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Detection of Moisture Damage from Laboratory Tests

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DETECTION OF MOISTURE DAMAGE FROM LABORATORY TESTS

by

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16. Abstract

THIS STUDY WAS AN ATTEMPT TO DEVELOP A LABORATORY TEST PROCEDURE FOR MEASURING THE STRIPPING POTENTIAL OF ASPHALT MIXES. THE APPROACH WAS TO ESTABLISH FIELD SIMULATED CONDITIONS IN A TESTING VESSEL THAT WOULD GENERATE STRIPPING. IT WAS ECTED THAT BY TESTING SPECIMENS WHILE SUBJECTED TO THE SIMULATED CONDITIONS ETHOD COULD BE ESTABLISHED FOR USE AS A PRACTICAL STRIPPING TEST. THE STUDY WAS SUCCESSFUL IN DEVELOPING THE TESTING VESSEL AND IN GENERATING FIELD-LIKE STRIPPING. HOWEVER, THE TESTING OF SPECIMENS USING THE EQUIPMENT AND METHODOLOGY DEVELOPED DID NOT PROVIDE A CLEAR INDICATION OF WHEN STRIPPING WAS DEVELOPING OR EVEN A CLEAR DELINEATION BETWEEN MIXES THAT STRIPPED AND THOSE THAT DID NO STRIP. AS A RESULT, IT WAS CONCLUDED THAT A PRACTICAL TEST PROCEDURE COULD NOT BE DEVELOPED USING THE METHODOLOGY AND IT WAS RECOMMENDED THAT THE STUDY NOT BE CONTINUED.

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CHAPTER I

INTRODUCTION

A major problem with some asphalt concrete mixes is asphalt stripping. This is a phenomenon in which adhesion of the asphalt coating detaches from the aggregates in the mix. With the detachment the asphalt no longer binds the aggregate particles together and the mix strength and integrity are lost.

Although much research has been conducted to study the stripping phenomenon, no test procedure has ever been developed that is totally satisfactory. Even the most universally accepted test procedures fail to identify every mix that is prone to stripping and they sometimes indicate stripping problems with mixes that do not strip in the field. The reason for this may be that the tests are artificial, not consistent with field conditions; and, as a result, stripping is not actually developed in a manner consistent with field conditions.

Most of the test procedures utilize some type of water conditioning with a strength test. Conditioned and unconditioned samples are tested for strength. The ratio of conditioned to unconditioned strengths is used as the measure of stripping potential without developing true field-like stripping.

Project TRC-9113, Detection of Moisture Damage by Laboratory Tests, was conducted with the objective of developing an improved test procedure for detecting the stripping potential of asphalt concrete mixes. The project was conceived and initiated by Miller C. Ford, Jr. The concept of the test development was to formulate as testing approach that would more closely duplicate the field conditions normally recognized as contributing to stripping in the field. These conditions are asphalt mixes subjected to repeated vehicle loadings while in the presence of water at elevated temperatures. Dr. Ford proposed the development of testing device in which an asphalt specimen could be subjected to repeated, dynamic loads while submerged in heated water.

The project was conducted in two phases. The first phase consisted of the development of the testing device and procedures for test monitoring and data acquisition. Also included in the first phase was the initial use of the test devise to establish preliminary testing approaches. This phase was conducted by Dr. Ford. The results of this phase were reported in the project interim report (1).

Figure 1 illustrates the test device developed in Phase One. It consists of a modified kitchen pressure cooker mounted in a loading frame capable of applying a dynamic, repeated load, and placed on a heating coil instrumented to control the temperature of water inside the pressure cooker. The loading frame used was a Retsina device that is normally used for measuring the resilient modulus of asphalt concrete specimens.

The pressure cooker was modified to permit the insertion of a steel loading

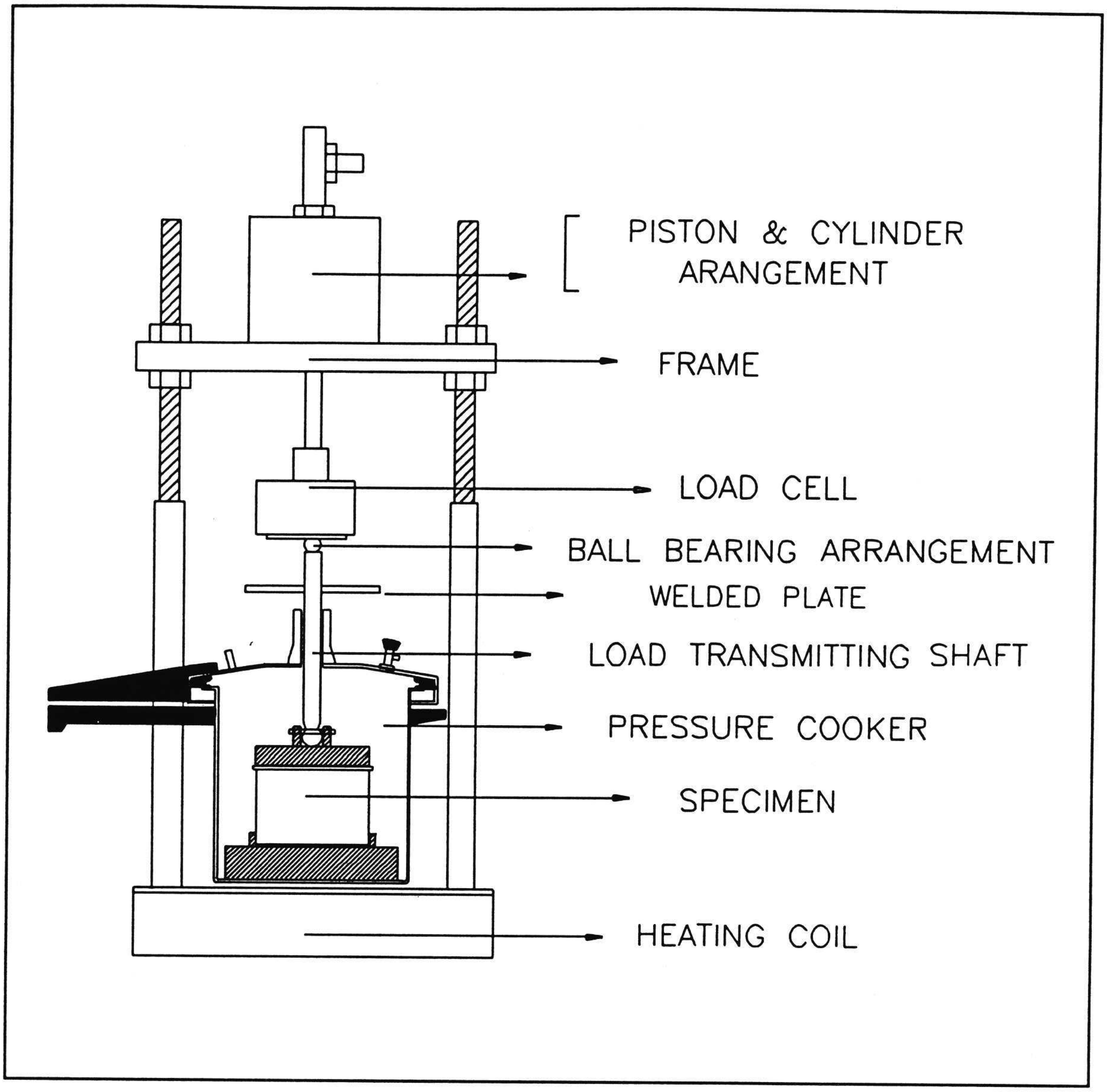

Figure 1. Illustration of the Pressure Cooker Test Device.

rod and a thermometer while retaining the capability of maintaining an internal pressure or vacuum. A plexiglass window was also installed in the side of the pressure cooker to permit observation of the specimen during testing.

Dr. Ford retired from the University at the conclusion of Phase One. In fact, his project interim report covering the Phase One work was completed by Dr. Ford after his retirement. As a result of his retirement, Phase Two of the project was conducted under the guidance of the author of this final report.

The objective of Phase Two was to develop specific test procedures and to evaluate the ability of the test to detect stripping potential. The approach used in this phase was to:

1. Develop a methodology that would generate field-like stripping in specimens of mix known to have poor stripping resistance.
2. Use the procedure with mixes having differing potential for stripping to identify measurement procedures for identification of stripping potential.
3. Judge the usefulness and practicality of the procedures developed.

CHAPTER 2

DEVELOPMENT OF TEST METHODOLOGY

The test methodology was developed using a surface course mix that was known to have exhibited severe stripping. The mix had been used on Job R10009 an overlay project on Interstate 40 near Forrest City. This mix had rutted prematurely as a result of asphalt stripping. The mix composition, aggregate gradation, and mix properties are listed in Table 1.

The concept used by Dr. Ford in developing the test device was that as a mix begins to strip its strength is reduced and its ability to resist permanent deformation under repeated loading diminishes. He reasoned that, if a mix were subjected to repeated loads while in the presence of water (perhaps heated to summer type temperatures and perhaps under pressure or vacuum) field-like stripping could be developed. He further reasoned that the monitoring of permanent deformation and/or mix stiffness could be used as an indicator of stripping development.

The approach used in developing the test methodology was to test a mix known to have high stripping potential under various conditions until a set of conditions could be identified that would produce the appearance of stripping. These conditions would then form the basis for the test methods.

Numerous variations in the test methodology were tried. Some variations

Table 1. Composition of Job R10009 Mix (Mix 1).

Mix Composition:

Aggregates - 35 % Crushed Gravel from White Hall

15% Crushed Limestone from Reed Quarry (Kentucky)

20 % Crushed Limestone from Three Rivers (Kentucky)

15% Coarse Sand from Bourham Fields, Forrest City

15% Fine Sand from Ingram Pit, Marion

Asphalt - 5.1 % AC 30 from Ergon

Mix Gradation -

SIEVE SIZE	PERCENT PASSING
3/4"	100
1/2"	89
3/8"	79
#4	62
#10	50
#20	39
#40	24
#80	11
#200	7

were attempted by Dr. Ford and some preliminary variations were attempted at the start of Phase Two while the new investigators were becoming familiar with the test equipment and preliminary procedures. The specimens tested at this time were split open using indirect tensile loading and examined for evidence of stripping. None was observed. At this point a more systematic approach to selecting test variations was adopted.

For each test variation four Marshall size specimens (4 inch diameter by 2.5 inches high) were tested. To closely control the mix composition, the aggregates were sieved and stored by each size fraction. The mix for each specimen was proportioned separately to contain the desired aggregate blend and gradation. The specimens were compacted using the gyratory compactor. The compaction pressure and number of gyrations was controlled to provide an air void of approximately 5 percent.

The test specimens were tested in the pressure cooker by applying dynamic repeated compressive loads. The loading cycle was repeated every 2 seconds with a peak load duration of 0.1 second. The data collected during testing were load repetitions and permanent vertical deformation. These data were recorded every 300 load repetitions (15 minutes). The load was applied for 9,600 repetitions (8 hours) unless the specimens experienced excessive deformation earlier.

The first seven test variations were conducted on specimens with no preconditioning. The following is a chronological listing of the variations tried.

1. The first variation consisted of repeated loading of 260 pounds (20.7 psi) and a test temperature of 140° F. These specimens all deformed excessively after approximately 2,500 repetitions. The samples were split and examined for stripping. No stripping was found.
2. For the second variation, the temperature was reduced to 122° F and the loading was reduced to 188 pounds (15 psi). These specimens deformed excessively after 2,500 to 5,000 repetitions. Again no stripping was found in the split specimens.
3. For this variation the loading was further reduced to 150 pounds (12 psi) but the temperature was maintained at 122° F. Some of these specimens survived for the entire 9,600 repetitions but others deformed excessively, some after as few as 2,400 cycles. Once more no stripping was found.
4. Next the load was reduced to 50 pounds (4 psi) with no temperature change. While all of these specimens survived the entire 9,600 load repetitions, no stripping was found when they were split.
5. The load for the next set was increased to 100 pounds (8 psi) and the temperature increased to 140° F. These specimens also survived for the 9,600 cycles but still exhibited no signs of stripping.
6. At this point is was decided to examine the effect of applying pressure inside the pressure cooker. These specimens were tested using the same loading and

temperature as used with the previous set; however, a pressure of 10 psi was applied inside the cooker. Again the specimens survived the test but no stripping was found.

7. The next set were tested in a similar manner except that a vacuum (15 inches of mercury) applied instead of a pressure. Still no stripping was found.

8. After trying all of these variations with no success in generating striping, it was decided that it might be necessary to precondition the specimens. The first preconditioning tried was to soak the specimens for 24 hours in a water bath at 77° F. These specimens were then tested using a loading of 50 pounds (4 psi) and testing temperature of 140° F. These specimens also did not strip.

9. For this variation vacuum saturation was used. The specimens were subjected to vacuum saturation for 10 minutes at 135 ° F. The specimens were then submerged for 48 hours in a 140° F water bath. For this variation 5 sets of two specimens each were tested. With each set, one specimen was subjected to repeated loading at 100 pounds (8 psi) and a water temperature of 140° F. The other specimen was not subjected to load testing. When the specimens were split, striping was noted in all specimens. However, the stripping was more pronounced and obvious in the specimens subjected to repetitive loading.

The stripping observed in the specimens subjected to loading in the pressure cooker had an appearance similar to that observed in the field. For the remainder of the study, this variation was selected as the test methodology. The test consisted of:

1. Vacuum Saturate - 10 minutes at 135° F
2. Soak - 48 hours in a water bath at 140° F
3. Pressure cooker testing - load 100 pounds (8 psi) at 140° F for up to 9,600 load repetitions.

CHAPTER 3

TEST EVALUATION

The successful generation of field-like stripping triggered an expectation that a practical stripping test could be developed with the pressure cooker. The next step in the development would be to evaluate the test methodology developed to this point; then, if this proved successful, simplifications to the testing process could be sought.

The approach taken in this evaluation was to test mixes with varying potential for stripping. From the data generated in this testing, evidence of stripping development would be sought. It was anticipated that differences in the rate of permanent deformation development could be used as measure of stripping. As described earlier, it was expected that mixes exhibiting stripping would also deform more rapidly.

For this part of the study two mixes were used. Mix 1 was the mix used in developing the methodology. Mix 2 was intended to be a mix not susceptible to stripping; however, during the testing this mix was also found to strip in the test. The composition of Mix 2 is listed in Table 2.

To provide variation in stripping potential, both mixes were tested with and without anti-strip agents. Mix 1 was tested using two anti-strip agents - hydrated lime and a liquid agent. Mix 2 was tested using only the hydrated lime.

Table 2. Composition Mix 2.

Mix Composition:

Aggregates - 49.0% Crushed Syenitefrom Granite Mountain Quarry

37.7% Crushed Screenings fron Granite Mountain

Quarry

13.3% Donnafil (manufactured Sand) from 3M

Corporation

Asphalt - 5.7 % AC 30 from Ergon

Mix Gradation -

SIEVE SIZE	PERCENT PASSING
3/4"	100
1/2"	93
3/8"	86
#4	69
#10	47
#20	32
#40	22
#80	12
#200	6

Table 3. Summary of Results from Mix 1 Testing.

ADDITIVE	None	Hydrated Lime	Liquid
Test Specimens	7	5	5
Air Void, mean	4.79	4.14	4.50
Air Voids, std. dev.	0.25	0.27	0.08
Loads to Failure	3600 to 14,100	1800 to 8700	1800 to 4800
Time to Failure, hours	3 to 11.75	6.5 to 9.5	1.5 to 4
Strain Rate micro strain/cycle	0.35 to 2.74	0.38 to 4.5	8.5 to 38.9
Stripping Observed	yes	no	no

The results from the Mix 1 testing are summarized in Table 3. Seven specimens with no anti-strip agent were tested, 5 were tested with hydrated lime, and 5 were tested with the liquid agent. In general, the specimens with no anti-strip agent survived more load repetitions before experiencing excessive deformation than did the other specimens (3600 to 14100, versus 1800 to 8700 and 1800 to 4800 respectively). The specimens with no anti-strip also generally experienced lower rates of strain. However, when examined after splitting, the specimens with no anti-strip displayed stripping while the specimens with anti-strip showed no observable stripping. In this respect, the anti-strip agents appeared to prevent stripping but the test data did not provide any measure of this fact.

The results from testing of Mix 2 are summarized in Table 4. Recall that this mix had been selected as being not susceptible to stripping. However, the specimens prepared with no anti-strip agent did develop stripping during the test. No stripping was found in the specimens prepared using hydrated lime as an anti-strip agent. Nevertheless, the test data provided no evidence of any difference in behavior. The numbers of load cycles applied before excessive deformation were quite similar and the rates of strain accumulation were similar. Again, the test procedure was not able to distinguish between specimens that stripped and specimens that did not strip.

Table 4. Summary of Results from Mix 2 Testing.

ADDITIVE	None	Hydrated Lime
Test Specimens	5	9
Air Void, mean	6.05	5.69
Air Voids, std. dev.	0.29	0.52
Loads to Failure	5100 to 6900	5100 to 6900
Time to Failure, hours	4.25 to 5.75	4.25 to 5.75
Strain Rate micro strain/cycle	0.26 to 0.30	0.22 to 0.44
Stripping Observed	yes	no

CHAPTER 4

CONCLUSIONS AND RECOMMENDATION

The test methodology developed under this study was successful in generating field-like stripping in the laboratory. However, the methodology requires sample preparation, sample conditioning, and testing that is not considered to be practical for routine testing unless the test results can provide a clear indication of stripping potential. The test data did not provide this indication. In fact, the data from mixes that stripped and mixes that did not strip were essentially identical. Based on these results, it is concluded that the test methodology cannot be used to develop a reliable, practical procedure for evaluating stripping potential.

It is therefore recommended that efforts to develop a test procedure based on this device not be continued. The fact that stripping was successfully generated in the lab may be useful sometime in the future; but, at this time, there appears to be no reasonable potential for use of the test device and procedures developed.