It should be emphasized at this point that the aggregates selected for use in this study are marginal and thus difficult to stabilize and that much greater success with foamed asphalt has been reported elsewhere in the literature. The asphalt cement used in this study may have contained a silicone antifoaming additive. As a result, the comparatively short half-life of the asphalt foam may have impeded thorough mixing with the aggregates.

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Sprinkle Treatment in Illinois

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Three sprinkle treatment projects built in Illinois in 1980 and 1981 have been evaluated by using accident data, friction measurements, texture measurements, chip counts, and visual observations. This construction technique of applying a precoated chip to a freshly placed asphaltic concrete mat has proved to be a practical, economical method for providing a high-macrotexture, high-friction mat that should reduce accidents.

Sprinkle treatment is a method that provides a safe riding surface by using a minimum amount of high-quality aggregates, which may be limited in supply and often expensive. This is achieved by sprinkling a precoated chip and rolling it into a freshly placed asphaltic concrete mat.

Three projects are involved in this research study, the oldest of which is about 2 years old. Varying chip spread rates, types of chips, and types of topography have been involved in the three projects. The projects are being evaluated by using friction, texture, and chip count measurements. Visual observations were made during construction and will continue to be made to evaluate performance. Traffic accident analyses both before and after sprinkle treatment have been made for one project constructed 19 months ago.

FIELD TEST PROGRAM

The first sprinkle treatment project built in Illinois is located on US-151/IL-35 from East Dubuque to the Illinois-Wisconsin line. The job is 1.93 miles long and was completed during August 1980. The average daily traffic (ADT) on the route is 8,600 vehicles, including 1,250 commercial vehicles in two lanes. IL-35 in this area is winding and hilly, and there is a third truck lane for about a quarter of a mile. Accident experience on this roadway had been a cause for concern and was the primary reason for placing the sprinkle treatment.

The second project is located on IL-185 from US-40 near Vandalia northwesterly to the Fayette-Montgomery County line. This project was done with both financial and technical assistance from Region 15 of the Demonstration Projects Division of FHWA. IL-185 carries an ADT of 1,300 to 1,600 over most of the project, and the mile nearest Vandalia carries

an ADT of 2,800. About 8.8 miles of 24-ft-wide pavement was resurfaced by placing 3 in. of a binder course mix and 1.5 in. of surface mix. The first sprinkle treatment was placed on September 12, 1980, and the last on October 6, 1980. Mild weather, with temperatures in the 55° to 75°F range, persisted throughout the job.

The third project included in this study is located on US-20 about 0.75 mile east of Elizabeth to Derinda Road. It consisted of 0.59 mile of winding roadway (multiple S-curves), with two lanes (26 ft wide and variable), on slightly rolling terrain. The curves have posted speed limits of 30 and 35 mph, and the ADT is about 3,400. The sprinkle treatment was placed into 1.25 in. of an asphaltic concrete mat during October 1981. Mild fall weather with temperatures in the 55° to 65°F range prevailed during construction. As with the East Dubuque job, accident history was the reason for placing the sprinkle treatment on these tight curves on US-20.

SPECIAL PROVISION FOR SPRINKLE TREATMENT

All three jobs described in this paper were governed by a special provision similar to the latest Illinois Department of Transportation (DOT) special provision for sprinkle treatment. This special provision is presented below.

Sprinkle Treatment Chips

Description: This work shall consist of precoating chips with asphalt, spreading the pre-coated onto a modified Bituminous Concrete Surface Course, Mixture C, Class I, and rolling the chips into the surface course at the locations shown on the plans.

Methods and Materials: The chips shall be crushed traprock, blast furnace slag, steel slag or prequalified crushed gravel meeting Class B quality or better and shall meet the following gradation:

Sieve	% Passing
1"	100
3/4"	90-100
1/2"	0-25
#4	0-5
#200	0-2

This gradation may be produced by screening and recombining prior to precoating the chips in the asphalt plant. The chips shall be run through an asphalt mix drier and dried to 250-300°F and then mixed in a pugmill with an asphalt cement of the same grade as is being used in the Class I surface mix; the lowest temperature which ensures complete coating shall be used. A drier-drum plant may be used to precoat the chips. A highly absorptive aggregate (absorption over 2.5 percent) may be required to be processed twice through the drier, to ensure drying to less than 0.7 percent residual moisture by weight. The exact percentage of asphalt cement necessary to coat the chips shall be set by the Engineer. The range of asphalt contents shall be between 0.5 and 2.5 percent by weight. An anti-stripping agent (to be approved by the Engineer in advance of its use) shall be added when required to the asphalt cement at a rate of from 0.5 to 1.5 percent by weight.

When the precoated chips are prepared in a batch-type mixing plant, the heated aggregate and the asphalt cement shall be measured separately and accurately by weight or by volume. The time required to add the asphalt cement shall not be more than 15 seconds. The total time required for adding the asphalt cement and completing the wet mixing period shall not be less than 30 seconds; if necessary to produce a mixture in which all particles of aggregate are coated uniformly, the time shall be longer.

When the precoated chips are prepared in a continuous or drum-drier-type mixing plant, the heated aggregate and asphalt cement shall be measured separately and accurately by volume or weight. The heated aggregate and asphalt cement shall be mixed for a period of not less than 45 seconds; if necessary a longer period shall be used to produce uniform coating.

Storage in Stockpile: The precoated aggregate shall be stockpiled in piles; not to exceed 3 feet in height, on a clean hard surface of sufficient size to permit manipulation of the aggregate (without contamination) to aid cooling. Stockpiling to a height not to exceed 3 feet is necessary to prevent heat buildup within the stockpile (which can burn off or harden the asphalt coating). After about 15 minutes, the stockpiles can be hosed down with water to cool them off and to make the chips flow more freely through the spreader. The stockpile chips shall be used by the day after precoating or the stockpile shall be covered with a suitable tarp to prevent the coated chips from collecting dust. The tarp should not be placed before the stockpile has cooled completely.

Equipment: The equipment for spreading shall be a Bristowes hydrostatic chip spreader or approved equal which can straddle the mat being laid. This machine shall be run immediately behind the paver which is laying the modified Bituminous Concrete Surface, Mixture C, Class I.

Construction Methods: The precoated aggregate shall be applied at the rate of 9 ± 2 pounds per square yard of lane surface, the exact rate being set by the Engineer. If an aggregate is used which has a bulk specific gravity outside of range between 2.55 and 2.85, an adjustment shall be made according to the following formula:

$$\text{Adjusted tons} = \text{tons used} \times (2.70/\text{bulk specific gravity of chips used}) \quad (1)$$

$$\text{Spread rate*} = 9 \times (\text{bulk specific gravity of chips used}/2.70) \quad (2)$$

*This should be rounded to the nearest half pound to determine the target value with a tolerance of ±2 pounds.

The rate should be checked several times daily on the road using a canvas tarp one yard square.

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-wheel roller; pneumatic-tired rollers shall not be allowed. Compaction shall be in accordance with Article 406.15 (1) except as herein revised. Traffic shall not be allowed on the mat until the mat has cooled sufficiently to prevent dislodging of chips. Water may be used to cool the mat. Any chips that fall outside the mat onto the adjacent lane shall be swept up and removed before placing the bituminous mixture on that lane.

Basis of Payment: All related work, equipment, materials, and labor, as required above, shall be paid for at the contract unit price per ton for sprinkle treatment chips.

Bituminous Concrete Surface Course, Mixture C, Class I

The initial mixture to be laid as a base for

the sprinkle treatment chips is to be Bituminous Concrete Surface Course, MIXTURE C, CLASS I, with the following modifications. Article 406.12 shall be modified to show that approximately 45% but not more than 50% shall be retained above the #10 sieve. The mixture formula shall be approved by the Engineer.

DESCRIPTION AND ANALYSIS OF PROJECTS

Chip Coating and Spreading

Three different aggregates were used in the three projects. A traprock from Dresser, Wisconsin, was used in the East Dubuque job, and a traprock from Iron Mountain, Missouri, was used on the Vandalia job. Blast furnace slag from Chicago was used on US-20 near Elizabeth. No significant problems were encountered with coating any of these aggregates with the same asphalt cement used in the mix (AC-10). The precoating asphalt in each case had an antistripping agent blended into it at 0.5 percent by weight of the asphalt. A dryer-drum continuous mixer was used on two of the projects and a batch pugmill mixer on the other. Both were effective in coating the chips.

The amount of asphalt to be placed on the chips was determined by making up small samples of coated chips in the laboratory with varying percentages of asphalt. These were judged by handling the cooled coated chips, which had been wet to simulate construction procedures. The highest percentage of asphalt by weight of mixture that still allowed the chips to be free-flowing was chosen. The amount of asphalt chosen for both the traprocks was 1.5 percent, whereas 2.5 percent asphalt was chosen for the blast furnace slag. These were adjusted slightly on the job if it was felt that the coating was too light or too heavy.

A range in temperature from 270° to 320°F was used to precoat the chips. After precoating, the chips were placed in shallow stockpiles (2 to 3 ft tall). An end loader was used to manipulate the stockpile and aid in cooling. After the chips had cooled somewhat, the stockpiles were watered down to provide additional cooling and aid in preventing agglomeration. The stockpiles only seldom covered with a tarpaulin because a tarpaulin retains heat; it was found to be unnecessary unless dust conditions were severe. Little stripping was noted on the coated chips and that only on the sharp edges of the Iron Mountain traprock.

As the coated chips were loaded onto the Flow boy transport trucks, they were hosed down again to aid in workability. An end loader was used on each job to move the chips from the transport truck to the Bristowes chip spreader, blocking both lanes in the process. This caused traffic control problems, especially on the East Dubuque job. At one time, there was a three-state traffic jam. Traffic was backed up into Dubuque, Iowa, to the southwest and into Wisconsin on the north. Shutting down for about a half-hour relieved this problem.

The flow of the chips through the Bristowes spreader appeared to be good, and no clumping together of the chips was noted as long as the operation moved ahead. However, the chips stuck together in the chip spreader whenever it stopped for more than a few minutes. Heat from the asphaltic concrete mat would cause the asphalt on the chips to soften and the chips to stick together. This prevented the chips from being free-flowing when the spreader started and required that the chips in the spreader be agitated with a broomstick.

The distribution of the chips on the mat was not uniform because the Bristowes spreader tended to clump the chips together. About 15 chips would be deposited in one pocket while the surrounding 1 to 1.5 in. of mat would be devoid of chips. Some characteristics of the Bristowes spreader, probably the rotating spined rod that keeps the chips from agglomerating in the bottom of the bin, were responsible for this clumping.

Another problem noted on all jobs was transverse streaking caused by alternating heavy and light chip applications. This could not be explained exactly from the standpoint of the Bristowes design. Possible causes for this are looseness or slippage of the chain drive mechanism and bouncing of the spreader on its tires. The Bristowes chip spreader does apply more chips when traveling upgrade.

The Bristowes spreader does not maintain a uniform amount of chips per square yard as it moves along the road. In the Vandalia job, a canvas tarpaulin was used several times daily to adjust the spreader to the target value. Table 1 summarizes the target values for a day's paving and the actual amount computed based on the tonnage applied on the Vandalia job. On both the East Dubuque and Elizabeth projects, an average of about 10 lb/yd^2 of chips was used.

In another attempt to estimate in-place spread rates, a chip-count technique was used. A 35-mm color slide was taken of two 1-ft^2 areas that were outlined on the pavement surface with a light wooden frame measuring 1x2 ft. The slide was projected onto a piece of paper, and the chips were marked off as they were counted. To determine a reliable average number of ships per pound, seven 1-lb samples of chips were counted. By using this information and accounting for the weight of the asphalt cement on the chips, a spread rate in pounds per square yard was computed. The photographs were taken on November 25, 1980, about 7 weeks after the project was completed. Twelve areas were photographed at random in each of the 6-, 9-, and 12-lb/yd^2 target areas. The results are given in Table 2.

As can be seen by examining the coefficient of variation, the most variable was the 9-lb/yd^2 target area and the least variable the 12-lb/yd^2 target area. The fact that the 9-lb/yd^2 target area constituted about 80 percent of the job is believed to be the cause of the higher variability.

In spite of the shortcomings of the Bristowes spreader described earlier in this paper, it is the best equipment available for sprinkle treatment and is effective in spreading the precoated chips. Improvements can be made, but that is not to say that the Bristowes spreader does not work well.

Compaction and Chip Embedment

Only steel-wheeled rollers were used. Both vibratory and static rollers have been used with similar results. No rubber-tired rollers were used because they tended to pull the precoated chips from the mat. Chip breakage under the rollers has not been a serious problem; very little occurred with the traprock, but some (not serious) did occur with the slag.

Chip embedment has not been a problem except in isolated areas. Heavy chip application (more than 12 lb/yd^2) in conjunction with a thin mat (1 in. thick or less) has caused poor embedment and chip loss. Otherwise, chip embedment and retention have been satisfactory. Even after multiple snowplowings in the severe winter of 1981-1982, chip loss has been minimal. Additional embedment and chip orientation, especially with the traprocks turning flat side up, have been noted. This has affected friction, which is discussed later in this paper.

Table 1. Chip spread rates for the Vandalia job.

Date	Direction	Stations	Chip Spread Rate (lb/yd²) Target	Actual
9-12-80	Westbound	1216+00 to 1308+50	9	7.9
9-15-80	Eastbound	1201+50 to 1308+20	9	8.1
9-19-80	Eastbound	1081+18 to 1201+50	6	6.3
9-22-80	Westbound	1101+90 to 1216+00	12	11.0
9-23-80	Westbound	970+95 to 1101+90	9	9.5
9-24-80	Eastbound	983+55 to 1081+18	9	8.4
10-01-80	Westbound	888+52 to 970+95	9	9.8
10-02-80	Eastbound	888+52 to 983+55	9	10.4
10-03-80	Westbound	1308+50 to 1356+23	9	10.1
10-06-80	Eastbound	1308+20 to 1356+23	9	11.0

Table 2. Estimated chip spread rates for three target areas.

Item	Chip Spread Rate 6 lb/yd²	9 lb/yd²	12 lb/yd²
1	6.8	9.4	10.6
2	6.9	10.7	11.7
3	6.6	10.6	11.2
4	7.1	10.0	11.9
5	7.2	9.2	11.8
6	6.9	8.7	12.2
7	8.8	8.2	10.9
8	7.2	9.4	12.2
9	7.7	10.2	13.3
10	8.0	6.9	12.0
11	6.5	8.2	11.7
12	6.7	9.8	12.3
Avg	7.2	9.3	11.8
Range	6.5-8.8	6.9-10.7	10.6-13.3
SD	0.67	1.12	0.71
Coefficient of variation (%)	9.3	12.0	6.0

Asphalt Mixtures

The asphaltic concrete mix used in these jobs was called a modified class I mixture C. Modified in this case means that the amount of aggregate larger than the No. 10 sieve mesh was less than normal. Usually class I surface mixes range from 57 to 63 percent or more on the No. 10 sieve. The modified mix, however, was kept below 50 percent. This was done to provide sufficient space in the mix for the chips to be embedded into the mat and to provide sufficient mortar to hold the chips. The proportions, gradation, and properties of the modified class I mixture C for the Vandalia job are given in the following tables:

Material	Blend (%)
Crushed stone	40.0
Natural sand	38.2
Fine-blend sand	12.8
Fly ash	3.3
Asphalt	5.7

Gradation	Mixing Extraction (%)		Formula (%)
Sieve Size			
0.75 to 0.5 in.	0.7	52.2	50.0
0.5 in. to No. 4	32.8		
No. 4 to No. 10	18.7		
No. 10 to No. 40	17.4	37.6	39.6
No. 40 to No. 80	11.5		
No. 80 to No. 200	8.7		
Minus No. 200	4.5	4.5	4.7
Asphalt	5.7	5.7	5.7

Property	Value
Marshall stability (lb)	1570
Marshall flow	16.4
Voids (%)	1.35

Mix designs for the other two jobs were similar to those for the Vandalia job except that a manufactured stone sand was used for part of the sand to increase stability. This was successful in that Marshall stabilities ranging from 1,700 to 2,200 lb were realized. One disadvantage and possible limitation of the sprinkle treatment is that stability must be sacrificed to allow chip embedment.

FIELD TEST RESULTS

Friction Tests

The friction test results are outlined in Table 3 for the three projects. All tests were performed at 40 mph with a standard trailer according to ASTM E274. Both treaded-tire tests (ASTM E501) and smooth-tire tests (ASTM E524) were run to permit an estimate of surface drainage or macrotexture. The treaded-tire tests were performed on the inside wheel path, and the smooth-tire tests were performed on the outside wheel path, but not at the same time. All of the numbers reported in Table 3 are averages of several lockups.

As expected, the highest friction numbers were achieved with the air-cooled blast-furnace slag because its microtexture was much better than that of the traprocks. The traprocks are hard, fine-grained rocks that, with their angularity and sharp edges, provide adequate friction. As mentioned previously, particle orientation during compaction and under traffic causes the traprock chips to turn flat side up in the mat so that their sharp, angular edges are less exposed to vehicle tires. The smooth-tire friction numbers emphasize this orientation. Friction numbers were the lowest at East Dubuque, where the orientation of the traprock particles was particularly noted.

The change in friction numbers between the treaded- and smooth-tire tests is of interest. On the Vandalia job, for the tests performed on May 19, 1982, at the age of 20 months, a direct relation can be seen between the chip application rate and the change in friction number.

Texture Tests

Texture tests using the sand-patch technique were performed on November 17, 1981, when the Vandalia job was about 13 months old. The individual test results and the averages are given in Table 4. Again, because of the variability of the Bristowes chip spreader in applying the chips, a large range in texture depths was realized, as shown by the 24 to 26 percent coefficients of variation.

There is, of course, a direct relation between texture depth and chip application rate. The choice of the amount of chips to be used on future jobs was based primarily on this information. A spread rate of 6 lb/yd² was believed to be too low. Average texture depths of less than 0.04 in. on new construction were believed to be insufficient. Average texture depths of more than 0.06 in. are specified in the United Kingdom for new construction where chips are placed in hot-rolled asphalt surfaces. This was believed to be impractical for our purposes, although it was achieved by using the 12-lb application rate. A typical mix in the United Kingdom contains about 35 percent coarse aggregate. Difficulty was encountered during construction in getting 12 lb of chips embedded into the asphaltic

Table 3. Average friction numbers.

Project	Material	Spread Rate (lb/yd²)	Date Tested	Age (months)	FN, Treaded	FN, Smooth	ΔFN
Vandalia	Traprock	6	6/30/81	9	43	33	10
			5/19/82	20	44	34	10
		9	6/30/81	9	42	35	7
			5/19/81	20	42	35	7
		12	6/30/81	9	43	38	5
			5/19/81	20	42	39	3
East Dubuque	Traprock	10	8/31/81	12	36	32	4
			7/16/82	23	39	32	7
Elizabeth	Air-cooled blast-furnace slag	10	7/16/82	10	54	47	7

Note: FN = Friction number.

Table 4. Average texture depths recorded for the Vandalia job on Nov. 17, 1981.

	Avg Texture Depth by Target Area (in.)		
Measurement	6 lb/yd²	9 lb/yd²	12 lb/yd²
1	0.034	0.050	0.075
2	0.035	0.057	0.049
3	0.038	0.050	0.064
4	0.038	0.065	0.048
5	0.031	0.045	0.045
6	0.024	0.035	0.073
7	0.043	0.041	0.086
8	0.034	0.039	0.084
9	0.050	0.039	0.088
10	0.055	0.041	0.066
11		0.039	
12		0.039	
13		0.056	
14		0.080	
15		0.049	
16		0.031	
Avg	0.038	0.047	0.068
Range	0.024-0.055	0.031-0.080	0.045-0.088
SD	0.009	0.012	0.016
Coefficient of variation (%)	24	24	26

concrete mat with 50 percent plus no. 10 aggregate in the mat. This was mentioned previously where chip embedment was poor in thin-mat areas. Chip loss on the Vandalia project has not been a problem even in these areas because of the relatively light traffic volumes. It was believed that even less than 45 percent plus no. 10 aggregate would be required to accommodate the 12-lb rate. Because of this, the 9-lb rate was chosen as a compromise that would provide good texture, fewer construction problems, and a more stable surface mix.

The proof of the importance of texture depth was demonstrated by observing the water film on the 6- and 12-lb/yd² areas immediately after a brief, heavy spring rainstorm. The 6- and 12-lb/yd² areas lie side by side, the 6-lb/yd² area in the eastbound lane and the 12-lb/yd² area in the westbound lane. The difference between surface drainage and water-film thickness was dramatic. The increased texture of the 12-lb/yd² area caused the chips to protrude through the water film, whereas the texture in the 6-lb/yd² area was completely covered.

Accident Analysis

Because the oldest job was 2 years old when this paper was prepared and accident data require several months to compile, few accident data were available. The job at East Dubuque was analyzed because it was the oldest and a known high-accident-rate location and also because the only safety improvement made there was the sprinkle treatment overlay.

Accident data were compared for time periods 19 months before and 19 months after construction. This comprised the period from February 1979 through March 1982 (construction was completed on August 26, 1980). In the before period, there were 29 accidents in which wet pavement was involved, and in the after period, there were 10 accidents--a 66 percent decrease in wet-weather accidents. To evaluate the influence of weather, the number of days on which more than 0.01 in. of precipitation occurred was tabulated. In the 19-month period before construction, there were 173 days of precipitation; in the 19-month period after construction, there were 166 days. Therefore, the amount of precipitation should not have a different effect on the number of wet-weather accidents in the before and after periods.

The total number of accidents in the before period was 68, and in the after period 38--a 44 percent decrease in total accidents.

The types of accidents at this site were mainly rear-end, sideswipe, and collision with off-the-road objects.

Although a 19-month period is relatively short, it is believed that accidents on both wet and dry pavements can be significantly reduced by the use of a sprinkle treatment.

Cost Analysis

The costs of the sprinkle treatment were compared with the costs of other typical skid-resistant overlays--i.e., mixtures D and E, and the open-graded asphalt friction course, mixture C. Mixtures C, D, and E are defined in the Illinois DOT specifications (1) as follows:

> 704.03 Coarse Aggregate for Bituminous Courses.
> (a) Description....For Class I Bituminous Courses Mixtures C and D, the coarse aggregate shall be crushed gravel, crushed stone, crushed slag, crushed steel slag or chats except, limestone will not be permitted as the sole coarse aggregate in Mixture D. For Mixture D, limestone may be used if blended in equal proportions by volume with a crushed slag or crushed steel slag coarse aggregate. For Class I Bituminous Course, Mixture E, the coarse aggregate shall be crushed slag, crushed steel slag or a blend in equal proportions by volume, of crushed slag, or crushed steel slag with crushed gravel, chats or a crushed stone other than limestone.

The following excerpt from a design memorandum presents the policy governing use of the three surface course mixtures:

1. Mixture C should be used as surfacing on

Table 5. Costs of three sprinkle treatment projects (1980).

Cost Category	Mixture	Cost ($/yd²)
Statewide average	1.5-in. mixture D	2.67
	1.5-in. mixture E	2.89
	0.625-in. open-graded asphalt friction course plus 1.5-in. binder mix	4.14
East Dubuque project	1.5-in. mixture C plus sprinkle chips	4.05
Vandalia project	1.5-in. mixture C plus sprinkle chips	2.80
Elizabeth project[a]	1.25-in. mixture C plus sprinkle chips or 1.25-in. mixture C plus 0.625-in. open-graded asphalt friction course	4.52

[a]1981.

roads and streets, except on the primary system, having a design traffic ADT of 2000 or less.

2. Mixture D or E should be used as surfacing on secondary and local roads and streets having a design traffic ADT greater than 2000, on all two-lane primary highways, on four-lane primary highways having a design traffic ADT of 25,000 or less, and on six-lane or greater highways having a design traffic ADT of 60,000 or less.

3. Only Mixture E should be used as surfacing on four-lane highways having a design traffic ADT greater than 25,000 and on six-lane or greater highways having a design traffic ADT greater than 60,000.

The 1980 costs are given in Table 5. Costs for both the East Dubuque and Elizabeth projects appear high, probably because of the small quantities involved. For the larger job at Vandalia, more realistic cost comparisons can be made. In that case, the sprinkle treatment can compete with both mixture E and an open-graded asphalt friction course. It is also of interest to note that at Elizabeth the contractor had the option of placing either an open-graded friction course or a sprinkle treatment. The bid on the option for 9,114 yd² of either type of treatment was $0.85/yd², and the contractor chose the sprinkle treatment.

CONCLUSIONS

Friction numbers were good on all three projects. Macrotexture on the sprinkle-treated surface is excellent for the 12-lb/yd² chip spread rate, good for the 9-lb/yd² rate, but poor for the 6-lb/yd² rate. Based on limited data, reductions in both wet-weather and total accidents have been realized. It is therefore concluded that sprinkle treatment is a feasible, practical, and economical method for providing a safe riding surface.

An additional six sprinkle treatment projects were built in 1982. The extent of the future use of this type of treatment will depend on the overall evaluations of the nine projects built to date.

REFERENCE

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Publication of this paper sponsored by Committee on Characteristics of Bituminous-Aggregate Combinations to Meet Surface Requirements.

Experience in Iowa with Sprinkle Treatment of Asphalt Pavements

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Experience in Iowa with the use of sprinkle treatments to improve the frictional characteristics of pavement surfaces is described. 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. Manipulating coated chips in small piles and lightly sprinkling them with water just before use reduce congealment problems. Friction testing has shown the greatest improvement when quartzite and expanded shale were used: friction numbers were 8 to 10 points higher than those for nonsprinkled sections. Sprinkle treatments also yield greater macrotexture.

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 costs are concerns that have been addressed in some form in many conference programs and papers. Presented in this paper is a discussion of a method that is being used in Iowa as a means of treating the surface of asphalt pavements to increase texture characteristics and at the same time conserve the supply of high-quality, nonpolishing aggregates.

Open-graded friction courses have been used extensively as a means of improving the frictional characteristics of asphalt pavements. In Iowa this concept has been used in the construction of three experimental projects, but the results have been disappointing. Conclusions drawn from the open-graded friction course projects are that they

1. Quickly became impermeable because of dirt deposited on the pavement, and they lacked the edge drainage that is needed but that often requires an edge drop-off, a factor that is also recognized as a hazard;
2. Spalled excessively at reflected cracks; and
3. Required a minimum of 60 lb/yd² (32 kg/m²) of high-quality aggregate.

Sprinkle treating or chipping is a process of