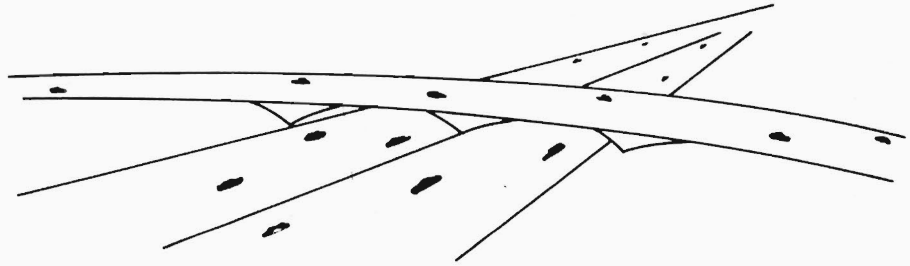

DEPARTMENTAL RESEARCH

Report Number SS 20.3

SPRINKLE MIX EXPERIENCES IN THE STATE OF VIRGINIA

[redacted]

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

SPRINKLE MIX EXPERIENCES IN THE STATE OF VIRGINIA

by

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TABLE OF CONTENTS

SUMMARY

Sprinkle treatment (sometimes called sprinkle mix) is a pavement wherein a layer of hot mix asphaltic concrete pavement has precoated stones or aggregate sprinkled on its surface immediately after "lay-down" prior to compacting. The rolling or compaction then embeds these stones into the surface of the hot mix asphaltic concrete pavement. The intent is to permit the asphaltic concrete mixture to be constructed of polish susceptible local materials which are usually readily available and more economical. The sprinkle aggregate which would be of polish resistant stone would provide a desired level of skid resistance.

This paper results from a visit to the State of Virginia by David Hustace, Senior Research Engineer, and Temple R. Kennedy, Research Operations Engineer, Texas State Department of Highways and Public Transportation on July 13-15, 1976. The visit was made to investigate Virginia's activities in experimentation and perfection of sprinkle treatment, circumstances warranting its use, benefits derived and field performance.

In Virginia on maintenance ACP overlays, the contractor is given the option of placing an asphaltic mixture made of polish resistant coarse aggregate or of using sprinkle treatment. If the latter option is selected, the sprinkle aggregate must be polish resistant aggregate but the asphaltic mixture may be made of polish susceptible aggregates. The many projects west of the Blue Ridge Mountains being constructed with sprinkle treatment indicate the economics of this design for that area of the State. An eight year field performance history bears out the durability and lasting skid qualities of sprinkle treatment.

OBSERVATIONS AND CONCLUSIONS

1. Pavements in the State of Virginia generally appear to be of excellent quality. Little or no flushed pavements were noted. Also very little cracking or raveling was seen.
2. The spreader fabricated in the State shop provided uniform distribution at the specified rate when the aggregate was at sufficiently high temperature. There was some unevenness at the beginning of the application of each new hopper load. This was probably due to the roller and the material in the bottom of the hopper being cool.
3. Precoating and hot placement presented no plant operation problems. It required only about five minutes to "pull" the hot bins and begin precoating. This was done two or three times each day depending on the overall job production.
4. The precoated aggregate remained suitably hot (300^{o} F.) in the covered haul truck for as long as six hours.
5. The S-5 ACP mix provided a dense layer of pavement and the size 78 sprinkle aggregate furnished satisfactory texture.
6. Two rollers (one 3-wheel and one tandem) embedded the sprinkle stone and achieved specification density with three passes each.
7. With hot sprinkle aggregate precoated with 3 percent AC-20, there was no noticeable loss of aggregate after opening to traffic.

RECOMMENDATIONS

An agitator bar could be placed lower in the spreader hopper nearer the roller drum and the roller drum or lower area of the hopper preheated with a propane torch prior to beginning spreading each new hopper load. This may prevent the initial slight uneveness of distribution.

Consideration should be given to using a slightly larger size sprinkle stone with a more nearly one-size gradation.

LIST OF FIGURES

Mr. David Hustace and I traveled to Charlottesville, Virginia on July 12, 1976, to meet with representatives of the Virginia Highway Research Council, inspect in-place bituminous sprinkle mix pavements, and observe on-going sprinkle mix construction. On the morning of the 13th, we met with Mr. Charles S. Hughes, Virginia Highway Research Council. Mr. Hughes was very knowledgeable of their sprinkle mix work and extremely cooperative, accompanying us on our entire visit.

Mr. Hughes told us that Virginia is divided north to south by the Blue Ridge Mountains. This was reiterated by Messrs. Dennison, Jordan and Powers (of the Bristol District) whom we met at a sprinkle mix construction site on IH-81. They explained that Virginia has a relative abundance of skid resistant aggregates on the east but very little in the western portion of the State. Stones to the west of the Mountains are predominately limestones which do not provide lasting skid resistance. The State of Virginia, which had for many years been working to provide pavements with high skid resistance, began experimenting with sprinkle mix. In August, 1968, they constructed a 1.2 mile test section on U.S. 340 north of Waynesboro. This experimental project consisted of 17 sections using five different materials for sprinkle aggregate and several different gradations of these materials. These materials were precoated with MC-70 at varying rates.* Figure 1 shows the sections, the aggregates used, and the percent asphalt content for each section.

* "Use of a Sprinkle Treatment to Provide Skid Resistant Pavements," J. H. Dillard and G. W. Maupin, Jr.

TEST SECTION ON U.S. 340
CONSTRUCTED BY
THE VIRGINIA HIGHWAY RESEARCH COUNCIL
AUGUST 26, 1968

SECTION 1	FINE WEBLITE 12 % A.C.	SECTION 7A	SAME AS "7" EXCEPT RUBBER TIRE FIRST (3)
SECTION 1A	SAME AS "1" EXCEPT APPLICATION DOUBLED	SECTION 8	#8 CRUSHED GRAVEL 3 % A.C.
SECTION 2	#8 CRUSHED GRAVEL 3% A.C.	SECTION 9	CONCRETE SAND 4 % A.C.
SECTION 3	CONCRETE SAND 4% A.C.	SECTION 10	SLAG SAND 7 % A.C.
SECTION 4	SLAG SAND 7% A.C.	SECTION 10A	SAME AS "10" EXCEPT HEAVIER APPLICATION
SECTION 5	#8 SLAG 3 ½ % A.C.	SECTION 11	#8 SLAG 3 ½ % A.C.
SECTION 6	WEBLITE (5/16" — 3/16") 10 % A.C.	SECTION 12	#8 GRANITE 2 ½ % A.C.
SECTION 6A	SAME AS "6" EXCEPT HEAVIER APPLICATION	SECTION 13	WEBLITE (5/16" — 3/16") 10 % A.C.
SECTION 7	#8 GRANITE 2 ½ % A.C.		

NOTES

1. CURVES NOT SHOWN
2. ROAD WIDTH — 22'
3. USED RUBBER - TIRE ROLLER FIRST AT SECT. 7A TO SECT. 13
4. SECTIONS LAID IN NUMBERED SEQUENCE SHOWN

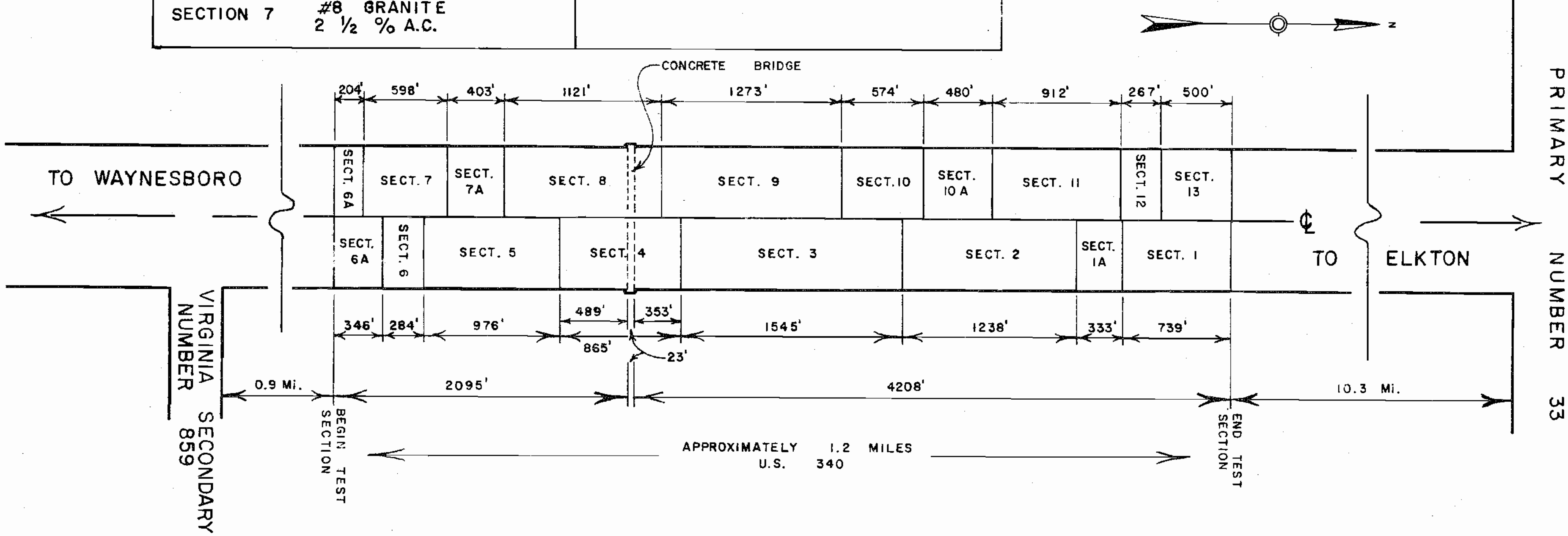


Figure 1

With this initial work in 1968, the Virginia Highway Research Council pioneered work on sprinkle mix in the United States. As reported,early in 1976 they had over 200 miles of sprinkle mix pavement surface under traffic. Following their lead, nine states have placed experimental sprinkle mix surfaces, Texas having the second largest mileage with 75 miles reported early in 1976.

The earlier Virginia work used a variety of aggregate gradations from sand size to their standard number 8 grading.

Virginia Size No. 8

Sieve Size	Percentage by Weight Passing
1/2	Min. 100
3/8	92 ± 8
No. 4	25 ± 15
No. 8	Max. 8
No. 16	Max. 3

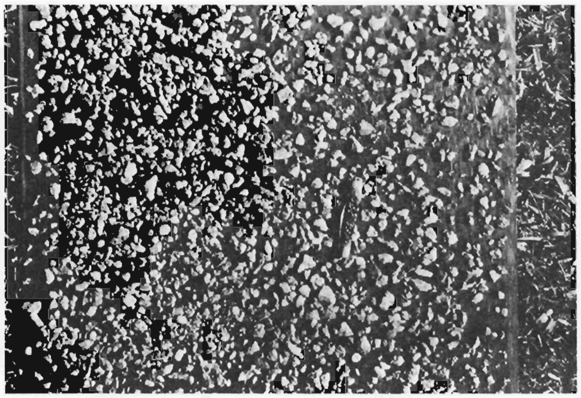
They have also used a one sized (5/16" - 3/16") synthetic material, Weblite. Initial experimenting included materials of concrete sand, slag, Weblite, crushed gravel and granite. This experimental work indicated that the finer sized aggregates did not provide the texture and lasting skid resistant properties as well as the coarser gradings did. The number 8 grading was used for a period of time before setting the coarser Virginia size number 78 as standard.

Virginia Size No. 78

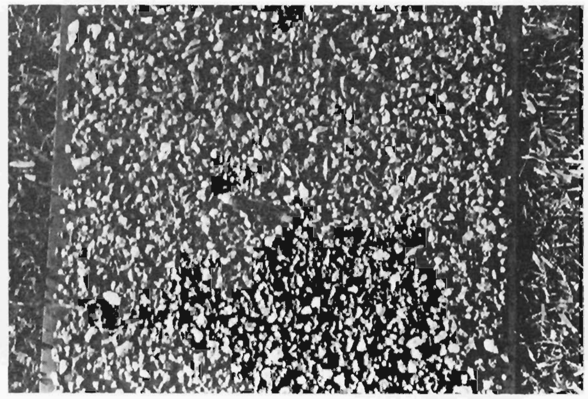
Sieve Size	Percentage by Weight Passing
3/4	Min. 100
1/2	95 ± 5
3/8	60 ± 20
No. 4	Max. 20
No. 8	Max. 8
No. 16	Max. 3

In early experiments, the aggregates were precoated in a plant with MC-70 and stockpiled, usually about four to six weeks before use. They were aerated periodically to remove volatiles and to cure-out. The percentage of asphalt content applied was varied from 2 1/2 percent for number 8 granite to as much as 12% on the fine Weblite. The various coatings used on different number 8 aggregates were 2 1/2, 3 and 3 1/2 percent.

The sprinkle distribution rates vary due to different gradations and specific gravities. With lightweight aggregate, 2.2 to 2.5 pounds were applied. With natural aggregate, the rates were varied from 3.5 to 5.2 pounds per square yard. As more experience was gained, they determined a rate of 5 to 7 pounds of natural aggregate per square yard of the large number 78 size to be preferred. Their specification establishes those limits. With lightweight aggregrate, they specify 3 to 5 pounds per square yard. The laboratory has prepared specimen boards about 18 inches square which depict the various rates (see figure 2).



Five Pounds Per Square Yard



Seven Pounds Per Square Yard

Figure 2

An inspector can visually compare what is being obtained on the road to the board. This assists him to adjust the rate of spread. A spin type salt or sand spreader was used to apply the aggregate. While they did obtain satisfactory distribution, it was difficult to get uniform spread, and "swirls" of the stone could be visually detected. Too, the trucks left tracks in the hot mix mat. This caused some concern but the tracks were ironed out with compaction rolling. Due to these difficulties, the Virginia Department decided to construct a model spreader for their use and to demonstrate to contractors and equipment suppliers that one could be made. They used the engine, transmission, axles, etc. from an old salvaged Dodge truck to shop fabricate a spreader. It is still in use and it has been used on all projects for the past three to four years. They loan it to contractors doing work for the State. The spreader straddles a 12' ACP mat and provides good even distribution. The mechanism which controls the distribution rate works well and the spreader is self propelled. (See figure 3)

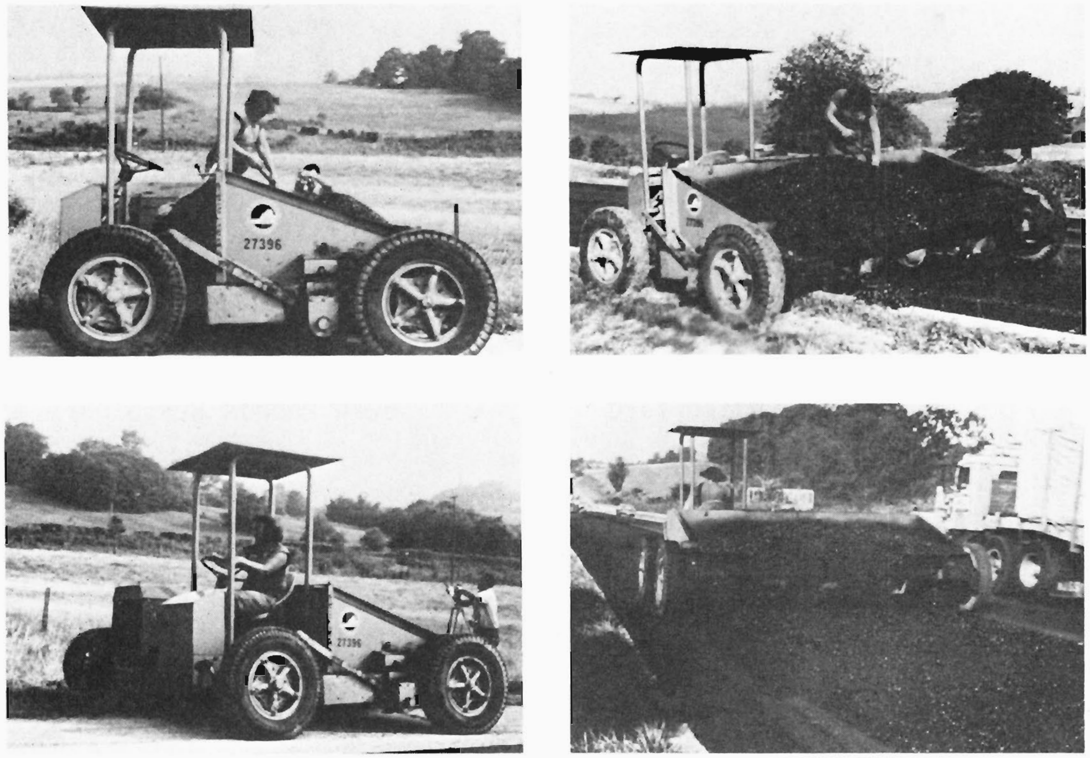


Figure 3

Following their experimental projects with further test sections in 1969 and 1970, they began to perform sprinkle mix maintenance overlays by contract. The contractor was given the option of making the hot mix overlay of polish resistant aggregates or of using polish susceptible aggregate in the hot mix and sprinkling with a precoated polish resistant aggregate. If he elected to place the sprinkle mix, he further had an option of precoating the aggregate about six weeks in advance with a cutback asphalt or precoating just prior to use with AC-20 and placing hot. After permitting these options for some time, they determined that the contractors usually did not get the material precoated with cutback sufficiently in advance nor properly manipulated to cure-out prior to use. Principally due to this shortcoming, they have stopped permitting the option. Specifications for all projects since 1974 have required the aggregate to be precoated with AC-20 and placed hot. See Appendix A for current Special Provision, SP-7.

After inspecting the experimental sections on U.S. 340 north of Waynesboro, we traveled to Bristol, Virginia, inspecting in-place sprinkle mix pavements encountered along the way.

The construction project which we were to observe is located on IH-81 northeast of Bristol near Abingdon. IH-81 is four lane with 1974-1975 traffic of about 13,000 ADT. This traffic is very heavily truck, breaking down to approximately 2,000 trailer trucks, 2,000 single unit trucks and 40 buses daily with the balance passenger cars. The traffic will vary from 7,000 to more than 14,000 VPD. They do not hesitate to use sprinkle mix on this type facility with this amount and class traffic. However, they have not used sprinkle mix on their heaviest traveled roads such as the Richmond Turnpike which has in excess of 40,000 VPD. They would probably want to work into that class highway gradually to gain experience on very high volume roads.

Virginia performs the work by use of maintenance funds, contracting the overlay and sprinkle mix operations. They have never applied it to new construction nor federally funded contracts. Probably for these reasons, the local FHWA offices have not exhibited much interest nor observed much of their sprinkle treatment work.

On the IH 81 project the construction contractor was State Contractors and Stone Company, Beaver Dam, Kentucky. They are a Division of Medusa Cement Company and own a stone quarry at Marion, Virginia. The Hot Mix plant is set up at the quarry which is about twenty-five miles from the project. The sprinkle treatment aggregate is a quartzite material from an approved skid resistance source, Newman Brothers Quarry, Sylvester, Virginia. Sylvester is located about fifty miles from the Marion plant toward Roanoke, Virginia.

The Hot Mix ACP design used with sprinkle mix is usually either S-5 or I-2. The S-5 is the finer mix with 100% passing the 1/2" screen. The I-2 is a coarser mix with 100% passing 1".

BITUMINOUS CONCRETE MIXTURES

Type	Percent by Weight Passing Square Mesh Sieves							Percent Bituminous Material	Mix Temperature (At Plant)
	1"	1/2"	3/8"	No.4	No.30	No.50	No.200		
S-5		100		50-70	15-30		2-10	5.0-8.5	225-300^{o} F.
I-2	100		60-80	40-60		5-14	1-7	4.5-8.0	225-300^{o} F.

AC-20 is used in both S-5 and I-2 mixes. The No. 78 size sprinkle stone is used with S-5 designs. With I-2 pavement design, a coarser grade of sprinkle treatment aggregate might be utilized. Usually the sprinkle mix contracts specify from 100 to 125 pounds per square yard of ACP. The IH 81 project stipulated 100 pounds per square yard of S-5 ACP mix. The asphalt content was 6.0% AC-20. The job specification called for 280^{o} F. hot mix temperature at the plant. A $\pm$ 20^{o} variation from this is allowed and a 30^0 drop is permitted from the plant to the road. The temperature at the road on this project checked out at 270^0 F.

To insure that the Hot Mix asphaltic concrete pavement can be adequately compacted and the sprinkle mix aggregate properly embedded, specifications provide certain base and asphaltic concrete pavement mixture temperature requirements. These temperature requirements are correlated with the ACP thickness being laid and breakdown rolling time for various number of rollers. A nomogram in pertinent specifications is used to control cold weather paving. (See figure 4)

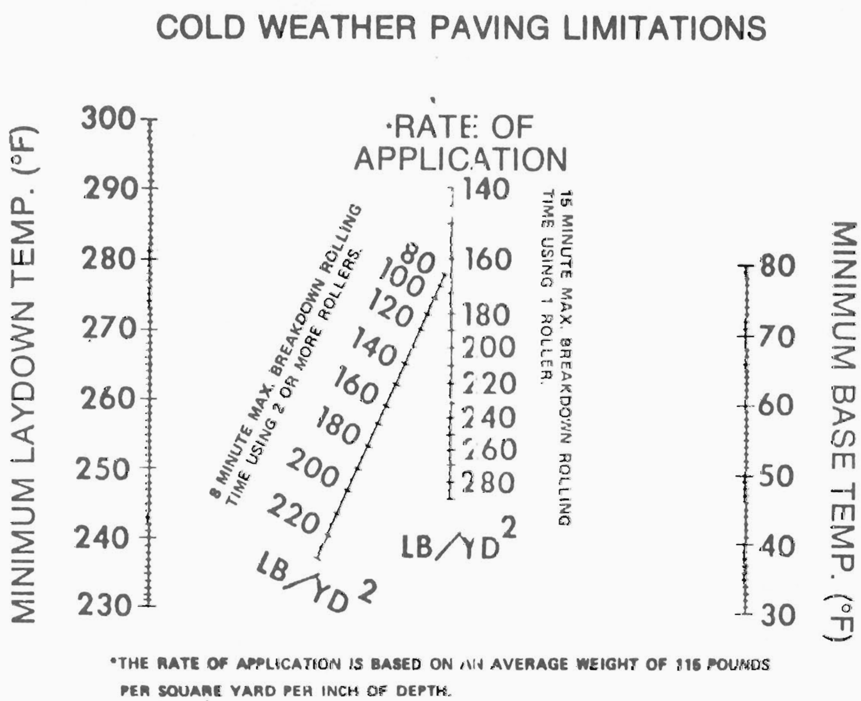


Figure 4

On the IH 81 project being constructed in mid-July, atmospheric temperatures naturally presented no problem. The contractor used one three-wheel power roller for breakdown rolling. The engineer preferred the three-wheel for breakdown rolling because the steel wheels were not as wide as on the tandem roller, therefore, they were less likely to bridge over any existing rutting or deformation in the wheel paths. Two to three complete passes are made with the three-wheel and three or more complete passes with the steel-wheel tandem roller. Project specifications required a minimum compaction of 92 percent of theoretical density. This was measured with a nuclear density device. On the day following placement, the pavement was cored for further laboratory testing and evaluation.

The sprinkle treatment aggregate was precoated hot with 3 percent by weight of AC-20 in the same plant that produced the ACP. The plant had four cold-stone bins with three bins containing sand, fine crushed stone and coarse crushed stone for the Hot Mix formulation and the fourth bin containing the sprinkle aggregate. The sprinkle aggregate was a proven skid resistant quartzite material from Newman Brothers Quarry. Two trucks were designated by the contractor to haul the sprinkle aggregate to the job site. These two independent truckers were paid at an hourly rate of $12 rather than by the load because only two to three loads were being used daily at the ACP laydown rate. Each truck hauled about 14,000 pounds. Due to the elevation of the aggregate spreader hopper, only certain trucks could charge the hopper. This was one reason for designating specific vehicles for this work. The first load each day produced by the plant was precoating of the sprinkle aggregate. This was usually done about 6:30 a.m. The 14,000 pound load normally lasted until about 11:00 a.m. to 1:00 p.m. When another load was needed, the plant's hot stone bins were "pulled" and the aggregate precoated. This did not present any problem and resulted in very little Hot-Mix production loss. These trucks stayed on the job until 6:00 p.m. (See Figure 5)

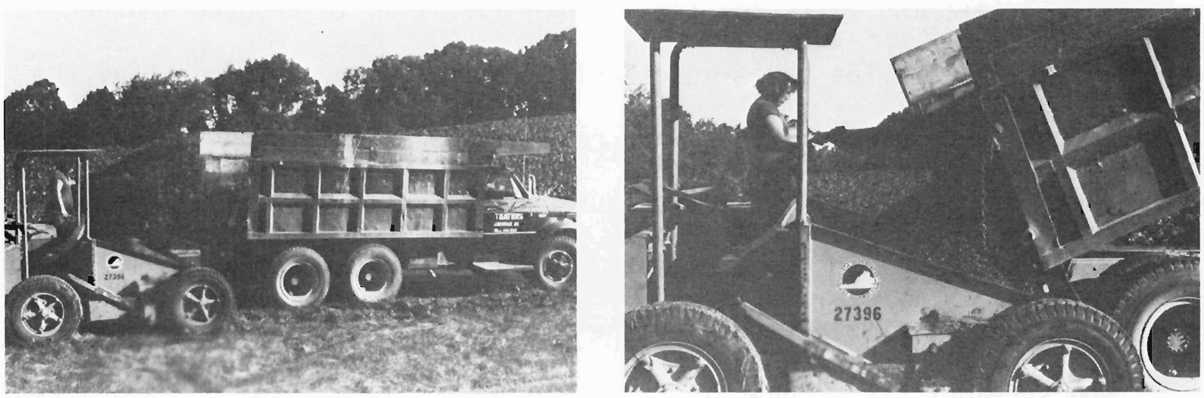


Figure 5

The aggregate was precoated at 300°-325° F. Specifications require all haul trucks to be covered. The aggregate which had been loaded out at 6:30-7:00 a.m. still had a temperature of 300° F. at 11:00 a.m. in the truck at the job site. In the July weather, maintaining adequate temperature was no problem except in the case of plant, hauling or laydown operation breakdown. It is very important to maintain sufficient temperature of the aggregate for even,uniform spreading. It is desirable that the stone be about the same temperature as the ACP. It works better at temperatures of 270^{0}-300^{0} F. and should definitely be kept above 250^{0} F. Below that temperature, the aggregate begins to ball and does not spread evenly. It probably would not go through the spreader at 200^{0} F. Material which has become too cold to spread is rejected by the inspector and wasted by the contractor.

The aggregate spreader operator waits until the laydown machine is 200-300 feet ahead, then spreads aggregate up to the paver, backs up 2-3 feet and waits for the laydown operation to proceed another 200-300 feet. The three-wheel roller follows immediately behind the aggregate spreader in breakdown rolling operations. The spreader operator can control the distribution rate while in motion by adjusting a lever. A 3' x 6' canvas cloth is used to check the rate. The cloth is placed flat,transversly on the Hot Mix after the paver has passed. The spreader passes over it. The cloth with aggregate is then picked up and weighed. (See Figure 6)

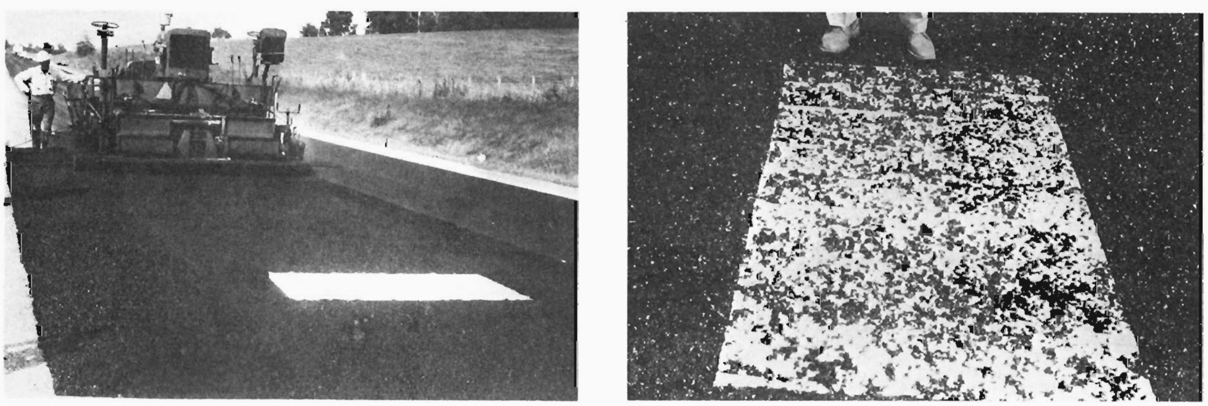


Figure 6

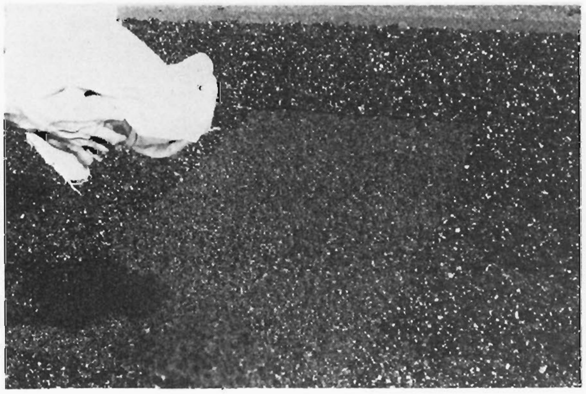
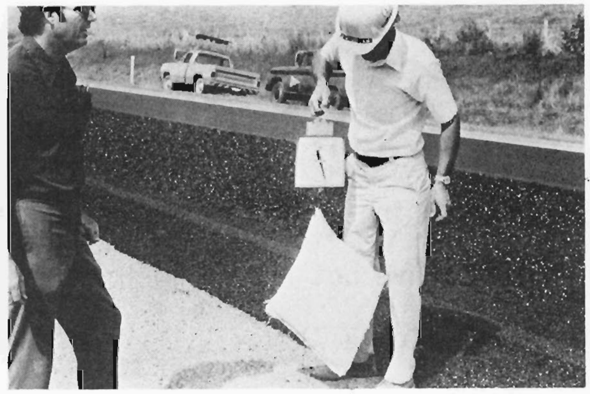
 

Figure 6 (Continued)

The rate of aggregate distribution on this project was 6.5 pounds per square yard.

A hopper of size 78 stone at this rate covered about 800-900 feet of pavement 12 feet wide. When the spreader hopper required recharging, it was pulled to the shoulder or ditch and emptied of any remaining aggregate and the agitator bar, roller and hopper sides sprayed with diesel oil. This was necessary to remove cool aggregate and reduce balling in the hopper. After recharging, distribution was a little uneven until the spreader roller and other parts became hot.

Better spreading of the sprinkle aggregate might be achieved by placing an agitator bar lower in the hopper nearer the roller drum. Preheating the roller drum with a propane torch (similar to the manner an asphalt spray bar would be preheated) might also help.

The present agitator bar is about one foot above the roller. It was installed there because the machine was originally designed for placing the aggregate cold.

After final compaction with the tandem steel-wheel roller, the traffic is kept off the completed pavement as long as possible. Usually it is detoured or kept off all day and opened to traffic the last thing in the afternoon. Practically no aggregate is whipped off. They have not had as much aggregate loss since requiring hot placement. (See Figure 7)

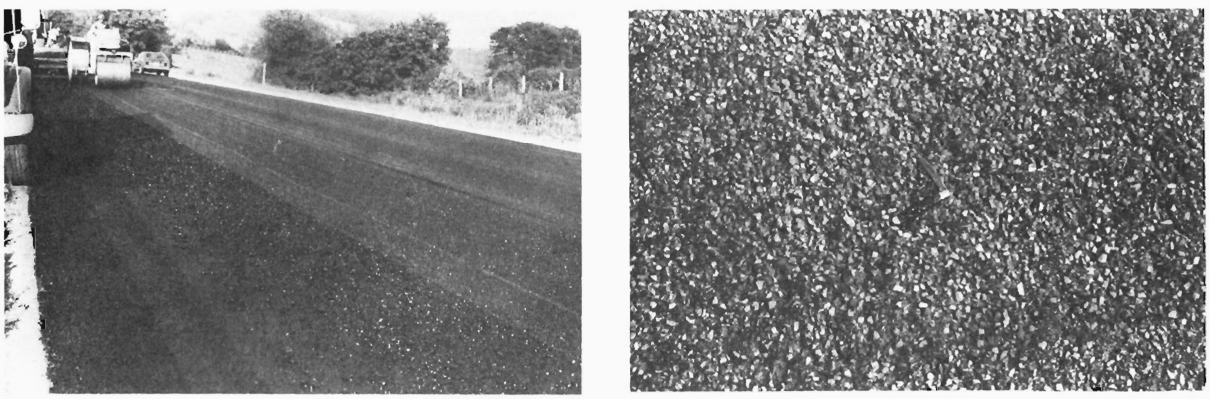


Figure 7

The Virginia Department of Highways and Transportation has not experienced undue problems of asphalt stripping from aggregate. They utilize the Idaho Stripping tests for aggregates and asphalts and evaluate anti-stripping agents for compatibility and improvements of the materials. See Appendix "B" for the Idaho Stripping tests. A shortage of non-polishing stone, particularly west of the Blue Ridge Mountains, prompts the use of sprinkle mixes. This permits the use of local polish susceptible materials in the ACP with polish resistant aggregates sprinkled on the surface. Otherwise, suitable aggregates would need to be transported from quarries east of the mountain range. They do not specify a polish value in their PS&E. Instead, they specify quarries which produce polish resistant stone of known quality with experience histories or they specify the aggregate type desired. The quarries are previously approved. Some seven or eight sources currently enjoy approved status.

A contractor has the option of placing sprinkle mix or using polish resistant aggregate in the ACP and it is felt that this flexibility permits the contractor to provide the most economical pavement. Many projects in the western portion of the State are sprinkle mixes while most of those in the east are skid resistant ACP.

Prior to visiting Virginia, a questionnaire regarding their sprinkle mix experience was sent to them. The questionnaire and their detailed replies are included in Appendix "C" of this paper. Usual skid test values of sprinkle treatment pavements are given in Appendix "C".

APPENDIX A

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION
SPECIAL PROVISIONS FOR PLANT MIX
WITH SPRINKLE OVERLAY TREATMENT

(SP-7)

DESCRIPTION:

Bituminous concrete surface or wearing course manufactured with a polish susceptible aggregate shall receive an additional overlay of precoated material as hereinafter specified unless polish susceptible aggregate is permitted in the surface. Bituminous concrete shall be the same mix as designated in the proposal.

MATERIALS:

(a) Cover Aggregate - The cover aggregate used in the overlay shall consist of No. 78 polish resistant aggregate. A sample of the aggregate to be furnished shall be made available to the Engineer in order to determine the correct asphalt content of the coated material. Aggregates manufactured from limestone, dolomite, or marble formations are not to be used as a cover aggregate.

(b) Bitumen - The asphalt used to coat the aggregate shall be AC-20.

PREPARATION OF MATERIALS:

Cover aggregate shall be run through an approved dryer and thoroughly dried and then mixed with asphalt. The hot mix shall be delivered and applied to the road prior to the loss of sufficient heat to render the mix unworkable.

CONSTRUCTION:

Immediately after the passage of the paver in placing bituminous concrete specified on this contract and prior to any rolling, the precoated aggregate shall be applied to the top as an overlay. The rate of application to be specified by the Engineer shall be within 3 to 5 psy for lightweight aggregate and 5 to 7 psy for regular aggregate. It shall be applied with a mechanical spreader which may be backed onto the layer of bituminous concrete to scatter or sprinkle the coated material over the surface prior to any consolidation even from tires. The spreader must be capable of distributing the material uniformly and across the full width of the lane. The spreader shall be equipped with wide tires without treads and shall have the load distributed in a manner to minimize compression of the bituminous concrete. A three-wheel roller will be required to imbed and roll the sprinkle applications.

Immediately after the application of the sprinkled overlay, the rolling operation shall be carried out according to specifications.

METHOD OF PAYMENT:

The cost of furnishing, preparing, mixing, and applying the sprinkle treatment shall be included in the bid price per ton of bituminous concrete, and the application rate of the sprinkle aggregate shall in no way be included as part of the application rate of the surface or wearing course specified.

APPENDIX B

IDAHO DEPARTMENT OF HIGHWAYS
Boise, Idaho

Idaho T-35-69

STANDARD METHOD OF TEST FOR STRIPPING OF ASPHALT COATING FROM MINERAL AGGREGATE

SCOPE

1. This method outlines the preparation and test procedure for measuring the resistance of asphalt films on aggregate to loosening and removal by action of water or moisture.

SAMPLE PREPARATION AND PROCEDURE

2. (a) Approximately 100 grams of aggregate passing the 3/8" sieve and retained on the Number 4 sieve shall be used for the test. The aggregate may be tested in any of the following conditions:

(1) Unwashed aggregate as received, including any dust coating adhering to the stone.

(2) Aggregate washed and dried at a temperature of 230°F ±10°F.

(3) Unwashed aggregate but including 1/2 of one percent hydrated lime thoroughly coating the stone.

(4) Aggregate as received but coated with a slurry of lime and water, the mixture cured moist for 72 hours and then oven dried at 230°F ±10°F.

(b) The aggregate is weighed to 95 grams ±0.5 gram into a pyrex dish or disposable aluminum foil pan.

(c) Five grams of asphalt of the grade and source to be used on the project are to be used with test. If the asphalt source is unknown, use a source most likely to furnish asphalt to the project.

(d) If an anti-stripping additive is to be used it should be mixed in the required percentage with the asphalt beforehand and included as part of the five grams of asphalt. Trials should be conducted with the additives available with potential asphalt sources. In addition it may be necessary to vary the concentration of the additive.

(e) Heat the aggregate and asphalt to the appropriate mixing temperature; 230°F for asphalt cements and 140°F for cutback asphalt. Mix the aggregate and asphalt with a steel spatula until the aggregate is completely coated. The sample may be mixed over a hot plate provided the specified mixing temperatures are not exceeded.

(f) The mixed samples are cured at 140°F for a minimum of 12 hours.

Pub. 1957
Rev. 1960
Rev. 3-64
Rev. 6-69

(g) At the end of the curing period, the samples are remixed before cooling to room temperature.

(h) Cover the sample with distilled water (pH 6.0-7.0) and seal the top of the pan with aluminum foil to minimize evaporation. Place the sample in a 120°F ±5°F oven.

STRIPPING EVALUATION

3. (a) The test sample shall be rated at the end of 48 hours. (For information ratings shall be made at 24 and 48 hours and thereafter once daily for seven days). Without agitating or disturbing the coated aggregate and while it is still immersed in water, the percentage of aggregate remaining coated is estimated visually. The specimen should be well illuminated to eliminate glare from the water surface. Any thin, brownish, translucent areas are to be considered as fully coated.

(b) The samples are rated for stripping using the following:

100% Asphalt Coating
90-100% Asphalt Coating
75-90% Asphalt Coating
50-75% Asphalt Coating
Less than 50% Asphalt Coating

(c) The stripping condition observed at the end of 48 hours shall be assigned the proper percentage range and recorded.

PRECAUTION

4. Do not use gas flame to heat the aggregate-asphalt combination in the remixing operation.

REFERENCES

5. ASTM D-1664
6. AASHO T-182

APPENDIX C

A PARTIAL LIST OF SUBJECTS CONCERNING SPRINKLE TREATMENTS
(Questionnaire)

Discussion should describe procedures actually utilized as well as recommendations based upon your experience.

I. Asphaltic Concrete

a. type (hot mix asphalt concrete for use with sprinkle treatment)

b. asphalt cement (percent asphalt, type, penetration, viscosity @ 77°F, etc.)

c. placement operation (temperature mix, temperature mat, tack coat, compacted depth)

d. type laydown machine - vibratory or tamping screed

e. other considerations such as ambient temperature and ground temperature

II. Aggregate (Sprinkle)

a. gradation recommended. What about grade 3 for natural skid resistant rock?

b. rates of application - square yards per cubic yard (unit weight of aggregate is needed if in pounds per square yard)

c. placed hot or cold. What about hot aggregate at beginning and end of placement season?

d. polish value. Should a polish value be required? If so, what range, etc.?

e. type (lightweight, etc.)

f. other considerations

III. Precoating Operation (If Used) Should aggregate be pre-coated?

a. batch plant

1. recommend temperature aggregate and asphalt cement

2. type asphaltic materials, AC

3. procedure for storing precoated material

4. other considerations

b. blade mix

1. type asphaltic materials recommended

2. moisture content of aggregate

3. procedure of application of asphaltic materials

4. stockpiling precoated material (depth, protection, (Should it be covered) manipulations), etc.

5. other considerations

IV. Application of Sprinkle Rock

a. type spreader, salt spread, modified tailgate (Grace), self propelled spreader. Discuss English spreader

b. time of application after laydown operation. Is it critical?

c. rollers utilized (weight, types and number of passes and sequence)

d. measurements of sprinkle rock application. What about a simple test to determine?

e. time of opening of finished roadway to traffic

f. other considerations

V. Maintenance

a. tabulation of projects in chronological order (location, date, description, skid history compared to control)

b. estimated pavement life

c. procedure for repair to deficient areas

e. other considerations. Methods of deterioration and unusual maintenance problems.

VI. Testing

a. percent residual asphalt on precoat aggregate (if used)

b. skid resistant history

c. minimum mat temperature at time of sprinkle rock application

d. other considerations

VII. Economics

a. Comparative costs of sprinkle application with that of high quality aggregate in hot mix asphalt concrete and high quality skid resistant aggregate blends in hot mix asphalt concrete.

b. Is there a minimum size project below which sprinkle treatment would not be practical nor economical?

c. other considerations

VIII. Unsuccessful procedures (description of activities which are considered unsatisfactory)

a. excessive penetration of aggregate into the mat

b. too much precoat on aggregate

c. too little or too much aggregate per square yard

d. opening mat to traffic too soon

e. precoating aggregate without dispersing agent causing aggregate to be only partially coated or speckled with asphalt cement

f. gradation not compatible with hot mix type

g. weather (temperature, rain, himidity, wind)

h. other considerations

I. a. dense graded surface mixes (S-5 or I-2)

b. AC-20

c. Placement operation is identical to a regular non-polishing dense graded mix. Mat and mix temperature is controlled by a nomograph in the specifications and the mix temperature is usually about 285°F. Tack coat is light and application varies with mix type (usually 100-150 psy).

d. tamping

e. controlled by nomograph in the specifications.

II. a. #78 (Virginia)

b. 5-7 psy for regular aggregate (S.G. 2.70)
3-6 psy for lightweight aggregate (S.G. 1.5)

c. Only use hot placement. Springkle aggregate must retain sufficient heat to be workable.

d. We do not use a polish value but rely on experience developed from dense graded mixes. Some slick pavements have developed where a marble was used. A good skid resistant aggregate should be used.

e. Any crushed aggregate that has given good skid resistance in a dense graded mix is acceptable. Lightweight aggregate is acceptable although it may wear excessively under very heavy traffic.

III. a.-1 Temperature necessary to coat aggregate and provide workability on jobsite. Usually dense graded mix temperature is used.

a.-2 AC-20

a.-3 Transported directly to jobsite.

b. Will discuss under "Summary."

IV. a. Salt spreader was used initially but discontinued due to non-uniform spread. A self-propelled spreader capable of straddling a 12' lane was built by the highway department and is available to the contractors. Self-propelled surface treatment spreaders with smooth tires may be used also.

b. Applied immediately behind paver. It is preferable to allow paver to advance several hundred feet and then the aggregate is spread. A happy medium must be reached between stopping and starting the spreader and allowing the mix to cool excessively.

c. 3 wheel steel breakdown roller and tandem finish roller. Rolling sequence same as regular dense graded mix.

d. Application rate determined by weighing amount of aggregate dropped on canvas square by spreader.

e. Usually same time schedule as regular dense graded mix. Have been required to water or dust pavement prior to traffic to prevent pick-up.

V. a. See attachment; the only listing available at the present is through 1972. Much additional mileage has been paved since 1972, however, an up-to-date listing is not readily available.

b. Pavement life is equivalent to regular dense graded mix except in cases where premature resurfacing had to be done for skid resistance. The reasons for loss of skid resistance is discussed in a latter section.

c. Resurface with non-polishing mix.

VI. a.

b. There were many problems that had to be worked out in order to get a good skid resistant pavement. Some problems that contributed to low skid resistance on some of the early pavements were: insufficient amount of sprinkle aggregate, non-uniform spreading of sprinkle aggregate, sprinkle aggregate not coated properly, use of marginal aggregate (marble) and using sprinkle aggregate that was too small. These problems have been solved by using a test method for determining application rate, requiring different types of spreaders, using asphalt cement rather than a cut-back as an asphalt coating, elimination of the use of marble aggregate and use of coarser sprinkle aggregate.

c. None

VII. a. Sprinkle mix is offered as an alternative where non-polishing mix is required. It has proven to be economically advantageous as evidenced by the contractor selecting to provide sprinkle mix in many instances.

b. Yes, but unable to provide minimum quantity.

VIII. I will attempt to add a general discussion of our experience with the sprinkle mix rather than answer these specific questions.

The major problems that have occurred in sprinkle mix and remedies are discussed as follows:

1. Lack of uniformity in application of sprinkle aggregate.

The whirly chemical spreader which was used for several years proved to be inconsistent in the amount of sprinkle aggregate applied and there was some objection to tire tracks not being completely removed by rolling. To improve the application the highway department constructed a self-propelled spreader that straddles a 12' pavement and spreads uniformly. This equipment is made available to contractors and has been used extensively for three years. A self-propelled "surface treatment" spreader with smooth tires is also allowed.

2. Application of improper quantity of sprinkle aggregate.

The inspectors were schooled in the sprinkle mix to impress upon them the importance of applying the proper rate. Also they were given a method to measure the rate. A canvas bag is placed on the mat, the spreader spreads the aggregate and the quantity on the bag is weighed and the rate computed.

3. Use of marginal type marble aggregate.

Low skid numbers have been experienced when a marble aggregate was used. Although surface mixes containing 100% of this material have been satisfactory, this material is no longer allowed as a sprinkle aggregate. The cover aggregate should be a good skid resistant aggregate.

4. Sprinkle aggregate penetrates limestone mat excessively.

On several jobs with coarse limestone mats the sprinkle aggregate had imbedded itself too deeply to offer skid resistance. A coarser sprinkle aggregate is now required to alleviate this problem.

5. Initially we used a cutback asphalt (MC-70) and later tried an emulsion (CAE-2) for precoating. While we have obtained good treatments out of many of these, improper or partially cured precoated aggregates have caused failures (loss of stone when opened to traffic). The use of asphalt cement is somewhat more trouble than using cutbacks or emulsions because cold bins may have to be cleaned out and the precoated material has to be kept warm to flow through the spreader, but the probability of aggregate retention is greatly increased.

Sprinkle Mixes — Staunton District (Thru 1972)

County	Route No.	Yr.	Location From	Location To	Begin Milepost	End Milepost
Alleghany	I-64 EBL	1972	0.46 Mi E Int. 220	1.23 Mi W Int 696	17.02	20.39
Alleghany	I-64 WBL	1972	0.46 Mi E Int. 220	3.41 Mi E Rt. 220	17.02	20.09
Alleghany	42	1972	Int. Rt. 636	Int. Rt. 60	3.34	5.22
Alleghany	60	1972	0.34 Mi. W. Int. 770	1.37 Mi. E. Int. 633	5.92	8.57
Alleghany	60	1972	0.04 Mi. W. Covington WCL	0.05 Mi. E. E Int. 651	27.08	29.59
Alleghany	311	1972	Rt. 0604	Rt. 159	3.15	6.62
Rockbridge	130	1971	Rt. 501	0.01 Mi. E. ECL Glasgow	2.43	2.70
Rockbridge	I-81	1971	1.08 Mi. N. Int. 692	1.33 Mi. N. Int. 690	4.13	6.70
Rockbridge	501	1972	0.03 Mi. S. Int. Y130	Amherst Co. Line	9.45	11.94
Augusta	42	1970	Int. Rt. 254	2.19 Mi. S. Int. 688	19.19	22.19
			Special Test Sections			
Rockingham	340	1968	2.23 Mi. N. Int. 659	1.00 Mi. N. Int. 659	13.92	15.15
Rockingham	340	1969	1.00 Mi. N. Int. 659	0.1 Mi. N. NCL Grottoes	15.15	19.60
Shenandoah	11	1971	0.04 Mi. S. Int. 767	0.05 Mi. S. Int. 719	31.50	33.60

Sprinkle Mixes in Salem District (Thru 1972)

County	Route No.	Yr.	Location From	Location To	Begin Milepost	End Milepost
Pulaski	I-81	1972	0.56 Mi. S. Int. 99	0.26 Mi. S. Int. 99	6.40	6.70
Pulaski	I-81	1972	0.26 Mi. S. Int. 99	0.20 Mi. W. Int. 99	6.70	7.20
Pulaski	I-81	1972	0.08 Mi. N. Int. 799	0.02 Mi. N. Int. 799	16.89	16.99
Pulaski	11 WBL	1972	WCL Dublin	ECL Pulaski	8.02	12.57
Pulaski	11 EBL	1972	WCL Dublin	0.30 Mi. N. Int. 643	8.02	10.60
Botetourt	460 WBL	1971	0.13 Mi. E. Int. 1411	0.34 Mi. E. Int. 659	2.58	3.42
Botetourt	460 EBL	1971	0.11 Mi. E. Int. 1411	0.37 Mi. E. Int. 659	2.60	3.39
Roanoke	I-81	1972	Int. 642	2.88 Mi. S. Boturt. CL	5.11	13.98
Roanoke	419	1972	0.11 Mi. N. Int. 780	0.07 Mi. S. Int. 863	10.18	10.53
Roanoke	419	1972	0.07 Mi. S. Int. 863	Mason Creek Bridge	10.53	10.67
Bedford	460	1971	W. Int. 221	WCL Bedford	15.40	16.05
Bedford	460 WBL	1971	WCL Bedford	E. Int. 831	16.05	18.80
Bedford	460 EBL	1971	WCL Bedford	E. Int. 689	16.05	20.40
Bedford	501	1972	Int. 600	Int. 122	2.35	4.31

Buchanan	460	71	0.02 Mi. E. Int. 83	Grundy SCL	17.33	19.34	MI-2	135# Pounding Mill,Va.	Sprinkle Aggr.	Rockydale-Lynchburg
Buchanan	460	71	0.70 Mi. W. Grundy WCL	1.17 Mi. W. Grundy WCL	24.27	24.74	MI-2	135# Pounding Mill,Va.	Sprinkle Aggr.	Rockydale-Lynchburg
Tazewell	369	71	Rt. 19 (too short)	Dead End			MI-2	135# Pounding Mill,Va.	Sprnkle Aggr.	Rockydale-Lynchburg
Tazewell	16	72	S. Int. 19	W. Int. 604	13.95	15.63	MS-5	100# Pounding Mill, Va.	Sprinkle Aggr.	Blue Ridge-Lynchburg
Tazewell	61	72	ECL Tazewell	0.08 Mi. E. 735	2.63	7.45	MI-2	135# Pounding Mill, Va.	Sprinkle Aggr.	Blue Ridge-Lynchburg
Tazewell	67	71	3.40 Mi. N. NCL Richlands	Rt. 616						
Wythe	I-81 NBL	72	0.40 Mi. N. Int. 625	0.98 Mi. N. Int. 663	6.32	10.32	MS-5	100# Pendleton-Wytheville	Sprinkle Aggr.	Newman Bros,Sylvatu
Wythe	I-81 SBL	72	0.37 Mi. N. Int. 666	0.98 M. N. Int. 663	7.70	10.32	MS-5	100# Pendleton-Wytheville	Sprinkle Aggr.	Newman Bros.Sylvat
Wythe	I-81	70	Pulaski CL	1.73 Mi. S. Pulaski CL			S-5	100# Pendleton-Wytheville	Sprinkle Aggr.	Solite Corp.
Lee	A58	72	Wise CL	Int. 620	0.00	4.67	MI-2	135# Natural Tunnel	Sprinkle Aggr.	Vulcan - Erwin
Lee	23	71	Wise CL (under const.)	0.10 Mi. N. Scott CL	0.00	4.31	MI-2	135# Natural Tunnel	Sprinkle Aggr.	Vulcan - Erwin
Lee	58	72	Int. 738	Int. 421	2.12	6.33	MI-2	135# Natural Tunnel	Sprinkle Aggr.	Vulcan - Erwin
Dickenson	63	71	S. Rt. 83	Rt. 643			MI-2	135# Clinch River Quarry	Sprinkle Aggr.	Vulcan - Erwin
Dickenson	80	71	S. Rt. 83 (under const.)	0.10 Mi. S. Rt. 607 W			MI-2	135# CLinch River Quarry	Sprinkle Aggr.	Vulcan - Erwin
Dickenson	83	71	Rt. 63	W. Rt. 80			MI-2	135# Clinch River Quarry	Sprinkle Aggr.	Vulcan - Erwin

Sprinkle Mixes — Bristol District (1970, 1971, 1972)

County	Route No.	Yr.	Location From	Location To	Begin Milepost	End Milepost	Source of Plant Mix Aggregate	Type of Mix	Application Rate of Mix	Source of Aggregate Non-Polishing
Wise	A 58	71	Norton WCL	Int. 610	23.76	24.75	Levisa Quarry	MS-5	105#	Vulcan - Erwin
Wise	A 58	72	Big Stone Gap WCL	Lee CL	38.19	40.25	Nautral Tunnel	MI-2	135#	Vulcan - Erwin
Wise	C 23	72	SCL Pound (too short)	0.29 Mi. S SCL Pound	2.74	3.03	Levisa Quarry	MS-5	100#	Vulcan - Erwin
Wise	23	71	Kentucky S. L.	0.88 Mi. N NCL Pound	0.00	1.33	Levisa Quarry	MS-5	105#	Vulcan - Erwin
Wise	23	72	0.88 Mi. N NCL Pound	0.57 Mi. N Int. 630	1.33	2.74	Levisa Quarry	MS-5	105#	Vulcan - Erwin
Wise	23	71	0.57 Mi. N Int. 630	0.11 Mi. N. Int. 630	2.74	3.20	Levisa Quarry	MS-5	105#	Vulcan - Erwin
Wise	23	71	0.04 Mi. N. Int. 692	1.96 Mi. S. Int. 692	9.92	11.92	Levisa Quarry	MS-5	100#	Vulcan - Erwin
Wise	23	72	0.04 Mi. S. Int. 692	1.96 Mi. S. Int. 692	10.00	11.92	Levisa Quarry	MS-5	100#	Vulcan - Erwin
Wise	23	71	Norton SCL	S. Int. 610	19.78	20.77	Levisa Quarry	MS-5	105#	Vulcan - Erwin
Wise	23	72	S. Int. 668 (under const.)	0.50 N. Lee CL	35.91	37.61	Natural Tunnel	MI-2	135#	Vulcan - Erwin
Wise	23	71	0.50 Mi. N. Lee CL	Lee CL	37.61	38.11	Natural Tunnel	MI-2	135#	Vulcan - Erwin
Wise	72	72	Rt. 652	Int. A 58	8.45	10.08	Clinch River	MI-2	165#	Vulcan - Erwin
Wise	72	72	Rt. 663	Scott CL	13.50	16.40	Clinch River	MI-2	135#	Vulcan - Erwin
Wise	382	72	Rt. 646 (could not test)	Dead End	0.00	1.19	Levisa Quarry	MI-2	135#	Vulcan - Erwin
Wise	58	70	Rt. 657	0.78 Mi. E. Rt. 725			Clinch River	MS-5	100#	Clinchlite - Carb
Wise	23	71	Rt. T-640	S. Rt. T-1410			Levisa Quarry	MS-5	105#	Vulcan - Erwin
Wise	646 and T 646	71	Rt. T-640	E. Rt. 382			Levisa Quarry	MS-5	105#	Vulcan - Erwin
Wise	T-1103	70	Rt. 72	0.35 Mi. E. Rt. 72			Clinch Rivery	S-5	100#	Clinchlite - Carb
Smyth	I-81	72	0.65 Mi. N. Int. 16	0.57 Mi. S. Int. 691	12.30	12.50	Holston River Quarry	MS-5	100#	Newman Bros.
Smyth	I-81	72	0.57 Mi. S. Int. 691	0.63 Mi. N. Int. 691	12.50	13.70	Holston River Quarry	MS-5	100#	Newman Bros.
Smyth	11	72	E. CL Chilhowie	Int. 107	21.64	22.46	Holston River Quarry	MS-5	100#	Newman Bros.
Smyth	107	72	Int. 11	Int. 762	8.07	8.39	Holston River Quarry	MS-5	100#	Newman Bros.
Washington	91	72	0.[illegible]0 Mi. S. NCL Glade	S. Int. 91 B	6.14	7.[illegible]	Holston River Quarry	MI-2	135#	Newman Bros.

Route	County	Location From	Location To	Year Const.	Traffic Volume VPD	Sprinkle Aggregate	Skid Tests (Avg. SN at 40 mph) 1974
340 (½ coarse & ½ fine slag)	Rockingham	NCL Grottoes	1.0 Mi. N. Rt. 659	1969	1500	coarse & fine slag	
340	Rockingham	1.0 Mi.N. Rt. 659	2.2 Mi.N Rt. 659	1968	1500	see attached sheet	55 Avg. of coarse & fine sections
I-81	Rockbridge	Fancy Hill		1971	9,000	granite	57
I-81	Roanoke	Rt. 581 South		1972	14,000	quartzite	52
117	Roanoke	Rt. 11	Rt. 626	1973		AC coated	at Archies
221 or 720	Roanoke	Go S. on Rt. 419 toward Rt. 220 paving N. of 419 on Rt. 221 or 720		Maintenance Resurfacing			
I-81	Pulaski	0.2 Mi. N. Rt. 99	0.56 Mi. S. Rt. 99	1972	8600		58
I-81 SBL	Wythe	0.4 Mi. N. Rt. 666	1.0 Mi. N. Rt. 663	1972	7000	quartzite	57
I-81	Wythe	Pulaski C.L.	1.7 Mi. S. Pulaski C.L.	1970	8400	lightweight	51
I-81	Wythe	Smyth C.L. (See Sketch)	6.3 Mi. N. Smyth C.L.	1973			
I-81	Smyth	0.6 Mi. N. Rt. 691	0.6 Mi. N. Rt. 16	1972	8400	quartzite	53
11	Smyth	E.C.L. Chilhowie	Rt. 107	1972	6000	quartzite	47
I-81	Washington	0.13 Mi. N. Rt. 611	Rt. 794	1975	Maintenance Resurfacing		
91	Washington	0.2 Mi. S. NCL Glade Springs	S. Rt. 91B	1972	2500	quartzite	54

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