and procedures for precoating shall comply with the applicable requirements of 2001.22 and 2303.04.
The aggregate shall be precoated at a temperature between 240F and 275F and shall have a uniform, complete coating. The aggregate should be coated at the lowest temperature that insures complete coating. If coated aggregate is stockpiled, it shall be stockpiled on a clean, paved surface. Stockpiling methods which minimize segregation shall be used. Provisions should be made for manipulation or wetting of the coated aggregate if crusting of the aggregate occurs. The engineer may require the stockpile to be covered.
At the option of the contractor, precoated aggregate remaining at the completion of the work will be purchased and paid for by the contracting authority. The precoated aggregate shall be hauled and stockpiled at a site designated by the engineer. The haul may be as far as the nearest maintenance garage of the contracting authority. The engineer may limit the quantity of aggregate to be precoated to assure this quantity is reasonable.

0.5.0.49 50+

650015
H-6777

TABULATION OF CONSTRUCTION AND MATERIAL BIDS
IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

BID ORDER NO.

LOCATION ON IOWA 930 (OLD U S 30) FROM 0.5 MILE EAST OF I-35 EAST 5.3 MILES INTO NEVADA

5.291 MILES

COUNTY: STORY
TYPE OF WORK: ASPH. CEMENT CONC. RESURF.
PROJECT NO.: P-930-0(14)--3C-85
DATE OF LETTING: MAY 23, 1978

Bidder: IOWA ROAD BUILDERS CO. DES MOINES, IOWA.

NO.	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT
1	BASE, CLEANING & PREPARATION OF	5.300	MILES	750.00	3,975.00				
2	PRIMER OR TACK-COAT BITUMEN	3799	GALS.	.68	2,583.32				
3	PATCHES, FULL DEPTH	228	SQ. YDS	45.00	10,260.00				
4	PATCHES, ASPHALT CEMENT CONCRETE SURFACE	45	TONS	57.00	2,565.00				
5	GUARDRAIL, FORMED STEEL BEAM	379	LIN. FT	9.75	3,667.50				
6	GUARDRAIL, POSTS, BEAM	46	ONLY	49.22	2,264.12				
7	STEEL, STRUCTURAL	936	LBS.	3.96	3,706.56				
8	GUARDRAIL, END ANCHORAGES, BEAM RC-52	4	ONLY	440.00	1,760.00				
9	AGGREGATE FOR SPRINKLE TREATMENT	232	TONS	70.00	16,240.00				
10	~~SHOULDERS, GRANULAR SURFACING OF~~	1446	TONS	8.72	12,609.12				
11	ASPHALT CEMENT CONCRETE, TYPE B SURFACE COURSE, MIXT. SIZE 1/2	2045	TONS	17.77	36,339.65				
12	ASPHALT CEMENT CONCRETE, TYPE B SURFACE COURSE, MIXT. SIZE 3/8"	1498	TONS	19.05	28,536.90				
13	ASPHALT-SAND SURFACE COURSE	1638	TONS	17.30	28,337.40				
14	TEMPORARY PAVEMENT MARKINGS	280	STAS.	4.80	1,344.00				
15	ASPHALT CEMENT	351.700	TONS	89.50	31,477.15				
16	SEALER, RUBBER ASPHALT CRACK	4600	LBS.	1.63	7,498.00				
	TOTAL				$193,163.72				

NO TIES OR RESERVATIONS

(1,056.37)

Appendix E

52+

Appendix F

SP-217

IOWA DEPARTMENT OF TRANSPORTATION

Ames, Iowa

SPECIAL PROVISION

for

CLEANING AND FILLING CRACKS
AND JOINTS PRIOR TO RESURFACING

Story P-930-0(14)--30-85

May 23, 1978

THE STANDARD SPECIFICATIONS, SERIES OF 1977, ARE AMENDED BY THE FOLLOWING ADDITIONS. THIS IS A SPECIAL PROVISION AND SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

217.01 *GENERAL. In addition to the cleaning* and preparation of the old base as required by Article 2212.04 of the Standard Specifications, Series of 1977, the following additional work shall be done:

Dirt and granular material shall be cleaned from areas where spalled and scaled material has been removed and from cracks and joints by use of compressed air or other means approved by the engineer.

Joints and cracks to be sealed shall include distress cracks and longitudinal and transverse joints or cracks which exceed 1/4" in width and 1" in depth or as designated by the engineer.

All joints and cracks to be sealed shall be completely filled to the pavement surface with the rubber sealant. Cracks beneath areas requiring asphalt concrete surface patches in accordance with Paragraph 2212.04 B.1 shall be filled with rubber sealant to the base of the patch if the crack exceeds 1/4" in width.

217.02 MATERIALS. Material used shall be Overflex MS, as manufactured by CRAFCO, Inc., of Phoenix, Arizona, or an approved equal as follows:

A. Asphalt shall be 200-300 penetration grade asphalt complying with requirements of AASHTO M 20.

B. Granulated crumb rubber (100 percent vulcanized) shall meet the following requirements:

Sieve	Percent Passing
No. 8	100
No. 10	98-100
No. 40	0- 10

The granulated crumb rubber, irrespective of diameter, shall not exceed 7 mm in length.

C. The packaged proportions of the two materials by weight shall be 75% ± 2% asphalt and 25% ± 2% rubber. Temperatures of mixed materials shall be held at 350 degrees F until reaction time has occurred, depending on the asphalt, and then the material can be applied at a temperature of from 250 to 350 degrees F. Equipment for applying the sealer shall be that recommended by the manufacturer.

217.03 METHOD OF MEASUREMENT. The engineer will calculate the quantity of sealing material actually used by count of packages and net weight of each package of the sealing material used.

217.04 BASIS OF PAYMENT. For the number of pounds of rubber asphalt crack sealer used in cleaning and filling cracks and joints, the contractor will be paid the contract price per pound. Such payment shall be full compensation for cleaning and filling the cracks and joints and for furnishing all the materials, equipment, tools, and labor therefor, including traffic control.

Article 1109.03 shall not apply.

0.50.52 59+

Appendix G

Specification 847
Supersedes 842

IOWA DEPARTMENT OF TRANSPORTATION
Ames, Iowa

Supplemental Specification
for

SPRINKLE TREATMENT OF ASPHALT CEMENT CONCRETE SURFACES

April 24, 1979

THE STANDARD SPECIFICATIONS, SERIES OF 1977, ARE AMENDED BY THE FOLLOWING ADDITIONS. THESE ARE SUPPLEMENTAL SPECIFICATIONS, AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

847.01 DESCRIPTION. Sprinkle treatment shall consist of properly graded aggregate, precoated with asphalt cement and applied to the surface of hot-mix asphalt cement concrete pavement as designated in these specifications and elsewhere in the contract documents.

847.02 MATERIALS. The materials used in sprinkle treatments of asphalt cement concrete surfaces shall meet the following requirements.

A. Aggregate shall be composed of --
   1. A Type III crushed gravel or a Type II, III or IV crushed stone as classified in Materials Instructional Memorandum T-203, or
   2. Lightweight aggregate (expanded shales).

The aggregates will be shown on the proposal as alternates.
Crushed gravel shall be produced as a separate operation by crushing gravel to the extent that 100 percent will pass the 3/4-inch sieve; the aggregate shall be prescreened prior to crushing on a screen at least 1/4 inch larger. The prescreen size shall be adjusted to compensate for screening efficiency, material variability, and carryover.
All limestone and gravel aggregates shall be washed products.
All aggregate sources and production procedures shall be subject to approval of the engineer, and the aggregate shall meet the following requirements.

1. Freezing-and-Thawing Test. The freezing-and-thawing loss, when tested according to Laboratory Test Method 211, Method A, shall not exceed 10 percent.
2. Abrasion Loss. The percentage of wear, as determined by AASHTO T 96, shall not exceed 35 for lightweight aggregate and 40 for all other aggregate.
3. Size of Particles. When tested by means of laboratory sieves, the aggregate shall meet the following limits. The percentage passing the No. 200 sieve shall be determined by washing, followed by dry sieving. Any mudballs present shall be completely broken up and dissolved.

Sieve Size	Percent Passing
3/4	100
3/8	0 - 15*
No. 4	0 - 5
No. 200	- 1.5**

*For lightweight aggregate, a maximum of 17 percent will be allowed.
**The maximum percent passing the No. 200 sieve may be increased to 2.5 percent provided the documented production limit agreed to and maintained is 1.0 percent or less and any increase up to 2.5 percent is due to degradation of the parent material and not to contamination by other material.

B. Asphalt. The asphalt cement used to coat the aggregate shall be the grade used in the asphalt surface course.

C. Aggregate Coating. Samples of aggregates to be used for sprinkle treatment shall be submitted to the Central Laboratory for testing prior to precoating. The Laboratory will designate the proper coating, and this may be modified by the engineer. The designated coating will be between 0.75 percent and 2.0 percent, expressed as percent by weight of asphalt cement in the total mixture. The designated coating shall be considered a target value.

847.03 EQUIPMENT. The equipment used for spreading the precoated aggregate shall be a Bristowes Chip Spreader. An equivalent spreader may be approved by the engineer.
Initial rolling shall be with a self-propelled, smooth, steel-tired roller meeting requirements of 2001.05B.

847.04 PRECOATED AGGREGATE. The equipment and procedures for precoating shall comply with the applicable requirements of 2001.22 and 2303.04.
The aggregate shall be precoated at a temperature between 240F and 275F and shall have a uniform, complete coating. The aggregate should be coated at the lowest temperature that insures complete coating. If coated aggregate is stockpiled, it shall be stockpiled on a clean, paved