INTERIM REPORT

EVALUATION OF CHEM-CRETE

by

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Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

Two test sections, one on new construction and the other on a maintenance resurfacing project, were installed in the fall of 1980 to evaluate the proprietary asphalt product Chem-Crete. Dynaflect and density measurements were performed on the experimental and control mixes and the performance of the pavements is being evaluated.

Raveling was noticed, especially in the Chem-Crete mix, approximately 2 months after paving; however, the deterioration stabilized shortly thereafter. Traffic appeared to heal the control mix; however, some deep raveling and several potholes remain in the Chem-Crete portions. The high-absorption sand used in the mixes might have been partially responsible for the failures.

Pavement deflections were not reduced significantly in either of the overlaid sections. Strength did not develop as rapidly in either mix on the pavement as it did in specimens prepared and cured at 140°F. (60°C) in the laboratory. There was no significant difference between the results of stripping tests on the control mix and those on the Chem-Crete mix prepared in the laboratory. The Chem-Crete mix exhibited superior fatigue characteristics under constant stress tests and the control mix did the same under constant strain tests.

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PURPOSE AND SCOPE

Recently, the proprietary asphalt product Chem-Crete was introduced for experimentation. Some of the benefits cited by the manufacturer were that it increased strength, reduced creep, improved temperature susceptibility, improved adhesion, and improved fatigue life. An allowable 25% reduction in the thickness of the bituminous concrete because of the forementioned benefits is claimed. Although experimental costs are estimated by the manufacturer to add about 25% to the normal price of bituminous concrete, the additional cost is claimed to be only about 3% when the process is fully operational.

Thus, an investigation was undertaken to compare the performance of a Chem-Crete surface mix to that of a regular surface mix. Test sections are being evaluated on a new construction project and on a maintenance resurfacing job. Laboratory tests have been performed on the regular and the Chem-Crete mixes.

TEST SECTIONS

Route 220 — Roanoke City-Co.

An S-5 surface mix was placed at the rate of 100 lb./yd.^{2} (37.9 kg/m^2) on a section of new construction (project no. 6220-128-105, P-402, 6220-080-104, P-401) in Roanoke City-Co. by the Virginia Asphalt Paving Company, Inc. (see Figure 1). The Chem-Crete mix was placed October 28, 29, and November 6, 1980, and the control mix during the period November 8-20, 1980. The average results of extraction tests on both mixes are listed in Table 1.

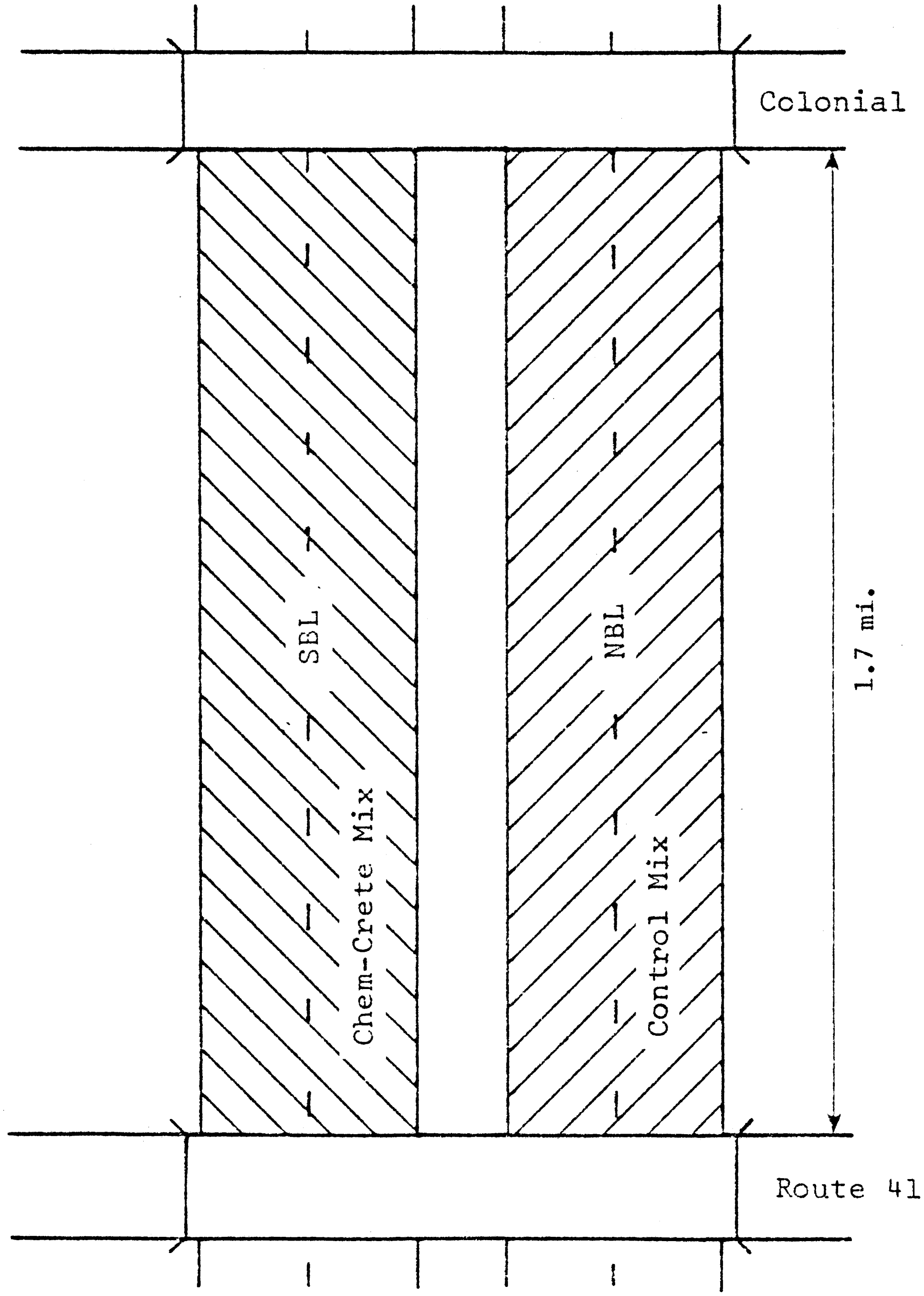

Figure 1. Test section in Roanoke City Co.

Table 1. Job Mix and Extraction Results — Roanoke City-Co.

	Percent Passing		
Sieve	Job Mix	Control Mix	Chem-Crete Mix
1/2	100.0	100.0	100.0
4	58.0	59.0	59.0
30	22.0	22.0	22.0
200	7.0	5.7	6.4
Percent asphalt	5.9	5.5	5.9

The sources and blend of materials are listed in Table 2. The natural sand was highly absorptive. The method described in Asphalt Institute Manual MS-2 was used to compute the absorbed asphalt and effective asphalt content of the mix at 0.49% and 5.46%, respectively.

Table 2. Materials and Sources

Material	Source
30% #8's	- Vulcan Materials, Stoneville, N. C.
55% crusher run	- Vulcan Materials, Stoneville, N. C.
15% natural sand	- Martin property, Roke, Va.
5.9% AC-20	- Fuel Oil and Equipment Co., Roanoke, Va.
Chem-Crete concentrate	- Chem-Crete Corp., Menlo Park, California

Chem-Crete liquid concentrate was stored at the asphalt terminal at 210°F. (99°C) and blended with AC-20 asphalt cement at a 1:9 weight ratio. The blend was transported to the storage tank at the hot mix plant and allowed to circulate overnight.

Route 220 — Franklin Co.

For the overlay, an S-5 mix was placed at the rate of 165 lb./yd.^{2} (62.6 kg/m^2) on a section of maintenance schedule 202-80 by the Virginia Asphalt Paving Company, Inc. (see Figure 2). The control mix was placed October 2-7, 1980, and the Chem-Crete mix October 7-9, 1980. The average results of extraction tests on both mixes are listed in Table 3.

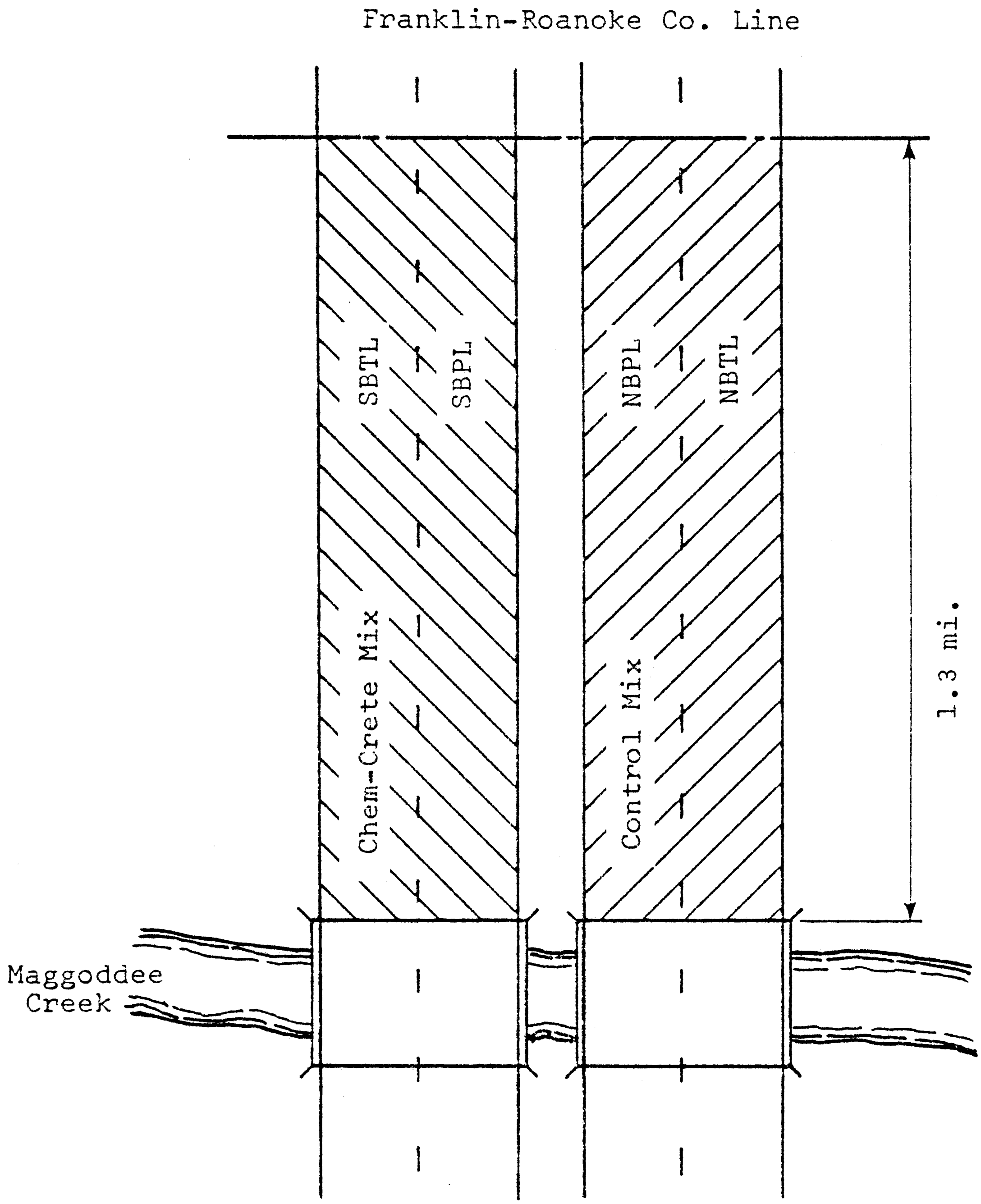

Figure 2. Test section in Franklin Co.

Table 3. Job Mix and Extraction Results — Franklin Co.

Sieve	Percent Passing		
	Job Mix	Control Mix	Chem-Crete Mix
1/2	100.0	100.0	100.0
4	58.0	63.0	60.0
30	22.0	25.0	23.0
200	7.0	7.4	6.7
Percent asphalt	5.9	6.0	6.1

The sources and blend of materials were the same as those listed in Table 2, and the method of blending the Chem-Crete concentrate and asphalt cement was the same as that described previously.

TESTING PROGRAM

Field Tests

Density tests were performed in the laboratory on cores removed from the pavement on the test section in Franklin Co., but the section in Roanoke City-Co. was not cored because the surface layer was thought to be too thin to allow accurate density measurements.

Dynaflect measurements were performed every 100 ft. (30.5 m) before and after paving on both projects to determine the stiffening effect of the surface layer.

Laboratory Tests

The laboratory work included Marshall tests (ASTM D1559), density tests of cores (ASTM D2726), viscosity and penetration (ASTM 2170 and 2171) (ASTM D5) tests of the asphalt before mixing and after Abson recovery (ASTM D1856).

The mix was not made from aggregate and asphalt as described in ASTM D1559 but was sampled at the hot mix plant, transported to the laboratory, and reheated in an oven prior to being compacted into Marshall specimens. In some cases, specimens were cured for various times at 140°F. (60°C) to determine the strength-time relationship, as Chem-Crete reportedly requires approximately 1 month to reach full strength.

Stripping tests were performed according to a modification of a test method developed under NCHRP Program 4-8(3).[1]

Constant stress and constant strain fatigue tests were conducted at 72°F. (22°C) on 3 in. x 3 in. x 15 in. (7.6 cm x 7.6 cm x 38 cm) beams with sawed surfaces. The mixes were prepared and the beams fabricated in the laboratory.

RESULTS

Mix Voids

The voids total mix (VTM) values for cores removed from the control and Chem-Crete mixes on the Franklin Co. project after 1 week and 5 weeks are listed in Table 4. The difference in voids between mixes should not be large enough to influence performance. The variation in voids was considered normal and satisfactory for maintenance resurfacing.

Table 4. Voids Total Mix — Franklin Co. Cores

Mix	Average Percent Voids	
	1 week	5 weeks
Control	7.6	7.5
Chem-Crete	7.5	7.2

The voids data for the Marshall specimens (Table 5) revealed that both mixes were at the recommended upper limit of 85% voids filled with asphalt (VFA) and slightly below the lower limit of 3.0% VTM, thereby indicating a potential problem with bleeding pavement.

As noted previously, no cores were removed from the Roanoke City-Co. project because the mix was too thin— 0.87 in. (2.2 cm)— to allow accurate measurement of the voids. The voids values for the Marshall specimens were within Virginia specifications; however, the pavement had a potential to be less dense than the pavement on the Franklin Co. project discussed previously. The application of a thin layer— 0.9 in. (20 mm)— and cold weather conditions also increased the likelihood of pavement density being low.

Table 5. Average Voids of Marshall Specimens at 50 Blows

	Franklin Co.		Roanoke City-Co.	
	Control	Chem-Crete	Control	Chem-Crete
Percent Voids Total Mix	2.7	2.7	4.0	5.4
Percent Voids Filled With Asphalt	85.0	85.0	78.0	73.0
Percent Voids in Mineral Aggregate	18.0	18.0	18.0	20.0

Dynaflect

On the Franklin Co. project, dynaflect measurements were made before the surface mix was placed, and then at 1 week, 5 weeks, and 13 months after construction. On the Roanoke City-Co. project, they were made before the surface mix was placed and soon after completion of paving.

When the average deflections (Table 6) and standard deviations (Table 7) were examined it was evident that the populations of the measurements made before and after construction overlapped at a 95% confidence level. Therefore, there was no significant difference between before and after measurements on either project.

Table 6. Maximum Deflection, in.

Project	Mix	Before Paving	1 Week After	5 Weeks After	13 Months After
Roanoke City-Co.	Control	0.008*	0.007	-	-
	Chem-Crete	0.008	0.008	-	-
Franklin Co.	Control	0.025	0.021	0.021	0.018
	Chem-Crete	0.021	0.020	0.019	0.018

Note: 1 in. = 25.4 mm
*Dynaflect deflection converted to Benkleman beam values.

Table 7. Standard Deviation of Maximum Deflection, in.

Project	Mix	Before Paving	1 Week After	5 Weeks After	13 Months After
Roanoke City-Co.	Control	0.003*	0.001	-	-
	Chem-Crete	0.002	0.002	-	-
Franklin Co.	Control	0.009	0.006	0.006	0.006
	Chem-Crete	0.007	0.004	0.003	0.003

Note: 1 in. = 25.4 mm
*Dynaflect deflection converted to Benkleman beam values.

The deflections of the control and Chem-Crete sections are approximately equal on both projects; therefore, they are being subjected to the same strain levels. The Franklin Co. project had much higher deflections than the Roanoke City-Co. project because of its less stiff underlying pavement structure, and therefore should be the first to yield conclusions concerning performance. The thin surface layer on the Roanoke City-Co. project had a negligible effect on the deflections; therefore, no measurements were made except those immediately following construction.

Asphalt Properties

The physical properties of the asphalt cement with and without the Chem-Crete concentrate are listed in Table 8. There were significant changes in the properties when the concentrate was added; the penetration increased and the viscosity decreased.

Table 8. Physical Properties of Asphalt Cement

	Franklin Co.		Roanoke City-Co.	
	Control	Chem-Crete	Control	Chem-Crete
Pen. at 77°F. (25°C), 0.1 mm	83	106	80	120
Vis. at 140°F. (60°C), P	2,310	1,470	2,170	1,272
Vis. at 275°F. (135°C), cSt	671	384	-	-

The decrease in viscosity increased the possibility of the asphalt being absorbed into the aggregate during and immediately after mixing; however, the chance of absorption decreases during construction because the asphalt hardens and behaves as an untreated asphalt. The stiffening of the asphalt and pavement is reported to continue for about 1 month, but this period can depend upon the chemical composition of the concentrate and other factors.

As mentioned previously, the sand was very absorptive, and more asphalt could have been absorbed in the Chem-Crete mix than in the control mix. The high absorption could have been partially responsible for raveling, as is discussed subsequently under Performance.

Strength Tests

Figure 3 illustrates the strength development of the mixtures sampled during construction, compacted to the approximate pavement density, cured at 140°F. (60°C), and tested by the Marshall method at various time intervals. The Chem-Crete mixes experienced similar rates of increase; however, the Roanoke City-Co. Chem-Crete mix attained approximately 40% more strength than the Franklin Co. mix at 28 days. Both control mixes experienced no significant strength change during the 28-day testing period.

Figure 4 illustrates the strength development of the Franklin Co. mixes compacted with a standard 50-blow compactive effort. The average VTM was 3.1% compared to 7.0% for the mixes discussed previously. The decrease in void content resulted in an approximately 50% strength increase for both the control and Chem-Crete mixes.

Figure 5 illustrates the indirect tensile strength development of lab specimens cured at 140°F. (60°C) and cores extracted from the pavement. The cores received no curing except from the natural pavement environment. The lab specimens gained strength at a faster rate and attained higher strengths than the core specimens. The difference in absolute strengths of the lab and core specimens might be partially due to their thickness. The cores averaged 1.4 in. (36 mm) thick and the specimens were 2.5 in. (64 mm) thick. It is possible that the strength of the Chem-Crete mix did not develop as quickly as anticipated and it had not reached full strength when the last cores were taken.

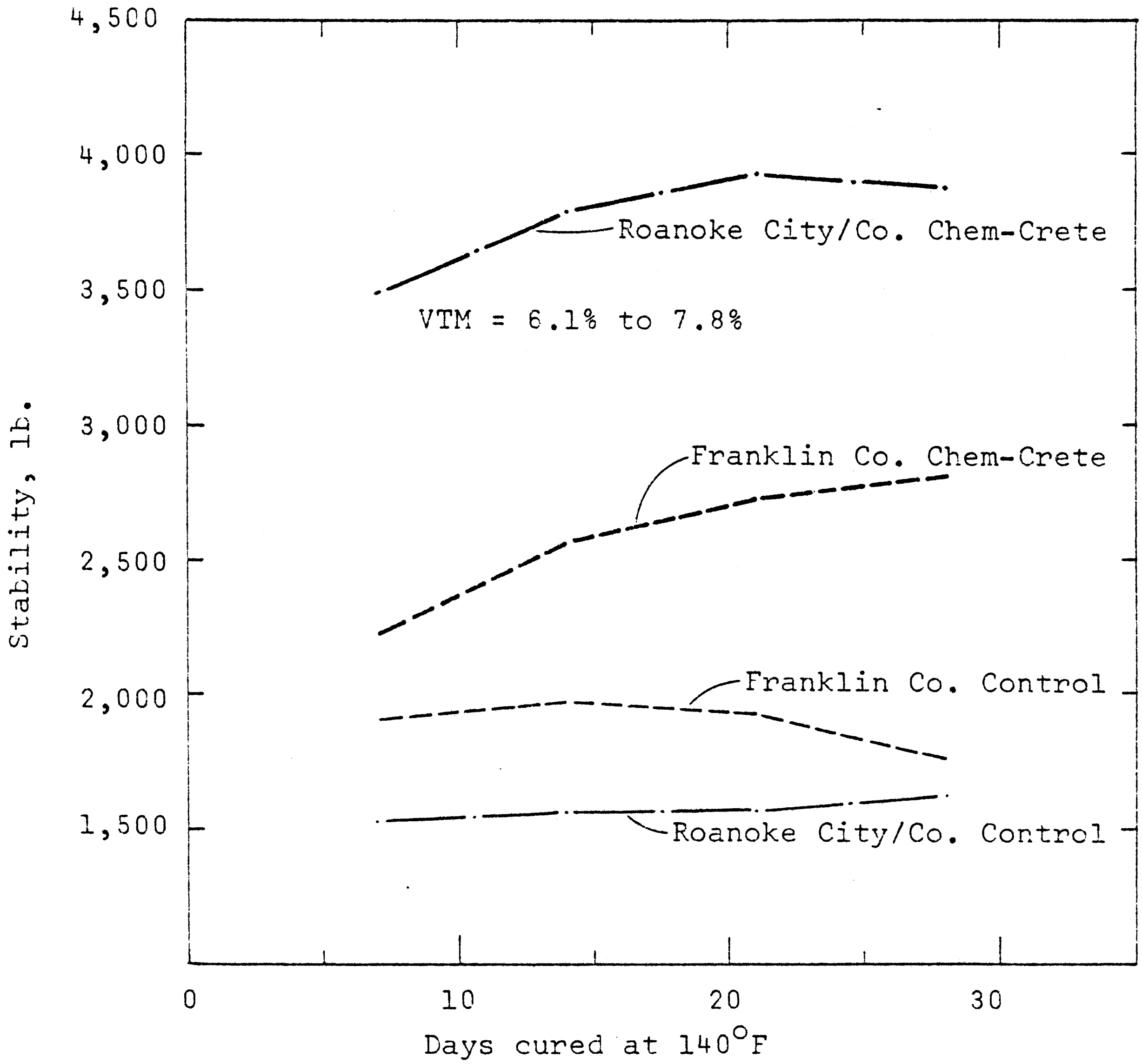

Figure 3. Marshall stability vs. days at 140°F for specimens at pavement density. Tests by Materials Lab. 1 lb. = 4.45 N; °C = 9/5 (°F-32).

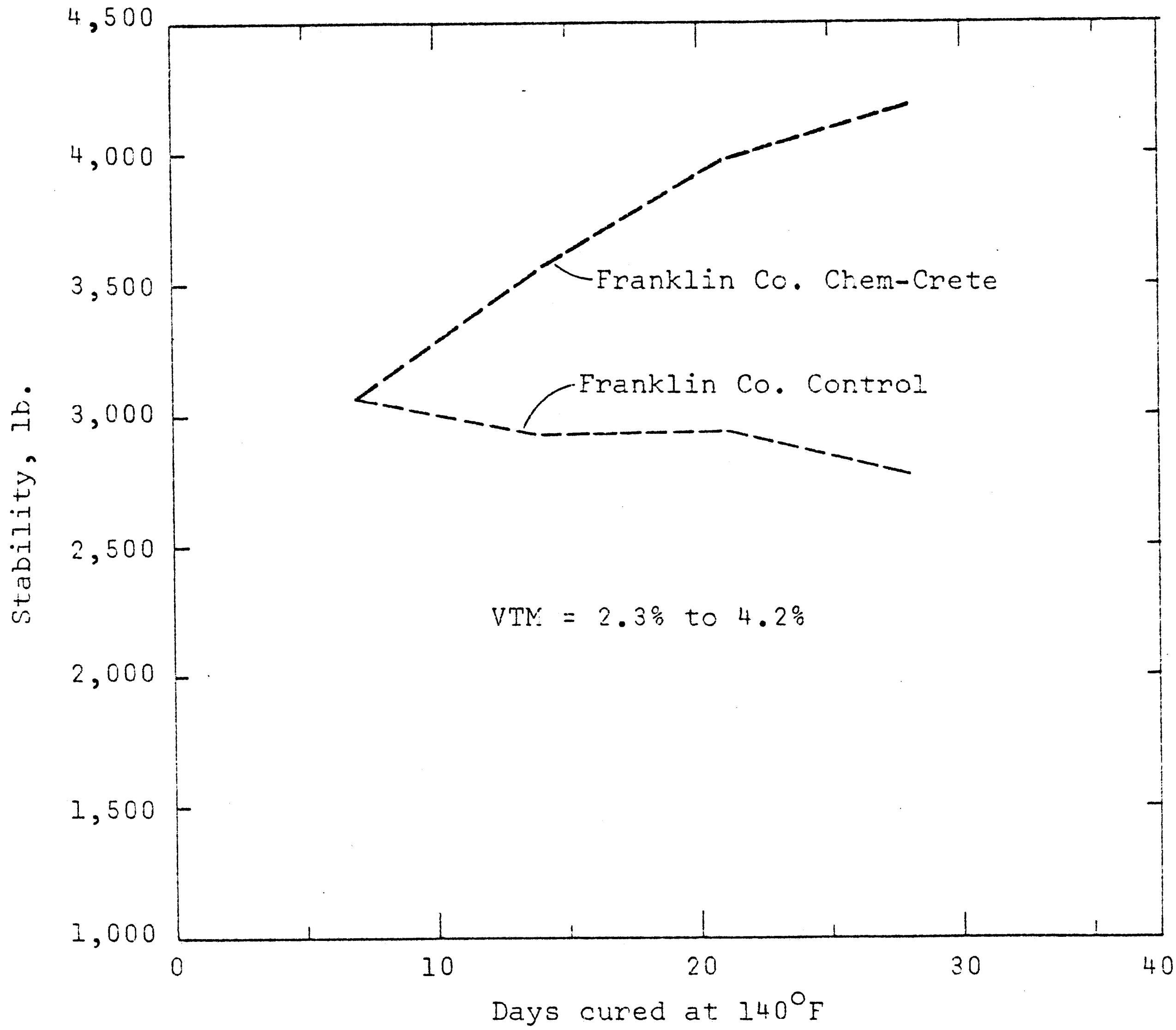

Figure 4. Marshall stability vs. days at 140°F for specimens compacted with 50 blows. Tests by Materials Division. 1 lb. = 4.45 N; °C = 9/5 (°F-32).

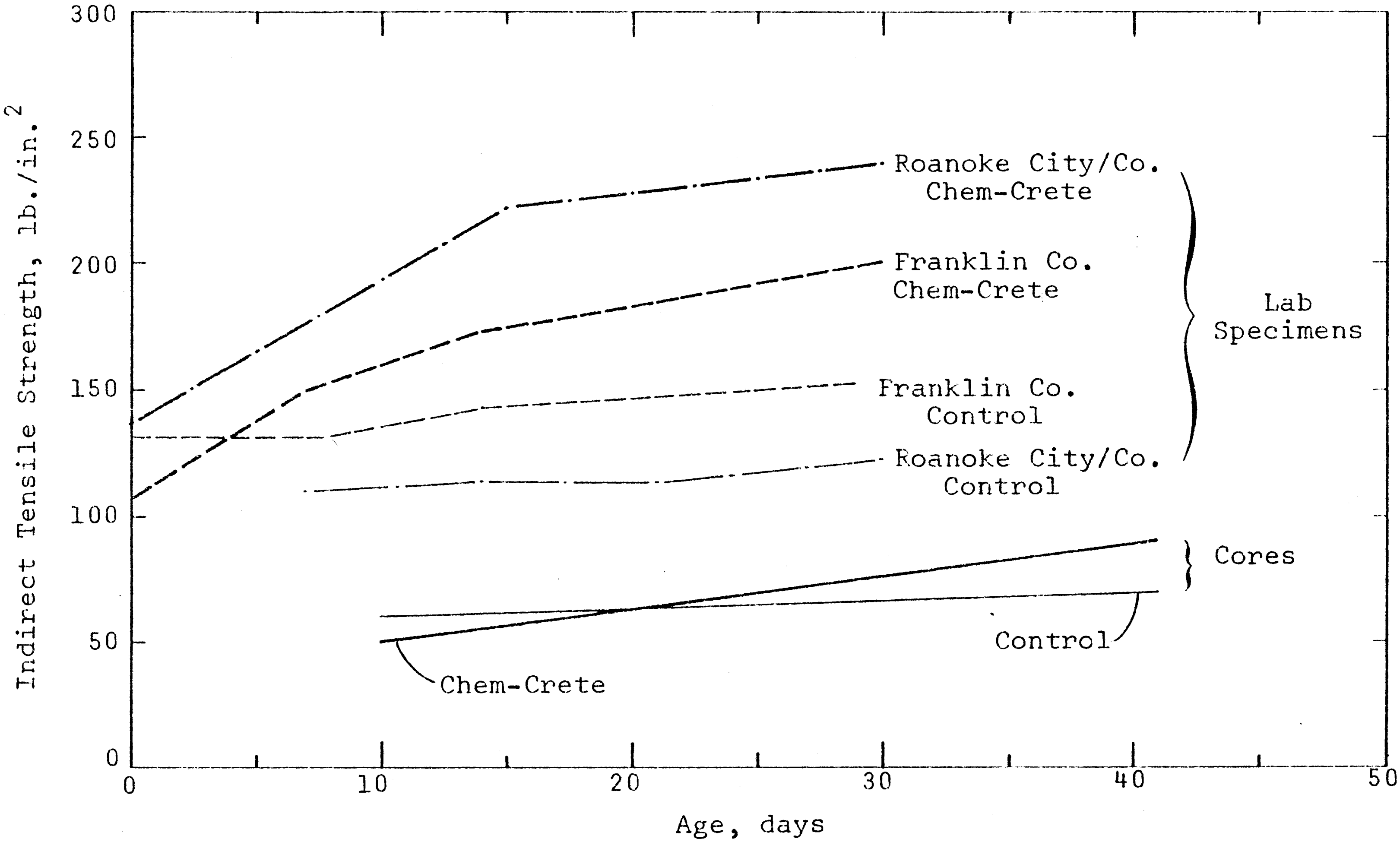

Figure 5. Indirect tensile strength vs. age.
Tests by Research Council.
1 lb./in.^{2} = 6894 Pa.

Stripping Tests

The tensile strength ratio, TSR, is the ratio of preconditioned strength to the dry strength of a mix. A low TSR indicates that a mix is susceptible to stripping. The results of the stripping tests are presented in Table 9, where it can be seen that there were no significant differences in the tensile strength ratio results for lab specimens of the control and Chem-Crete mixes. The tests on pavement cores revealed that the Chem-Crete mix had a much lower TSR than the control mix. Since both mixes contained antistripping additives; there should have been no difference, and it is speculated that the difference might have been caused by the high variability inherent in testing cores.

Table 9. Stripping Test Results

Project	Type of Mix	Type of Specimens	TSR
Franklin Co.	Control	Pavement Cores	0.91
	Chem-Crete		0.64
Franklin Co.	Control	Lab Specimens	0.70
	Chem-Crete		0.75
Roanoke City-Co.	Control	Lab Specimens	0.66
	Chem-Crete		0.58

Fatigue Tests

The results of constant stress and constant strain fatigue tests are illustrated in Figure 6 and Figure 7, respectively. The former is applicable to the analysis of thick layers — greater than 4 in. (100 mm) — and the latter to thin layers — less than 2 in. (50 mm) —[2] as is the case for the surface courses being evaluated.

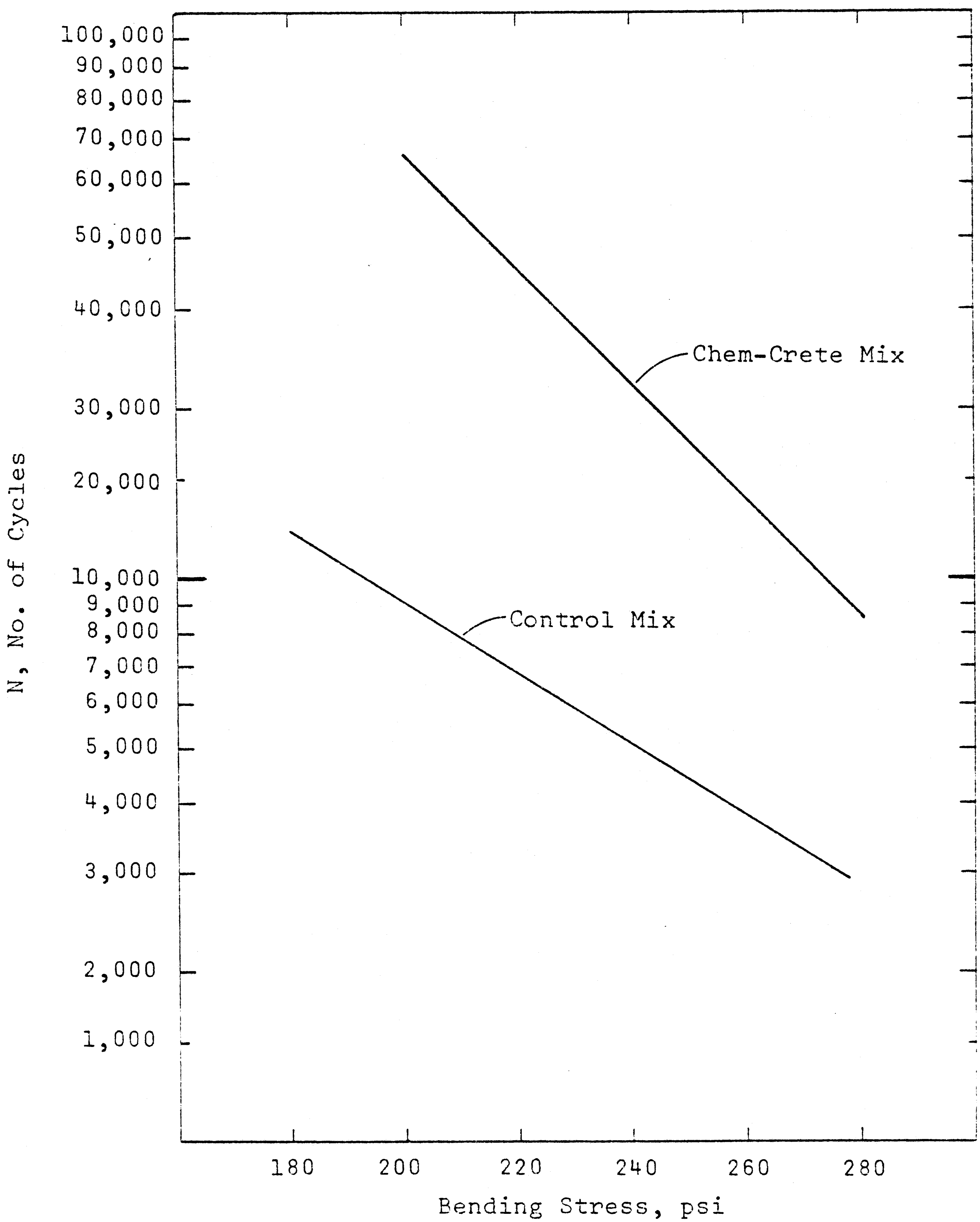

Figure 6. Constant stress fatigue tests.
1 psi = 6894 Pa.

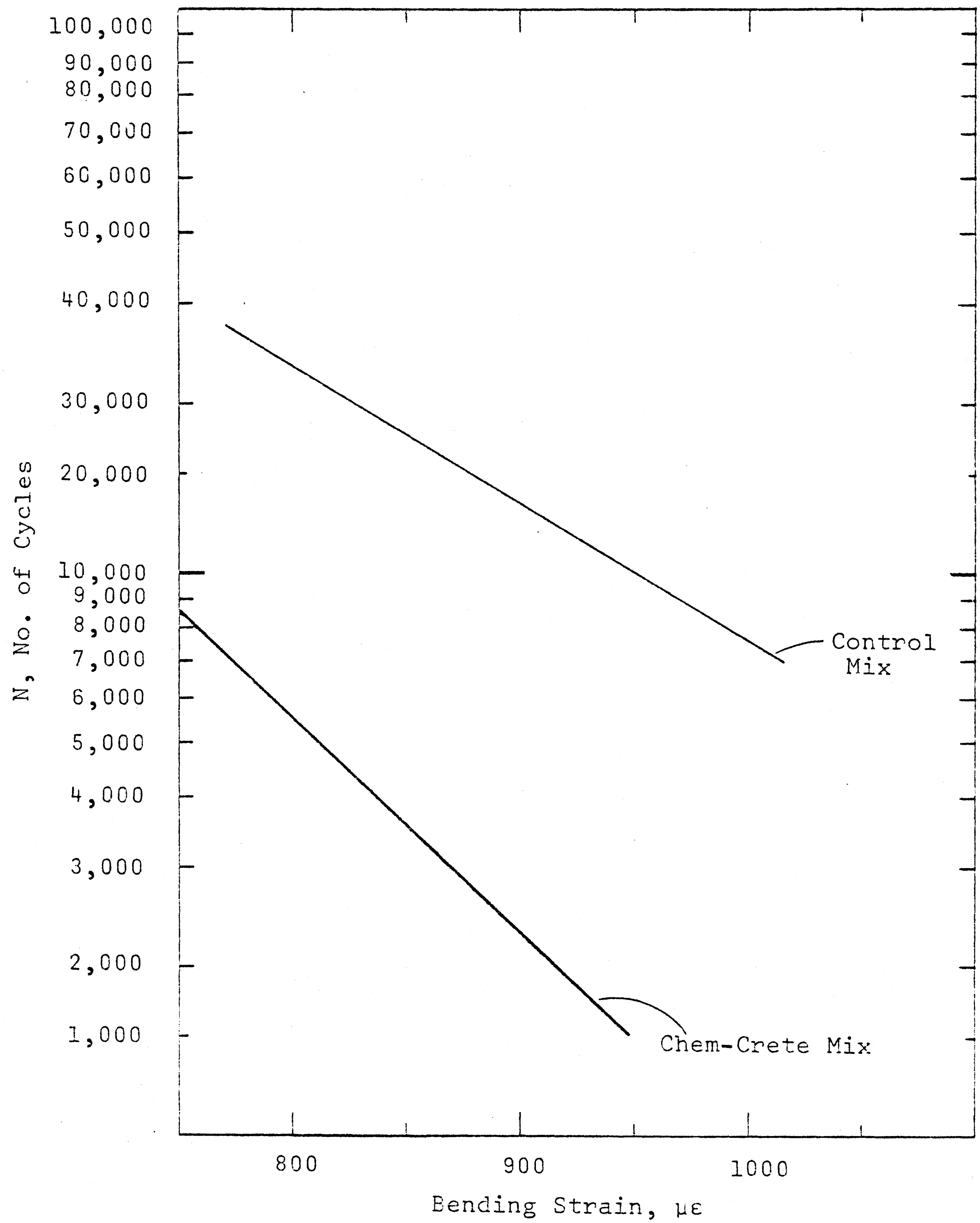

Figure 7. Constant strain fatigue tests.

The control mix gave superior fatigue performance at the tested strain levels, which are higher than those anticipated to occur in pavements. The fatigue curves (Figure 6) of the control and Chem-Crete appear to converge at lower strain levels; therefore, the apparent difference in the fatigue performance of the two mixes might not hold true for low strain levels — ∿100μ in./in. (100μ m/m).

The Chem-Crete mix demonstrated superior fatigue performance under constant stress testing and thus would perform better than the control mix in a thick layer.

Performance

Approximately 2 months after paving, raveling was observed in all test sections. The removal of fines was severe in the wheel paths of the Chem-Crete sections and noticeable but less severe in the control sections. The full depth of the Chem-Crete layer was eroded at several locations on the Roanoke City-Co. project. The raveling of the control sections has healed with traffic and it does not appear to be detrimental to the performance of the pavement. The deterioration of all sections stabilized after several months and appears not to be progressing.

As discussed previously, because the viscosity of the Chem-Crete asphalt was lower than that of the control asphalt during pugmill mixing, it is possible that an excessive amount of it was absorbed by the highly absorptive sand. However, the voids of Marshall specimens did not indicate excessive absorption during laboratory mixing. They did indicate that the mix could not have tolerated additional asphalt without the likelihood of producing a "rich" pavement.

Representatives of the Chem-Crete Corp. believe that the performance of their product would have been improved if the material had been altered chemically.

The weather conditions and control of density were considered satisfactory on the Franklin Co. job. Although cores were not obtained to check the density on the Roanoke City-Co. project, it is doubtful that adequate density was attained because the temperatures were low and the surface layer was very thin — 0.9 in. (20 mm).

ACKNOWLEDGEMENTS

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2. Monismith, Carl L., "Design Considerations for Asphalt Pavements to Minimize Fatigue Distress Under Repeated Loading", paper presented at Fourth Paving Conference, University of New Mexico, Albuquerque, New Mexico, December 8-9, 1966.