

INTERIM REPORT

PREDICTING MOISTURE-INDUCED DAMAGE TO ASPHALTIC
CONCRETE — FIELD EVALUATION PHASE

by

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(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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SUMMARY

Virginia is one of seven state and federal agencies participating in a field evaluation of a stripping test method developed under NCHRP Project 4-8(3), "Predicting Moisture-Induced Damage to Asphaltic Concrete." The test method is being used to evaluate the efficacy of the method in predicting the degree of stripping that will occur on a 1,000 ft. (300 m) test section constructed with an asphaltic concrete believed to have a tendency to strip. The degree of stripping of the pavement will be evaluated by visual observation of cores taken periodically and by pavement surveys.

In the test method resilient modulus and indirect tensile tests are being performed on preconditioned and nonpreconditioned specimens in predicting the potential stripping. The strength or stiffness loss resulting from vacuum saturation preconditioning is used to indicate potential immediate stripping, and the strength or stiffness loss under a more severe accelerated preconditioning indicates potential stripping after a long period of time.

The tests have predicted that stripping will occur over a long period rather than a short period. Tests on cores taken 12 months after construction have shown a minor amount of stripping.

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INTRODUCTION

This report is offered as fulfillment of the working plan requirement that an interim report be submitted 15 months after construction of the Virginia test section included in the field evaluation phase of National Cooperative Highway Research Program Project 4-8(3) "Predicting Moisture Induced Damage to Asphaltic Concrete." Project 4-8(3) was initiated in 1974 to develop a reliable test procedure for predicting if a given asphaltic concrete mixture will strip in service. The laboratory phase of the project was completed in 1974.

Virginia is one of seven states and federal agencies participating in the field evaluation phase. Each participant agreed to install a 1,000 ft. (300 m) test section of pavement using an asphalt-aggregate combination believed to have a tendency to strip. The test method developed in the laboratory phase of the project is being used to obtain data on cores taken periodically from the test sections and also on similar laboratory prepared specimens. The performance of the test pavements is being recorded along with traffic and weather data. The NCHRP project contractor will examine the data from all participants to evaluate the test method and possibly suggest test criteria.

This interim report describes the Virginia test installation and presents the data obtained to date.

PURPOSE AND SCOPE

The purpose of this project is to provide field and lab data to be used in the evaluation of a newly developed stripping test. The test is performed on laboratory specimens and on cores from a field test section. The test section is inspected periodically for possible stripping failures.

In addition to the stripping tests, fatigue tests will be performed on laboratory beam specimens to determine the effect of stripping on the pavement fatigue life.

TEST INSTALLATION

On May 6, 1976, a section 950 ft. (290 m) long in the westbound traffic lane of Greenwood Drive (Project 026-124-103-C501-B606) in Portsmouth, Virginia, was paved with an asphaltic concrete mix containing a stripping-susceptible aggregate. The pavement consists of a 1.5-in. (3.8-cm) surface layer of S-5 asphaltic concrete, a 5.5 in. (14-cm) I-2 asphaltic base mix course, a 6-in. (15-cm) subbase of compacted 21A material, and a 6-in. (15-cm) cement stabilized subgrade. The subgrade is a type A-2-4(0) or A-3 sandy soil.

The base originally was to be a B-3 mix with a 1.5-in. (3.8-cm) maximum sized aggregate; however, because test specimens were limited to a 4-in. (10.2-cm) diameter, an I-2 mix with a 1-in. (2.5-cm) maximum aggregate size was substituted. It is generally agreed that the diameter of the specimen should be at least four times the size of the largest aggregate in the mix. The bottom 2.5-in. (6.4-cm) of the I-2 base are being analyzed in this study.

The average gradation and asphalt content of the mix placed in the test section are listed in Table 1. The location of the test pavement and a typical cross section are shown in Figures 1 and 2, respectively.

Table 1

Average Gradation and Asphalt Content of I-2 Bituminous Concrete
(Note: 1-in. = 25.4 mm)

<u>Sieve</u>	<u>% Passing</u>
1"	100
3/8"	71
#4	44
#50	10
#200	2
A.C.	5.2%

The mix contained 60% granite from Trego Stone Corporation, 40% natural sand from Lone Star Industries, and 5.2% AC-20 asphalt cement, (with no antistripping additive) from Texaco Oil Company.

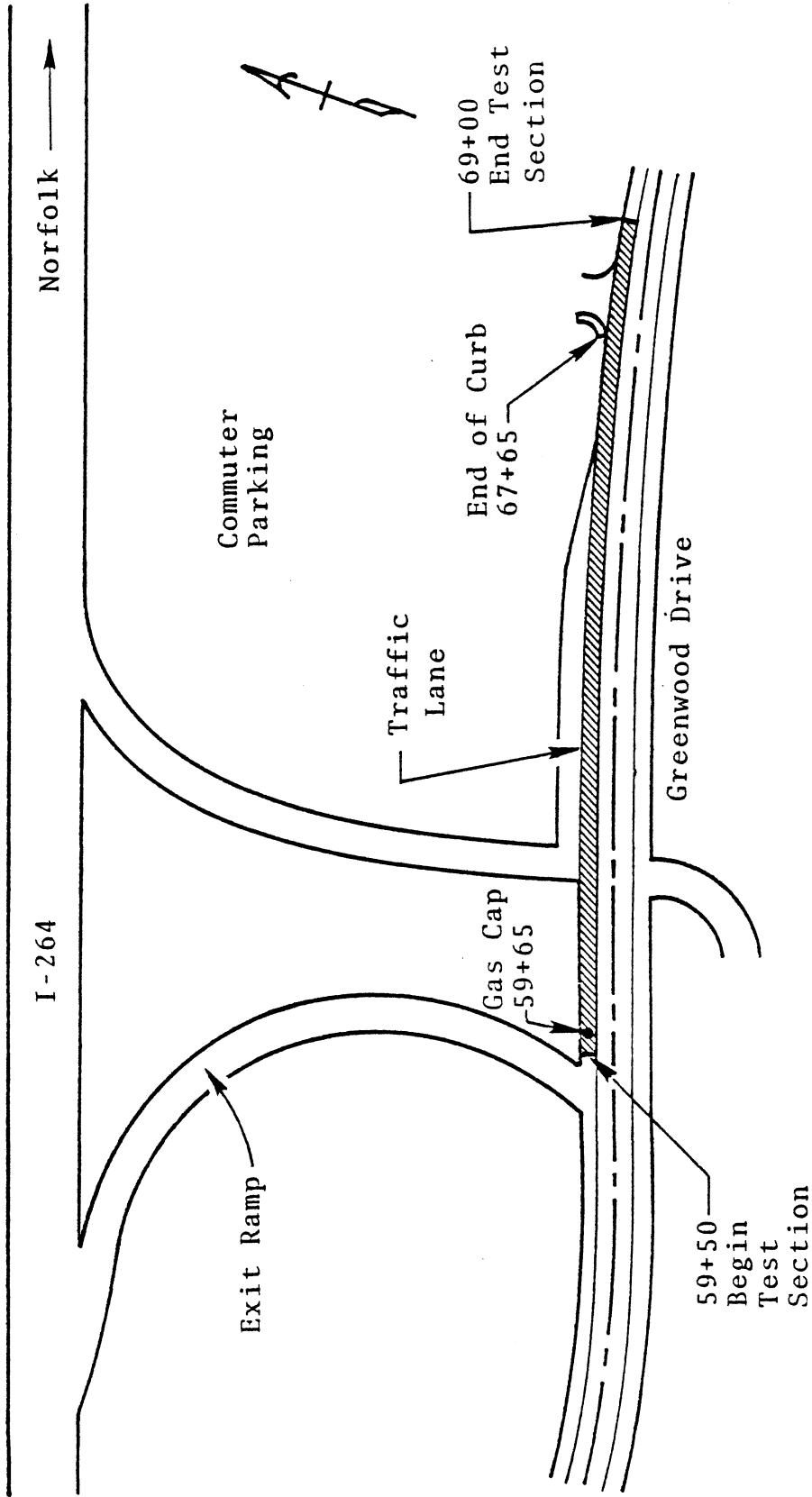
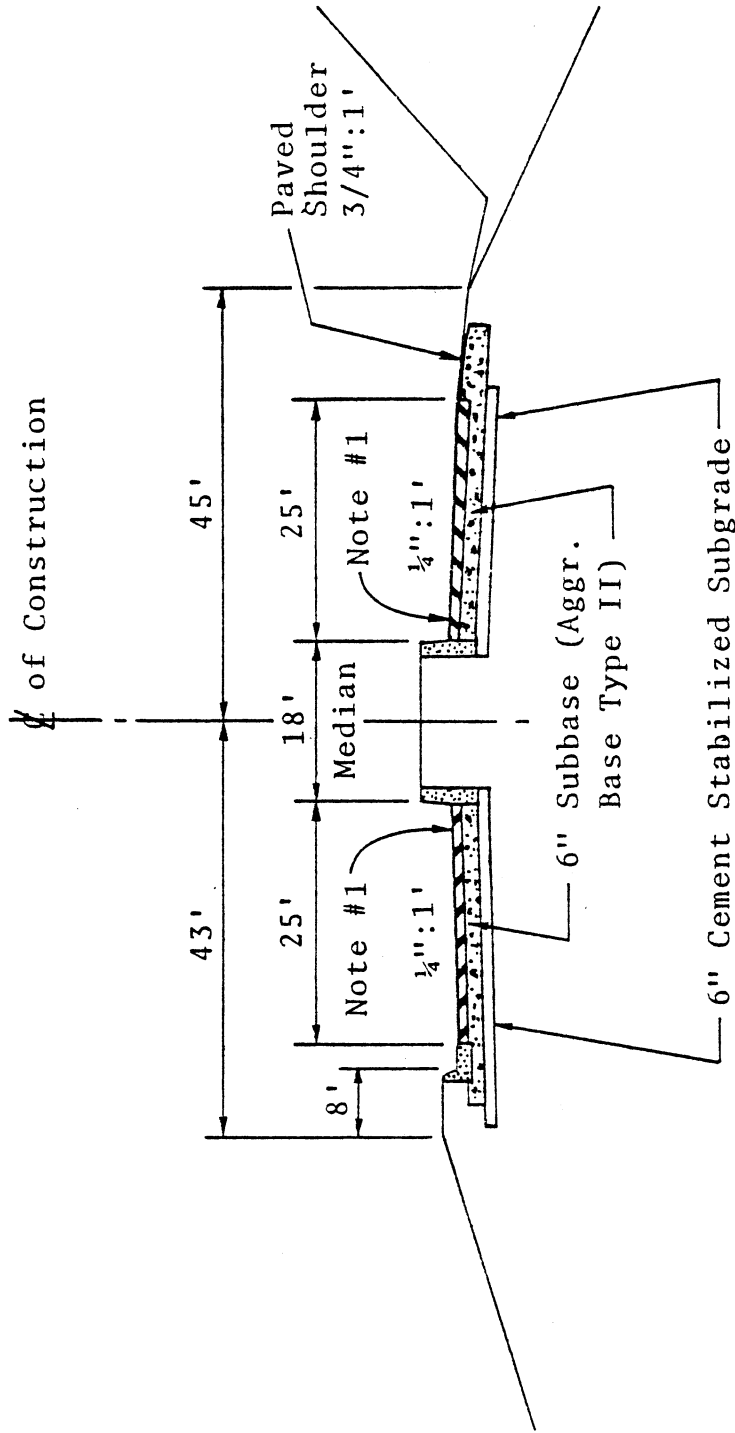


Figure 1. Test section location.



Note #1: 5 1/2" bituminous concrete, type I-2 with 165 lb. per sq. yd. of type S-5 surface mix.

Figure 2. Typical section --- Greenwood Drive.

(Note: 1 in. = 2.54 cm.; 1 ft. = 0.305 m)

Cores

Cores 4-in. (10.2-cm) in diameter were taken the day after the I-2 mix was placed, and cores will continue to be taken at 4-month intervals for 2 years and then at 6-month intervals for 3 additional years. Some of the initial cores were stored in the laboratory and tested after 2, 5 and 10 months. Cores are taken randomly from both between and in the wheel paths.

Laboratory Specimens

Aggregate and asphalt cement was obtained at the asphalt plant producing the I-2 mix for laboratory test specimens. Specimens 4-in. (10.2-cm) in diameter and 2.5-in. (6.4-cm) high were compacted with a drop hammer using a compactive effort that duplicated the field density. The field gradation and asphalt content listed in Table 1 were used. It was planned to increase the compactive effort to make specimens with less air voids to determine the effect of less air voids on stripping; however, a compactive effort that would decrease the air voids could not be achieved. The laboratory specimens were tested initially and after storage periods of 2, 5, and 10 months.

Test Procedure

Preconditioning

Two types of moisture preconditioning are being used to attempt to duplicate the stripping damage that will occur in the field.

One set of 4 specimens is placed in a large plastic container, submerged in water, and subjected to a vacuum for 30 minutes. The stripping that occurs after the vacuum preconditioning simulates the degree of stripping predicted to occur in the field shortly after construction. This type of preconditioning is referred to hereafter as vacuum saturation.

After being vacuum saturated as described above, each specimen in a second set of 4 is placed in a plastic bag with 10 ml of water, put in a freezer at 0°F (-18°C) for 15 hours, and then in a 140°F (60°C) water bath for 24 hours. This treatment which is supposed to duplicate stripping that will occur in the field over a long period is referred to hereafter as accelerated preconditioning.

Mechanical Testing

Tests are performed on 3 sets of cores or specimens: dry, vacuum saturated preconditioned, and accelerated preconditioned. Two types of tests are used: the diametral dynamic resilient modulus test and diametral indirect tensile test.

The former is performed at 72°F (22°C) and 55°F (13°C), and the later at 55°F (13°C).

The dry specimens are stored at room temperature (72°F [22°C]) prior to testing with the resilient modulus device. After testing the specimens are wrapped in aluminum foil, sealed with melted wax, and placed in a 54°F (12°C) water bath for 3 hours. Then the foil and wax are removed and the resilient modulus test is repeated. Following the second resilient modulus test, the indirect tensile test is performed.

Vacuum saturated and accelerated conditioned samples are kept in a 72°F (22°C) water bath for 2 hours prior to the resilient modulus testing. After testing, the specimens are placed in a 54°F (12°C) water bath for 3 hours. The specimens are removed from the water bath, blotted with a towel and subjected to the resilient modulus and indirect tensile tests.

Fatigue Testing

Flexural fatigue tests were performed on unconditioned and vacuum saturated preconditioned beam specimens to determine the possible effect of stripping on the fatigue life of the bituminous concrete. The 3-in. (7.6 cm) x 3-in. (7.6-cm) x 15-in. (38.1 cm) sawed beams are compacted on a California kneading compactor at an effort that attempts to duplicate the field density. Fatigue tests originally were planned for accelerated preconditioned beams; however, after one test it was apparent that the severity of stripping made the test unfeasible.

Ten constant stress fatigue tests were performed at various stress levels for both the unconditioned and vacuum saturated preconditioned series.

Results of fatigue tests on the unconditioned beams have revealed a relatively low flexural stiffness and short fatigue life. The average stiffness of approximately 65,000 psi (0.448 GPa) compares to 184,000 psi (1.27 GPa) for a surface mix with AC-20 asphalt cement and 93,000 psi (0.641 GPa) for a surface mix with 120-150 pen. asphalt cement obtained in previous tests. The low initial stiffness could result in a shorter fatigue life than normally would be expected.

There was no significant difference in the fatigue life of the unconditioned and preconditioned beams at a 95% confidence level.

RESULTS

Stiffness and Strength Ratio

Figures 3 and 4 illustrate the effect of aging on the resilient modulus ratio at 72°F (22°C) and 55°F (13°C) test temperatures, respectively. The resilient modulus ratio at 72°F (22°C) shows a

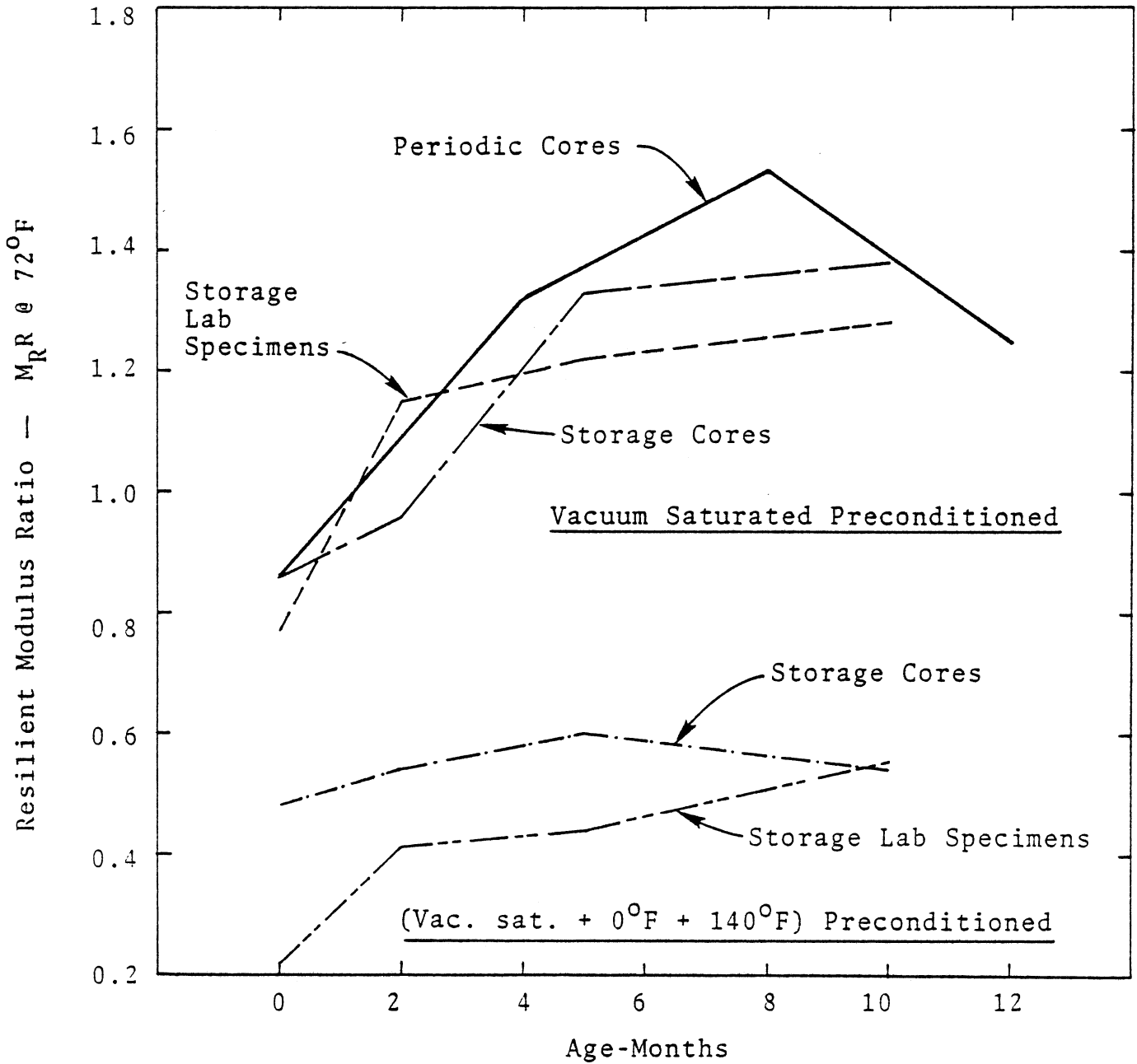


Figure 3. Resilient modulus ratio at 72°F vs. age.

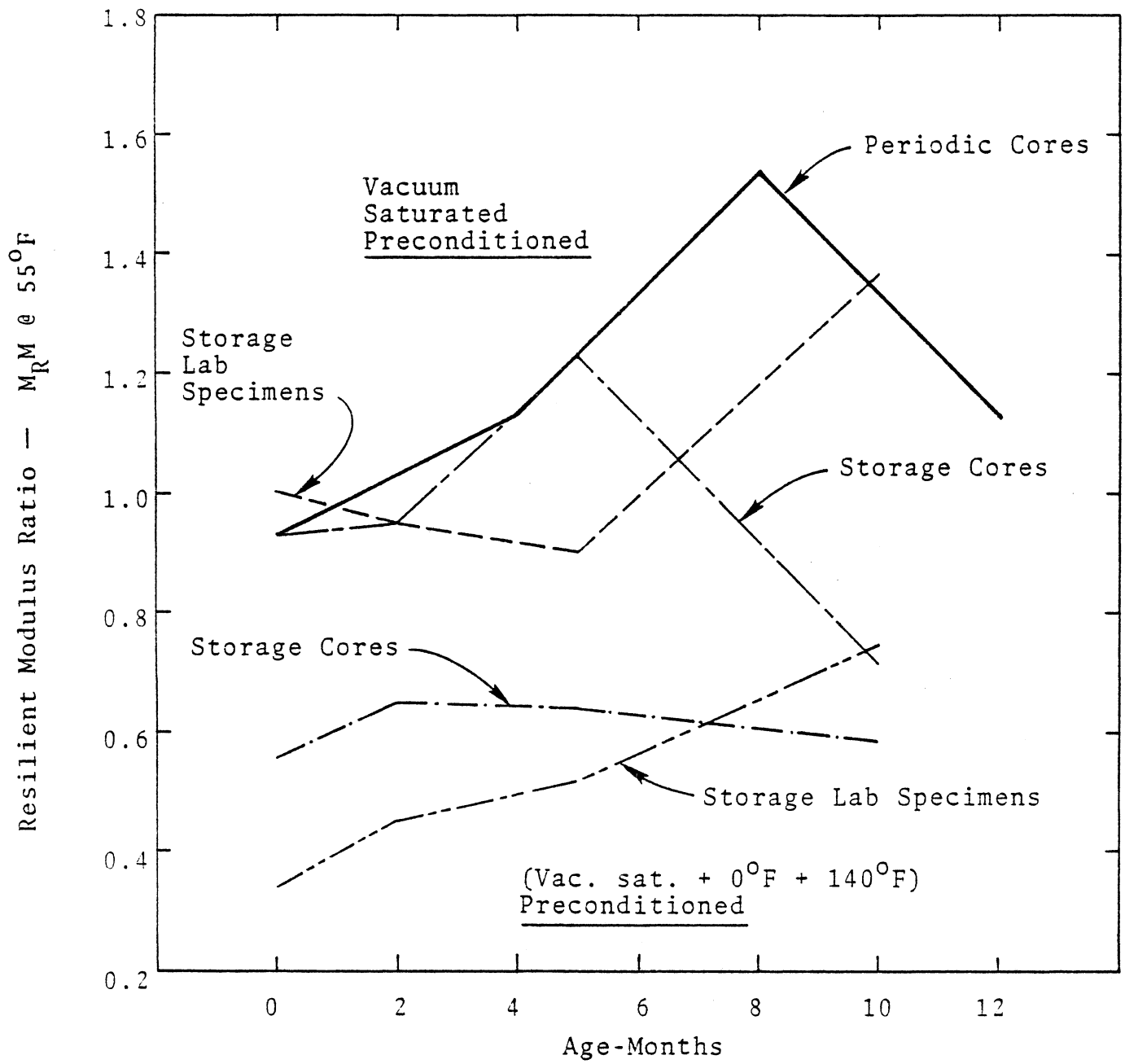


Figure 4. Resilient modulus ratio at 55°F vs. age.

definite increase with age for the vacuum saturated preconditioning after 10 months of aging; however, the ratio does not appear to change significantly with age for the accelerated preconditioning. The vacuum saturated cores taken from the test section 12 months after construction displayed a decrease in the resilient modulus ratio. The resilient modulus ratio ranges from 0.7 to 1.5 for the vacuum saturated preconditioning, and from 0.3 to 0.65 for the accelerated preconditioning. While the ratio ideally should always be less than 1.0, it is greater than 1.0 for some of the vacuum saturated specimens.

As illustrated by Figure 3, the modulus of the vacuum saturated specimens is 40%-50% higher than the modulus of the unconditioned specimens after 8-10 months of aging. It is possible that the vacuum saturation process caused the asphalt cement to become brittle after aging, and thereby caused an increase in stiffness and a high ratio. This hypothesis cannot be proven at present; however, the phenomenon will be considered as the work progresses.

The resilient modulus ratio at 55°F (13°C) shows no trends for vacuum saturated cores or specimens.

The resilient modulus ratio at both 55°F (13°C) and 72°F (22°C) is 0.1 - 0.2 lower for the lab prepared specimens than are the cores for the accelerated preconditioning. Although the lab specimens contained approximately the same quantity of air voids as the field cores, the type of compaction and size and shape of air voids might have resulted in more stripping damage for the accelerated preconditioned lab specimens and a resultant lower resilient modulus ratio.

The tensile strength ratio shows no significant change with age for either vacuum saturated or accelerated preconditioning (Figure 5). As noted with the resilient modulus ratio, the tensile strength ratio was approximately 0.2 lower for the lab prepared specimens than for the cores in the accelerated preconditioning.

Experience has indicated that stripping is likely to occur in the field if the ratio drops below 0.75. The accelerated preconditioning produced ratios near 0.5; therefore, there is a good chance that stripping will take place after the pavement has been in service for a number of years. As already discussed, the ratios under the vacuum saturated preconditioning were greater than 0.75 and have increased with age; therefore, it is not likely that the pavement will experience moisture damage in the near future.

After the tensile tests the specimens were pulled apart to visually assess the moisture damage. Through 10 months of age, damage was nondetectable in the specimens that were vacuum saturated preconditioned, but very severe in the specimens that were accelerated preconditioned. There was some stripping visible in the 12-month cores, both dry and vacuum saturated. Figure 6 shows a typical set of tested specimens.

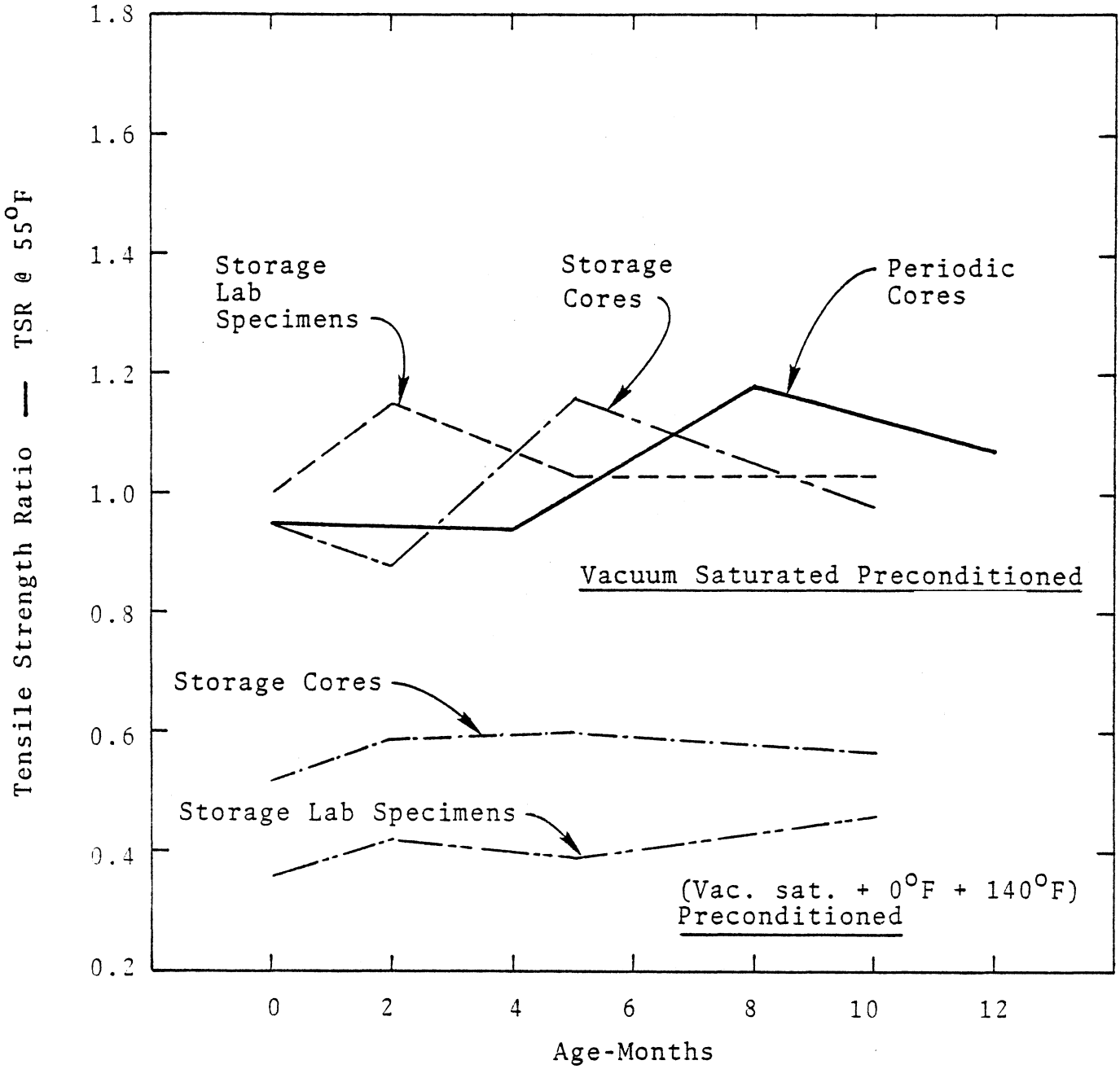


Figure 5. Tensile strength ratio at 55°F vs. age.

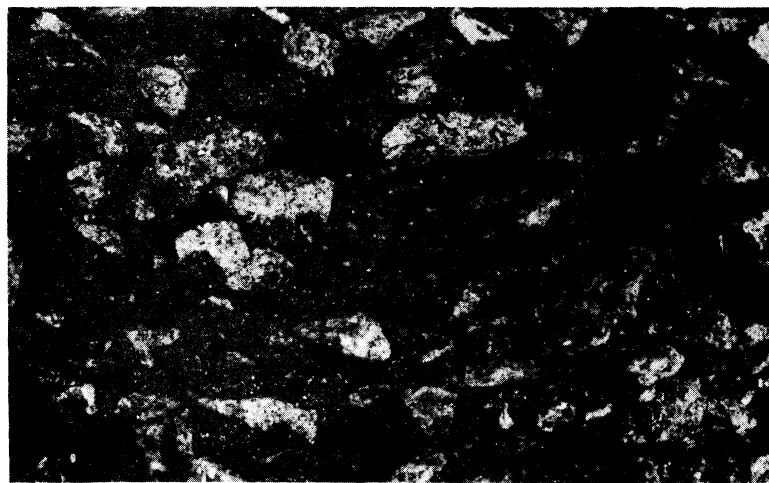
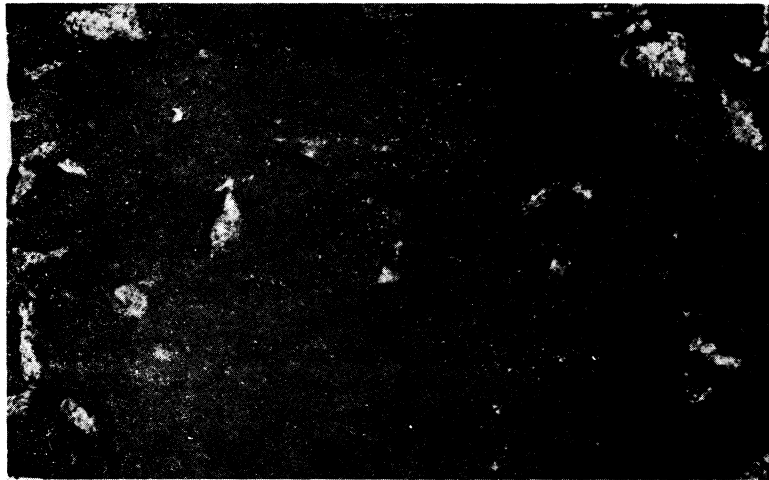
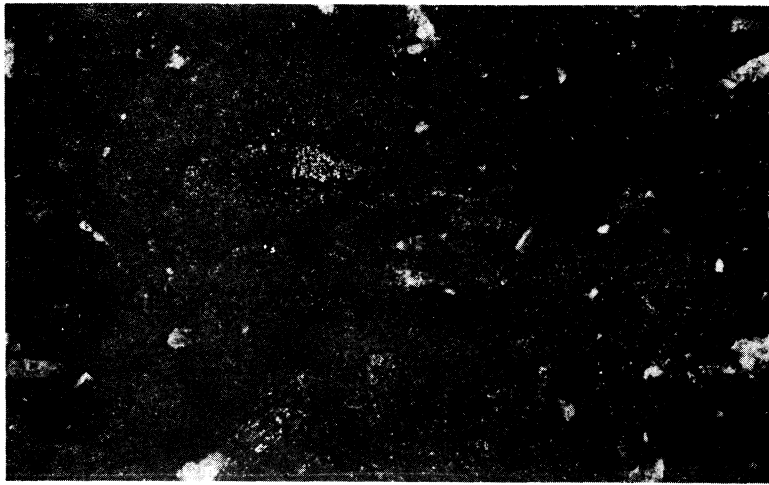


Figure 6. Typical stripping in cores. From the top: dry, vacuum saturated, and accelerated.

Effects of Aging on Strength

Because it is possible for aging of the pavement to affect stripping, the degree of aging is being considered in the evaluation. Figures 7 and 8 illustrate the effect of age on the resilient modulus at two temperatures for the lab specimens, cores taken periodically from the pavement, and cores taken immediately after construction and stored for later testing. Figure 9 gives the indirect tensile strength of the cores and specimens that had previously been used for the resilient modulus tests. In general, the resilient modulus and indirect tensile strength were highest for the lab specimens and lowest for the cores that were stored for various time intervals before testing. As expected, the resilient modulus at 72°F (22°C) and indirect tensile strength at 55°F (13°C) increased as the specimens, initial cores, and pavement aged. The resilient modulus at 55°F (13°C) shows no definite trends possibly because the aging of the asphalt cement has less effect on the stiffness at this lower temperature.

It should be pointed out that the strength and moduli curves for the cores taken periodically are the average of wheel path and between wheel path cores. The cores taken between the wheel path had approximately 1.5% fewer air voids than the cores taken in the wheel paths, which resulted in differences in strengths and stiffnesses. The strength and stiffness of cores taken between wheel paths were greater than these values for the cores taken in the wheel paths.

TENTATIVE CONCLUSIONS

1. Resilient modulus and tensile strength ratios predict that moisture damage in the field test section will occur over a long period rather than a short period.
2. Aging is causing an increase in the resilient modulus ratio at 72°F for vacuum saturated cores and specimens.
3. Aging is causing a strength and stiffness increase in the lab specimens, the cores taken periodically, and the initial cores.
4. Stripping has been observed in the accelerated conditioned cores and specimens, and also in the 12-month cores.

FUTURE WORK

Cores will continue to be taken periodically and tested to determine if stripping is taking place. The stored cores and lab specimens will be tested as scheduled.

The pavement condition will be monitored periodically for deterioration caused by stripping. Also weather and traffic data will continue to be collected.

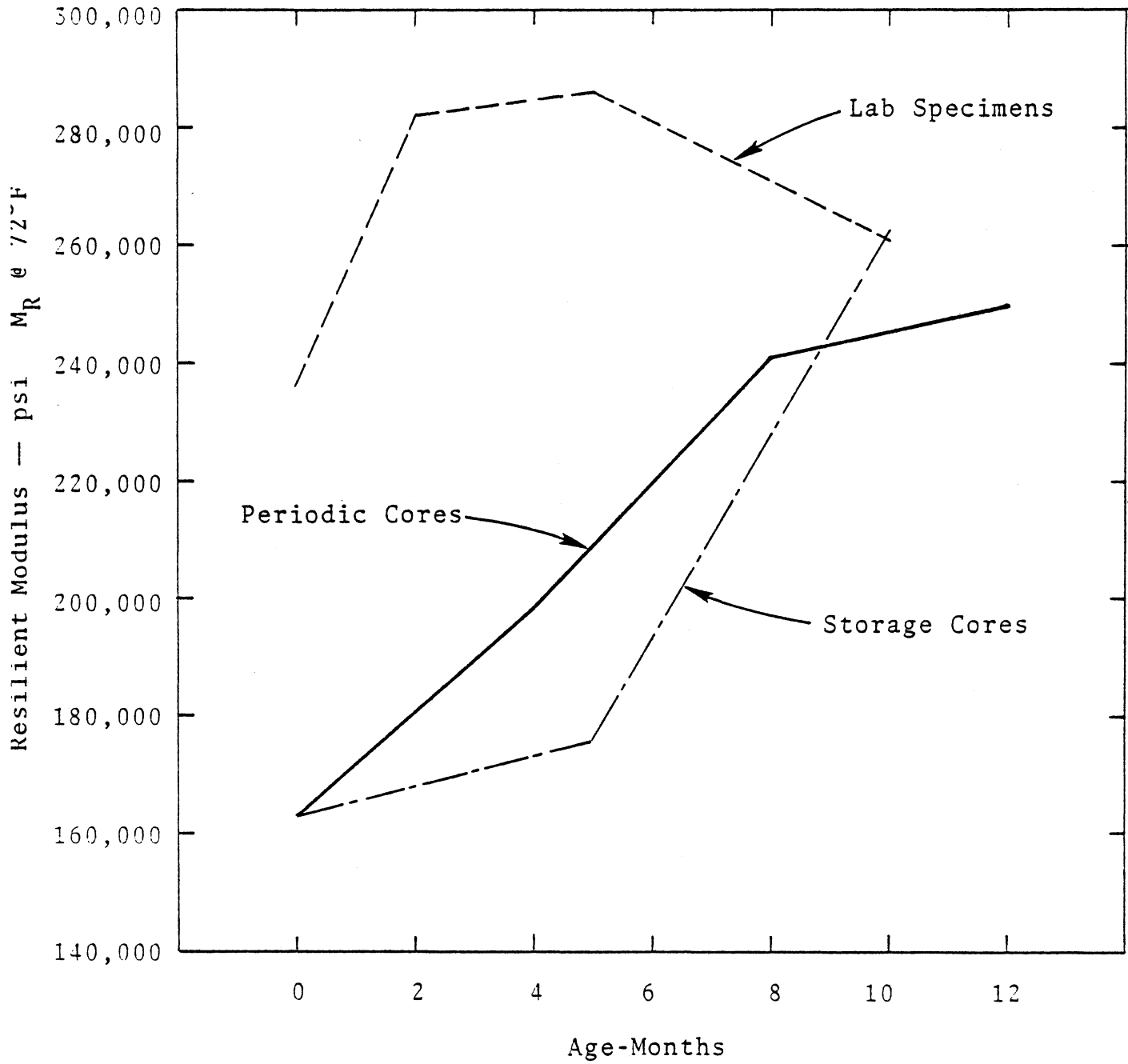


Figure 7. Unconditioned resilient modulus at 72°F vs. age.

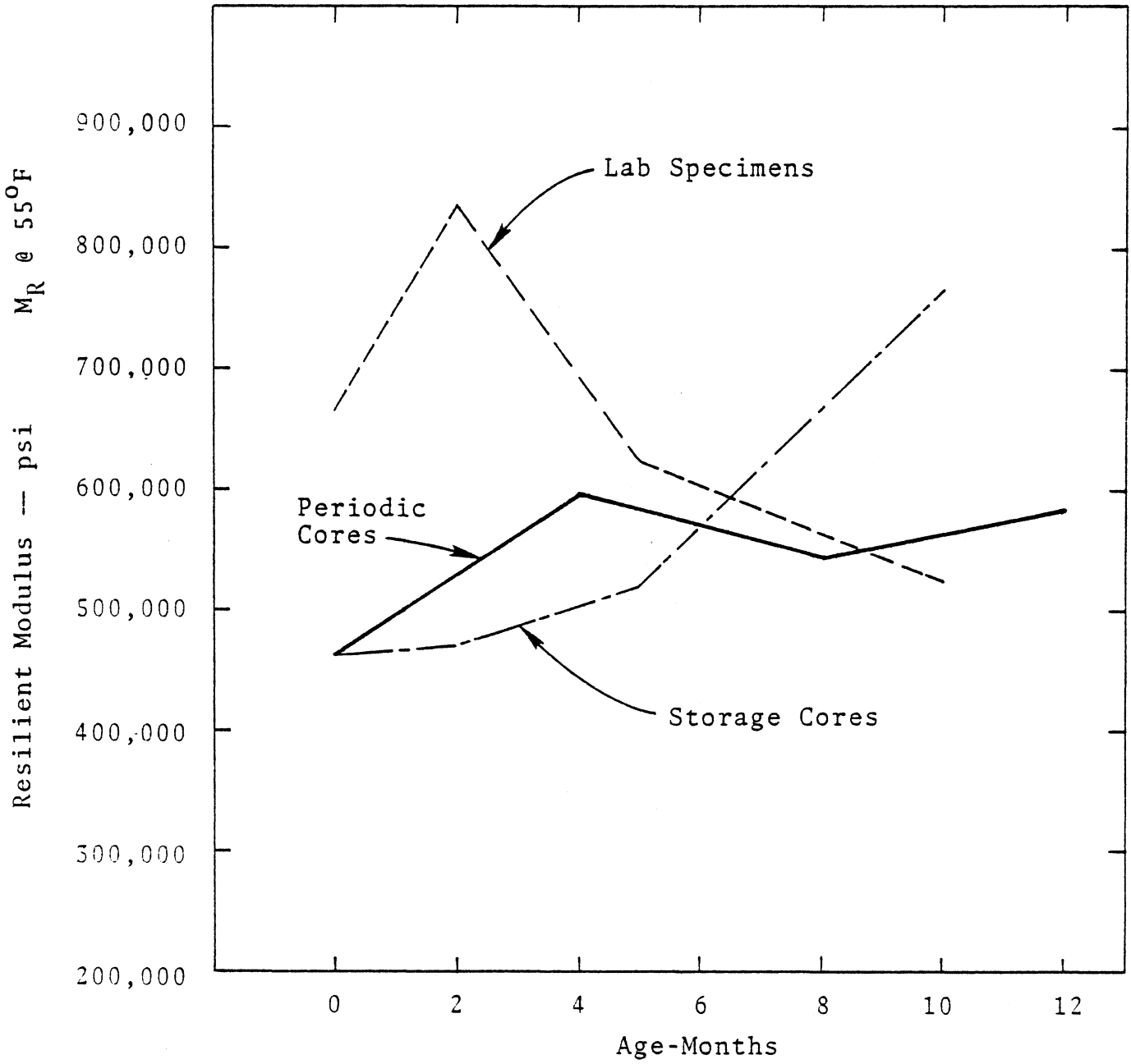


Figure 8. Unconditioned resilient modulus at 55°F vs. age.

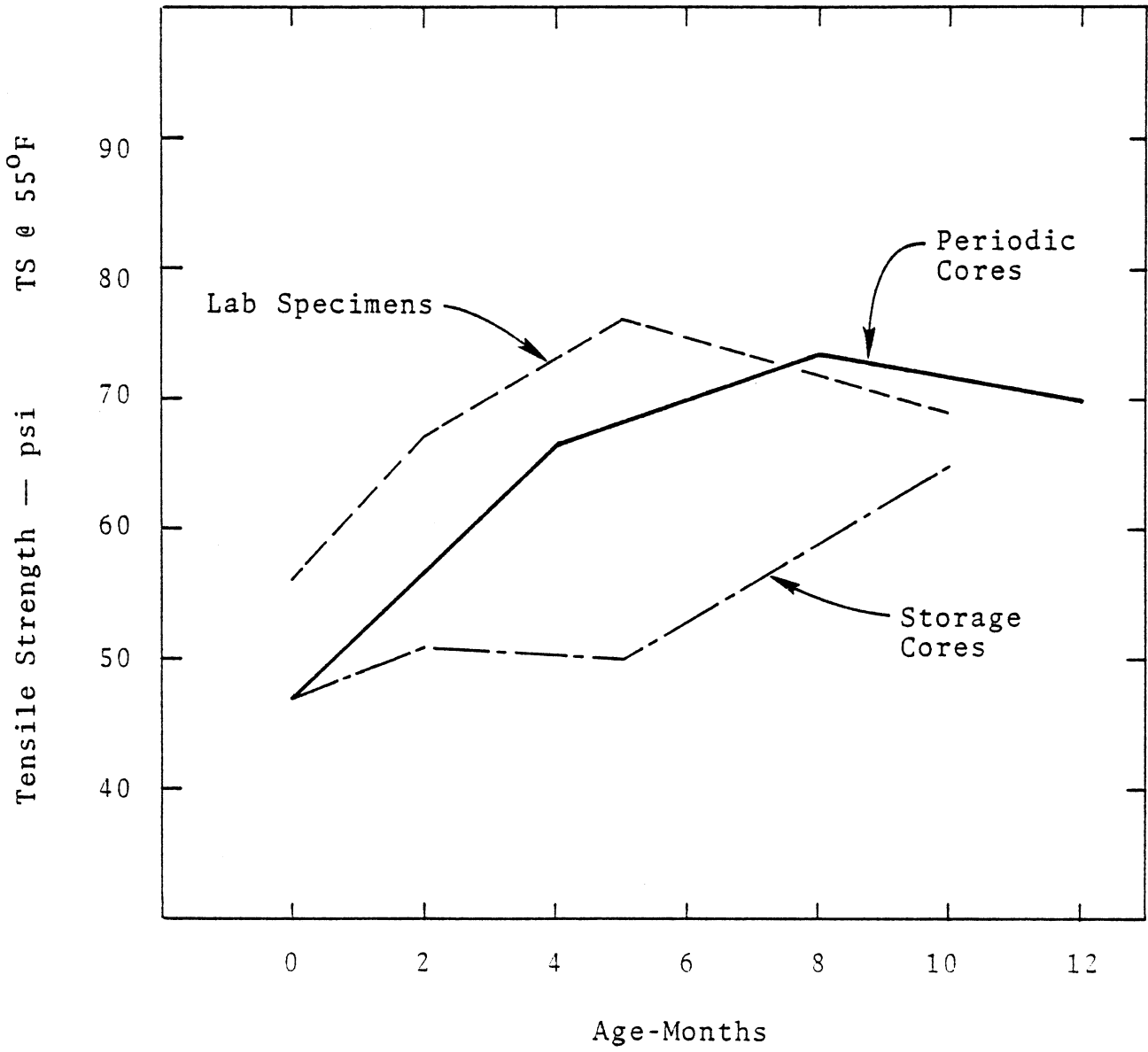


Figure 9. Unconditioned tensile strength at 55°F vs. age.

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