COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT, KENTUCKY 40601

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July 28, 1968

M-3-1
S-1-5-2

MEMO TO: W. B. Drake
Assistant State Highway Engineer

FROM: Jas. H. Havens, Director
Division of Research

DATE: July 22, 1968

SUBJECT: Report on the "Construction and Performance of Trial Sections of Treated Shoulders on the Mountain Parkway Extension"

Submitted herewith is our report on the trial stabilization treatments employed last year on the shoulders of the Mountain Parkway Extension. Construction methods, costs, and performance are described.

Summarily, it seems to me that none of the stabilization methods produced satisfactory results. The cement-treated sections cost $1.29 per sq. yd., and the sections treated with asphalt emulsion cost $1.50 per sq. yd.; the structural adequacy and durability of the cement-treated sections remains questionable, and the curing problem and stability of the sections treated with emulsion remains unfavorable. Considering the possibility that we might have realized 3 in. of bituminous concrete for a direct cost of $1.50 per sq. yd. (established at $.50 per sq. yd. per inch of thickness), and considering that removal and disposal of 3 in. of existing DGA might result in an asset or credit of $.10 per sq. yd. per inch of thickness, the net cost might be in the order of $1.20 per sq. yd. Of course, projecting this thought further indicates that 5 in. of bituminous concrete might be realized for $2.00 per sq. yd. I might point out that a bituminous concrete operation would not interfere so much with traffic or require extensive use of barricades. Obviously, high-type paving on the shoulders would involve enormous costs. One reason for mentioning such a possibility is to emphasize how stabilization might be viewed on a cost scale. Stabilization to any degree which could be constructed to be less than adequate could also complicate maintenance thereafter.

We had previously studied both cement and asphalt stabilization of DGA in the laboratory,* and the conclusions then with respect to portland cement were:

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*"Lean Concretes Using Kentucky's Dense Graded Aggregate (Portland Cement and SS-1 Emulsified Asphalt), June 1968.

"... none of the non-air-entrained portland cement mixes appears to have sufficient durability (resistance to F&T) to permit their use in exposed roadway surfacing. However, this should not prevent their use in the construction of bases, provided that they are overlain by sufficient thickness of other insulating pavement. ... the only mix that appears to be suitable for service as a pavement surface is the normal air-entrained slump-type mix. This, of course, would require the use of forms in construction, and any advantage that the DGA concrete might have over ordinary air-entrained lean concrete using conventional course aggregates would probably arise from the comparative costs of the two types of aggregate. The minimum practicable cement factor from the standpoint of durability appears to be 3 bags per cu. yd."

Note: A lean concrete base, 3.5 sacks of cement per cu. yd., No, 36 stone, 3 to 6 percent air, 6-8-6 inch section, with asphaltic concrete overlay, was constructed experimentally on 4.415 mi. section of US 60, Winchester-Mt. Sterling (SP87-117), in 1950.

The emulsion mixes studied in 1959 remained quite tender and sensitive to moisture until they had undergone extensive curing (drying). Freeze-thaw tests indicated that they were not as durable as the air-entrained, lean concrete.

I believe that we should dismiss the trials or experiments on the Parkway Extension from further consideration.

I may call your attention to a more recent development which seems to offer some promise as a shoulder treatment. Last June 12, the Maintenance Division made some trail applications of "Peneprime", a patented, cutback, asphalt cement, on small sections of DGA shoulders on the Thornhill By-Pass, at Frankfort. The material was applied at the rate of 1 gal. per sq. yd. The penetration was quite good--about 2-1/2 in. in two weeks. This material is covered by Patent No. 3,216,336, issued to Empire Petroleum Co., Denver, Colorado. Performance reports on those trials will be forthcoming.

JHH:em
cc: A. O. Neiser
J. T. Anderson
K. B. Johns
T. J. Hopgood
Bert Knight

MEMORANDUM REPORT

CONSTRUCTION AND PERFORMANCE OF TRIAL SECTIONS OF TREATED SHOULDERS ON THE MOUNTAIN PARKWAY EXTENSION

by

R. L. Florence
T. C. Hopkins
Research Engineers

Division of Research
DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

June 1968

M.3.1
S.1.5.2

MEMO TO: J.H. Havens, Director
Division of Research

FROM: R.L. Florence and T.C. Hopkins J.C.H. RLF
Research Engineers

DATE: June 24, 1968

SUBJECT: Construction and Performance of Trial Sections of Treated Shoulders on the Mountain Parkway Extension

In October 1966, J.W. Spurrier, Assistant Operations Management Engineer, requested that the Research Division make a study of a two-mile section of the shoulders on the Mountain Parkway Extension in Wolfe County (from Mile Post 43.8 to Mile Post 45.8) and make recommendations for design and construction procedures for cement stabilization of the shoulders. In compliance with this request, in January 1967, Research Division personnel made a survey of the full length of shoulder on the Mountain Parkway Extension. Included in this survey were measurements of depth of the dense graded aggregate, penetrations of the shoulder subgrade soil and samples taken of the DGA and soil. Compressive strengths were measured on sampled material treated with cement. A memorandum reporting the results of the shoulder survey, compressive tests, and recommended cement treatment design and construction procedures was prepared in March 1967 (see Appendix A). A typical section of the shoulder, as originally constructed, is shown in Figure 1.

During the spring of 1967 it was decided to expand the scope of the trial shoulder treatment to include a 1.0-mile test section of Road Packer (a chemical soil treatment), a 0.5-mile section designated as a control section for the Road Packer, and a 1500-foot test section of DGA treated with asphalt emulsion. The Road Packer is claimed to improve subgrade soil compactability and bearing capacity. The Road Packer was to be applied in accordance with instructions furnished by the supplier (see Appendix B). The supplier (North American Soil Stabilizers, Inc.) also recommended that a control section be provided that would be treated in the same manner as the Road Packer test section with the exception that "Road Packer" would not be used. The asphalt emulsion-treated section was to incorporate two types of slow setting emulsion, i.e. CSS-1h and SS-1h. The CSS-1h was to be used on one 1500-foot section of shoulder and the SS-1h in a 1500-foot section of the shoulder opposite the CSS-1h section. The Research Division recommended application rates and construction procedures for the emulsion-treated sections (see Appendix C).

In this report the construction and performance of each trail section is briefly presented on a section-by-section basis, in the order in which they were constructed. The labor and equipment for the construction work was provided by District Maintenance. Construction and material cost records were also kept and provided by District Maintenance. Shown in Figure 2 is a

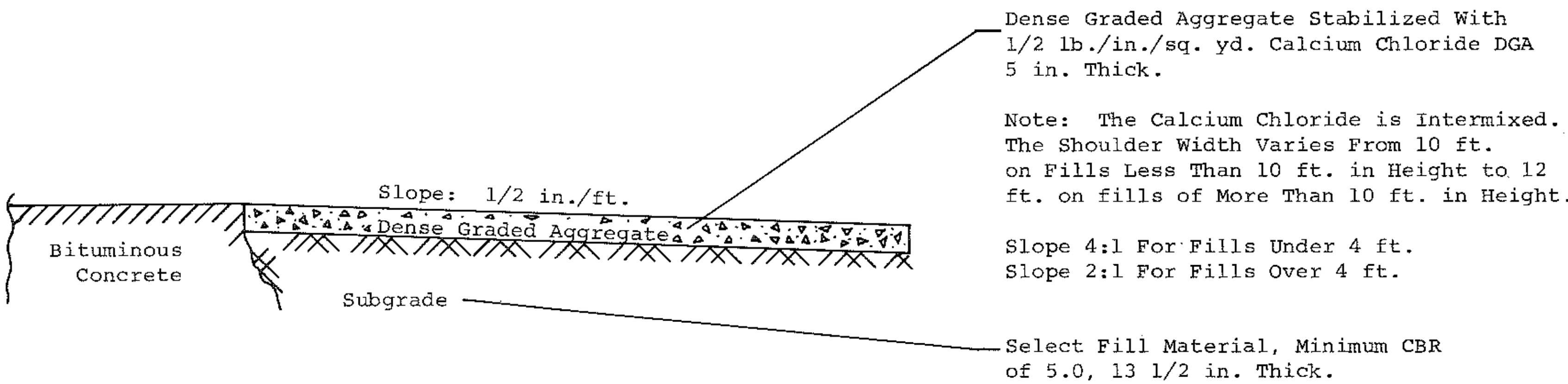

Figure 1. Typical Shoulder Section of the Mountain Parkway Extension as Originally Constructed.

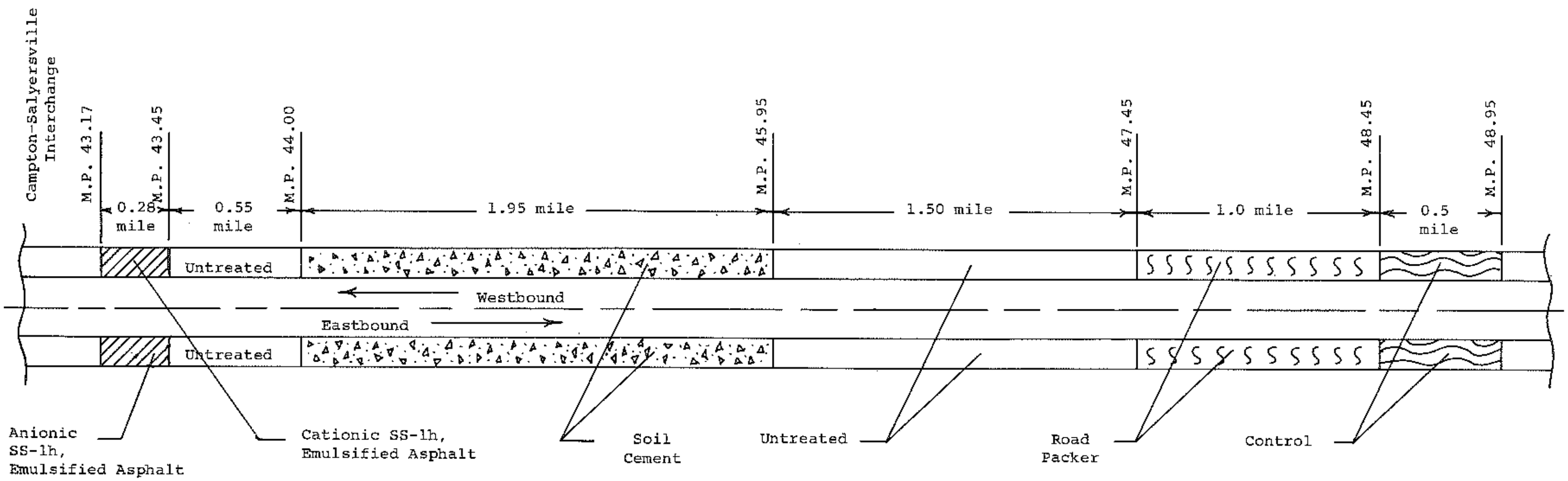

Figure 2. Schematic Diagram Indicating the Location of the Treated Sections of Shoulders.

schematic diagram indicating the location and treatment of each trial section.

ROAD PACKER TEST SECTION AND CONTROL SECTION

LOCATION: Test Section - shoulders between Mile Post 47.45 and Mile Post 48.45

Control Section - shoulders between Mile Post 48.45 and Mile Post 48.95

DATE CONSTRUCTED: Test Section - May 2 through May 26, 1967

Constrol Section - May 8, 1967

CONSTRUCTION PROCEDURES: The construction procedures for the test section were followed as outlined in "Condensed Instructions Covering Use of Road Packer," in Appendix B. The DGA was first scarified. A water truck (approximate capacity, 1200 gallons) was loaded with 1000 gallons of water and 1 gallon of Road Packer was added. The solution was then sprayed over a 10-foot width of shoulder until the load ran out. This sequence was repeated until the full amount of solution required for one shoulder was applied. The solution was then applied to the opposite shoulder. It was estimated that it would require a total of 20 gallons of Road Packer to treat one mile (10-foot width on each shoulder). Inasmuch as rain was experienced during application of the chemical and it was believed that much of the solution was lost by surface runoff, the total application of Road Packer was increased to 30 gallons of chemical to compensate for the runoff. After the solution was fully applied to both shoulders, water was applied at a rate of 3000 to 4000 gallons to each 1000 gallons of solution that was applied. The shoulders were than compacted with a 13-ton Galion, Model T10-14G roller towing an Essick vibratory roller.

The shoulders of the Control Section were scarified, watered, and compacted in the same manner as the Test Section. The only difference in treatment was that the Road Packer solution was not applied.

COST:

Test Section - The Road Packer was supplied at no cost to the Department. The following costs would, of course, be increased by the cost of Road Packer:

Labor (May 2 thru May 26, 1967)	$1,915.00
State Equipment (May 2 thru May 26, 1967)	692.45
Rented Equipment (May 25, 1967)	374.00
Material (30 gallons of Road Packer)	0.00
Total	$2,981.45

Cost per square yard (calculated using 9-foot wide treatment)------------------$ 0.28

Control Section:

Labor (May 8, 1967) ---------------------------	$	36.64
State Equipment (May 8, 1967) -----------------		28.16
Total ---	$	64.80

Cost per square yard (calculated using 9-foot wide treatment) ----------------$ 0.012

PERFORMANCE (TEST AND CONTROL SECTIONS): Nuclear density and moisture measurements were taken on the Test and Control Sections immediately before treatment, immediately after treatment, one month after treatment, two months after treatment, and one year after treatment. These test results are summarized in Tables 1 and 2. It is apparent that no significant differences were measured in subgrade or DGA densities at any time.

On May 15, 1968, one year after treatment, penetration measurements (ASTM D 1558-63) were made at the same locations tested for density. These test results are summarized in Table 3. It is apparent that there is only 100 psi difference in the average penetration resistance of the Test and Control Sections.

Visual inspection of the sections was also made early in May 1968. Both the Test and Control Sections appeared to be in good condition. Typical view of these sections of shoulder are shown in Figures 3 and 4.

CEMENT TREATMENT WITH ASPHALT SEAL

LOCATION: From Mile Post 44.00 to Mile Post 45.95

DATE CONSTRUCTED: Cement treatment and dilute SS-1h curing membrane - June 14 through June 30, 1967

Double A-2 Seal - August 17 through August 21, 1967

CONSTRUCTION PROCEDURES: The shoulders were first scarified and then the cement was applied at a rate of 34.8 pounds per square yard using a Flaherty Spreader. One pass was made with a Seaman Pulvi-mixer and then the shoulder was wetted. Mixing was finished with the Pulvi-mixer and then the shoulder was compacted with a pneumatic-tired roller and a steel-wheeled roller. A curing membrane, composed of two parts SS-1h and one part water, was applied to the compacted shoulder at a rate of 0.37 gallons per square yard. A double A-2 seal, composed of No. 8 stone, No. 9 stone, and RS-2, was then applied at a rate of 64 pounds per square yard.

TABLE 1. ROAD PACKER SECTION
SUMMARY OF MOISTURE-DENSITY TEST RESULTS

Location	May 1,2, 1967 Before Treatment				May 5, 1967 Before DGA Recompacted				June 27, 1967				August 8, 1967				April 26 and May 1, 1968			
	Subgrade		DGA		Subgrade		DGA		Subgrade		DGA		Subgrade		DGA		Subgrade		DGA	
	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)
Mile Post 48.265 Westbound Shoulder	112.6	17.6	140.1	3.4	110.9	19.0	–	–	116.1	15.8	144.0	2.5	–	–	–	–	104.2	18.0	139.6	2.7
Mile Post 47.982 Westbound Shoulder	112.0	17.7	142.0	4.3	113.8	17.9	–	–	115.1	16.9	130.5	3.8	111.5	16.6	122.2	4.8	121.6	10.8	117.5	3.4
Mile Post 47.816 Westbound Shoulder	115.7	15.0	133.3	4.0	107.4	20.8	–	–	116.6	15.8	138.8	3.9	–	–	–	–	–	–	–	–
Mile Post 47.703 Westbound Shoulder	118.8	15.2	139.5	4.3	121.6	14.1	–	–	118.5	14.3	137.5	2.9	–	–	–	–	118.5	13.5	135.9	2.3
Mile Post 47.514 Westbound Shoulder	107.7	17.7	140.8	4.1	117.6	16.1	–	–	113.1	17.2	140.6	3.1	117.3	14.7	135.6	2.5	–	–	–	–
Mile Post 47.600 Eastbound Shoulder	111.2	16.9	147.8	3.5	–	–	–	–	111.3	15.9	138.0	3.6	119.8	13.5	138.6	3.2	119.9	14.4	136.2	2.8
Mile Post 47.705 Eastbound Shoulder	105.7	16.8	142.0	4.2	–	–	–	–	119.6	14.5	139.4	3.3	119.9	10.5	140.1	3.1	109.4	12.8	131.6	3.2
Mile Post 47.817 Eastbound Shoulder	110.2	18.9	145.5	4.1	–	–	–	–	111.6	17.8	139.1	3.2	–	–	–	–	–	–	–	–
Mile Post 47.985 Eastbound Shoulder	108.5	16.6	130.7	5.2	–	–	–	–	111.1	15.7	133.2	3.6	112.7	15.8	131.3	2.8	116.5	16.3	137.7	2.9
Mile Post 48.156 Eastbound Shoulder	115.3	14.1	139.2	2.7	–	–	–	–	110.8	16.1	134.3	3.1	–	–	–	–	115.7	16.2	–	–
Mile Post 48.343 Eastbound Shoulder	111.0	18.9	137.2	3.8	–	–	–	–	111.0	17.1	135.0	3.0	–	–	–	–	–	–	–	–
Average	111.7	16.8	139.9	4.0	114.2	17.5	–	–	114.0	16.1	137.3	3.3	116.2	14.2	133.6	3.3	115.1	14.5	133.6	3.3

TABLE 2. CONTROL SECTION
SUMMARY OF MOISTURE-DENSITY TEST RESULTS

Location	May 3, 1967 Before Treatment				May 25, 1967 Before DGA Recompacted				June 27, 1967				August 8, 1967				May 1,2, 1968			
	Subgrade		DGA		Subgrade		DGA		Subgrade		DGA		Subgrade		DGA		Subgrade		DGA	
	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)
Mile Post 48.800 Eastbound Shoulder	110.2	15.2	-	-	113.1	16.3	-	-	110.8	15.5	135.3	3.1	-	-	-	-	113.2	15.2	138.1	2.5
Mile Post 48.440 Westbound Shoulder	113.4	17.3	-	-	110.9	19.0	-	-	110.1	12.6	141.3	2.3	-	-	-	-	-	-	-	-
Mile Post 48.491 Eastbound Shoulder	-	-	-	-	-	-	-	-	115.0	15.2	132.9	3.5	116.7	15.3	132.2	3.2	121.3	15.4	137.7	2.8
Mile Post 48.565 Eastbound Shoulder	-	-	-	-	-	-	-	-	112.1	17.3	136.4	2.6	110.7	17.4	137.2	2.6	117.1	16.0	140.7	2.9
Mile Post 48.680 Eastbound Shoulder	-	-	-	-	-	-	-	-	112.1	16.4	137.8	3.8	112.1	15.1	127.7	3.4	-	-	-	-
Mile Post 48.737 Eastbound Shoulder	-	-	-	-	-	-	-	-	113.4	15.5	130.3	3.2	-	-	-	-	119.5	13.6	120.5	4.0
Mile Post 48.836 Westbound Shoulder	-	-	-	-	-	-	-	-	117.2	16.0	132.4	2.7	-	-	-	-	94.6	20.3	132.0	2.9
Mile Post 48.700 Westbound Shoulder	-	-	-	-	-	-	-	-	120.1	13.7	134.5	2.2	-	-	-	-	-	-	-	-
Mile Post 48.646 Westbound Shoulder	-	-	-	-	-	-	-	-	112.5	16.0	143.7	1.9	-	-	-	-	113.3	16.1	139.8	2.4
Mile Post 48.563 Westbound Shoulder	-	-	-	-	-	-	-	-	114.2	16.5	137.8	2.3	113.5	16.3	131.9	2.1	-	-	-	-
Mile Post 48.489 Westbound Shoulder	-	-	-	-	-	-	-	-	115.8	15.7	139.6	3.2	-	-	-	-	124.7	13.5	-	-
Average	111.8	16.3	-	-	112.0	17.7	-	-	113.9	15.5	136.5	2.8	113.3	16.0	132.3	2.8	114.8	15.7	134.8	2.9

TABLE 3. SUMMARY OF SOIL PENETROMETER TEST RESULTS

	Mile Post	Lane	Soil Penetrometer Reading of Subgrade (psi), May 15, 1968
Road Packer Section	48.27	W-B	1018
	47.98	W-B	1119
	47.82	W-B	1004
	47.70	W-B	1406
	47.51	W-B	1018
	47.70	E-B	1345
	47.82	E-B	1331
	48.00	E-B	1420
	48.16	E-B	1070
	48.34	E-B	990
Average			1172
Control Section	48.80	E-B	1199
	48.49	E-B	924
	48.57	E-B	924
	48.68	E-B	1560
	48.84	W-B	703
	48.70	W-B	924
	48.65	W-B	1440
	48.56	W-B	924
	48.49	W-B	943
Average			1060

Figure 3. A Typical View of the Control Section at Mile Post 48.64, May 1, 1968.

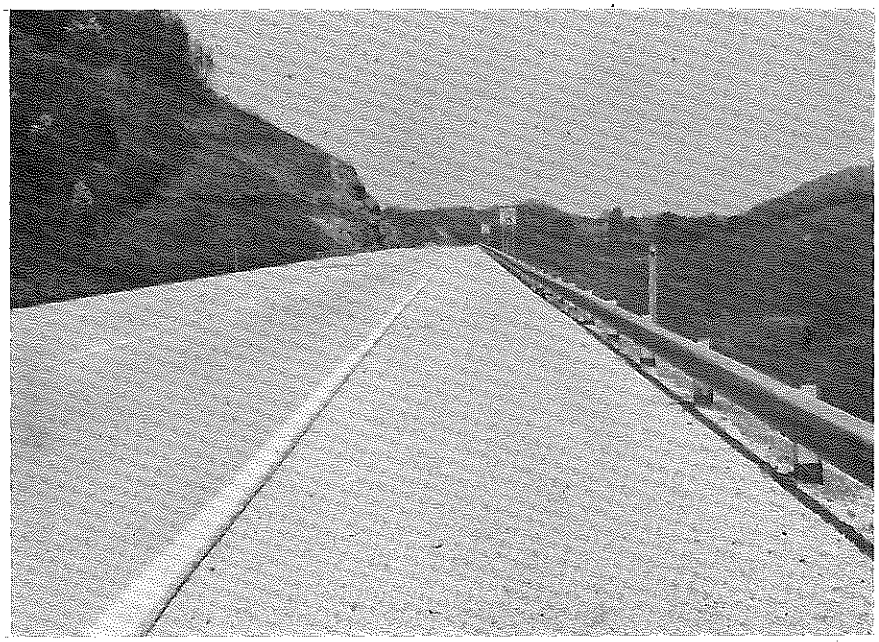

Figure 4. A Typical View of the Road Packer Section at Mile Post 48.00, May 1, 1968.

COST:

Labor - June 14 through June 30, 1967	$ 5,508.61
August 17 through August 21, 1967	428.29
State Equipment - June 14 through June 30, 1967	2,261.28
August 17 through August 21, 1967	428.29
Rented Equipment	2,750.00
Materials:	
Cement - 1905 barrels	10,948.80
No. 9 maintenance stone - 248.88 tons	657.04
SS-1h emulsion - 5095 gallons	691.67
RS-2 emulsion - 14275 gallons	1,935.45
No. 8 stone - 352.00 tons	929.28
Total	$26,538.71

Square yards treated - 20,592

Cost per square yard ———— $1.287

PERFORMANCE: Nuclear density and moisture tests were performed on the subgrade soil and DGA before treatment, on the DGA after cement treatment but before sealing, and on the sealed DGA one year after treatment. These data are summarized in Table 4. These data indicate that the subgrade soil density approximated that of the Road Packer Test and Control Sections. These data also indicate that the density of the DGA was approximately the same before and after cement treatment. The density measurements, taken on the asphalt seal one year after treatment, are of little value as the measurements were affected by the seal.

Visual inspection was made of the shoulder in early May 1968. Notes were made as to the location and extent of defects in the shoulder. A pick was used to test the soundness of the cement-treated material across the width of the shoulder at 1000-foot intervals.

The finished, sealed shoulder was generally higher than the roadway surface at the edge and this resulted in the seal being shaved over a width of about 1-1/2 feet at the pavement edge by snow removal equipment. The soundings indicated that the cement distribution was not uniform across the 9-foot width of treated shoulder. The shoulder was generally softer at the pavement edge and toward the outer edge of the treatment. The center of the shoulder was generally hard throughout the length of the treatment. The bituminous seal, other than that damaged by snow removal equipment, appeared

TABLE 4. CEMENT-TREATED SECTION
SUMMARY OF MOISTURE-DENSITY TEST RESULTS

Location	April 27 and 28, 1967 Before Treatment				June 21, 1967 Performed on Cemented DGA, Asphalt Seal Not Present		April 26, 1968 Cement Section Coated With Asphalt	
	Subgrade		DGA					
	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)	Dry Density (lbs/ft^3)	M.C. (%)
Mile Post 44.0 Eastbound Shoulder	112.3	17.1	142.0	3.5	–	–	–	–
Mile Post 44.4 Eastbound Shoulder	113.1	16.4	–	–	–	–	110.7	10.3
Mile Post 44.8 Eastbound Shoulder	108.3	15.9	–	–	–	–	–	–
Mile Post 45.4 Eastbound Shoulder	111.4	16.7	118.8	4.0	–	–	111.1	8.4
Mile Post 45.9 Eastbound Shoulder	114.7	17.7	126.8	2.8	–	–	–	–
Mile Post 45.9 Westbound Shoulder	109.3	16.2	134.3	3.5	–	–	–	–
Mile Post 45.4 Westbound Shoulder	116.8	16.0	–	–	–	–	–	–
Mile Post 44.8 Westbound Shoulder	97.0	24.7	–	–	–	–	–	–
Mile Post 44.4 Westbound Shoulder	108.0	23.2	–	–	–	–	113.5	9.0
Mile Post 44.2 Westbound Shoulder	104.0	21.2	–	–	–	–	–	–
Mile Post 44.0 Westbound Shoulder	108.8	20.2	–	–	–	–	–	–
Near M.P. 45	–	–	–	–	126.5	3.3	–	–
Near M.P. 45	–	–	–	–	129.6	5.1	–	–
Near M.P. 45	–	–	–	–	133.5	7.5	115.3	8.0
Near M.P. 45	–	–	–	–	134.5	5.2	–	–
Near M.P. 45	–	–	–	–	130.2	4.5	–	–
Near M.P. 45	–	–	–	–	131.0	7.6	–	–
Near M.P. 45	–	–	–	–	135.2	4.7	–	–
Near M.P. 45	–	–	–	–	133.1	4.1	–	–
Average	109.4	18.6	130.4	3.4	131.7	5.2	112.6	8.9

to be in good condition and to be firmly attached to the cement-treated aggregate. It is estimated that in approximately 7000 lineal feet of the total 21,000 lineal feet some rutting or deformation of the shoulder has occurred. Only a very small portion of the shoulder is severly broken. Typical views of this section of shoulder are shown in Figures 5 and 6.

ASPHALT EMULSION (SS-1h) TREATMENT

LOCATION: From Mile Post 43.17 to Mile Post 43.45

DATE CONSTRUCTED: August 14 through August 16, 1967

CONSTRUCTION PROCEDURES: A detailed description of the construction of this section is given in a memorandum dated August 24, 1967, in Appendix C.

COST:

Labor - August 14 through August 16, 1967 ---------- $	668.36
State Equipment - August 14 through August 16, 1967-	356.70
Rented Equipment --	750.00
Materials:	
CSS-1h - Cationic Asphalt Emulsion, 9074 gallons ----------------------------------	1,534.65
SS-1h - Anionic Asphalt Emulsion, 9009 gallons-	1,223.01
Total---$	4,532.72

Square yards treated - 3000

Cost per square yard ------------$1.511

PERFORMANCE: District Maintenance ordered sufficient emulsion for an application rate of one gallon per square yard per inch of depth of aggregate. This should have resulted in a mix with a base asphalt content of about five percent. The Pulvi-mixer was set to mix a six-inch depth of shoulder; but, the mixing tines were worn and mixing was only effective to a depth of about four inches. This effectively raised the base asphalt content to near 7.5 percent. The net effect of this was that the shoulder was very soft and sticky immediately after treatment and the shoulder was still soft in May 1968. It was necessary to cover the anionic emulsion-treated shoulder with crushed stone shortly after treatment. In May 1968, the cationic- and anionic-treated shoulders appeared to be about equal in stability. Both shoulders were so soft in May 1968 that the tires of a parked automobile would sink into the treated DGA. Views of each bituminous treated shoulder are shown in Figures 7 through 10. Table 5 summarizes density readings on the treated shoulder.

Figure 5. Typical Appearance of Cement-Treated Section near Mile Post 44.18, May 1, 1968. Note the dark strip next to the pavement where the seal was shaved by snow removal equipment.

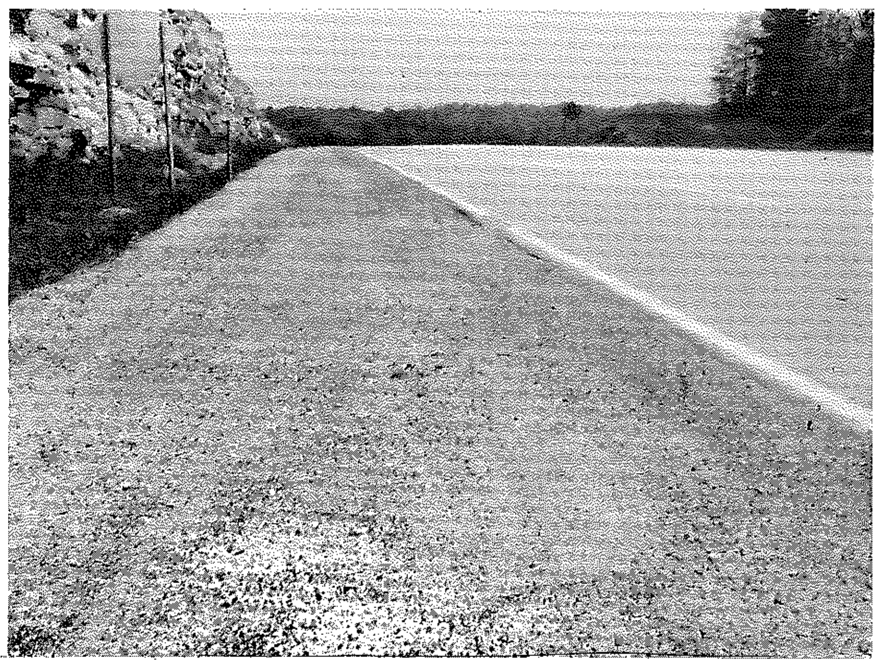

Figure 6. Cement-Treated Section Near Mile Post 44.49, May 1, 1968. This was one of the most severely distressed areas of shoulder.

Figure 7. Typical Appearance of Anionic Emulsion-Treated Shoulder, May 1968. This section was covered with crushed stone shortly after treatment.

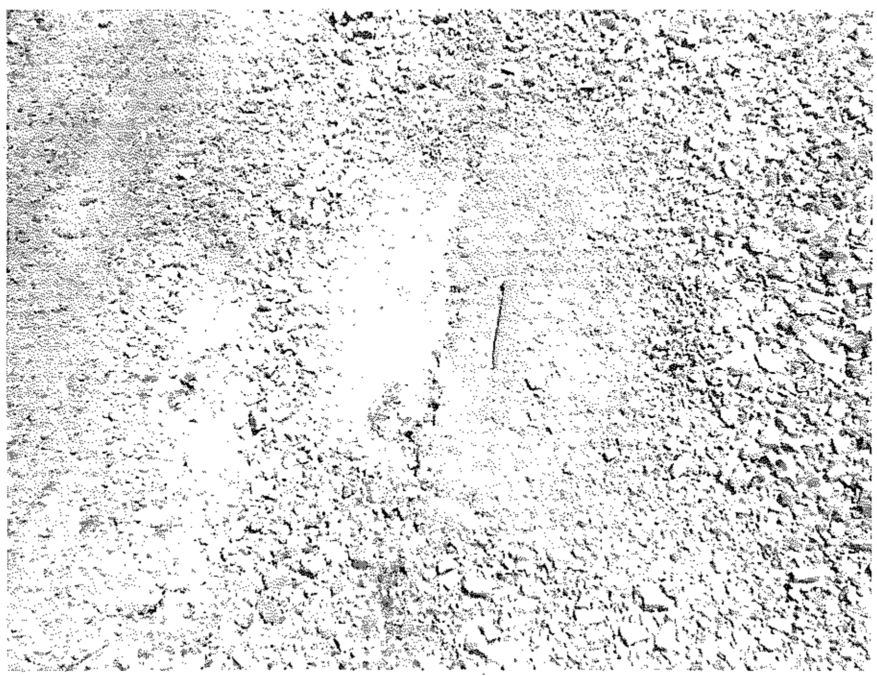

Figure 8. A Rutted and Cracked Area in the Anionic Emulsion Treatment, May 1968.

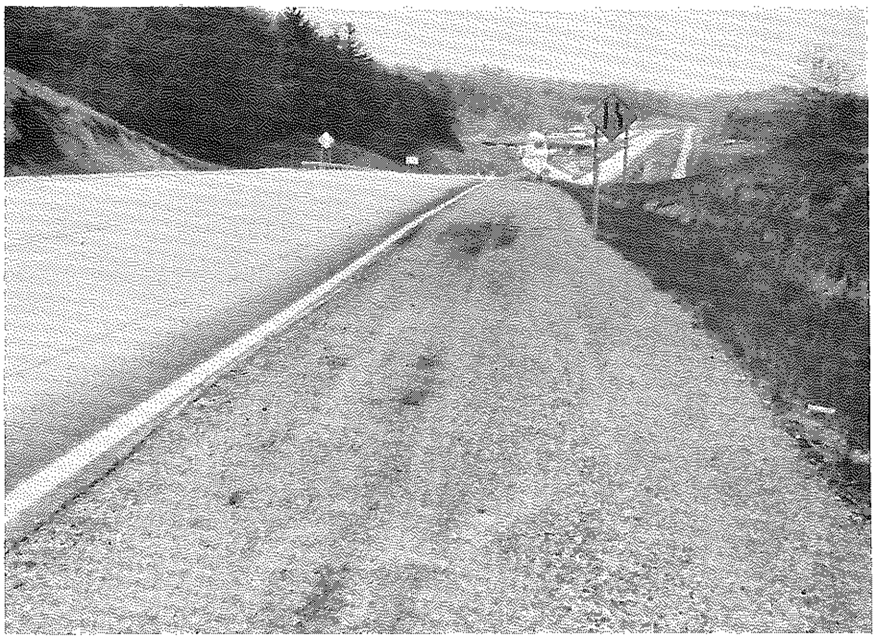

Figure 9. A Typical View of the Cationic Emulsion-Treated Shoulder, May 1968.

Figure 10. A Rutted and Cracked Area in the Cationic Emulsion Treatment, May 1968.

TABLE 5. ASPHALT EMULSION SECTION
SUMMARY OF DENSITY TEST RESULTS

Location	April 26, 1968 Wet Density (lbs/ft^3)
Sta 20+23 Westbound Shoulder	130.4
Sta 20+23 Eastbound Shoulder	128.0
Sta 20+31 Eastbound Shoulder	129.2
Sta 20+31 Westbound Shoulder	127.1
Average	128.6

SUMMARY OF PERFORMANCE

ROAD PACKER TEST AND CONTROL SECTIONS: At best, the use of the Road Packer resulted in only a marginal increase in density and bearing capacity of the subgrade soil. This slight increase in bearing strength does not appear to justify the cost of the treatment.

CEMENT TREATMENT WITH BITUMINOUS SEAL: The cement treatment was a least partially successful. The seal was constructed high and cement was not distributed and(or) mixed well toward the edges of the shoulder. Modifications of construction procedures should remedy these problems. There was some degree of deformation evident in approximately 1/3 of the treated shoulder. At present, this must be taken as an indication that the shoulder is still structurally inadequate with this degree of cement treatment.

ASPHALT EMULSION TREATMENT: This shoulder was treated with an excess of asphalt and is unstable. This makes it impossible to form any opinion as to the stabilizing effect of a proper treatment. However, the construction experience indicated that emulsion treatment would involve curing problems. The total quantity of liquid - mixing water and emulsion - which must be applied is in excess of that required for proper compaction. Therefore, a large proportion of the water must be evaporated from the shoulder before proper compaction can be attempted. This would require that the shoulder be left uncompacted for several days under ideal drying conditions. This, of course, would be a hazard to traffic using the roadway.

APPENDIX A

March 13, 1967

MEMORANDUM M.3.1

TO: Jas. H. Havens
Director of Research

FROM: John W. Scott
Principal Research Engineer

SUBJECT: Cement Stabilization of Mountain Parkway Extension Shoulders

On January 25, 1967, several samples of soil and dense-graded aggregate base were taken at various locations on the roadway shoulders of the Campton-Salyersville extension of the Mountain Parkway. Subsequent laboratory test results, as tabulated in the attached Sampling Report, indicate that the subgrade consists of yellow clay having ample penetration-resistance values of 500 psi (ASTM D 1558-63). The depth of the dense graded aggregated on the shoulders ranged from 3 to 6 inches; and the gradation was essentially the mean of Kentucky's specification limits with the exception of being on the lower limit in the finer sizes. Assuming a design thickness of 6 inches, tests consisting of gradation, standard proctor, and compressive strength were performed on blended samples; and these results are summarized in the attached table. Based on gradation and density of the material, the Soil-Cement Laboratory Handbook published by the Portland Cement Association recommends cement contents of 5 and 6 percent.

Most criteria concerning cement stabilization deals primarily with base courses, and little detail is given on shoulder design. In most states compressive strength and durability tests are performed on soil samples proposed for stabilization; and cement requirements are based upon these tests. Typical minimum 7-day compressive strength requirements for base courses are: Alabama, 600; Arizona, 300-500; California, 400-750; Colorado, 400; Idaho, 400-650; Louisiana, 300; Mississippi, 500; Montana, 550; New Hampshire, 250-400; New Mexico, 300-650; New York, 300; Pennsylvania, 300; Vermont, 300; Virginia, 500; Washington, 850; West Virginia, 300; and Wyoming, 300. Typical cement-treated shoulder thicknesses currently used are: Indiana, 6"; New Hampshire, 9"; Pennsylvania, 4-5"; and South Carolina 5-6".

For practical purposes, a uniform cement content and design thickness should be specified for the entire project. Test results indicate that a cement content of 6 percent for a 6-inch stabilized shoulder would be satisfactory. The material should be placed at its optimum moisture content and at not less than 95% of maximum density as determined by AASHO T 99.

A windrow, flat, or multiple-pass, rotary, traveling, mixing machine would be best suited for mixing materials in place. The required amount of cement may be spread by mechanical, bulk cement spreaders. This operation should proceed just ahead of mixing operations. Water, supplied by tank trucks, should be thoroughly mixed with the soil and cement throughout the full depth and width of treatment. Compaction may be with a sheepsfoot, pneumatic-tired or steel-wheeled roller. Final finish should be obtained by scraping with a motor grader and rolling with a pneumatic-tired roller.

If compacted and cured properly, finished soil-cement contains sufficient moisture for complete cement hydration. A curing application of 0.3 gallon diluted SS-1h (2 parts SS-1h, 1 part water) per square yard should be made while the compacted surface is still moist. A double A-2 seal should be added for protection against abrasion and water penetration.

For a cement content of 6 percent by weight (0.37 bag per square yard), the cement requirement per mile for 10 feet of shoulders on each side would be 4,340 bags. Probable cost breakdown per square yard would be $0.45 for cement, $0.50 for processing, $0.30 for compaction and finishing, and $0.30 for seals. This results in a unit cost of $1.55 per square yard or a total cost of $18,200 per mile.

JWS:mm

SAMPLING REPORT

The following samples were obtained from the right lane, eastbound shoulders of the Mountain Parkway extension on January 25, 1967.

Sample No.	DGA Thickness (inches)	Subgrade Penetration (psi)	Location and Subgrade Description
1	5	170	0.6 mile E. of Campton Interchange near mile post 43; Subgrade shaley in 40' roadway cut.
2	3 1/2	1500	3.9 miles E. of Campton Interchange, 250' E. of Toll Plaza; Subgrade yellow clay in 12' roadway fill.
3	4	500	7.6 miles E. of Campton Interchange; 0.6 mile E. of Ky 1010; Subgrade yellow clay in 10' roadway fill.
4	6	500	11.5 miles E. of Campton Interchange; Yellow clay subgrade; 1" of asphaltic material sprayed onto shoulders; 10' roadway cut.
5	3	550	15.8 miles E. of Campton Interchange; Yellow clay subgrade in 5' fill.
6	5	300	19.8 miles E. of Campton Interchange; Yellow clay subgrade in 60' roadway cut; 1" of asphalt material sprayed onto shoulders.
7	4	500	23.8 miles E. of Campton Interchange; 2.8 miles E. of Magoffin Co.; Yellow clay subgrade in 10' roadway fill.
8	3	625	27.5 miles E. of Campton Interchange; Yellow clay subgrade in 50' roadway fill.
9	3	400	31.8 miles E. of Campton Interchange; 1.7 miles E. of Ky 30; Yellow clay subgrade in 80' roadway cut.
10	6	400	34.1 miles E. of Campton Interchange; 0.9 mile E. Ky 7 Interchange; Yellow clay subgrade in 9' roadway fill.
Avg.	4.25		

LABORATORY TEST RESULTS

Assumed Depth (inches)		Percent by Weight		Percent Retained #4 Seive	Percent Passing 0.05 mm	Maximum Dry Density (lbs/cu ft)	Optimum Moisture Content (percent)	Percent Cement by Weight Recommended by PCA	Percent Cement by Weight Tested	Compressive Strength (psi)	
DGA	Soil	DGA	Soil							3-day	7-day
3	3	51.7	48.3	30.1	24.6	126.0	10.6	6	6	440	516
4	2	68.2	31.8	31.9	17.8	-	-	-	-	-	-
5	1	84.3	15.7	39.1	11.2	134.3	8.9	5	6	646	1,225
6	0	100.0	0	43.5	4.7	-	-	-	-	-	-

APPENDIX B

CONDENSED INSTRUCTIONS COVERING USE OF ROAD PACKER
(Read the instructions on container label)

EQUIPMENT REQUIRED

Tank truck. 1000- to 5000-gallons capacity. Know exact capacity. Tank to be equipped with gravity spreader pipe 1 1/4" to 4" diameter, 8 feet long, with 3/8" to 1/2" holes, 2 rows, 2" to 3" apart. Tank to have pump for filling from river or lagoon.

Roller. 8 to 10 ton, or larger. Steel wheel type with vibrator preferred. Rubber-tired wobble wheel roller or sheepsfoot roller may be used.

Patrol grader with scarifier. Not required in all cases. Grader is used where surface of soil to be treated is rutted. Use scarifier where solution or water tends to runoff or down hill.

PROCEDURE

A. Preparation of subgrade - new construction.
   1. Bring soil to specified subgrade elevation (see note 1). Make density test in accordance with prevailing specifications.
   2. Place 3" to 6" of specified subbase material. Roll to obtain even depth.

B. Preparation of existing road and shoulder surface.
   1. Fill ruts and holes with grader. Slope shoulder away from roadway.
   2. Scarify lightly, 2" to 3", to keep solution from puddling or running off. Scarifying too deeply simulates ruts; the solution will be at bottom of ruts leaving 4" to 6" of untreated soil and when levelled off and compacted will leave a soft layer of untreated soil on top.
   3. Where the existing roadway pavement is deteriorated asphalt, scarify the asphalt, breaking it into small pieces. Then proceed the same as in D,E,F, below.

C. Fill water tank, adding 1 gallon of ROAD PACKER to each 1000 gallons of water. Agitation to mix ROAD PACKER and water is not required.

D. Apply ROAD PACKER solution, operating truck at a speed required to prevent runoff or puddling. Apply evenly so that about 1/4" of solution covers entire area to be treated. Apply as fast as soil will absorb the solution. 1000 gallons of solution will treat 5000 to 6000 square feet. This is 8.71 gallons of ROAD PACKER maximum and 6.20 gallons of ROAD PACKER minimum per acre. Calculate number of square feet in area to be treated.

E. After all solution has been applied and absorbed, follow with application of plain water for a minimum of three days, longer if deeper penetration of the solution is desired. Record the number of gallons of water used including the amount in the solution.

F. After water has been applied, begin compaction with roller. Continue compaction until tests indicate the required density has been obtained to the depth desired. Record the number of passes made with the roller. If rubber-tired roller is used, inflate all tires alike, 30 to 45 psi for the first four passes. Increase the tire inflation pressure for the remaining passes to maximum pressure for which the tires are designed.

CONTROL (Optional)

A. Set up a control section, untreated, adjacent to the treated section with the same soil characteristics.
   1. Prepare subgrade in exactly the same manner as treated subgrade was prepared. Make density test.
   2. Apply water, same amount, spread evenly, as used on treated section.
   3. Compact untreated section using same amount of compactive energy used on the treated section - same weight roller, same number of passes and same speed of operation. Make density test.
   4. Make density tests on both treated and untreated sections at the same time, i.e., immediately before treatment and immediately after compaction. Continue tests for six months, one test per month being sufficient.

NOTE 1. The specified subbase depth of stone, gravel or sand can be reduced up to 1/3 or more depending upon the depth of penetration of the solution and the amount of compactive energy used.

NOTE 2. Roads, parking lots, etc., not subject to heavy truck and equipment traffic can be constructed with 3" to 6" of subbase material topped with 2 1/2" of asphalt. The final top, sealed, should slope sufficiently to permit surface water to runoff.

NOTE 3. The treated and control sections should be identified by stakes set at the ends of the sections.

North American Soil Stabilizers, Inc.
P.O. Box 1283, Syracuse, New York
February 13, 1967
L.B.

APPENDIX C

July 21, 1967

MEMORANDUM M.3.1

TO: J.H. Havens, Director
Division of Research

FROM: R.L. Florence *RLF*
Research Engineer

SUBJECT: Experimental Asphalt Emulsion Stabilization of Dense Graded Aggregate Shoulders on the Mountain Parkway in Wolfe County.

Recently the Division of Maintenance requested that the Research Division make recommendations as to material application rates and construction procedures and to monitor the construction of a trial section of asphalt emulsion stabilization of the dense graded aggregate shoulders on the Mountain Parkway in Wolfe County. The Maintenance Division also indicated a particular interest in using cationic slow setting emulsion with a hard base asphalt (designated as CSS-1h). It is understood that 1500 feet of the shoulder will be stabilized on both sides of the roadway, that the stabilization will be nine feet in width and the existing aggregate is four to six inches in depth. Cationic emulsion will be used in one shoulder and anionic emulsion (designated as SS-1h) will be used in the other.

It is our recommendation that the base asphalt content be four percent for both types of emulsion. Assuming that the base asphalt content of the emulsion is 61.5 percent and that the unit weight of the finished shoulder will be 142 lb per cu ft, the following estimate of required quantity of emulsion may be made:

Weight of 1 sq yd of material, 5 inches deep = 142 pcf x 9 sq ft x 5/12 ft = 532.5 lb.

Weight of emulsion required per sq yd for 4 percent base asphalt = 532.5 lb x .04 x 1/.615 = 34.63 lb.

Gal of emulsion required per sq yd for 4 percent base asphalt = $\frac{34.63 \text{ lb}}{8.34 \text{ lb/gal}}$ = 4.15 gal.

Gal of emulsion required for 1500 ft of shoulder, one side = 4.15 gal/sq yd x 1500 sq yd = 6225 gal.

Gal of emulsion required for 1500 ft of shoulders, both sides = 6225 gal x 2 = 12,450 gal.

Some brief preliminary mixing tests in the laboratory with aggregate from the shoulder and CSS-1h indicate that all aggregate surfaces must be wetted prior to introducing the emulsion in order to achieve thorough dispersion of the emulsion. It is believed that the same will be true for the anionic emulsion. The total amount of liquid (emulsion and water) required to supply four percent base asphalt and to insure good mixing is above the optimum required for compaction of the aggregate. Therefore, the compaction of the shoulder should be delayed after mixing to allow some of the moisture to evaporate.

Our recommendations pertaining to the stabilization of the shoulder using both types of emulsion may be summarized as follows:

1. The shoulder should be scarified and all aggregate surfaces thoroughly wetted prior to applying the emulsion. The aggregate should be removed from the edge of the pavement and placed toward the center of the shoulder (windrowed). The exposed pavement edge should then be primed with emulsion.

2. The base asphalt content should be four percent. This will require 4.15 gallons of emulsion per square yard of shoulder. As the treatment is to be nine feet in width this will amount to 4.15 gallons per lineal foot of shoulder. This may be too much liquid to apply at one time on the shoulder. Some variations of the application and mixing procedures may be necessary on the trial section in order to establish the best procedures to follow. It may prove that some variation in procedure between the sections with anionic and cationic emulsion may be necessary.

3. Compaction of the shoulder should be delayed until a portion of the water has evaporated from the loose mix. Density measurements should be correlated with roller passes to establish an optimum compaction procedure.

4. After compaction, sealing of the shoulder should be delayed for two or more weeks, depending upon climatic conditions, for curing. The material should develop stability as the moisture dries out.

August 24, 1967

MEMORANDUM M.3.1

TO: J.H. Havens
Director of Research

FROM: R.L. Florence RLF
Research Engineer

SUBJECT: Trial Emulsion Stabilization of Mountain Parkway Shoulders

From Monday, August 14 ghrough Wednesday, August 16, District Maintenance stabilized approximately 3000 feet of shoulder on the Mountain Parkway near Campton. The following construction procedures were generally followed on all stabilized sections. The entire 3000 feet of shoulder was scarified using a partrol grader. The scarified material was then wetted using an water truck. The slow-setting emulsion was applied in 6 to 7 applications of approximately 1 gallon per square yard per application using an asphalt distributor truck with the spraybar extended out over the shoulder. The distributor could carry approximately 800 gallons of emulsion. District Maintenance ordered enough emulsion for 1 gallon per square yard per inch of depth. Two passes of Seaman Pulvi-mixer were made after each application of emulsion. The Pulvi-mixer was set to mix a 6-inch depth of material. The shoulder was then shaped with a patrol grader and compacted with a 10-ton tandem roller. The work was actually done in four 750 foot sections. Following is a discussion of the construction of each 750-foot section.

On Monday, August 14, a 750-foot section of the westbound shoulder from Station 2021+00 to Station 2028+50 was stabilized with CSS-1h (cationic slow setting with a hard base asphalt) emulsion. This section was constructed shortly after the shoulder was scarified. No mixing water was needed as the aggregate was damp. Two passes of the Pulvi-mixer were made before any bituminous material was applied. It was necessary to make two passes with the Pulvi-mixer to cover the full width of shoulder. The emulsion was applied in five full loads and one partial load. On this section the material was not mixed well in a 6- to 8-inch strip next to the asphalt concrete pavement. It was noted tht the Pulvi-mixer wheels caused depressions in the shoulder material and the emulsion tended to collect in these depressions. After mixing, the liquid content of the shoulder was much too high for good compaction.

On Tuesday morning, August 15, a second 750-foot section of the westbound shoulder was stabilized with CSS-1h. This section was adjacent to the section previously stabilized and extended from Station 2028+50 to approximately Station 2036+00. This section was wetted prior to the application of any emulsion. The procedures were approximately the same in constructing this section as in construction of the first section. As it was noted that the emulsion was breaking before the Pulvi-mixer made a pass on the first section, the Pulvi-mixer was placed immediately behind the distributor in constructing the remaining three sections. The shoulder material was also bladed away from the edge of the pavement and away from the outer edge of the shoulder during the mixing process for all except the first section constructed.

The thrid 750-foot section was constructed Tuesday afternoon, August 15, on the eastbound shoulder between Stations 2036+00 and 2028+50. The procedure in constructing this section was the same as used in constructing the second section except SS-1h was used.

The fourth section was constructed Wednesday morning, August 16, on the eastbound shoulder between Stations 2028+50 and 2021+00. The construction procedures were the same as used on the second and third sections except this section was not compacted immediately after it was mixed.

I asked Mr. Roy Back to wait a few days before attempting any further compaction of the shoulders. He said he would wait until Friday, August 18, and then compact all of the treated shoulder. Mr. Back also had soft shoulder warnings signs put out on the roadway.

At the completion of the construction, none of the test sections were very stable as there was excess liquid in the mix. It was also noted that the emulsion was only mixed through the top three to four inches of material. The tines on the Pulvi-mixer were worn, especially on the right side of the machine, but I do not believe this fully explains the shallow application and mixing. Of course, the top 4 inches of material is excessively rich in asphalt. I do not believe 6 inches of material can be mixed with the Pulvi-mixer at one time. The anionic material appears to be worse in this respect than the cationic. The anionic material appears to migrate upward in the mix. I doubt if the anionic-treated shoulder will become stable with the evaporation of water. We intend to check the bearing strength of the shoulder at intervals with our soil penetrometer. We also intend to check the density of the shoulder with the nuclear density apparatus. If these shoulders do not stabilize within a reasonable period of time, some further work will have to be done. In any event we intend to inspect these sections of the shoulder at frequent intervals.

RLF:lhs