TRANSPORTATION DEPARTMENT
DIVISION OF HIGHWAYS

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BEAR RIDGE BASE
STABILAZATION INVESTIGATION

RESEARCH PROJECT NO. 5

By
William A. Sylvies, P. E.
Associate Materials Engineer II

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MATERIALS and RESEARCH SECTION

BEAR RIDGE BASE
STABILAZATION INVESTIGATION

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From Information Contained in Other Existing Reports and Test Data

August 1976

Idaho Transportation Department
Division of Highways
Materials Section

Boise, Idaho

A

RESEARCH REPORT

FROM

IDAHO TRANSPORTATION DEPARTMENT

DIVISION OF HIGHWAYS

RESEARCH SECTION

JAMES W. HILL, P.E.
Research Supervisor

IDAHO TRANSPORTATION DEPARTMENT
DIVISION OF HIGHWAYS
P.O. BOX 7129
BOISE, IDAHO 83707

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This report has been compiled primarily from the existing reports by Mr. Helm, Mr. Miller, and Mr. Munoz as listed in the bibliography. It was prepared by the Moscow Laboratory, typed by Mrs. Donna Parkes, Senior Clerk and Mrs. Kathy Whitehead, Senior Clerk, and reviewed by the Research Section.

Thanks are extended to all of the above persons, to District IV for their assistance in obtaining samples, and to all the student engineering technicians who helped with the physical testing and the drafting and proofreading of the written report.

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INTRODUCTION

Bear Ridge base stabilization Project S-4769(6) is located approximately eight miles south of Deary on S.H. 3 in Latah County. Winter climate in the area is severe and truck traffic consists mainly of heavy logging trucks, wood chip trucks and wheat trucks.

An untreated base constructed on this roadway section in 1957 was to be used as a gravel surface with a roadmix surface to be added later. Extensive pot holes and weak spots developed in the base during the winter, however, and it was determined that the roadmix surface could not be placed on the existing base without risk of serious failure. Approval was thus obtained from the Federal Highway Administration to construct a 2.16 mile long stabilized base project to compare the effectiveness of hydrated lime, portland cement, SS-1 emulsion asphalt, and a special road oil in improving base stability and preventing further aggregate degradation.

Seven different test sections were constructed in 1959 consisting of five treated base sections and two untreated base sections for comparison. Numerous tests were made during construction to establish the quality of the roadway materials for comparison with similar future test results. The roadmix surface course was added in 1960.

Benkelman Beam tests have been performed at various times since construction to determine changes in wheel load deflections. Moisture contents have been obtained at various depths in the roadway ballast by a nuclear moisture probe. Unconfined compression strength and weight per cubic foot have been determined periodically for the cement treated base and lime treated base sections, while aggregate gradation, asphalt content, Atterberg Limits, sand equivalent, and resistance values have been obtained for the SS-1 emulsion asphalt, special road oil and untreated base roadway sections. And finally, periodic visual inspections of the roadway have been made to observe any signs of distress which may have developed and to help determine the serviceability of each test section.

CONCLUSIONS

Results from this investigation provide the following conclusions:

1. No one base treatment included in this project is clearly superior to the other treatments in providing both a good stable base and a maintenance free pavement surface.
2. Each treated base section had slightly favorable values for some tests and slightly unfavorable values for other tests.
3. Portland cement or hydrated lime are the most effective treatments to improve base stability and prevent further aggregate degradation. However, they both have the disadvantage of extensive reflective cracking in the pavement.
4. Unconfined compression strength and weight per cubic foot of the hydrated lime treated base materials is approximately the same as that of the portland cement treated base materials at the present time. However, the lime treated base material seemed to have a greater rate of increase in unconfined compression strength the first two years after construction than did the cement treated base material.
5. Neither the SS-1 emulsion asphalt nor the special road oil treatments were fully effective in preventing further degradation of the base material as was shown by the decrease in percentage of aggregate passing the No. 4 and the No. 10 sieves with time.
6. The effectiveness of both the SS-1 emulsion asphalt and the special road oil as treatments is questionable because of the significant reduction in asphalt content in both types of treated base between 1963 and 1971.

7. No information seems to be available as to what type of asphalt the special road oil was.
8. There seems to be no correlation between wheel load deflections and the moisture content in the treated base material, i.e., high wheel load deflections were not necessarily associated with high moisture contents.
9. There is no correlation between weight per cubic foot or air void content of the roadmix surfacing and water content in the underlying treated base or any treated base test results such as residual asphalt content, increase in fine aggregate or Atterberg Limits. Thus the final degree of pavement compaction seemed to have no correlation with the condition of the underlying treated base.

RECOMMENDATIONS

Recommendations based upon conclusions and past experience are:

1. Neither SS-1 emulsion asphalt nor the Special Road Oil should be used again as base treatments to help prevent further degradation of aggregate base material. Loss of asphalt content with time reduces their effectiveness as treatments.
2. Treated base investigations of this type are valuable and should be continued in the future using new treatment material as it is developed and placed on the market. This is a pratical way to help the Division of Highways continue to develop effective methods of upgrading marginal sources of aggregate.
3. Certain types of cationic emulsion asphalt such as CMS-2S and CSS-1h should be tried in future projects requiring base treatment. Recent experience has shown that both CMS-2S and CSS-1h have proven quite effective in some areas in providing good base stability and preventing further aggregate degradation.
4. A new means of measuring moisture content needs to be developed such as a device that could be buried in the roadway base for periodic monitoring of the moisture content.
5. In future base treatment investigations it is suggested that Benkelman Beam readings and cores of the base materials be taken every two years for proper evaluation of the effectiveness of each base treatment.

DISCUSSION

PROJECT LOCATION

Bear Ridge base stabilization project, ITD-Division of Highways Project No. S-4769(6), is located approximately eight miles south of Deary on State Highway 3 in Latah County. The gently rolling hills in the area are cut by deep canyons on the east and the south. Winter climate is severe with up to 20 inches of frost penetration in unprotected areas. Annual rainfall is between 20 and 30 inches. Outcroppings of basalt are local sources of highway construction material (1) (2).

Truck traffic consists mainly of heavy logging trucks, wood chip trucks, and wheat trucks. Annual average daily traffic increased from 180 vehicles in 1941 to 250 vehicles in 1960 with 18% being commercial traffic. Annual average daily traffic was 490 vehicles in 1975 with 29% being commercial traffic.

BACKGROUND HISTORY

In 1957, an untreated base was constructed on this section of roadway under Project S-4769(3). The base was to be used as a gravel surface with roadmix surface to be added at a later date. However, extensive potholes and weak spots developed in the base during the fall and winter of 1958. Investigation of the severe distress showed an excess of plastic fines was present in the material due to aggregate degradation. Details of those test results are in the report by Munoz (3) while aggregate degradation is explained in the reports by Miller (1) and Erickson (4).

Analysis of the problem showed that the roadmix surface could not be placed on the existing base without risk of serious failure. Hence it was recommended to the Federal Highway Administration that the base be stabilized prior to further construction. That agency, in turn, approved the construction of a test project to compare the effectiveness of hydrated-lime, portland cement, SS-1 emulsion asphalt, and a special road oil in improving base stability and preventing further degradation (1) (2).

AGGREGATE SOURCE

Division of Highways Pit No. Latah 126 is located approximately 1200 feet east of project Station 285. The aggregate is basalt ranging in quality from fresh and unaltered to greatly altered and partially decomposed. Approximately half of the available basalt appears to be borderline to greatly altered in quality. An attempt was made during crushing operations to prevent clay and altered or disintegrated rock from being crushed and used. Additional information is in the report by Helm (2).

PROJECT CONSTRUCTION

Construction of the 2.16 mile long base stabilization project, S-4769(6), was started in July 1959. Seven different test sections were constructed as shown in Figure 1. Hydrated lime at 3.0 percent by weight of aggregate, SS-1 emulsion asphalt at 5.0 percent, and Special Road Oil at 3.5 percent were used based on past experience. Portland cement at 4.0 percent was selected because soil-cement tests (5) showed that amount to be both satisfactory and economical. Past experience had also shown these additives to be reasonably effective on other projects both in improving base stability and preventing aggregate degradation. The two untreated sections served as references to permit proper evaluation of the different treatment benefits.

<u>Portland Cement and Hydrated Lime Base Stabilization</u>. The existing

base was scarified to a depth of about 5 inches, the loosened material pulverized and placed in windrows, and the cement and lime added dry in the proper amount. Mixing was done by a Woods Mixer at the proper moisture content until the mixture was homogeneous as practical. Compaction was done by a Jackson Vibrator, the initial rolling by a pneumatic roller, and the final rolling by a steel wheeled roller. An RC-2 curing seal coat was then applied to the base to prevent moisture loss.

Special Road Oil and SS-1 Emulsion Asphalt Base Stabilization. The existing base was scarified to a depth of approximately 5 inches, the loosened material pulverized until it passed a 1-inch sieve and placed in windrows, and the bituminous treatment applied by a distributor. Mixing and compaction was the same as for the cement and lime treatments. An RC-2 prime coat was applied to the Special Road Oil base section to prevent raveling, but past experience indicated that a prime coat was unnecessary on the SS-1 emulsion base section. Examination of available data and reports does not reveal what type of asphalt the special road oil was.

Untreated Base Sections. The existing base was reshaped and compacted using pneumatic and steel wheeled rollers to maximum weight per cubic foot at optimum moisture content. An RC-2 prime coat was then applied to the surface of the sections.

Roadmix Surface Course. All base sections were completed by fall of 1959. During that winter, traffic was detoured around those test sections from Stations 240 to 325 and allowed to travel over the rest of the project. A roadmix surface course was constructed starting in the spring of 1960 using MC-3 liquid asphalt at 4.0 percent by weight of aggregate. The surface course was then sealed using RC-5 liquid asphalt. Full construction details are contained in the report by Munoz (3).

PAVEMENT AND BASE THICKNESSES	BASE TREATMENT	STA.
	--	238+00
0.2' Roadmix Cl. "B" 0.4' Treated Base 0.7' Cr. Rk. Base, 2" Max. 0.3' Cr. Rk. Base, 3/4" Max. Type "B"	Test Section 1: SS-1 emulsion asphalt (5% by weight of aggregate)	
	--	253+50
	Test Section 2: Portland Cement (4% by weight of aggregate)	
	--	270+00
	Test Section 3: No treatment	
	--	278+50
	Test Section 4: SS-1 emulsion asphalt (5% by weight of aggregate)	
	--	293+50
	Test Section 5: Special Road Oil (3.5% by weight of aggregate)	
--	--	319+00
	--	322+50
0.2' Roadmix Cl. "B" 0.4' Treated Base 1.1' Cr. Rk. Base, 2" Max. 0.3' Cr. Rk. Base, 3/4" Max. Type "B"	Test Section 6: Hydrated lime (3% by weight of aggregate)	
	--	338+00
	Test Section 7: No treatment	
	--	351+80

Figure 1. Plan of Base Stabilization Project

TESTING PROGRAM

In the spring of 1959 prior to treatment, samples were taken from the crushed rock base constructed under Project S-4769(8) that had been left in place through the winter of 1958-59. Aggregate gradation, liquid limit and plastic index values determined for that material are shown in Tables V and VI under the heading "Prior to Treatment".

Materials Tests During Construction. Numerous tests were made during construction to establish the quality of the roadway materials for comparison with similar future test results. These included aggregate gradation, extracted asphalt content, liquid limit values, plastic index values and sand equivalent values as shown in Tables V, VI and VII under the heading "As Constructed". Three-foot long sections of steel pipe sealed with removable caps were driven vertically in the roadway at various intervals along the centerline to permit determination of the ballast material moisture content by means of a nuclear moisture probe. Weight per cubic foot and compressive strength in p.s.i. were also determined at the end of 90 days for cement treated base and lime treated base specimens as indicated in Tables I and IV.

Materials Tests Performed Since Construction. Periodic visual inspections of the roadway have been made since completion of construction to observe any signs of distress which may have developed. Benkelman Beam tests have also been performed at various times over the entire test section to determine changes in wheel load deflections. Moisture contents have been obtained at various depths in the roadway ballast by means of the nuclear moisture probe. Unconfined compressive strength and weight per cubic foot have been determined periodically for both the cement treated base and the lime treated base sections, while aggregate gradation, asphalt content, Atterberg Limits and sand equivalent values have been obtained for the SS-1 emulsion asphalt, special road oil and untreated base roadway sections. All of these tests were run according to Idaho test methods. The last series of tests was run on cores obtained in November 1971. A description of these cores is contained in Appendix A.

A combination moisture absorption and Resistance Value test was developed by John Miller (1) for this research project. It consisted of compacting a sample with 5 percent moisture in the kneading compactor using 140 blows at 250 p.s.i., soaking the sample with water in its mold for 14 days at 140°F, determining the sample's moisture content, and testing it for resistance value in the Hveem stabilometer.

ANALYSIS OF TEST RESULTS

Portland Cement Stabilized Base Section. Visual observations in 1962 by Helm (2), in 1970 by Sylvies (See Appendix B), and in 1975 by Sylvies and Sanchez (See Appendix C) indicated that both longitudinal and transverse cracks had developed in the roadway throughout this section. The transverse cracks occur every 20 to 30 feet and have been filled with asphalt to prevent water penetration into the base. By 1975, there were a number of skin patches and some serious distress in the section.

Weight per cubic foot and unconfined compression strength test results for base cores taken at various times are shown in Table I. The values are the averages of a number of tests.

TABLE I

WEIGHT PER CUBIC FOOT AND UNCONFINED COMPRESSION STRENGTH VALUES FOR PORTLAND CEMENT STABILIZED BASE SPECIMENS

	90 Day Control	Nov. 1960	July 1962	Nov. 1971
Weight per cubic foot	142.0	147.5	146.4	143.9
Unconf. Compr. Strength, psi	1216	1228	1940	2875

As expected, unconfined compression strength has increased with time while weight per cubic foot decreased moderately. The Nov. 1971 core samples were quite solid with no cracks but did have a few entrapped air holes.

Benkelman beam wheel load deflection readings are shown in Table II. Average southbound lane readings increased from 11 in March 1961 to 15 in November 1964, while average northbound lane readings increased from 13 to 16 at the same time. Maximum deflection was 24 in the southbound lane and 28 in the northbound lane. The average deflections are the lowest of any for the seven test sections and show no appreciable increase with time.

Nuclear moisture probe test results for the base material are shown in Table III. The cement treated base section has a noticeably higher moisture content at all depths than the other base sections have. This has not seemed to affect the wheel load deflections, but the higher moisture content may have helped to reduce pavement durability.

Hydrated Lime Stabilized Base Section. Visual inspection showed no distress in 1962 and several patched pot holes in 1970 but no other surface failure. However, by 1975 there was lateral cracking across both

TABLE II

BENKELMAN BEAM DEFLECTIONS IN 1/1000 INCHES FOR 15,000 LB. AXLE LOAD

Test Section	March 15, 1961 SB Lane Ave.	SB Lane Max.	°F	NB Lane Ave.	NB Lane Max.	°F	July 12, 1962 SB Lane Ave.	SB Lane Max.	°F	NB Lane Ave.	NB Lane Max.	°F
No. 1 SS-1	19	28	68	19	26	50	17	25	85	16	22	72
No. 2 Cement	11	24	71	13	22	51	9	9	85	14	17	72
No. 3 None	21	26	70	23	28	49	15	19	88	27	28	72
No. 4 SS-1	20	32	70	20	26	47	18	21	88	21	26	72
No. 5 Special Road Oil	18	28	65	18	28	43	22	31	87	21	38	81
No. 6 Lime	15	26	68	15	224	40	13	19	85	13	19	83
No. 7 None	20	28	64	20	28	37	8	11	85	10	19	85

TABLE II (CONTINUED)

BENKELMAN BEAM DEFLECTIONS IN 1/1000 INCHES FOR 15,000 LB. AXLE LOAD

Test Section	May 1964						November 1964			
	SB Lane			NB Lane			SB Lane		NB Lane	
	Ave.	Max.	°F	Ave.	Max.	°F	Ave.	Max.	Ave.	Max.
No. 1 SS-1	21	34	60	20	26	62	23	34	20	26
No. 2 Cement	14	24	62	15	27	68	15	24	16	28
No. 3 None	24	30	62	25	34	69	25	30	26	34
No. 4 SS-1	24	36	64	24	34	82	26	36	22	32
No. 5 Special Road Oil	22	40	63	20	34	82	23	38	20	30
No. 6 Lime	19	26	64	17	22	53	20	30	19	26
No. 7 None	19	31	50	19	29	54	16	21	20	26

TABLE III

WATER IN POUNDS PER CUBIC FOOT BY NUCLEAR PROBE TESTS

Test Section & Treatment	No. 2 Portland Cement		No. 3 None		No. 4 SS-1		No. 5 Special Road Oil		No. 6 Hyd. Lime		No. 7 None		Average Value for all Test Sections
Station	262 +00	267 +00	271 +00	277 +00	283 +00	290 +00	304 +00	317 +00	331 +00	337 +00	343 +00	347 +00	
May 13, 1961													
Depth 0.5 ft.	9.0	8.4	6.0	6.5	6.7	6.5	6.8	6.4	8.3	7.8	6.3	6.4	7.1
1.0 ft.	12.0	9.3	7.3	8.0	8.8	9.0	8.1	8.2	9.7	7.6	8.2	9.7	8.8
1.5 ft.	15.7	10.5	8.6	6.5	6.5	9.0	11.0	9.6	9.3	6.0	7.8	8.4	9.1
2.0 ft.	18.1	14.3	14.3	6.2	11.7	12.5	13.6	13.3	18.3	7.8	13.3	4.7	12.3
2.5 ft.	17.4	16.0	17.0	6.9	14.8	18.8	14.8	15.9	19.2	9.7	13.0	---	14.9
June 23, 1961													
Depth 0.5 ft.	7.3	7.2	5.0	5.4	6.9	6.1	6.1	5.5	7.5	7.2	6.1	6.5	6.4
1.0 ft.	11.2	99.1	7.5	7.5	8.8	9.1	8.0	8.0	9.5	7.7	8.0	9.3	8.6
1.5 ft.	13.4	15.3	8.0	6.3	6.8	8.7	11.3	9.6	9.7	7.0	10.3	8.2	9.6
2.0 ft.	18.0	15.8	13.9	6.3	11.7	12.4	13.7	13.7	17.7	7.9	13.5	13.2	13.2
2.5 ft.	17.0	----	16.4	6.4	15.0	14.2	16.6	16.2	18.8	9.7	13.1	----	14.3
July 25, 1962													
Depth 0.7 ft.	6.8	5.5	4.5	4.9	5.5	6.1	5.0	5.0	5.6	4.9	4.6	5.5	5.3
1.2 ft.	5.9	5.5	4.5	4.5	4.5	5.6	5.6	5.4	5.4	5.8	4.5	5.2	5.2
1.7 ft.	9.8	8.0	8.6	4.0	4.9	7.0	9.2	8.6	6.8	4.5	8.0	7.3	7.2
2.2 ft.	11.5	10.6	10.3	4.0	9.4	9.3	9.8	10.1	10.3	4.7	8.8	---	9.0
2.5 ft.	11.3	10.3	13.2	4.0	10.3	---	----	----	----	---	---	---	9.8

lanes about every 50 to 75 feet throughout the section. There was also severe distress in a 40 foot length of the inner wheel path in the southbound lane on the north end of the section.

Weight per cubic foot and unconfined compression strength test results for base cores for this section are shown in Table IV. Again, the values are the averages of a number of tests.

TABLE IV

WEIGHT PER CUBIC FOOT AND UNCONFINED COMPRESSION STRENGTH VALUES FOR HYDRATED LIME STABILIZED BASE SPECIMENS

	90 Day Control	Nov. 1960	July 1962	Nov. 1971
Weight per cubic foot	144.6	148.8	148.2	142.8
Unconf. Compr. Strength, psi	758	1835	2560	2866

Unconfined compression strength has increased with time while weight per cubic foot has decreased substantially. The 1971 core samples were solid with a horizontal crack partly through one core but neither core had entrapped air pockets.

Benkelman beam readings in the southbound lane increased from 15 in March 1961 to 20 in November 1964. Average northbound lane readings increased from 15 to 19 at the same time. Maximum deflection was 30 in the southbound lane and 26 in the northbound lane. The average deflections are still quite low and again show no appreciable increase with time.

Moisture probe test results show the moisture content at depths over 1.5 feet at Station 331+00 is well above average while the moisture content at depths over 1.5 feet at Station 337+00 is well below average. This has not seemed to affect wheel load deflections, but may have affected pavement durability.

SS-1 Emulsion Asphalt Stabilized Base Sections. Visual inspection showed no distress in 1962. However, by 1972 there was some surface ravelling in the southbound lanes of Test Section 1 and a number of skin patches and patched pot holes in the southbound lanes of Test Section 4. By 1975 there was some pavement distress in the southbound lane of Test Section No. 1 and serious pavement distress in the southbound lane of Test Section No. 4.

Aggregate gradation, extracted asphalt content, Atterberg limits and sand equivalent values are shown in Table V for 1959 through 1971, together with stability, resistance value, and moisture content test results for 1960 and 1962. As before, the values are averages of several tests.

Comparison of the aggregate gradations shows a decrease in percent passing the No. 4 and the No. 10 sieves with time. This could be caused by continued degradation and loss of fine material to the underlying 2 inch maximum untreated crushed rock base. The reduction in asphalt content from approximately 2 percent in 1963 to 0.5 percent in 1971 would tend to support that possibility. No particular change occurred in Atterberg limits with time. Structural integrity of the 1971 core samples ranged from part of the core being a cohesive mass to the core having fallen apart completely. The remaining asphalt was not apparent in any core by visual inspection.

In Test Section 1, Benkelman beam readings in the southbound lane increased from 19 in March 1961 to 23 in November 1964. Average northbound lane readings remained at 19 and 20 during the same time. In Test Section 4, average southbound lane readings increased from 20 to 26 while average northbound lane readings increased from 20 to 22. Hence the deflections show no appreciable increase with time.

TABLE V

PERTINENT DATA FOR SS-1 EMULSION ASPHALT STABILIZED BASE SPECIMENS

	Prior to Treatment	As Constructed	Nov. 1960	June 1962	June 1963	Nov. 1971
Moisture Content, %	-	--	-	4.7	4.6	-
Asphalt Content, %	-	2.3	-	1.8	1.9	0.5
% Passing						
3/4 inch	97	99	100	98	95	99
No. 4	55	54	58	54	57	49
No. 10	40	38	42	40	41	32
No. 40	23	23	25	22	27	20
No. 200	12	13	14	10	16	12
Liquid Limit, %	22.2	-	21.8	24.0	23.7	21.7
Plastic Index, %	NP	-	NP	3.0	5.3	4.5
Sand Equivalent	22	-	38	36	26	-
Stability Value	-	-	-	42	-	-
Resistance Value	-	-	76	73	76	-
% Absorption	-	-	6.5	10.5	9.3	-

Moisture probe test results again show average moisture content at all depths as compared to other base sections. This may have contributed somewhat to the pavement distress and higher wheel load deflections.

Special Road Oil Stabilized Base Section. Visual inspection showed no distress in 1962 and little or no distress in either lane in 1970. By 1975 there was minor pavement distress in the southbound lane on the south end of the section.

Aggregate gradation, extracted asphalt content, Atterberg limits and sand equivalent values are shown in Table VI along with stability, resistance value, and moisture content test results for 1960, 1962 and 1963. Once again, these are average values.

Aggregate gradation again shows a decided decrease in percent passing the No. 4 and the No. 10 sieves with time. As before, this could result from continued degradation and loss of fines to the underlying untreated curshed rock base. Reduction in asphalt content from 2.6 percent in 1963 to 1.0 percent in 1971 also supports that possibility. Atterberg limits do not change appreciably with time. Structural integrety of the 1971 core samples ranged from part of the core being a cohesive mass to the core having fallen completely apart. The remaining asphalt was partly apparent in three of the four cores.

Benkelman beam readings in the southbound lane increased from 18 in March 1961 to 23 in November 1964. Average Northbound lane readings increased from 18 to 20. Again, the deflections show no appreciable increase with time.

Moisture probe test results show slightly higher than average values at depths greater than 1.0 foot. This could be a contributing factor towards aggregate degradation and loss of fines.

<u>No Treatment Base Sections</u>. Visual inspection showed no distress in 1962. However, by 1970 the southbound lane in Test Section 7 had a number of patched pot holes and about 400 foot maintenance overlay on the north part of the section. Test Section No. 3 showed little or no distress in 1970. By 1975 Test Section No. 3 showed serious pavement distress in 100 feet of the southbound lane on the north end of the section. Test Section No. 7 showed lateral and longitudinal cracking in the southbound lane in the north 300 feet of the section.

Average values of aggregate gradation, Atterberg limits and sand

TABLE VI

PERTINENT DATA FOR SPECIAL ROAD OIL STABILIZED BASE SPECIMENS

	Prior to Treatment	As Constructed	Nov. 1960	June 1962	June 1963	Nov. 1971
Moisture Content, %	-	-	-	4.5	2.7	-
Asphalt Content, %	-	2.4	-	3.1	2.6	1.0
% Passing						
3/4 inch	99	99	100	100	97	100
No. 4	53	56	58	60	55	49
No. 10	38	40	43	44	41	33
No. 40	22	24	25	26	26	20
No. 200	12	13	14	13	14	12
Liquid Limit, %	20.7	-	22.2	24.2	22.3	20.5
Plastic Index, %	NP	-	NP	2.9	2.5	3.4
Sand Equivalent	-	-	-	26	27	-
Stability Value	-	-	-	40	37	-
Resistance Value	-	-	79	78	79	-
Absorption, %	-	-	6.3	9.3	7.6	-

equivalent values are shown in Table VII. Also shown are average values of stability, resistance value, and moisture content test results for 1960, 1962, and 1963.

Aggregate gradation shows no change in fine material with time. Atterberg limits indicate a slight development of plasticity. Structural integrity of the 1971 core samples ranged from part of the core being a cohesive mass to the core having fallen completely apart with the aggregate particles completely separated from each other.

In Test Section 3 Benkelman beam readings in the southbound lane increased from 21 in March 1961 to 25 in November 1964. Average northbound lane readings increased from 23 to 26 during the same time. In Test Section No. 7 average southbound readings decreased from 20 to 16 while average northbound readings remained at 20. Hence deflections show no increase with time.

Moisture probe test results indicate average moisture content in Test Section No. 7. However, the moisture content at depths over 2.0 feet at Station 271+00 in Test Section No. 3 is well above average while the moisture content at all depths at Station 277+00 in that section is well below average. Thus there seems to be little correlation between water content and distress in the base in these two test sections.

Pavement Density and Air Void Content. Weight per cubic foot and air void content of the roadmix surfacing covering the treated base sections are shown in Table VIII for six of the test sections. Values were determined from core samples taken in November 1971. Core samples were not taken in Test Section No. 7 because cores had not been taken there in the past and no comparison with past test results was possible.

There is no correlation between weight per cubic foot or air void content of the roadmix surfacing and water content in the underlying treated base as determined by the nuclear probe tests. Neither is there any correlation between pavement weight per cubic foot or air void content and any treated base test results such as residual asphalt content, increase in fine aggregate or Atterberg limits. Thus the final degree of pavement compaction seemed to have no bearing on the condition of the underlying treated base.

TABLE VII

PERTINENT DATA FOR NO TREATMENT BASE SPECIMENS

	As Constructed	Nov. 1960	June 1962	June 1963	Nov. 1971
Moisture Content, %	-	-	10.7	5.4	-
% Passing					
3/4 inch	100	100	99	100	99
No. 4	59	59	55	58	63
No. 10	42	41	40	42	43
No. 40	23	24	21	25	26
No. 200	10	13	10	14	16
Liquid Limit, %	17.8	20.4	23.2	18.9	12.8
Plastic Index, %	NP	NP	NP	NP	3.9
Sand Equivalent	40	55	37	29	31
Stability Value	-	-	-	-	-
Resistance Value	-	81	66	76	-
Absorption, %	-	8.7	11.0	9.8	-

TABLE VIII

WEIGHT PER CUBIC FOOT AND AIR VOID CONTENT OF ROADMIX SURFACING AS OF NOVEMBER 1971

Test Section		Individual Values @ Indicated Station & Distance from Centerline				Average Wt/ft^3	Values Air Voids
No. 1:	SS-1 Asphalt	249+50 6' Rt CL	249+50 7' Rt CL				
	Wt/ft^3 in lbs/ft^3	161.8	164.0			162.9	
	Air Voids in %	4.3	3.5				3.9
No. 2:	Portland Cement	261+00 6' Lt CL	261+01 6' Lt CL	262+00 6' Lt CL	262+01 6' Lt Cl		
	Wt/ft^3 in lbs/ft^3	156.8	157.9	155.8	155.3	156.5	
	Air Voids in %	6.6	6.0	7.2	6.4		6.6
No. 3:	No Treatment	273+50 6' Rt CL	273+51 6' Rt CL	275+75 6' Rt CL	275+76 6' Rt CL		
	Wt/ft^3 in lbs/ft^3	153.2	154.1	153.0	152.1	153.1	
	Air Voids in %	10.4	8.1	8.2	8.9		8.9
No. 4:	SS-1 Asphalt	283+00 6' Rt CL	283+01 6' Rt CL	290+00 6' Rt CL	290+01 6' Rt CL		
	Wt/ft^3 in lbs/ft^3	150.6	152.5	152.8	154.1	152.5	
	Air Voids in %	10.0	9.1	9.5	7.6		9.1
No. 5:	Special Road Oil	304+00 6' Rt CL	304+00 7' Rt CL	320+00 6' Rt CL	320+01 6' Rt CL		
	Wt/ft^3 in lbs/ft^3	155.1	164.0	154.8	154.7	157.2	
	Air Voids in %	7.7	2.6	7.2	7.5		6.3
No. 6:	Hydrated Lime	331+00 5' Lt CL	331+01 5' Lt CL				
	Wt/ft^3 in lbs/ft^3	158.7	158.0			158.4	
	Air Voids in %	5.3	5.6				5.5

EVALUATION OF TEST SECTIONS

Only Test Section No. 7, an untreated base section, showed any serious pavement distress by 1970. The other six test sections, including Test Section No. 3, another untreated base section, showed only minor or no pavement distress. As expected, the pavement over the cement treated base section also showed the usual transverse reflection cracks.

By August of 1975, however, all test sections showed some degree of pavement distress. There was severe pavement distress in the hydrated lime treated, one SS-1 treated, one no treatment, and the portland cement treated base sections. There was minor pavement distress in the other no treatment, the special road oil treated, and the other SS-1 treated base sections. Lateral cracking in the pavement had also occurred across both lanes throughout the hydrated lime treated base section. This was to be expected in view of the values shown in Table IV for weight per cubic foot and unconfined compression strength for the hydrated lime stabilized base core specimens.

No particular treated base section seems to have performed appreciably better than any other treated base section. Test Sections No. 1 and No. 4, SS-1 emulsion asphalt treated base, show some minor and severe pavement distress, respectively. They had above average wheel load deflections, average water content, no apparent change in the amount of No. 200 material or the Atterberg limits, and a decided loss in asphalt content. Test Section No. 2, portland cement treated base, shows severe pavement distress, has the usual reflection cracks, had below average wheel load deflections and above average water content. Test Section No. 5, special road oil treated base, shows minor pavement distress, had above average wheel load deflections, average water content, no apparent change in the amount of No. 200 material or the Atterberg limits, and had a decided loss in asphalt content. Test Section No. 6, hydrated lime treated base, shows severe pavement distress and has developed reflection cracks in the pavement. It had below average wheel load deflections and slightly above average water content.

It is thus evident that each treated base test section had favorable values for some tests and unfavorable values for other tests. Portland cement or hydrated lime is the most effective treatment to improve base stability and prevent further degradation in the aggregate base material. However, the resulting reflective cracking in the pavement and the associated problems that follow require extra maintenance that is both expensive and unsightly. When all factors are considered, no one base treatment included in this project is superior to the other treatments in providing both a good stable base and a maintenance free pavement surface.

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APPENDIX A

DESCRIPTION OF CORE SAMPLES

TAKEN IN NOVEMBER 1971

DESCRIPTION OF CORE SAMPLES TAKEN IN NOVEMBER 1971

Test Sec. / Treatment	
No. 1 / SS-1	Core fell apart completely; small clusters of aggregate have some cohesion; remaining SS-1 not apparent by visual inspection.
No. 1 / SS-1	Top part of core was cohesive mass separated from roadmix surfacing; bottom part of core fell apart completely with small clusters of aggregate having some cohesion but remaining SS-1 not apparent by visual inspection.
No. 2 / CTB	Good solid core joined firmly to roadmix surfacing; no cracks or entrapped air pockets evident in core.
No. 2 / CTB	Good solid core joined firmly to roadmix surfacing; no cracks or entrapped air pockets evident in core.
No. 2 / CTB	Solid core separated from roadmix surfacing; no cracks present; some entrapped air pockets in sides of core.
No. 2 / CTB	Solid core separated from roadmix surfacing; no cracks but some holes in vertical line down the side of the core.
No. 3 / No Treatment	Core separated into medium and small sized clusters having some cohesion. Clusters were all separated from roadmix surfacing.
No. 3 / No Treatment	Half of core was cohesive mass separated from roadmix surfacing; other half of core fell apart completely with aggregate particles completely separated from each other.
No. 3 / No Treatment	Core separated in large, medium and small size clusters having some cohesion, but completely separated from road-

mix surfacing; some aggregate particles were completely by themselves.

No. 3 No Treatment	Core fell apart completely with aggregate particles completely separated from each other.
No. 4 SS-1	Part of core was cohesive mass separated from roadmix surfacing; other part of core fell apart completely with small clusters of aggregate having some cohesion but remaining SS-1 not visually apparent.
No. 4 SS-1	Core fell apart completely with aggregate particles being completely separated from each other; remaining SS-1 not visually apparent.
No. 4 SS-1	Part of core was cohesive mass separated from roadmix surfacing; other part of core fell apart completely with most aggregate particles completely separated from each other; remaining SS-1 not visually apparent.
No. 4 SS-1	Core fell apart completely into small clusters having some cohesion; and completely separated particles; remaining SS-1 not visually apparent.
No. 5 Spec. Road Oil	Core fell apart completely into medium and small sized clusters having some cohesion, and completely separated particles; remaining SRO partly apparent.
No. 5 Spec. Road Oil	Half of core was cohesive mass separated from roadmix surfacing; rest of core separated into 2 large clusters, many small clusters, and completely separated particles; remaining SRO was quite apparent.
No. 5 Spec. Road Oil	Core fell completely apart into small clusters having some cohesion, but primarily into completely separated particles; remaining SRO not visually apparent.

No. 5
Spec. Road Oil

Core fell completely apart into some small clusters having some cohesion, but primarily into completely separated particles; remaining SRO partly apparent.

No. 6
Hyd. Lime

Solid core separated from roadmix surfacing; no cracks or entrapped air pockets visible in core.

No. 6
Hyd. Lime

Solid core separated from roadmix surfacing; horizontal crack partly through core at approximate midpoint of core; no entrapped air pockets visible in core.

APPENDIX B

VISUAL OBSERVATIONS OF TEST SECTION PAVEMENT

MADE IN FEBRUARY 1970

MATERIALS & RESEARCH DIVISION

MOSCOW MATERIALS SECTION

February 24, 1970

William A. Sylvies

William A. Sylvies, P.E.
Associate Materials Engineer

Completion of Field Work

Visual observation of the Bear Ridge Base Stabilization project pavement was made on February 20 as requested in your letter of December 19, 1969. Present condition of the pavement is generally as follows:

1. No Treatment Base Section: Sta. 351+80 to 338+00

   S.B. Lane - has a number of patched pot holes and about a 400 foot maintenance overlay on the north part of the section. The remainder of the section has several patched pot holes and skin patches.

   N.B. Lane - shows little or no distress.

2. Lime Treated Base Section: Sta. 338+00 to 322+50

   S.B. Lane - has several patched pot holes.
   N.B. Lane - shows little or no distress.

3. Special Road Oil Treated Base Section: Sta. 322+50 to 293+50

   S.B. Lane - shows little or no distress.
   N.B. Lane - shows little or no distress.

4. SS-1 Treated Base Section: Sta. 293+50 to 278+50

   S.B. Lane - has a number of skin patches and patched pot holes.
   N.B. Lane - shows little or no distress.

5. No Treatment Base Section: Sta. 278+50 to 270+00

   S.B. Lane - has two patched holes but shows no other distress.
   N.B. Lane - shows little or no distress.

6. CTB Base Section: Sta. 270+00 to 253+50

   S.B. Lane - has transverse cracks every 15-20 feet which have been filled with asphalt. There are also a number of skin patches in the section.
   N.B. Lane - has transverse cracks every 15-20 feet which have been filled with asphalt.

7. SS-1 Treated Base Section: Sta. 253+50 to 207+00

S.B. Lane - has some surface ravelling.
N.B. Lane - shows little or no distress.

The difference in surface condition between the southbound lanes and the northbound lane may be due in part to heavy truck traffic from Deary and Bovill to Kendrick and points south. Little heavy truck traffic has been observed on the northbound lane due to the Kendrick hill.

The following action is recommended to complete the report:

1. Benkleman Beam Deflection Readings should be taken in March and in July 1970 for comparison with data previously obtained. The March readings will have to be performed by District Four and Boise Materials Laboratory personnel since the Moscow Laboratory will not have the necessary trained personnel available during March and April. The July readings can be handled by the Moscow Laboratory with assistance from District 4 personnel.

2. Base cores should be taken at the same times to evaluate strength and degradation conditions. The Moscow Laboratory can obtain the necessary cores on both occasions and make the proper evaluation.

3. Evaluation of the moisture content of the base material by means of a nuclear moisture probe will depend on the availability of a trained operator from the Boise Materials Laboratory. Several of the pipe caps on the eight or so vertical steel pipes in the roadway have come off and the pipes may no longer be usable for their original purpose.

Please make the necessary arrangements with the Boise Materials Laboratory for the March Benkelman Beam deflection readings and, if appropriate, the nuclear moisture probe readings. The Moscow Laboratory will then correlate the obtaining of the necessary base cores with the Boise Materials Laboratory operation.

dp
cc: ASHE (E)
Materials Engineer
District Engineer, District 4
Moscow Laboratory

APPENDIX C

VISUAL OBSERVATIONS OF TEST SECTION PAVEMENT

MADE IN AUGUST 1975

RESEARCH SUPERVISOR — August 29, 1975

MOSCOW MATERIALS SECTION — WILLIAM A. SYLVIES, P.E., Associate Materials Engineer II

Research Project #5

Completion of Field Work

Visual observation of the Bear Ridge Base Stabilization Project pavement was made on August 14, 1975 as per your request. Present condition of the pavement is generally as follows:

1. <u>No Treatment Base Section: Sta. 351+80 to 338+00</u>

   S.B. Lane - the north 300+ feet of the section shows lateral cracking across the roadway. There is also longitudinal cracking and rutting in both wheel paths. The balance of the S.B. Lane shows little or no distress.

   N.B. Lane - shows occasional lateral cracking, otherwise little or no distress.

2. <u>Lime Treated Base Section: Sta. 338+00 to 322+50</u>

   There is lateral cracking across both lanes about every 50 to 75 feet throughout the section. There is also severe distress in a 40 foot length of the inner wheel path in the S.B. Lane on the north end of the section. There is little or no distress in the N.B. Lane other than lateral cracking.

3. <u>Special Road Oil Treated Base Section: Sta. 322+50 to 293+50</u>

   There is minor longitudinal cracking in the inner wheel path in both the N.B. and S.B. Lanes on the north end of the section. There is also minor distress in the outer wheel path of the S.B. Lane on the south end of the section.

4. <u>SS1 Treated Base Section: Sta. 293+50 to 278+50</u>

S.B. Lane - there is a 400 foot + skin patch at the beginning of the north part of the section together with a number of pot holes. There are also skin patches showing distress together with a few pot holes in the south part of the section. Furthermore, there is serious distress in the inner wheel path of the S.B. section for approximately 300 feet on the south end of the section.

N.B. Lane - there are several lateral cracks in the northern part of the section.

5. <u>No treatment Base Section: Sta. 278+50 to 270+00</u>

S.B. Lane - shows serious distress in about the first 100 feet of both the inner wheel path and the outer wheel path on the north end of the section. There is also some minor longitudinal cracking in the rest of the inner wheel path and outer wheel path on the north end of the section.

N.B. Lane - there is a 10 foot distressed are in the outer wheel path on the south end of the section. Otherwise, there is little or no distress.

6. <u>CTB Base Section: Sta. 270+00 to 253+50</u>

There are transverse cracks across both lanes every 20 to 30 feet. There is also: a) serious longitudinal cracking between the center line and the inner wheel path in the S.B. Lane for about 150 feet at the beginning of the north end of the section, b) some cracking in the outer wheel path of the N.B. Lane on the north end of the section, c) much longitudinal cracking between wheel paths in the S.B. Lane in the middle of the section, d) serious distress in the inner wheel path and moderate distress in the outer wheel path in approximately 300 feet of the S.B. Lane in the middle of the section, e) some longitudinal cracking in the inner wheel path in the S.B. Lane on the south end of the section.