VERMONT'S TEST METHODS TO DETERMINE THE EFFECTIVENESS OF ANTI-STRIP ADDITIVES

Report 81-2
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Reporting On
Work Plan 81-B-1

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

TOM EVSLIN, SECRETARY OF TRANSPORTATION
S. J. GAGE, P.E., DIR. OF ENGINEERING & CONSTRUCTION
R. F. NICHOLSON. P.E.. MATERIALS & RESEARCH ENGINEER

Prepared by

E. L. Chaffee
Bituminous Concrete Technician

Reviewed by:

R. F. Nicholson

R. F. Nicholson, P.E.
Materials & Research Engineer

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TABLE OF CONTENTS

INTRODUCTION

The objective of this investigation is to produce acceptable test methods to be used by the Vermont Agency of Transportation, to accurately evaluate anti-strip additives.

Anti-strip additives are used to aid the retention of a bituminous film by an aggregate in the presence of water. Anti-strip additives have been used for several years to prevent a process referred to as "stripping". Stripping occurs when water becomes entrapped in a bituminous mixture. The water can destroy the bond between the aggregate and the asphalt. Depending on the severity of stripping, premature failure of the bituminous pavement can occur.

With increased research being conducted world wide on bituminous pavements, the process of stripping has surfaced as a major factor contributing to reduced life of pavements. As the concern of stripping has increased, so has the number of anti-strip additives, and a need has developed for test methods to accurately evaluate their effectiveness. In evaluating Vermont's present test methods, it is possible the present methods have not effectively progressed to meet the needs of the Agency.

The Vermont Agency of Transportation is aware of the problems of stripping and the need for effective anti-strip additives. In order to find such products, acceptable test methods must be produced to accurately evaluate the effectiveness of these additives. It is the purpose of this report to produce such test methods and documentation to prove their validity.

LITERATURE SEARCH

A literature search was first conducted to evaluate varying methods of tests that are used by several agencies and additive producers to determine the acceptance of anti-strip additives. Following is a list of the users, the methods, and a brief description of the methods that were evaluated in the literature search:

1. Virginia Test Method for Heat Stable Additive Designation VTM-13.

   Description: A 96 hour heat stability test run with reference aggregate and AC-20 viscosity graded asphalt cement. The effectiveness of the additive is determined by a boiling test method.

2. Lancaster Chemical Test Method for Heat Stable Additive.

   Description: A 96 hour heat stability test run with reference aggregate and AC-20 viscosity graded asphalt cement. The effectiveness of the additive is determined by a boiling test method.

3. Louisiana Method of Test for Qualification of Anti-Stripping Additives DOTD Designation TR 317-77.

   Description: A 24 hour heat stability test run with a reference aggregate, AC-40 viscosity graded asphalt cement and 0.5 percent additive only. The effectiveness of the additive is determined by a boiling test method.

4. New York State Tentative Test Method for Determining Possible Stripping Tendencies for Coarse Aggregates - 76.

   Description: A 96 hour heat stability test run with reference aggregate and the specified asphalt cement. The effectiveness of the additive is determined by a boiling test method.

5. Pennsylvania Stripping Test as used by the Nostrip Chemical Works, Inc.

   Description: A 96 hour heat stability test. The effectivenss of the additive is determined with the use of specialized equipment.

6. Arizona Tentative Heat Stability Test for Anti-Stripping Agents. Arizona 507 Oct. 77 as used by the Nostrip Chemical Works Inc.

Description; A 48 hour heat stability run at 300°F.

7. Georgia Test Method for Heat Stable Anti-Strip Additive GHD-56 as used by Carstab Corporation.

   Description; A 96 hour heat stability test. The effectiveness of the additive in determined by a boiling test method.

8. Static Immersion Test as used by Armak Highway Chemical Department.

   Description; Bituminous mix with additive, is immersed in water for 24 hours, and examined for percent of coating.

9. Coating and Stripping of Bitumen Aggregate Mixtures AASHTO Designation: T 182-70.

   Description; A static immersion procedure not intended to be used as a measure of field performance.

10. Vermont Method of Test for Anti-Strip Additive for Heat Stability AOT - MD1-77.

    Description; A 96 hour heat stability test run with reference aggregate and AC-5 viscosity graded asphalt cement. The effectiveness of the additive is determined by a boiling test method, AOT - MD 10-77.

Criteria for acceptance of all the above methods is based on a visual examination at the end of the procedure. The aggregate must remain 95 percent to 100 percent coated.

EVALUATION OF LITERATURE SEARCH

In evaluating the literature search on the ten methods of determining acceptance of anti-strip additives, the following facts were noted:

Eight of the methods use a heat stability method. Of these, six were 96 hour tests, one was a 48 hour test, and one was a 24 hour test. The remaining two methods were static immersion tests. The static immersion test is not recommended to be used as an indication of field performance and therefore were not investigated further.

Of the eight heat stability methods evaluated, six incorporated a boiling procedure to determine the effectiveness of the anti-strip additive before and after heating. One method incorporated an immersion and rotation method that involved special equipment to determine the effectiveness of the additive. Data was not available describing the procedure for evaluating the effectiveness of the Arizona method.

The majority of the methods evaluated incorporated the 96 hour stability procedure and a boiling procedure, to prove the effectiveness of the additive, as one test. Vermont uses the same procedures in two separate tests. The literature search also showed that all of the test methods were to be conducted on reference aggregates and a single grade of asphalt cement only. This limits the scope of the test. It was deduced that it would be more beneficial for Vermont to have methods that could be applied to either actual materials to be used on any specific project or on reference materials for preliminary evaluations of anti-strip additives, at any time.

Vermont's test methods were found to be very similar to the methods that are used by the majority of agencies and additive producers that were investigated. In comparing Vermont's boiling method of test with the other boiling methods, no major discrepancies were found. In comparing Vermont's heat stability test method, two irregularities were noted that could possibly make Vermont's method excessively severe. These were the type of container used for the oven-heating process and the volume of asphalt cement-additive mixture in the container. Vermont was using

100 grams of mixture placed in an 8 ounce single friction top ointment can (seamless), while the other methods analyzed used larger volumes of mixture in triple friction top containers, (one pint paint cans).

The theory was formed that an inadequate seal on the container and the smaller volume of mixture used in Vermont's test method, may cause adverse effects to the mixture during the heating process.

INVESTIGATIVE TESTING PROCEDURE

Extensive testing was conducted to determine what effects the two irregularities have on the test results.

Samples of an 85/100 pen. asphalt cement from BP Oil Limited, Montreal, Que., Canada and an anti-strip additive, Kling Beta XP-251, were prepared using 0.75% additive by weight of asphalt cement.

These samples were tested to determine their original values, as follows: Absolute Viscosity at 140° F, Kinematic Viscosity at 275° F, Penetration at 77° F, and Percent stripping by the Boiling Method, VT-A.O.T. MRD 10-81.

Duplicate samples were then subjected to varying time intervals in the oven at 275° F, at various volumes, one in single friction top cans (ointment cups) and one in triple friction top cans (paint cans). At the end of each interval, the duplicate samples were removed from the oven and their values were tested as they had been prior to heating. Samples were tested before and after for 24, 48, 72, and 96 hour intervals, and in 100, 200, 250, and 300 gram samples of asphalt cement-additive mixture.

INVESTIGATIVE TESTING RESULTS

The results proved that the asphalt cement and additive mixtures in single friction top containers were adversely affected when subjected to heat at all time intervals and volumes tested. The viscosity increased and the penetrations decreased substantially from their original values. The effectiveness of the additive was also decreased dramatically. In some cases the mixtures lost nearly

all ability to resist stripping.

The most dramatic loss of values occurred with the 100 gram samples and decreased as the volume of mixture was increased in the container.

The samples that were in triple friction top cans retained a greater percentage of their values at all intervals and volumes.

Although the triple friction top containers gave better results at all time intervals and volumes, it was evident that varying the volume of mixture had a great effect on all values, in each type of container.

Based on test data, the 300 grams of asphalt cement-additive mixture in triple friction top containers proved to be the combination that would produce the most accurate and representative results. Test results are shown on pages 7 and 8.

Hrs. in Oven	Sample Wt. g.	Type Container	Type Additive	% *** Additive	Pen. 77°F	Abs. Vis. 140°F Poises	Kin.Vis 275°F C.S.	% Coated
ORIGINAL VALUE			XP-251	.75	95	1164	308	100
24	100	SF *	XP-251	.75	78	1656	378	100
24	100	TF **	XP-251	.75	87	1365	323	100
48	100	SF	XP-251	.75	63	2455	429	50
48	100	TF	XP-251	.75	81	1523	350	100
72	100	SF	XP-251	.75	63	2441	429	50
72	100	TF	XP-251	.75	77	1701	314	95
96	100	SF	XP-251	.75	46	4493	539	10
96	100	TF	XP-251	.75	68	2189	383	90

Note: * SF = Single Friction Top (ointment cup)
** TF = Triple Friction Top (paint can)
*** Manufacturer's recommended application rate

Hrs. in Oven	Sample Wt. g.	Type Container	Type Additive	% Additive	Pen. 77°F	Abs. Vis. 140°F Poises	Kin.Vis 275°F C.S.	% Coated
ORIGINAL VALUE			XP-251	.75	95	1164	308	100
24	200	SF	XP-251	.75	87	1373	334	100
24	200	TF	XP-251	.75	92	1232	304	100
48	200	SF	XP-251	.75	95	1193	313	95
48	200	TF	XP-251	.75	88	1341	331	100
72	200	SF	XP-251	.75	91	1254	309	95
72	200	TF	XP-251	.75	93	1367	317	98
96	200	SF	XP-251	.75	76	1723	370	95
96	200	TF	XP-251	.75	85	1428	338	100
ORIGINAL VALUE			XP-251	.75	85	1386	333	100
96	250	TF	XP-251	.75	80	1550	351	100
96	300	TF	XP-251	.75	83	1504	332	100

CONCLUSIONS OF LITERATURE SEARCH AND INVESTIGATIVE TESTING

Evaluation of the literature and the results of the investigative testing conducted, led to the following conclusions:

1. A test for heat stability is a valid test used by the majority of state agencies and the chemical producers checked.

2. A boiling method of test to determine the effectiveness of anti-strip additives is a valid test used by the majority of State agencies and the chemical producers checked.

3. Vermont's present test methods are similar to the majority of the test methods used by other State agencies and the chemical producers checked, with the exception of the two irregularities that were investigated.

4. The majority of the test methods are conducted on reference materials only, which limits their use. Vermont needs methods that can be conducted on any aggregate, asphalt, and additive combination that is applicable.

DEVELOPMENT OF NEW TEST METHODS

To best serve the needs of Vermont, test methods were written to determine the heat stability and the effectiveness of the anti-strip additives based on conclusions formed from the literature search and investigative testing. The methods are as follows:

VERMONT TEST FOR HEAT STABILITY OF ANTI STRIP ADDITIVE IN ASPHALT CEMENT, VT-AOT-MRD 1-81 and VERMONT TEST FOR EFFECTIVENESS OF ANTI-STRIP ADDITIVE IN ASPHALT CEMENT BOILING METHOD, VT-AOT-MRD 10-81. See appendix A and B for tests.

These tests are conducted in conjunction with each other. VT-AOT-MRD 1-81 describes the mixing and heating procedure of an asphalt cement additive mixture and VT-AOT-MRD 10-81 determines the effectiveness of anti-strip additives in asphalt cement before and after heating.

EVALUATION OF NEW TEST METHODS

After the new methods were written, seven different additives were tested at 0.5% additive, to determine the effectiveness of the new methods. Of the seven products tested, six were determined to be heat stable at 96 hours.

The results of the products tested are not to be used as acceptance or rejection of the products. The products were tested only to prove the effectiveness of the new test methods. The samples of additives were obtained from bituminous mix producers with the exception of one, which came directly from the additive producer. Complete manufacturer's data was not furnished with the samples.

The product names and test results are shown on page 11.

Hrs. in Oven	Sample Wt. g.	Type Container	Type Additive	% Additive	Pen. 77°F	Abs. Vis. 140°F Poises	Kin.Vis 275°F C.S.	% Coated
ORIGINAL VALUE			ACRA 500	.5	95	1011	299	
96	300	TF	ACRA 500	.5	88	1191	320	98
ORIGINAL VALUE			Pave Bond LP	.5	94	1083	305	
96	300	TF	Pave Bond LP	.5	86	1174	314	100
ORIGINAL VALUE			Pave Bond Special	.5	90	1131	302	
96	300	TF	Pave Bond Special	.5	93	1117	305	97
ORIGINAL VALUE			Redicote 82-S	.5	94	1041	292	
96	300	TF	Redicote 82-S	.5	92	1142	313	99
ORIGINAL VALUE			Kling-Beta LV	.5	95	1046	287	
96	300	TF	Kling-Beta LV	.5	83	1240	325	80
ORIGINAL VALUE			XP 251	.5	94	1038	284	
96	300	TF	XP 251	.5	85	1216	300	95
96	300	TF	~~Dehydro~~ H-86	.5	—	—	—	98

SUMMARY

Test methods to be used by the Vermont Agency of Transportation have been produced to evaluate anti-strip additives.

These methods were written based on a literature search and extensive testing. The methods are a composite of the most applicable segments of the methods investigated. The test methods are comparable with the methods most used by the Bituminous Industry, which to our knowledge are the best methods available at this time.

These methods are written to accomodate the testing of any combination of aggregate source, grade of asphalt cement and anti-strip additive that is applicable.

The methods were determined to be effective by testing several different additives. The test results indicated that the test methods were neither too lenient nor too severe.

RECOMMENDATIONS

Based on the results of this report, it is recommended that the new test methods be incorporated into the Vermont Standard Specifications, and be applied to all projects requiring the use of heat stable anti-strip additives in bituminous mixtures.

E.L.C.
Prepared by: E. L. Chaffee

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

VERMONT TEST FOR HEAT STABILITY OF ANTI-STRIP ADDITIVE IN ASPHALT CEMENT 96 HOUR METHOD

VT-AOT-MRD 1-81

1. SCOPE

A 96 hour test for checking heat stability of anti-strip additives. Anti-strip additives will be evaluated at 0.5% by weight of the asphalt cement, unless otherwise specified.

2. APPARATUS

2.1 Scale or balance conforming to requirements of AASHTO Designation: M 231 Class D.

2.2 Oven - the oven shall be capable of maintaining a temperature of 275°F (135°C.)

2.3 Container - one pint, triple friction top, can. (Paint can is sufficient.)

2.4 Metal Spatula - six inch.

3. MATERIALS

3.1 Additive; the anti-strip additive to be tested shall contain no ingredients harmful to the bituminous material and shall not alter appreciably the specified characteristics of the bituminous material. It shall be capable of thorough dispersion in the bituminous material.

3.2 Asphalt Cement; the asphalt cement to be used on a specific project will be used for testing the anti-strip additive selected for the project.

An acceptable AC-10 viscosity graded or 85-100 penetration graded asphalt cement will be used for testing when an anti-strip additive is submitted for a preliminary evaluation.

3.3 Aggregate; the aggregate to be used on a specific project will be used for testing the anti-strip additive selected for the project.

A reference aggregate (Barre Granite) will be used for testing when an anti-strip additive is submitted for a preliminary evaluation.

4. PROCEDURE

4.1 Heat asphalt cement to 275°F (135°C).

4.2 Place 300 grams of asphalt cement into a tared, one pint, triple friction top can, that contains the proper amount of anti-strip additive. Stir the mixture thoroughly with a metal spatula for two minutes.

4.3 Using the proper materials, perform Vermont Test for Effectiveness of Anti-Strip Additive in Asphalt Cement - Boiling Method, VT-AOT-MRD 10-81 to determine if the anti-strip additive is acceptable initially.

4.4 Seal the container with the remaining mixture and place in an oven maintained at 275°F (135°C) for a period of 96 hours.

4.5 At the end of 96 hours, remove the container from the oven and repeat Vermont Test for Effectiveness of Anti-Strip Additive In Asphalt Cement - Boiling Method - VT-AOT-MRD 10-81.

5. REPORT

5.1 Visual examination: The anti-strip additive will be considered heat stable when after the 96 hour test period, the aggregate remains 95% to 100% coated.

E.L.C
Prepared by: E. L. Chaffee
Date: March 5, 1981

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

VERMONT TEST FOR EFFECTIVENESS OF ANTI-STRIP ADDITIVE IN ASPHALT CEMENT BOILING METHOD

VT-AOT-MRD 10-81

1. SCOPE

A boiling test for checking the effectiveness of anti-strip additives in asphalt cement.

2. APPARATUS

2.1 Sieves - 3/8 inch (9.5mm) and No. 4 (4.75mm) conforming to requirements of AASHTO DESIGNATION: M 92

2.2 Scale or balance conforming to requirements of AASHTO DESIGNATION: M 231 Class E.

2.3 Burner - Open flame, gas operated. (Bunsen burner)

2.4 Metal spatula - six inch.

2.5 Container - metal seamless, 8 oz. capacity.

2.6 Stopwatch - accurate to the nearest second.

2.7 Metal thermometer - range $50^{o}F$ to $500^{o}F$.

3. MATERIALS

3.1 Additive; the anti-strip additive to be tested shall contain no ingredients harmful to the biutminous material and shall not alter appreciably the specified characteristics of the bituminous material. It shall be capable of thorough dispersion in the bituminous material.

3.2 Asphalt Cement; the asphalt cement to be used on a specific project will be used for testing the anti-strip additive selected for the project.

An acceptable AC-10 viscosity graded or 85-100 penetration graded asphalt cement will be used for testing when an anti-strip additive is submitted for a preliminary evaluation.

3.3 Aggregate; the aggregate to be used on a specific project will be used for testing the anti-strip additive selected for the project.

A reference aggregate (Barre Granite) will be used for testing when an anti-strip additive is submitted for a preliminary evaluation.

3.4 Distilled Water.

4. PROCEDURE

4.1 Obtain sample of aggregate from the stockpile using method outlined in the Vermont Materials Sampling Manual.

4.2 Quarter the sample in accordance with AASHTO DESIGNATION: T 428 Method for Reducing Field Sample of Aggregate to Testing Size.

4.3 Sieve aggregate through the 3/8 inch (9.5mm) and number 4 (4.75mm) sieves.

4.4 Weigh out 200 grams of material retained on the number 4 (4.75mm) sieve.

4.5 Place the ~~200 grams of aggregate in the mixing container and heat to~~ 275°F (135°C).

4.6 Heat asphalt cement to 275°F (135°C).

4.7 To the heated aggregate add 10 grams of preheated asphalt cement containing the correct proportion of anti-strip additive. Mix contents vigouously with a metal spatula until uniformly coated. No bare spots are permissable.

4.8 Let the coated aggregate cool to room temperature.

4.9 Add distilled water to the container, containing the sample, completely

submerging the coated stone.

4.10 Place container over open flame and bring water to a full, rolling boil. Start stopwatch at this point and boil for one minute. After time has elapsed, remove container from the open flame and immediately rinse contents with tap water until cool. Drain off the water and examine.

5. REPORT

5.1 Visual examination: The anti-strip additive will be considered effective when the aggregate remains 95% to 100% coated after the procedure is completed.

Prepared By: E. L. Chaffee
Date: January 12, 1981

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

RESEARCH INVESTIGATION

Work Plan No. 81-B-1

Subject Anti-Strip Additives (testing procedures)

Investigation Requested By Materials & Research Engineer Date January 12, 1981

Date Information Required March 1, 1981

Purpose of Investigation To determine acceptable test methods to be used by the Vermont Agency of Transportation to prove effectiveness of anti-strip additives.

Proposed Tests or Evaluation Procedure

1. Evaluate Method of Test for Anti-Strip Additive for Heat Stability - Vermont AOT - MD 1.
2. Evaluate Method of Test for Anti-Strip Additive, Boiling Method - Vermont AOT - MD 10.
3. Literature Evaluation of other existing test procedures.
4. Produce test procedures based on the above evaluations that will serve the needs of the Vermont Agency of Transportation.
5. Evaluate the new test procedures by testing various additives and aggregates.

Proposal Discussed With C. Jerd & R. Frascoia Projected Manpower Requirements 35 man-days

Investigation To Be Conducted By W. Royce, D. Day, & E. Chaffee

Proposed Starting Date Jan. 12, 1981 Estimated Completion Date March 1, 1981

Approval/Disapproval by Materials & Research Engineer K. H. Nicholson 1/28/81

Comments by Materials & Research Engineer

Materials & Research Division
Agency of Transportation
Date Typed: January 27, 1981