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16. Abstract

This report contains a description of the development and use of the Texas Boiling Test to evaluate stripping of materials susceptible to moisture damage. Included is a review and comparison of boiling tests currently in use by several agencies and a recommended tentative test procedure. Preliminary testing indicated that three factors related to testing were important. These factors were the number of times the aggregateand asphalt was heated and mixed before testing, the initial temperature to which the aggregate was heated prior to mixing, and the type of water used for boiling. These three factors were investigated to determine the effect of their variation on test results.

Tests were performed on eight mixtures of which five had stripped in the field and three had not. Each mixture and its individual aggregate components were tested to determine whether the results could be used to differentiate between stripping and nonstripping mixtures. Based on these tests and other field testing it was tentatively concluded that mixtures that retained less than 70 percent of the asphalt on the aggregate are moisture susceptible and require treatment.

Test results indicate that valuable information is provided by the Texas Boiling Test. The test is simple and easy to perform; it can be performed either in the laboratory during mixture design or on the field-mixed materials. In general, the Texas Boiling Test offers good potential for use in detecting moisture susceptible mixtures before they are placed in the field.

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by

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Moisture Effects on Asphalt Mixtures
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conducted for

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in cooperation with the
U. S. Department of Transportation
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The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

PREFACE

This is the fifth in a series of reports dealing with the findings of a research project concerned with moisture effects on asphalt mixtures. This report describes the Texas Boiling Test and includes a description of the Texas Boiling Test Procedure. The objectives of the study were to define and evaluate the test procedure, adapt it for use by a highway agency, and evaluate the test results to determine if the results can be used to differentiate between stripping and nonstripping asphalt mixtures.

The work required to develop this report was provided by many people. Special appreciation is extended to Messrs. Pat Hardeman and Eugene Betts for their assistance in the testing program. In addition, the authors would like to express their appreciation to Messrs. Paul E. Krugler and Billy R. Neeley of the Texas Department of Highways and Public Transportation for their suggestions, encouragement, and assistance in this research effort and to other personnel who provided the asphalt cements, their physical properties, and the various aggregates used in the testing program. Appreciation is also extended to the Center for Transportation Research staff who assisted in the preparation of the manuscript. The support of the Federal Highway Administration, Department of Transportation is acknowledged.

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LIST OF REPORTS

Report No. 253-1, "Stripping and Moisture Damage in Asphalt Mixtures," by Robert B. McGennis, Randy B. Machemehl, and Thomas W. Kennedy, summarizes a study to determine the extent, nature, and severity of moisture related damage to asphalt mixtures used in pavements in Texas.

Report No. 253-2, "An Evaluation of the Asphaltene Settling Test," by Thomas W. Kennedy and Chee-Chong Lin, summarizes a testing program designed to evaluate the Asphaltene Settling Test, the test procedure, factors affecting the test results, and relationships between settling time and asphalt characteristics.

Report No. 253-3, "Texas Freeze-Thaw Pedestal Test for Evaluating Moisture Susceptibility for Asphalt Mixtures," by Thomas W. Kennedy, Freddy L. Roberts, Kang W. Lee, and James N. Anagnos, includes a detailed description of the Texas Freeze-Thaw Pedestal Test and describes how it can be used to distinguish between stripping and nonstripping asphalt concrete mixtures or individual aggregates.

Report No. 253-4, "Lime Treatment of Asphalt Mixtures," by Thomas W. Kennedy and James N. Anagnos, summarizes information related to stripping of asphalt mixtures and the use of hydrated lime as an antistripping agent and makes recommendations concerning the construction techniques for adding lime.

Report No. 253-5, "Texas Boiling Test for Evaluating Moisture Susceptibility of Asphalt Mixtures," by Thomas W. Kennedy, Freddy L. Roberts, and James N. Anagnos, includes a detailed description and evaluation of the Texas Boiling Test Method and also describes how it can be used to distinguish between stripping and nonstripping asphalt concrete mixtures or individual aggregates.

ABSTRACT

This report contains a description of the development and use of the Texas Boiling Test to evaluate stripping of materials susceptible to moisture damage. Included is a review and comparison of boiling tests currently in use by several agencies and a recommended tentative test procedure. Preliminary testing indicated that three factors related to testing were important. These factors were the number of times the aggregate and asphalt was heated and mixed before testing, the initial temperature to which the aggregate was heated prior to mixing, and the type of water used for boiling. These three factors were investigated to determine the effect of their variation on test results.

Tests were performed on eight mixtures of which five had stripped in the field and three had not. Each mixture and its individual aggregate components were tested to determine whether the results could be used to differentiate between stripping and nonstripping mixtures. Based on these tests and other field testing it was tentatively concluded that mixtures that retained less than 70 percent of the asphalt on the aggregate are moisture susceptible and require treatment.

Test results indicate that valuable information is provided by the Texas Boiling Test. The test is simple and easy to perform; it can be performed either in the laboratory during mixture design or on the field-mixed materials. In general, the Texas Boiling Test offers good potential for use in detecting moisture susceptible mixtures before they are placed in the field.

KEY WORDS: stripping, water damage, boiling test, asphalt mixtures, stripping aggregates, stripping mixtures

SUMMARY

The Texas Boiling Test was developed as a quick laboratory test that could be used to determine if a proposed asphalt-aggregate mixture is prone to stripping. The procedure tests the moisture susceptibility by evaluating the amount of asphalt that remains after boiling a sample of the asphalt mixture according to a definite recommended procedure. The amount of asphalt retained is visually determined by comparing the tested sample to a standard scale and the percent asphalt retained on the aggregates is determined.

The purpose of this research was to develop a rapid laboratory test procedure that could be used to determine and evaluate the water susceptibility of asphalt paving mixtures. The recommended test procedure is a composite of boiling tests used by several states and is described in this report.

Using the Texas Boiling Test, a series of tests was performed using five stripping and three nonstripping mixtures. The results demonstrate an ability to distinguish between stripping and nonstripping aggregate-asphalt mixtures.

IMPLEMENTATION STATEMENT

Tentative evaluations indicate that the Texas Boiling Test can be used to determine quickly whether a mixture is prone to stripping. Therefore, it is recommended that the Districts of the Texas State Department of Highways and Public Transportation use the test procedure, on a trial basis, to evaluate mixtures selected for use in construction projects. As a result of this trial use, needed modifications and improvements can be made to improve the ability of the test to detect mixtures which are susceptible to moisture damage and to evaluate antistripping agents.

If the test is as successful in detecting stripping aggregates as preliminary laboratory results suggest, significant savings in construction and maintenance costs and improved pavement performance can be achieved.

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CHAPTER 1. INTRODUCTION

Water-induced damage of asphalt mixtures has produced serious distress, reduced performance, and increased maintenance for pavements in Texas, as well as in other areas of the United States. This damage occurs due to stripping of asphalt from aggregate and in some cases possibly due to softening of the asphalt matrix. Moisture-induced damage produces several forms of distress including localized bleeding, rutting, shoving, and ultimately complete failure due to permanent deformations and cracking. The two basic forms of moisture-related distress are stripping and softening.

Stripping, which is of primary concern, is the physical separation of the asphalt cement and aggregate produced by the loss of adhesion between the asphalt cement and the aggregate surface primarily due to the action of water or water vapor. Stripping is accentuated by the presence of aggregate surface coatings and by smooth surface textured aggregates. Softening is a general loss of stability, strength, and stiffness of a mixture that is caused by a reduction in cohesion due to the action of moisture within the asphalt matrix.

Field and laboratory experience to date (Refs. 1 through 6) indicates that while stripping is primarily an aggregate problem, the type of asphalt is also important. Thus, it is necessary to evaluate the mixtures with both the asphalt and the aggregate proposed for use. In addition, attempts to reduce the magnitude of the problem often have centered on introducing various antistripping additives to asphalt mixtures. Unfortunately, there has been no generally accepted, reliable way to evaluate proposed aggregate-asphalt combinations to determine their water susceptibility.

In response to the above problem, the Center for Transportation Research (CTR) and the Texas Department of Highways and Public Transportation (DHT), through their cooperative research program, initiated a research project to study water-induced damage of asphalt mixtures in Texas. This study included an evaluation of proposed test methods for ascertaining the water susceptibility of asphalt mixtures and the effectiveness of antistripping agents.

As a result of the study three tests were identified and were found to provide significant information with respect to distinguishing between known stripping and known nonstripping mixtures. These tests are

Texas Freeze-Thaw Pedestal Test

Texas Boiling Test

Wet-Dry Indirect Tensile Test

The Texas Boiling Test is a rapid method to evaluate the moisture susceptibility of an aggregate-asphalt mixture prior to using the mixture in the field. The Texas Freeze-Thaw Pedestal Test is described in References 3 and 6 and the Wet-Dry Indirect Tensile Test is contained in Reference 5. This report summarizes the development of the Texas Boiling Test procedure and the findings of studies to evaluate its effectiveness. Chapter 2 contains the test procedure and Chapter 3 summarizes the evaluation of the test and its effectiveness.

CHAPTER 2. DEVELOPMENT AND EVALUATION OF THE TEXAS BOILING TEST

The Texas Boiling Test is a rapid method to evaluate the moisture susceptibility, stripping of aggregate-asphalt mixtures, with and without antistripping agents, and is a composite of the procedures described in References 7 through 10, and summarized in Table 1. In this test a visual observation is made of the extent of stripping of the asphalt from aggregate surfaces after the mixture has been subjected to the action of boiling water for a specified time. After reviewing the various test methods and performing a preliminary evaluation, the best features of each procedure were synthesized to produce a test procedure that would minimize potential field problems while minimizing the difficulty and cost of performing these laboratory tests. The standard procedure used in this study was designed for evaluating both the potential stripping mixtures and the effect of adding antistripping additives. The standard procedure is included in Chapter 3.

This procedure was developed at the Center for Transportation Research while at the same time the Materials and Tests Division (D-9) developed and published Tex-530-C, the official Department procedure. There are a number of differences in the two procedures. Those most likely to be significant involve the preconditioning of the asphalt cement, differences in mixing temperature and time, and agitation of the test sample during boiling.

The effect of three major test variables were considered in developing the Texas Boiling Test procedure. These variables were the number of times the asphalt and aggregate are mixed, the temperature to which the aggregate is heated prior to mixing, and the type of water used to boil the mixture.

AGGREGATE

Aggregate mixtures consist of several materials that are blended naturally or by the contractor to satisfy grading requirements. These individual materials and the total mixture vary in size, shape, surface texture, and chemical composition. The test method allows the individual materials and the total mixture to be evaluated.

TABLE 1. COMPARISONS OF BOILING TEST PROCEDURES FROM DIFFERENT SOURCES

Test Factors		Shah (7) I	Shah (7) II	Louisiana DOT (Ref 5) TR 3/7-77	Virginia DOT (Ref 4) VTM-13	Texas DHT (Ref 3)
Evaluation of		Stripping or Additives		Additives Only	Additives Only	Stripping or Additives
Aggregate		Complete Mixture	-3/8 - #4	-3/8 - #4	Standard aggregate 50:50 of #8 and #10 Quartzite (14g ea)	Tex-205-F
Asphalt		Desired asphalt content by TR 3-3-71	4% AC-40 & AC-10	AC-40 5g (AC + additive)	AC-20 6% treated asphalt (18g)	
Additive		0.5%	0.5%	0.5%	Not to exceed 1.0%	----
Temperature and Time	Aggregate	----*	----	325°F for 1 - 1½ hrs	----	275°F
	Binder	----	----	325°F for 24 - 26 hrs	275°F for 96 hrs	250°F
Mixing Method		Manually or mechanically	----	Manually	Manually on hot plate	Manually or mechanically
Mixture, Weight		----	----	100g	300g	Approx. 500g
Cooling Before Boiling		----	----	2 hrs	----	24½ hrs
Specimen Weight		----	----	----	----	100g
Boil in Water		10 min	10 min in 60°C water bath	10 min in 400cc beaker half full	10 min	10 min in 400 cc beaker half full
Report		Avg. visual ratings from panel. No more than 5% stripping acceptable.	Avg. visual rating from panel.	Compare stripping of test mixture to that of reference mixture Accept if less.	No signs of stripping acceptable.	Visual estimate immediately and after 24 hrs.

* No statement in test procedure on this factor.

Individual Aggregates

When an individual aggregate is to be evaluated, most of the boiling test procedures specify that the particles passing the 3/8-inch sieve and retained on the No. 4 sieve be used. The proposed Texas Boiling Test permits testing individual component materials in each of the following four categories:

(1) passing 3/8-inch retained on No. 4,

(2) passing No. 4 retained on No. 10,

(3) passing No. 10 retained on No. 40, and

(4) passing No. 40 retained on No. 80.

Additional size ranges can also be tested if needed.

Total Aggregate Mixture

When evaluating the total mixture, the sample should have the same gradation as proposed for construction, aggregates greater than 7/8 inch are normally eliminated. Care should be taken in the evaluation to ensure that a proper determination is made of the amount of asphalt retained on the aggregate since the fine aggregates have a significant effect on the visual appearance of the mixture.

ASPHALT CEMENT

Both the type and amount of asphalt cement influence stripping and test results.

Type and Source

The asphalt cement should be the same as that proposed for use during construction. It is recommended that the asphalt-aggregate mixture be retested if the source or type of asphalt changes.

Asphalt Content

To evaluate the total aggregate mixture, the aggregates should be blended according to the specified project gradation and the asphalt content should be that determined by Tex-204-F (Ref. 6) or other design procedures. When the individual components of the mix are evaluated, a constant asphalt content can produce different film thicknesses since the design asphalt content varies with the size, shape, absorption, and surface area (Ref. 7) of the aggregate being tested. To produce an asphalt film thickness for an individual aggregate which approximates the film thickness for the total mixture, the asphalt content should be increased or decreased until the proper film thickness, as determined visually, is secured. This can be done by visually ensuring that all particles are coated and that excess asphalt is not left in the mixing pan. Future refinements could consider the surface area of the aggregates as a means of establishing asphalt content for individual aggregates.

MIXTURE PREPARATION

The asphalt cement, with or without antistripping agents, is heated at 325 ± 5°F for 24 to 26 hours. This will cause some hardening of the asphalt and, therefore, more closely simulate asphalts which have been plant mixed. More important, however, heating will evaluate the temperature stability of antistripping agents in the asphalt. For the evaluation of the total aggregate mixture, 300 g should be used; for the evaluation of an individual aggregate component, 100 g of material should be utilized. The dry aggregate is heated at 325 ± 5°F for 1 to 1-1/2 hours. At the appropriate time the asphalt cement is added to the aggregate and mixed manually on a hot table. The mixture is allowed to cool at room temperature (75°F) for at least 2 hours before testing.

TEST PROCEDURE

A 1,000 ml beaker is filled one-half full (approximately 500 cc) with distilled water and heated to boiling. The prepared aggregate-asphalt mixture at 75°F (room temperature) is added to the boiling water which will temporarily lower the temperature below the boiling point. The heat should be increased so that the water reboils in approximately 2 to 3 minutes. The water should be maintained at a medium boil for 10 minutes, stirring with a glass rod at 3-minute intervals. During and after boiling, the stripped asphalt should be skimmed away from the surface of the water with a paper towel to prevent recoating of aggregate. The mixture is then allowed to cool to room temperature (75°F) while still in the beaker. After cooling, the water is drained from the beaker and the wet mixture is emptied onto a paper towel and allowed to dry.

A possible refinement would involve the use of a larger container to eliminate the need for physically stirring the mixture and provide greater surface area exposure of the mixture during boiling.

EVALUATION AND REPORTING

The amount of stripping is determined by a visual rating, expressed in terms of the percent of asphalt retained (scale 0 to 100 percent retained). Such a rating is subjective and will vary with time and for different operators. To standardize the evaluation, a standard rating board (Fig. 1) has been developed with 10 intervals from 0 to 100 percent retained. This scale is constructed using a set of specimens which have been selected to provide visual examples of varying degrees of stripping which can be compared to the test specimen to obtain a test value. The mixture should not be evaluated until air dried since laboratory results have shown that stripping of the fines in some mixtures is not as apparent if the mixture is wet.

ANALYSIS OF CRITICAL TEST VARIABLES

Initial laboratory evaluation of the test method indicated that test results were sensitive to three test variables. The three variables were the number of times the asphalt and aggregate were mixed, the temperature to which the aggregate was heated before mixing, and the type of water used to boil the mixture. Thus, these variables were evaluated to determine their effects and to establish the procedure to be used.

Number of Times Mixed

Boiling test results indicated that reheating and remixing the asphalt-aggregate mixtures dramatically increased the amount of asphalt retained (Fig. 2). A set of specimens, prepared from seven individual aggregates and one mixture, were prepared by mixing the aggregates and asphalt once, a second set of specimens were prepared that were mixed, reheated, and mixed again, and a third set of specimens were prepared that were mixed three times. The results are summarized in Table 2a and Figure 3. As shown, the amount of retained asphalt was greater for mixtures which were reheated and remixed. In addition, the separation between stripping and nonstripping mixtures was best when specimens were mixed once. The standard procedure,

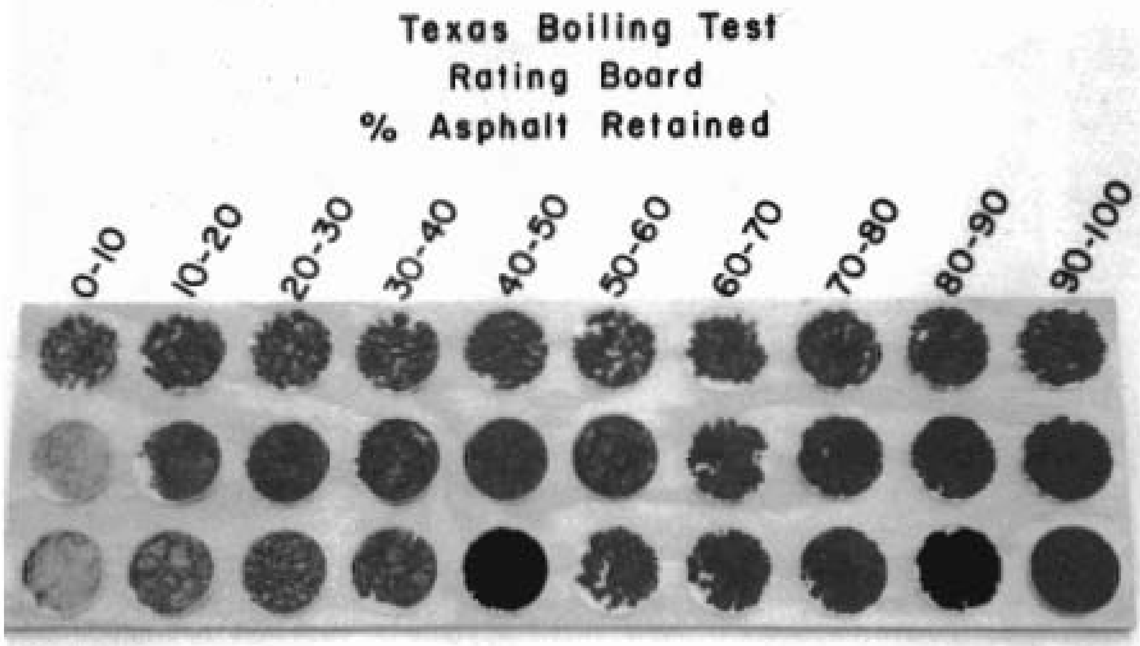

Fig 1. Texas Boiling Test Rating Board.

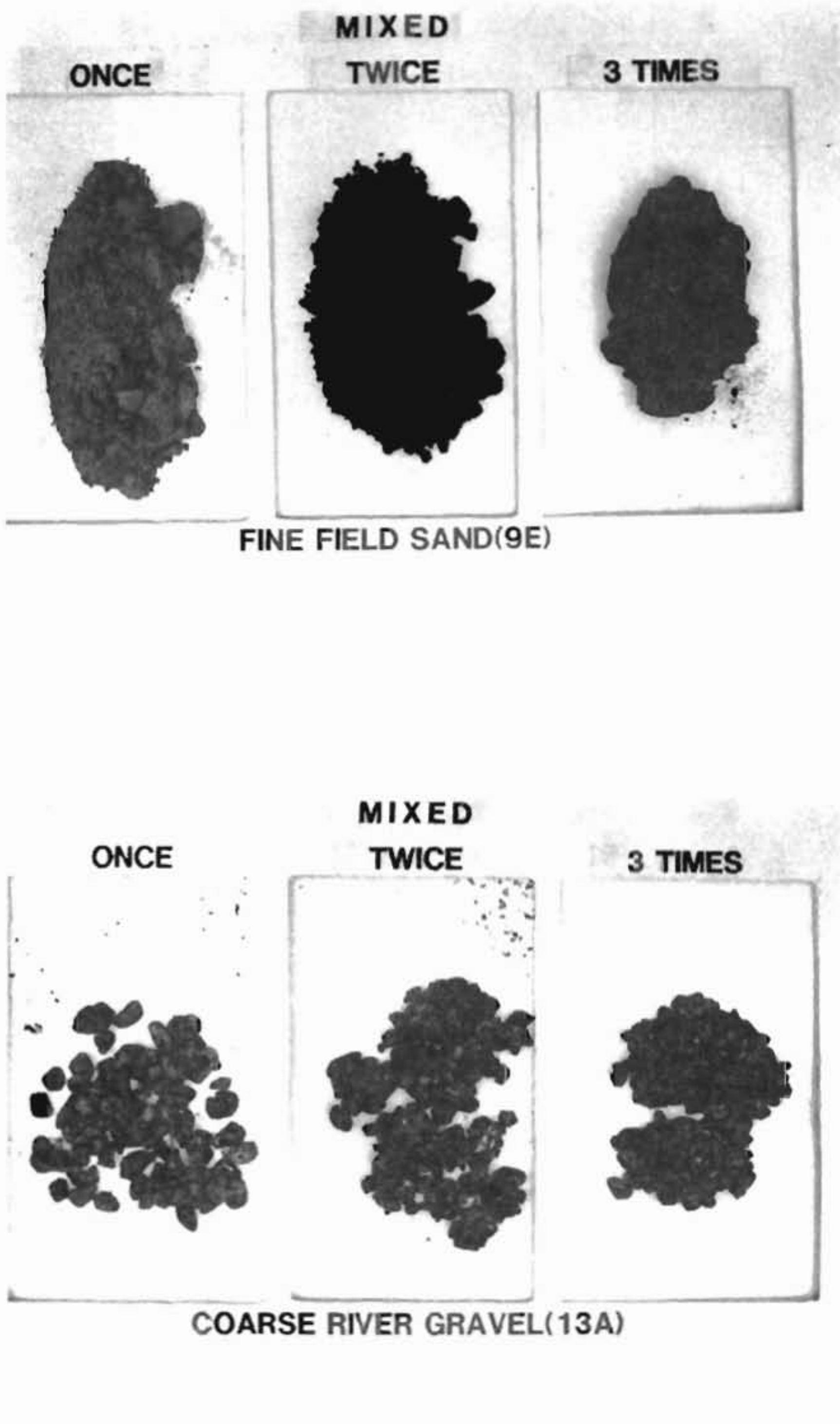

Fig 2. The effect of number of times mixed on Texas Boiling Test.

TABLE 2. SUMMARY OF RESULTS FOR THE EFFECT OF MIXING TIMES AND INITIAL AGGREGATE TEMPERATURE

a. Number of Times Mixed

Field Performance	Individual Aggregates and Mixture	Aggregate Size	Asphalt Content %	Asphalt Retained, %		
				Mix Once	Mix Twice	Mix 3 Times
Stripping	River gravel, 9D	-3/8 + 4	2.3	45	65	95
	Washed sand, 9F	-10 + 40	6.3	15	35	85
	Field sand, 9E	-40 + 80	6.3	15	75	95
	Coarse river gravel, 13A	-3/8 + 4	3.0	5	75	75
	Coarse field sand, 13C	-10 + 40	7.0	15	75	75
	Combined mixture, 13A & C		6.0	35	65	85
Nonstripping	Coarse crushed limestone, 14I	-3/8 + 4	3.4	75	75	85
	Limestone screening, 14K	-4 + 10	3.4	75	85	95

b. Initial Aggregate Temperatures

Field Performance	Individual Aggregate	Aggregate Size	Asphalt Content %	Asphalt Retained, %		
				200°F	250°F	325°F
Stripping	Field sand, 9E	-40 + 80	0.3	15	15	55
	Coarse field sand, 13C	-10 + 40	7	25	25	65
	Gem sand, 13M	-3/8 + 4	3	5	5	26
	Coarse sand, 13N	-10 + 40	7	15	25	65
Nonstripping	Sandstone, 13L	-3/8 + 4	3	35	35	85
	Field sand, 13O	-40 + 80	7	85	65	85

* Size range of individual aggregates.

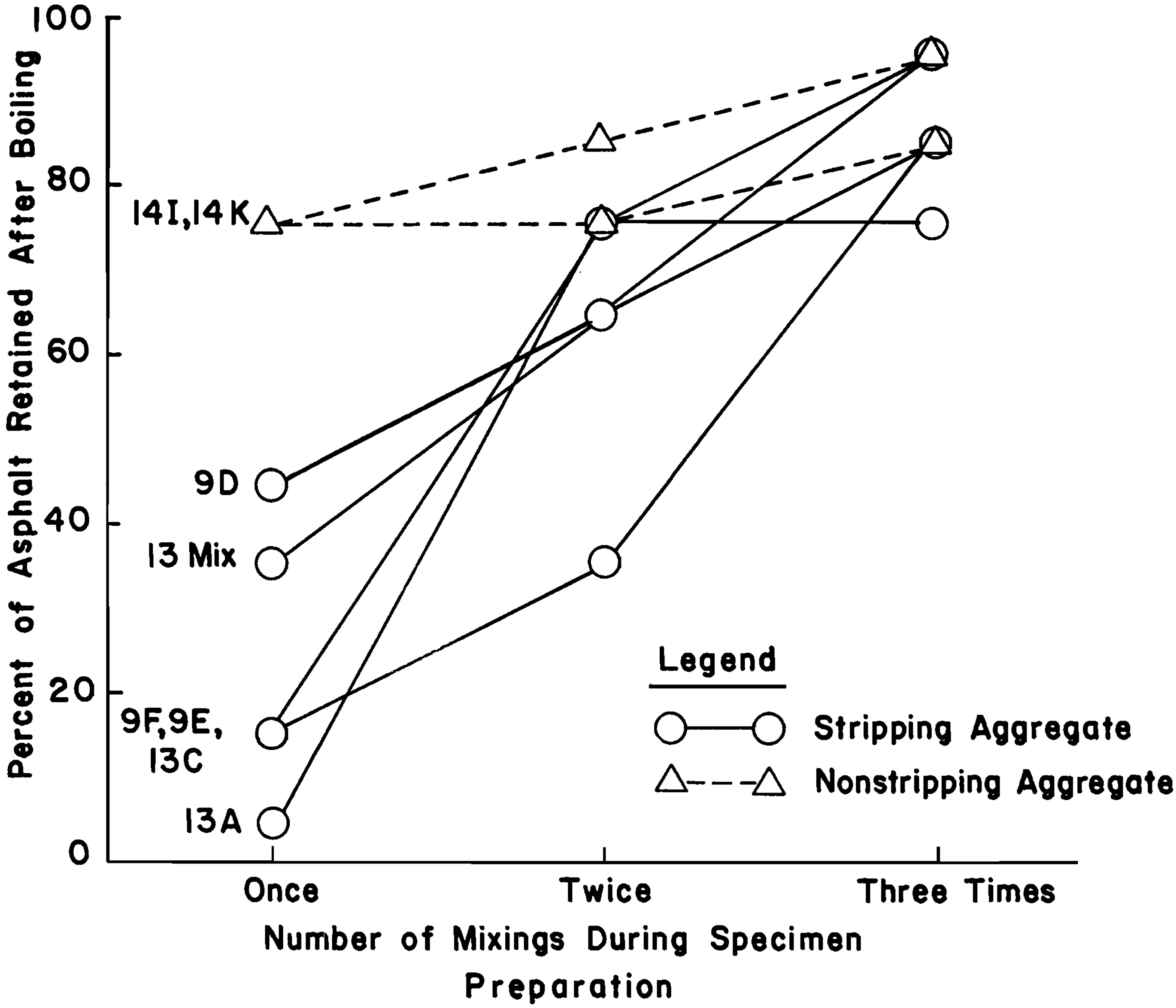

Fig 3. Effect of number of times mixed on Texas Boiling Test.

therefore, involves mixing the asphalt and aggregate only once before cooling and boiling.

Some difficulty in coating larger aggregates may be experienced.

Mixing Temperature

In addition, the effect of the initial aggregate temperature (mixing temperature) was evaluated. A series of boiling test specimens were prepared with aggregates heated to either 200°F, 250°F, or 325°F, and then mixed with asphalt cement at 325°F. After mixing and cooling, each mixture was boiled and the amount of asphalt retained was determined. The results indicated that a greater amount of asphalt was retained when the aggregate and resulting mixing temperatures were higher (Table 2a and Figs. 4 and 5). Therefore, in the standard boiling test procedure both the aggregates and the asphalt cement are heated to 325°F before mixing.

Water for Boiling

A comparison of test results obtained using distilled water and tap water indicated that dramatically different results can be obtained and that the type of water also produces effects (Fig. 6). Similar effects were also reported by personnel of the Alabama Department of Transportation (Ref. 9). Thus, the standard procedure utilizes distilled water.

STANDARD TEST PROCEDURE

(1) Scope

(1.1) The method is used as a screening device to evaluate the moisture susceptibility of an asphalt concrete mixture by visually estimating the degree of stripping after boiling in distilled water. The procedure can also be used to evaluate the effectiveness of antistripping additives added to moisture-susceptible mixtures.

(2) Apparatus

(2.1) Oven - an electric oven capable of maintaining a temperature of 163 ± 2.8°C (325 ± 5°F) is used to heat the asphalts and to heat or dry the aggregates.

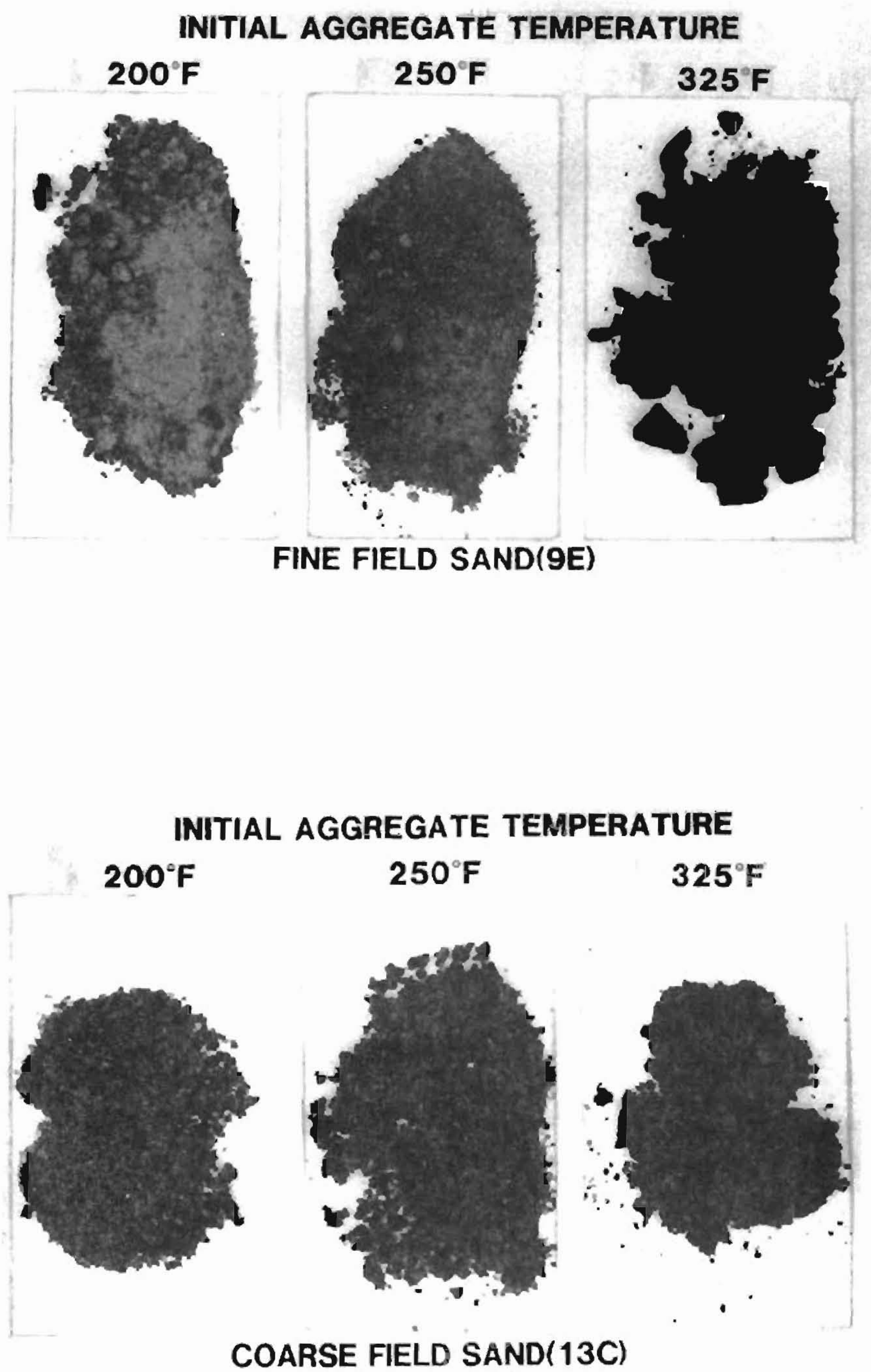

Fig 4. The effect of initial aggregate temperatures of aggregate on Texas Boiling Test.

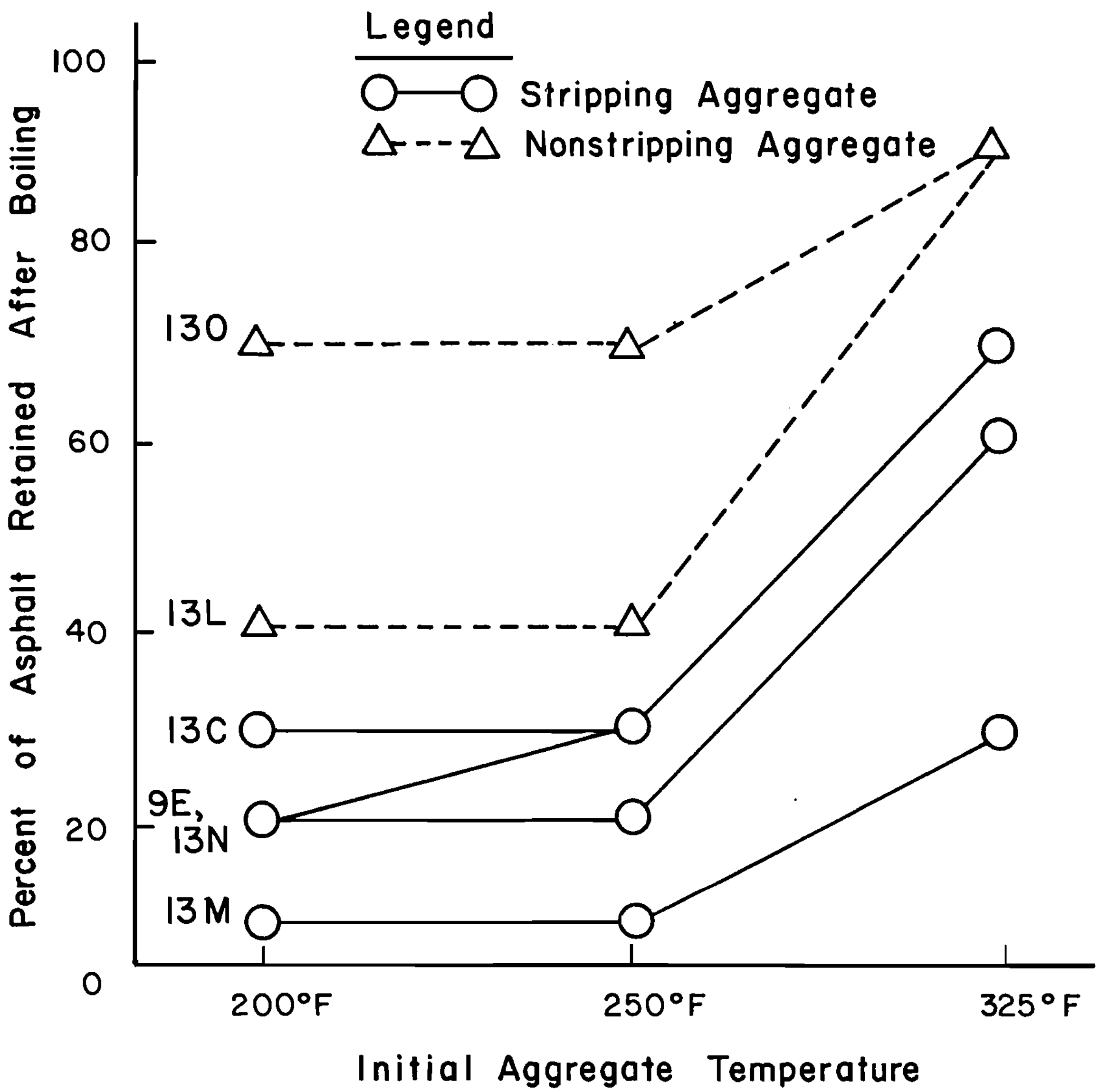

Fig 5. Effects of initial aggregate temperatures on the Texas Boiling Test.

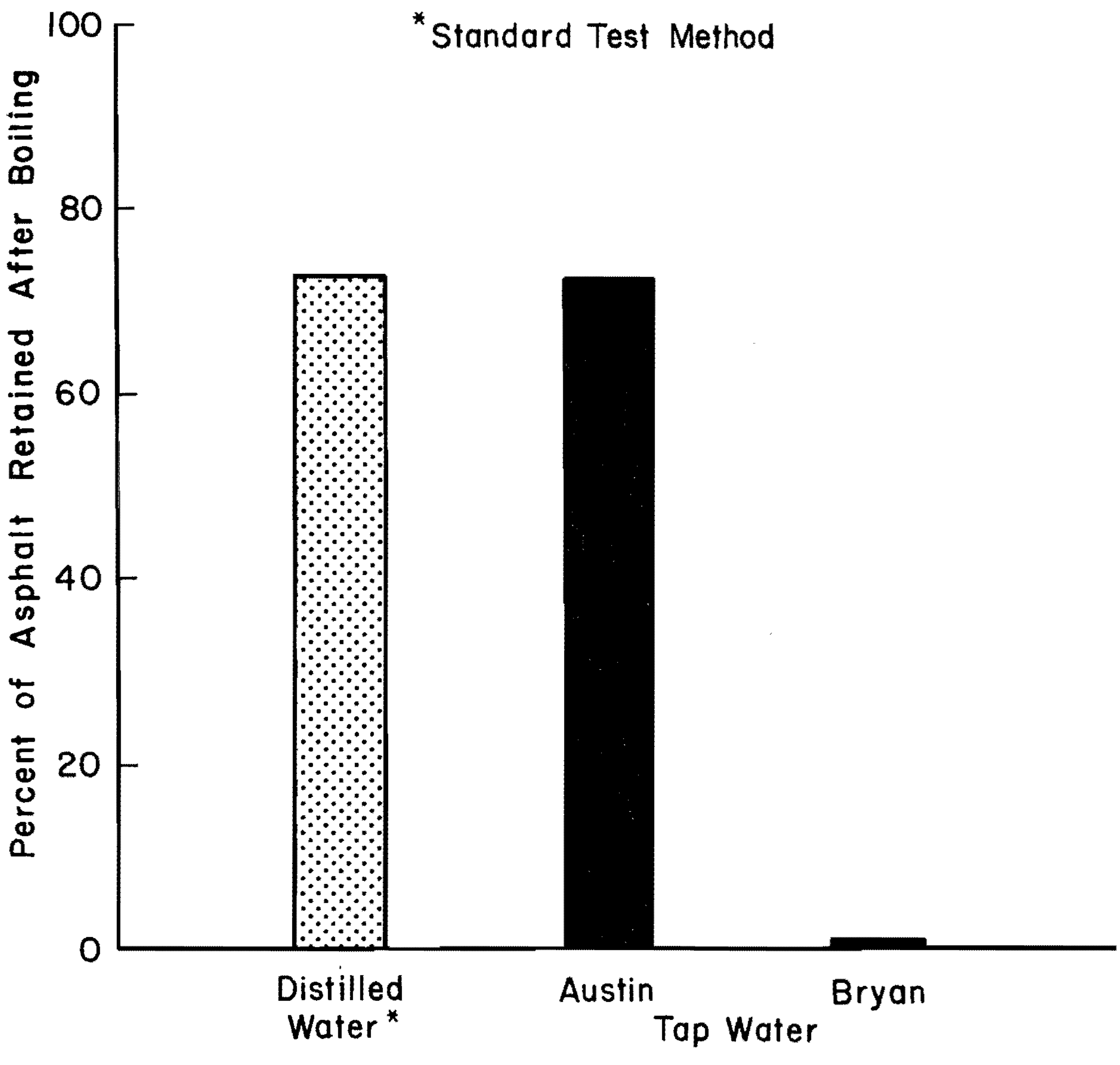

Fig 6. Effects of type of water on the Texas Boiling Test.

(2.2) Sample Mixing Apparatus - suitable equipment for hand mixing the aggregate and asphalt is required and includes round mixing pans of various sizes, small masonry pointed trowels, and spatulas.

(2.3) Balance - a balance with a capacity of 5 kg that is sensitive to at least 0.1 grams.

(2.4) Hot Table - an electric hot table capable of maintaining a temperature during mixing.

(2.5) Beaker - a 1,000 ml beaker, capable of being heated.

(2.6) Source of Heat - a heat source consisting of a burner or an electric heater, with beaker support or an oil bath with an internal chamber capable of holding 500 cc of distilled water and the sample.

(2.7) Miscellaneous Apparatus - stop watches, scoops, gloves, paper towels, and aluminum foil.

(3) Preparation of Specimen Mixture

(3.1) Selection of Asphalt Content - Determine the optimum asphalt content for the asphalt-aggregate mixture for which the individual aggregate or mixture is a part by performing test method Tex-204-F (Ref. 6) or other design method. If some of the aggregate is not coated well or if the mixture appears rich, increase or decrease the asphalt cement content respectively until a satisfactory mixture is secured, i.e., all aggregates are coated and no excess asphalt is left on the mixing bowl.

(3.2) Preparation of Aggregates - If a mixture is to be evaluated, the mixture must have components representative of each of the aggregate sources and sizes. All materials should be combined in the specimen mixture in the same gradation that they occur in the field mixture. If an individual aggregate is being evaluated, use the fraction passing the 9.52 mm (3/8 inch) and retained on the 4.76 mm (No. 4) sieves. If the predominance of the material is smaller than the No. 4, a finer fraction can be tested, e.g., the interval between the No. 40 and No. 80 sieves.

(3.3) Adding Antistripping Additives - If an antistripping additive is to be evaluated, it must be either blended with the asphalt or placed on the aggregate before final mixing. In case of blending with the asphalt, the asphalt needs to be preheated at 135 to 149°C (275 to 300°F). Pour 100 g of asphalt into a 6-ounce can. Add the desired amount of antistripping additives as a weight percent of the asphalt. Immediately stir the two materials with a small spatula for approximately 2 minutes.

(3.4) Preparation of Mixtures - Weigh out 300 g of the mixture aggregates or 100 g of an individual aggregate. Heat the asphalt cement at 163 ± 2.8°C (325 ± 5°F) for 24 to 26 hours, and heat the aggregate at 163 ± 2.8°C (325 ± 5°F) for 1 to 1-1/2 hours. After both materials are hot, pour the required asphalt cement into the preweighed aggregate, which is in a metal container on the hot table. Mix the aggregate and asphalt by hand as thoroughly and rapidly as possible. Transfer the mixture to a piece of aluminum foil and allow to cool at room temperature (75°F) for 2 hours.

(4) Test Procedure

(4.1) Boiling Mixture in Water - Fill a 1,000 ml beaker one-half full (500 cc) with distilled water and heat to boiling. Add the mixture to the boiling water. Addition of the mixture will temporarily cool the water below the boiling point. Apply heat at a rate such that the water will reboil in not less than 2 or more than 3 minutes after addition of the mixture. Maintain the water at a medium boil for 10 minutes, stirring with a glass rod 3 times during boiling, then remove the beaker from the heat. During and after boiling dip a paper towel into beaker to skim any stripping asphalt from the surface of the water. Cool to room temperature (75°F), drain the water from the beaker, and empty the wet mix onto a paper towel and allow to dry.

(4.2) Visual Observation - Visually estimate the percent cement retained after boiling by comparing the specimen with a standard rating scale (Fig. 1). A photograph should not be used. The mixture should also be examined on the following day after it has been allowed to dry since stripping of the fines is not as apparent when the mixture is still wet.

NOTE: The standard rating scale (Fig. 1) consists of samples that represent various degrees of stripping selected to provide examples at 10 percent intervals ranging from 0 percent to 100 percent retained asphalt cement.

(5) Report

(5.1) The percent asphalt retained after boiling should be based on a comparison with the standard scale, not a photograph. Select the specimen nearest in appearance to the test specimen and report that as the test result.

CHAPTER 3. APPLICATION OF BOILING TEST TO EVALUATE MATERIALS

MATERIALS

Eight project mixtures from seven Texas highway department districts were selected for use in this study. Of these eight projects, five previously exhibited stripping in the field and three did not. The stripping mixtures were from the Waco, Lufkin, Yoakum, Houston (Harris County), and Lubbock districts. The major components of these stripping mixtures were silicious river gravel and sand. The nonstripping mixtures were from the Houston (Galveston County), Austin, and Atlanta districts. The major components of these nonstripping mixtures were crushed limestone, caliche, or slag. The composition of each mixture by aggregate type and percentage is shown in Table 3. The asphalt cements included in the testing program were the same as those used in the pavement constructions.

AGGREGATE GRADATION

The gradations for materials used to prepare specimens for the boiling test are the same as those used in construction. The Yoakum and Lubbock materials met the requirements of Grade 1 flexible base Item 238 (processed gravel) and Item 232 (caliche), respectively (Ref. 8). Gradations of the other six materials met the requirements of Type D surface course paving mixtures.

EVALUATION OF MIXTURES

The aggregates and asphalt cements described above were used to determine whether results from the Texas Boiling Test can be used to differentiate between stripping and nonstripping asphalt-aggregate mixtures.

Project gradations were used to prepare 300 g specimens to evaluate stripping. Results for each of the eight mixtures are shown in Figure 7. All mixtures that experienced stripping in the field retained less than 70 percent asphalt after boiling. The nonstripping mixtures retained more than 75 percent.

Using these data as well as other test results from evaluations of various mixtures used or proposed for use on actual projects as a basis, it

TABLE 3. SUMMARY OF AGGREGATE MIXTURES

A. STRIPPING

District	Aggregate Type	Aggregate Proportion %	Asphalt Content, %	Asphalt Retained After Boiling, %
Dist. 5	Crushed caliche (5A)	100.0		
Lubbock	Design mixture		9.0	25
	Coarse gravel (9D)	65.0		
Dist. 9	Washed sand (9F)	21.0		
Waco	Field sand (9E)	14.0		
	Design mixture		4.3	25
	Crushed limestone (11C)	27.0		
Dist. 11	Pea gravel (11D)	15.0		
Lufkin	Coarse sand (11E)	15.0		
	Local fine sand (11F)	43.0		
	Design mixture		5.0	25
Dist. 12	Gravel screenings (12B)	63.3		
Houston	Crushed limestone (12A)	10.3		
(Harris	Local field sand (12C)	26.4		
Co.)	Design mixture		4.3	65
	Lone Star coarse agg. (13A)	43.0		
Dist. 13	Lone Star Gem sand (13B)	12.2		
Yoakum	Styles coarse sand (13C)	13.3		
	Tanner Walker sand (13D)	31.5		
	Design mixture		5.0	35

B. NONSTRIPPING

District	Aggregate Type	Aggregate Proportion %	Asphalt Content, %	Asphalt Retained After Boiling, %
Dist. 12	Crushed limestone (12E)	55.0		
Houston	Limestone screenings (12F)	20.0		
(Galveston	Field sand (12G)	25.0		
Co.)	Design mixture		6.0	85
	Crushed limestone (14I)	61.0		
Dist. 14	Limestone screenings (14K)	22.0		
Austin	Local field sand (14L)	17.0		
	Design mixture		5.4	95
	Coarse slag (19A)	60.0		
Dist. 19	Slag screenings (19B)	15.0		
Atlanta	Field sand (19C)	12.0		
	Local field sand (19D)	13.0		
	Design mixture		7.5	75

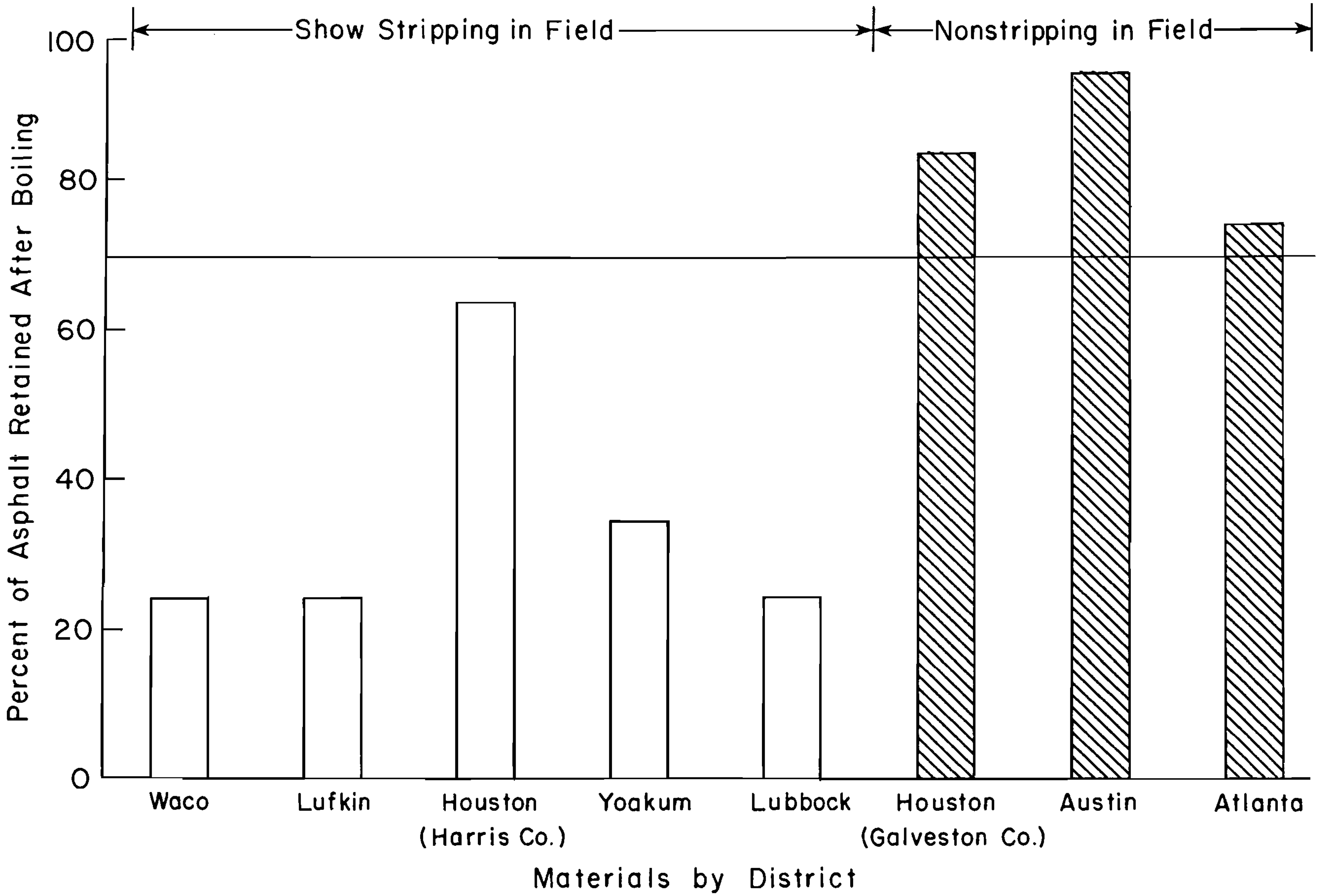

Fig 7. Texas Boiling Test results for stripping and nonstripping mixtures.

is tentatively recommended that 70 percent of asphalt retained after boiling be the division between stripping and nonstripping mixtures. This value may be modified and refined as additional experience is obtained. Thus, the Texas Boiling Test offers a quick method of detecting asphalt-aggregate mixtures that are susceptible to stripping and moisture in the field. Because this test can be performed quickly in either the laboratory or the field and since the results provide a good indication of stripping it is recommended for use in evaluating mixtures during both design and construction.

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations based on the findings of this investigation are summarized below.

CONCLUSIONS

Results from the Texas Boiling Test provide valuable information that can differentiate between asphalt mixtures that are known to strip in the field and those that do not strip. Specific conclusions are:

(1) The number of mixing times affects the test results significantly. The best differentiation between stripping and nonstripping mixtures occurred when the specimen was mixed only once. Therefore, in the standard procedure, the specimen is prepared by mixing once.

(2) The mixing temperature produced a significant effect on test results, the higher initial aggregate temperature induced less stripping. Test results, however, indicated that when aggregates were heated to 325°F the results could be used most successfully to differentiate between stripping and nonstripping mixtures. Therefore, 325°F was incorporated in the standard boiling test procedure.

(3) Aggregates which retain less than 70 percent asphalt are tentatively judged to be moisture susceptible; aggregates which retain more than 85 percent are felt to be moisture resistant. Between 70 and 85 percent are probably borderline and would benefit from treatment.

(4) A rating board (Fig. 1) should be used to make the visual estimates of the amount of asphalt retained in order to ensure uniformity of results.

RECOMMENDATIONS

Results from this study indicate that the Texas Boiling Test can detect asphalt mixtures that exhibit stripping tendencies in the field. The test is rapid and can be conducted with a minimum amount of special equipment and with existing staff in the District laboratories. Thus the test offers a method for the field control of aggregates and asphalts to ensure moisture resistant asphalt mixtures and a means to evaluate proposed antistripping additive.

Because of the potential offered by this test the following recommendations are offered:

(1) Both the Districts and D-9 laboratories should begin to use the Texas Boiling Test to evaluate the moisture susceptibility of asphalt-aggregate mixtures proposed for use in construction and as a quality control test. A refinement in the procedure could involve consideration of the surface area of the aggregate in the determination of asphalt content of test mixtures containing a single size aggregate. It is suggested that differences in this procedure and Tex-530-C be evaluated. These differences include:

   a. The preconditioning of the asphalt prior to preparing the test mix.
   b. The size of sample and boiling container in the test.
   c. Possible additional evaluation of mixing temperatures and the number of times mixed.
   d. The effect of stirring during the boiling.

   Based on this evaluation, changes to the Texas Boiling Test procedure or Tex-530-C may be warranted.

(2) Although antistripping additives were not evaluated, it is felt that the test can be used for determining the effectiveness of antistripping additives and has been used in a number of studies. It is recognized that the Boiling Test results are not always consistent with the results of other tests. Thus, a long-term field evaluation study is needed to determine which test(s) accurately predict field performance.

(3) In the event that a stripping mixture is detected, the proposed antistrip additive should be tested using the Texas Boiling Test to evaluate its effectiveness in improving the adhesion between the asphalt cement and each aggregate in the mixture.

(4) If any component of a mixture is changed, the mixture should be reevaluated since stripping is dependent on the asphalt as well as the aggregate and since the effectiveness of some antistripping agents appears to be aggregate and asphalt dependent.

(5) Other tests such as the Texas Freeze-Thaw Pedestal Test and the Wet-Dry Indirect Tensile Test should also be conducted, if time allows.

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