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16. Abstract

This report summarizes the results of determining the moisture susceptibility by the primary test methods:

(a) Original Lottman Method
(b) Modified Lottman Method (Tex-531-C)
(c) Tunnicliff-Root Method
(d) Boiling Test (Tex-530-C)

Comparisons were made between the laboratory mixtures, plant mixtures, and cores obtained from the field test sections to determine the effectiveness of the various antistripping additives and to evaluate the various methods for measuring that effectiveness.

All test methods were found to be effective in differing degrees in estimating the moisture susceptibility of the asphalt-aggregate mixtures. Reasonable correlations could be obtained between the various procedures.

Most liquid antistripping additives were found to be effective on the gravels but less effective on limestones and sandstones. Hydrated lime applied in a slurry form was found to be effective for all aggregates tested.

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EVALUATION OF STRIPPING AND MOISTURE DAMAGE IN ASPHALT PAVEMENTS TREATED WITH LIME AND ANTISTRIPPING AGENTS

by

W. Virgil Ping
Thomas W. Kennedy

Research Report Number 441-1

Research Project 3-9-86-441

Treatment of Asphalt Mixtures with Lime and Antistripping Agents

conducted for

Texas Department of Transportation

in cooperation with the

U. S. Department of Transportation
Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH

Bureau of Engineering Research

THE UNIVERSITY OF TEXAS AT AUSTIN

April 1991

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PERMIT, OR BIDDING PURPOSES

Thomas W. Kennedy, P.E. (Texas No. 29596)
Research Supervisor

PREFACE

This is the first of two reports for Project 3-9-86-441, "Treatment of Asphalt Mixture with Lime and Antistripping Agents." This report presents the information and findings based upon laboratory, plant and initial field performance of mixtures designed, produced and placed in eight SDHPT districts. A final report presenting the findings based upon the performance of these test sections under service is currently planned.

The assistance and close cooperation of the Texas State Department of Highways and Public Transportation, especially personnel from those Districts directly involved and Donald O'Connor of the Materials and Tests Division, is acknowledged.

Appreciation is also expressed to the Center for Transportation Research Staff, James N. Anagnos, Eugene Betts, Maghsoud Tahmoressi, Min-Jen Liu and Bess Dougherty.

Wei-Chou Virgil Ping

Thomas W. Kennedy

ABSTRACT

This report summarizes the results of determining the moisture susceptibility by the primary test methods:

a. Original Lottman Method

b. Modified Lottman Method (Tex-531-C)

c. Tunnicliff-Root Method

d. Boiling Test (Tex-530-C)

Comparisons were made between the laboratory mixtures, plant mixtures, and cores obtained from the field test sections to determine the effectiveness of the various antistripping additives and to evaluate the various test methods for measuring that effectiveness. The final decision as to long-term effectiveness of the additives is dependent on the long-term performance of the test sections.

The test methods utilizing the indirect tensile test provide different values for the tensile strength ratio with the original Lottman being the most severe and the Root-Tunnicliff the least severe. The selection of the test method which best predicts moisture damage in pavements and the establishment of an acceptance level is dependent on the long-term performance of the test sections.

Compatible acceptance levels should be established for the various test methods currently being used and for

laboratory and plant mixtures. These acceptance levels can be estimated using the correlations contained in the report.

All additives tended to improve resistance to moisture as measured by the test methods utilized; however, the actual combination of asphalt, aggregate and additive must be tested.

KEY WORDS: Asphalt mixtures, Tensile Strength Ratio (TSR), Wet-Dry Indirect Tensile Strength, Antistripping Additives, Stripping, Moisture Damage, Test Methods, Lottman, Boiling Test, Tunnicliff-Root Method, Hydrated Lime

SUMMARY

Moisture susceptibility of asphalt mixtures and the resulting damage is recognized as a major contributor to distress of asphalt concrete pavements. Numerous research studies have been conducted to determine the causes of moisture damage, to develop tests to estimate the moisture susceptibility of asphalt mixtures, and to develop methods to minimize moisture damage.

PROJECT OBJECTIVES

To further evaluate previous findings and recommendations the Texas State Department of Highways and Public Transportation (SDHPT) funded a research study at The University of Texas at Austin. The objectives of the study were:

1) To evaluate the effectiveness of hydrated lime and various antistripping additives under field conditions,
2) To verify the ability of various laboratory tests and techniques to predict potential field performance with respect to stripping and moisture damage,
3) To establish the relationship between different laboratory test values,

4) And, to improve the tests and establish realistic specifications based on the field performance.

STUDY OBJECTIVES

The specific objectives of the research study summarized in this report were:

1) To determine the effectiveness of hydrated lime and selected antistripping agents as measured by currently used laboratory tests,
2) To evaluate the relationships between various moisture damage test values for a range of mixtures and antistripping agents,
3) To construct field test sections for different mixtures using different antistripping agents, and
4) To begin monitoring the field performance of the test sections for future long-term evaluation.

SCOPE

This report summarizes information related to the construction of eight field test projects containing 92 test sections involving a range of asphalts, aggregates and antistripping agents. In addition the moisture damage evaluation of laboratory prepared mixtures and plant mixed-laboratory compacted mixtures, and the relationship between test values for different moisture susceptibility tests are reported. The test methods were the original Lottman, modified Lottman (Tex-531-C with and without curing), Root-Tunnicliff, and a cyclic freeze-thaw procedure, all of which utilize the indirect tensile test. In addition, the boiling test was utilized and evaluated.

The subsequent findings of this long-term field monitoring program will provide information related to the field performance of treated mixtures and the relationship between performance and the predicted performance based on the laboratory test methods.

CONCLUSIONS

Comparison of Moisture Damage Tests

1. The moisture susceptibility test methods used in this study were:
   a. Original Lottman method
   b. Tex-531-C method
   c. Tunnicliff-Root method
2. Excellent correlations were obtained between the TSR (Tensile Strength Ratio) values of the modified Lottman (Tex-531-C) and the TSR values of both the original Lottman (C) and

Tunnicliff-Root procedures (D) with R^2 values of 0.84 and 0.85. The correlation equations were:

$$TSR_{(Tex-531-C)} = 11.8 + 0.90\ TSR_{(C)}$$

$$TSR_{(Tex-531-C)} = 0.20 + 0.94\ TSR_{(D)}$$

Other correlation equations are contained in Table 4.1.

3. The correlation between the boiling test results and the TSR values were reasonably good with R^2 values ranging from 0.71 to 0.79. The correlation equations were:

$$TSR_{(Tex-531-C)} = 10.9^{\,0.024X}$$

$$TSR_{(Tunnicliff-Root)} = 12.5^{\,0.023X}$$

$$TSR_{(Original\ Lottman)} = 8.4^{\,0.026X}$$

where X = percent asphalt retained after boiling. Other equations to estimate the percent asphalt retained in terms of TSR values are contained in Figure 4.11.

4. These correlations of test values provide a means of estimating compatible acceptance values for different test methods and indicates that the acceptance TSR values should be different for different test procedures.

5. The effect of curing on TSR values specified by the modified Lottman (Tex-531-C) with and without

curing during the mixing and specimen preparation was not significant. This suggests that the time required for moisture damage testing could be shortened significantly.

Comparison Between Laboratory Mixture and Plant Mixture

1. Both the dry and wet tensile strength of the plant mixtures generally were equal to or higher than that of the laboratory mixtures.
2. The plant mixtures generally had greater TSR values than the laboratory mixtures; the magnitude of the difference, however, were dependent on the asphalt-aggregate mixture, the antistripping additives, and the testing methods.
3. The amount of asphalt retained after boiling of the plant mixtures generally was greater than that of the laboratory mixtures.
4. The acceptance TSR values for plant mixtures should be greater than the acceptance levels of the laboratory mixtures since all of the tests procedures produced higher values of moisture resistance for plant mixed material. The correlation equation for TSR values (Tex-531-C) was

$$TSR_{(Plant)} = 33.3 + 0.63\ TSR_{(Lab)}$$

The scatter was quite large with an R^2 value of 0.61.

5. The acceptance level for the boil test should be slightly greater for plant mixtures. The correlation equation between percent asphalt retained or the laboratory mixtures (X) and the plant mixtures (Y) was

$$Y = 19.3 + 0.80X$$

with and R^2 value of 0.71.

Effectiveness of Various Antistripping Additives

1. The hydrated lime was effective for both laboratory mixtures and most plant mixtures as compared to untreated mixtures. The slurry form of adding the hydrated lime worked very well both in the laboratory and in the field.
2. The liquid additives in general were effective compared to the untreated mixtures.
3. Boiling test results favored the liquid additives, whereas the tensile strength ratios favored the the hydrated lime.

Multiple Freeze-Thaw Cyclic Test Results

1. The TSR values decreased with increased freeze-thaw

cycles. The rates of deterioration for the treated and untreated mixtures, however, were not significantly different.

2. The mixtures treated with hydrated lime generally exhibited a significantly larger TSR value at cycle one; thus the TSR value for lime treated mixtures was greater than the value for most of the mixtures treated with liquid additives throughout the nine freeze-thaw cycles.
3. The raw materials with no additive exhibited the lowest TSR values under the cyclic testing condition.

Field Cores

1. The boiling test results for the field cores were essentially equal to the results for the plant mixtures, i.e., the data obtained from the plant mixture was representative of the field core data.
2. The relationships between the TSR values and air voids of the field cores generally were not statistically significant at the 5% level using the linear regression; however, the sample size and the range of air voids were small, and it is felt that the effect would be significant.

3. The field core TSR-values were compared with the laboratory values at air voids of approximately 7 percent. A good correlation was obtained between the plant mixture and the field-cored mixture. Therefore, the test results based on the plant mixtures could be used to estimate the TSR values of the field cores.

RECOMMENDATIONS

Applications

1. The correlations should be used to establish compatible acceptance levels for the various tests used by the Texas State Department of Highways and Public Transportation and by other highway agencies.
2. Different acceptance levels should be established for plant mixtures and laboratory mixtures. The correlations can provide an estimate for these values.
3. It should be recognized that the test values for plant mixtures more closely estimate the values for cores.
4. Serious consideration should be given to shortening the procedures used in Tex-531-C since the effect of curing was minimal. Additional evaluation may be needed.

5. Based on the test procedures used, hydrated lime and the other antistripping additives can be used to improve resistance to moisture; however, the actual asphalt, aggregate and additive should be tested.

Future Work

1. Ultimately, the effectiveness of the antistripping agents and usefulness of the laboratory test methods must be related to long-term field performance. Thus, the 92 test sections should be monitored periodically to evaluate the long-term performance of the selected liquid additives and the hydrated lime.
2. The laboratory test methods should be related to the field performance. A predictive performance model based on the actual field evaluation should be developed to improve the laboratory tests and acceptance values.
3. Realistic acceptance values for moisture damage tests and specifications should be developed based on the field performance.

IMPLEMENTATION

Pending additional information developed in a long-term study of the 8 test pavements constructed as a part of this study, it is recommended that the present procedures and specifications in use by the Texas State Department of Highways and Public Transportation be continued but that compatible acceptance levels be established for the modified Lottman and boiling test and for laboratory and plant mixtures. It is also necessary to continue the procedure of evaluating the actual asphalt, aggregate and additive combination proposed for use in construction.

It is recommended that the 92 test sections be evaluated yearly or at shorter periods of time if conditions indicate the need in order to determine which tests actually predict moisture damage, to established realistic acceptance levels for the test values, and to determine the long-term performance of the various antistrippng additives.

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CHAPTER 1

INTRODUCTION

Moisture damage of asphalt mixtures is a major problem for asphalt pavements constructed throughout much of the United States. The seriousness of the problem, which has been studied for decades (Refs 1-34), is evidenced by the large number of research efforts conducted in the United States during the last ten years (Refs 12-34).

BACKGROUND

Moisture damage ranges in severity from stripping to minor softening of the asphalt matrix which causes the mixture to lose stability or load carrying capacity. Stripping is a phenomenon in which a binding material is separated from the surface of an aggregate either by the action of water alone or by the interaction of traffic loads, temperature, and water. Pavement distress resulting from stripping commonly occurs as shoving and rutting, fatigue cracking, and bleeding or flushing. Similar distress, except for bleeding, can occur as the result of softening. Unlike stripping, which is a loss of adhesion, softening is a reduction in the stiffness and strength of the asphalt matrix or possibly a reduction in cohesion.

During the past ten years, a number of tests and test procedures were developed to evaluate the moisture damage potential of asphalt-aggregate mixtures. Unfortunately, while there are currently a limited number of basic tests, there are many variations of each test and many different acceptance criteria being used (Refs 12, 23, 25, 26, 29, and 40). It is also apparent that these different tests and test variations do not yield the same results and thus do not predict the same amount of moisture damage potential. In addition, it should be noted that the acceptance criteria often have been arbitrarily established or, at best, were based primarily on past performance or the testing of materials with an established performance history related to moisture damage (Refs 12, 14, 22, 25, 26, and 29).

In addition, a number of procedures and recommendations to eliminate or minimize moisture damage have been formulated. One of these procedures involves treating the asphalt mixture with an antistripping agent such as hydrated lime or other commercially available antistripping additives

(Refs 25, 26, 29, 31, and 35-44). Early studies concluded that hydrated lime was much more effective than many of the liquid antistripping additives which were being used at the time of the studies (Refs 19, 21, 39, and 41). Since that time, as the result of

(1) the recognition of the severity and importance of moisture damage and

(2) the industries use of hydrated lime, new and more effective liquid antistripping additives were developed and are being marketed and used in asphalt mixtures (Refs 26, 29, 31, 34, and 40).

Generally it has been found that the effectiveness of these additives is dependent on the particular combination of aggregate and asphalt cement. Many engineers and researchers feel that hydrated lime generally is a more effective additive to minimize moisture damage, but recognize that liquid antistripping agents do produce test results that exceed acceptance levels and in some cases are equal to or better than the values produced by hydrated lime. Nevertheless, there are still questions related to the tests, the acceptance levels, and the long-term effectiveness of all antistripping additives (Ref 34).

Finally, the hydrated lime has been added in a variety of ways some of which cause construction problems, increased costs, and reduced productions (Refs 39 and 41). When added as a slurry, it requires that the excess moisture be removed by drying, increasing drying costs and, more importantly, reducing plant capacity. These problems coupled with the fact that most liquid additives are cheaper have caused many states to accept both lime and liquid antistripping additives resulting in a trend to use liquid antistripping additives.

PROJECT OBJECTIVES

In recognition of these factors the Texas State Department of Highways and Public Transportation (SDHPT) funded a research study at The University of Texas at Austin. The objectives of the study were:

1) To evaluate the the effectiveness of hydrated lime and various antistripping additives under field conditions,
2) To verify the ability of various laboratory testing techniques to predict potential field performance with respect to stripping and moisture damage,
3) To establish the relationship between different laboratory test results,
4) And, to improve the tests and establish realistic

specifications based on the field performance.

STUDY OBJECTIVES

The objectives of the research study summarized in this report were:

1) To determine the effectiveness of hydrated lime and selected antistripping agents as measured by laboratory tests,
2) To evaluate the relationships between various moisture damage test values for a range of mixtures and antistripping agents,
3) To construct field test sections for different mixtures using different antistripping agents, and
4) To monitor the field performance of the test sections for future long-term evaluation.

REPORT ORGANIZATION

This report summarizes information related to the construction of eight field test projects in Texas. In addition the moisture damage evaluation of laboratory prepared mixtures and plant mixed-laboratory compacted mixtures, and the relationship between test values for different moisture susceptibility tests are reported. The subsequent findings of this long-term field monitoring program will provide information related to the field performance of treated mixtures and the relationship between performance and the predicted performance based on the laboratory test methods.

Research objectives and experimental program are described in Chapter 2. Field and laboratory experimental results are summarized and presented in Chapter 3. Laboratory and field core test results are analyzed and discussed in Chapters 4 and 5, respectively. The conclusions and recommendations based on the findings of this study are presented in Chapter 6. Information related to the eight field test projects are summarized in Appendices A through H. Detailed statistical analysis to evaluate the effectiveness of various antistripping additives is presented in Appendix I.

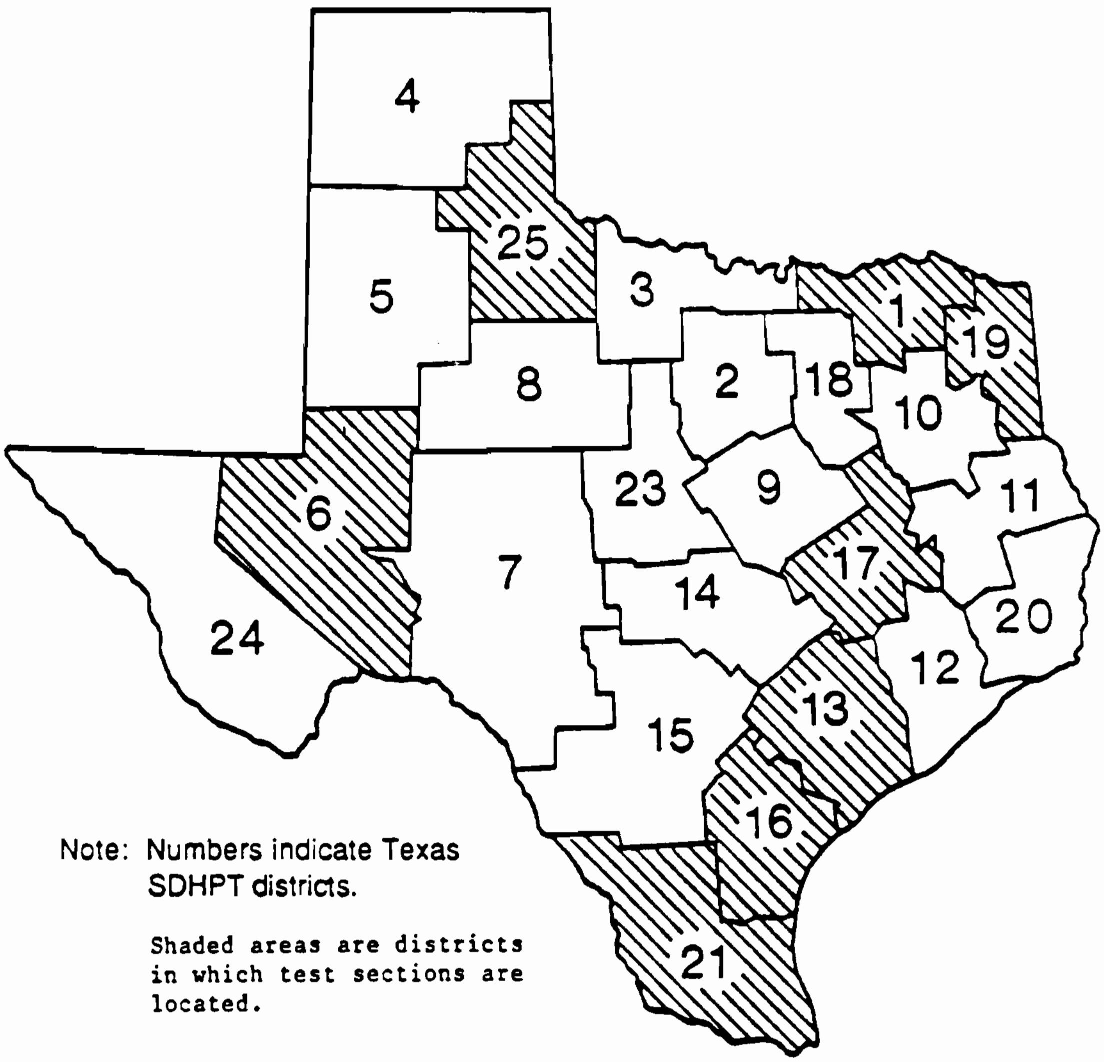
CHAPTER 2

EXPERIMENTAL PROGRAM

To achieve the objectives of this study, both laboratory and field studies were developed and conducted in cooperation with the Texas State Department of Highways and Public Transportation (SDHPT). The overall experimental program involved eight highway test sections which were constructed in eight different districts (Fig 2.1) and involved a range of traffic and climatic conditions, aggregates, and asphalt cements. The experimental programs including the test methods and the engineering properties analyzed are described in this chapter.

FIELD EXPERIMENTAL PROGRAM

Eight experimental test sections were designed in conjunction with the Materials and Tests Division (D-9) and the districts in which the test sections were constructed.



Note: Numbers indicate Texas SDHPT districts.

Shaded areas are districts in which test sections are located.

Fig 2.1 Location of field test sections.

Field construction was supervised by District personnel with technical assistance provided by project personnel.

Experiment Design

The basic experiment design is shown in Figure 2.2. Hydrated lime and two or more commercially available antistripping additives were included in each project. All additives were not included in each project. Control sections with no additive were also included in each test section. The selection of antistripping additives to be included was based upon the experience and recommendation of the Districts and the willingness of the proposed additive manufacturers to participate. Each treatment and control was constructed with both high and low densities, i.e., low and high air void sections. The low air void sections were targeted for a range of 3 to 8 percent as specified by the Texas SDHPT. The high void content sections were targeted to have approximately 4 percent more air voids than the low void section. These target values were difficult to achieve because of the length of the individual test sections and in some cases there was no difference.

It should be noted that the annual precipitation varied over a wide range and that the mean temperatures were also

DENSITY

TREATMENT	LOW VOIDS	HIGH VOIDS
CONTROL	X	X
HYDRATED LIME	X	X
Antistrip A	X	X
Antistrip B	X	X

Fig 2.2 Experiment design for field test sections.

significantly different. The fact that climate was not a controlled variable and that test sections were not systematically repeated may confound results.

Construction of Test Sections

The eight field projects involved a total of ninety-two test sections containing a range of aggregates and asphalt cements and various antistripping additives with low and high air void content. The field operations and test variables for each of the eight test projects along with a description of the materials, additives, and construction techniques are summarized in Appendices A through H. The information related to field construction is summarized below.

Materials and Additives. The types of aggregate and the source and amount of asphalt cement for the mixtures utilized in the eight test projects are summarized on Table 2.1. The test locations are arranged in chronological order of field construction. Two or more liquid antistripping additives and hydrated lime were used in each test project. Identical raw material sources (aggregates and asphalt cement) were utilized for all test sections for each field project. In several cases, the actual asphalt contents

TABLE 2.1 SUMMARY OF MATERIALS FOR FIELD TEST PROJECTS

Location of Field Project	Aggregates	Asphalt	Asphalt Content, % Field+	Asphalt Content, % Design++	Appendix*
Dist. 17 Hearne	.Processed gravel 55% .Washed sand 25% .Coarse sand 10% .Fine sand 10%	.AC-20 .Texas Gulf Refinery	4.9	4.9	A
Dist. 16 Odom	.Field sand 20% .Limestone Screenings 22% .Coarse Limestone 58%	.AC-20 .Gulf States Refinery	5.1	4.3	B
Dist. 13 Victoria	.Crushed gravel 50% .Limestone 10% .Limestone screenings 20% .Field Sand 20%	.AC-20 .Texas Fuels & Asphalt Refinery	5.0	5.0	C
Dist. 6 Midland	.Rhyolite 56% .Screening 37% .Field Sand 7%	.AC-20 .American Petrofina Refinery	6.2	6.2	D
Dist. 25 Childress	.Coarse Aggr. 20% .Inter. aggr. 34% .Screening 46%	.AC-20 .Diamond Shamrock Refinery	5.2	5.2	E
Dist. 1 Sherman	.Coarse sandstone 55% .Unwashed screenings 30% .Field sand 15%	.A-20 .Total Petroleum Refinery	5.5	6.0	F
Dist. 19 DeBerry	.Coarse Aggregate 20% .Inter. Aggregate 40% .Screening 20% .Field sand 20%	.AC-20 .Lion Oil Refinery	5.6	5.3	G
Dist. 21 Cameron	.Coarse Aggregate 35% .Uncrushed aggregate 20% .Screening 25% .Field sand 20%	.AC-10 .Texas Fuel & Asphalt Coastal Refinery	5.2	5.2	H

* Details are contained in the indicated Appendices.

\+ Actual asphalt content used for the field test project mixtures

++ Laboratory design optimum asphalt content for the mixture design.

used in the field mixtures deviated from the preliminary laboratory design values due to decisions made during construction.

Fourteen different antistripping additives, including hydrated lime, were used in the eight projects. The additive information is summarized on Table 2.2. The actual additive dosages are summarized on Table 2.3. The plan was to use one percent lime by the weight of dry aggregates and one percent liquid additives by the weight of asphalt cement or the manufacturer's recommended dosage. All suppliers were requested to be present to ensure that their product was introduced properly. In most cases, the proper amounts were introduced into the mixture or asphalt cement and blended according to the experimental field plan; in a few cases, however, the desired dosages were not achieved due to field problems.

Construction Techniques. Seven of the projects utilized drum mix plants and one (District 13) utilized a batch plant. The techniques utilized to incorporate the various antistripping additives into the asphalt mixtures are summarized in Table 2.4.

In six projects, the lime was placed on the aggregate in a slurry form; in two projects (Districts 6 and 19), dry lime was added to the aggregates. At the seven drum plants

TABLE 2.2 SUMMARY OF ANTISTRIPPING ADDITIVES USED IN THE FIELD TEST PROJECTS

Additive	Additive Designation	SDHPT District Number*							
		17	16	13	6	25	1	19	21
No additive	0	x	x	x	x	x	x	x	x
Hydrated lime	1	x	x	x	x	x	x	x	x
ARR-MAZ (Adhere Regular)	2							x	
ARR-MAZ (Adhere HP)	2						x		x
Aquashield	3		x						
Aquashield II	4					x		x	x
BA 2000	5	x		x				x	
DOW	6		x				x		x
FINA-A	7					x	x		
FINA-B	8								x
Indulin AS-1	9						x		
Pavebond LP	10		x		x				x
Pavebond Special	11						x		
Perma-Tac	12				x	x		x	x
Perma-Tac Plus	13	x		x			x		
Unichem 8150	14				x	x			
No. of Additives Per District:		4	5	4	5	6	8	6	8
No. of Test Sections Per District**:		8	10	8	10	12	16	12	16
Total No. of Test Sections:									92

* In chronological order of field construction.

** One low and one high air void test sections were placed for each additive.

TABLE 2.3 SUMMARY OF ANTISTRIPPING ADDITIVES FOR FIELD TEST SECTIONS

Location of Field Project	Test Sections	Additive Designation	Additive Dosage*, %	Appendix**
District 17	.Control	0	0	
	.Lime	1	1.5	A
Hearne,	.BA 2000	5	1.0	
TX	.Perma-Tac	12	1.0	
	.Control	0	0	
District 16	.Lime	1	1.0	
	.Aquashield	3	0.5	B
Odom,	.Dow Anti-Strip	6	0.41	
TX	.Pavebond LP	10	0.5	
District 13	.Control	0	0	
	.Lime	1	2.0	C
Victoria,	.BA 2000	5	1.0	
TX	.Perma-Tac Plus	13	1.0	
	.Control	0	0	
District 6	.Lime	1	1.0	
	.Pavebond LP	10	1.0	D
Midland,	.Perma-Tac	12	1.0	
TX	.Unichem	14	0	
	.Control	0	0	
District 25	.Lime	1	1.0	
	.Aquashield II	4	1.0	E
Childress,	.Fina-A	7	1.0	
TX	.Perma-Tac	12	1.0	
	.Unichem	14	1.0	
	.Control	0	0	
District 1	.Lime	1	1.5	
	.ARR-MAZ	2	0.75	
	.Dow Anti-Strip	6	0.45	F
Sherman,	.Fina-A	7	1.0	
TX.	.Indulin AS-1	9	1.0	
	.Pavebond Special	11	1.0	
	.Perma-Tac Plus	13	1.0	
	.Control	0	0	
District 19	.Lime	1	1.0	
	.ARR-MAZ	2	1.0	G
	.Aquashield II	4	0.8	
DeBerry,	.BA 2000	5	0.5	
TX	.Perma-Tac	12	1.0	
	.Control	0	0	
District 21	.Lime	1	1.0	
	.ARR-MAZ	2	1.0	
	.Aquashield II	4	0.41	H
Cameron,	.Dow Anti-Strip	6	0.5	
TX	.Fina-B	8	0.41	
	.Pavebond LP	10	1.0	
	.Perma-Tac	12	1.0	

* The percentage of lime is by the total weight of dry aggregates; percentage of liquid additives is by the weight of asphalt cement.

** Details are contained in the indicated Appendices.

TABLE 2.4 SUMMARY OF FIELD APPLICATION TECHNIQUES

	FIELD APPLICATION METHOD	
DISTRICT	LIME TREATMENT	LIQUID/PELLET ADDITIVES
17	.Lime slurry applied to the aggregate on the cold feed belt of the drum mix plant.	.Liquid additives metered into the asphalt cement by an in-line blending systme.
16	.Lime slurry applied to the aggregate on the cold feed belt of the drum mix plant.	.Liquid additives by same method as above. .Dow polyethylene pellets were mixed with the asphalt cement in a separate storage tank 12 hours prior to use.
13	.Lime slurry applied to aggregate on cold feed belt of weigh batch plant.	.Liquid additives mixed with asphalt cement in the storage tank.
6	.Coarse aggregate stockpile was wetted and dry lime added in layers about 12 hrs prior to use.	.Liquid additives metered into the asphalt cement by an in-line blending system.
25	.Lime slurry applied to the aggregate on the cold feed belt of the drum mix plan.	.Liquid additives by the same method as above.
1	.Lime slurry added to aggregate stockpile and used the same day.	.Liquid additives by the same method as above. .Dow polyethylene pellets were mixed in asphalt distributor truck for 1 hour prior to use.
19	.Dry lime added to aggregate stockpiles and sprayed with water to hold lime to aggregate 12 hours prior to use.	.Liquid additives by the same method as above.
21	.Lime slurry applied to aggregate on cold feed belt of drum mix plant.	.Liquid additives by the same method as above. .Dow polyethylene pellets blended with asphalt cement at refinery.

the liquid additives were metered into the asphalt cement by means of an in-line blending system, whereas in the batch mix plant (District 13), the liquids were mixed with the asphalt cement in the storage tank. The Dow antistripping additive was in pellet form and was mixed by Dow with the asphalt cement in storage tank (Districts 16 and 1) or at the refinery (District 21). Actual treatment levels were determined in Dow Chemical's laboratory by analyzing a sample of the blended asphalt cement and additive obtained from the storage tank.

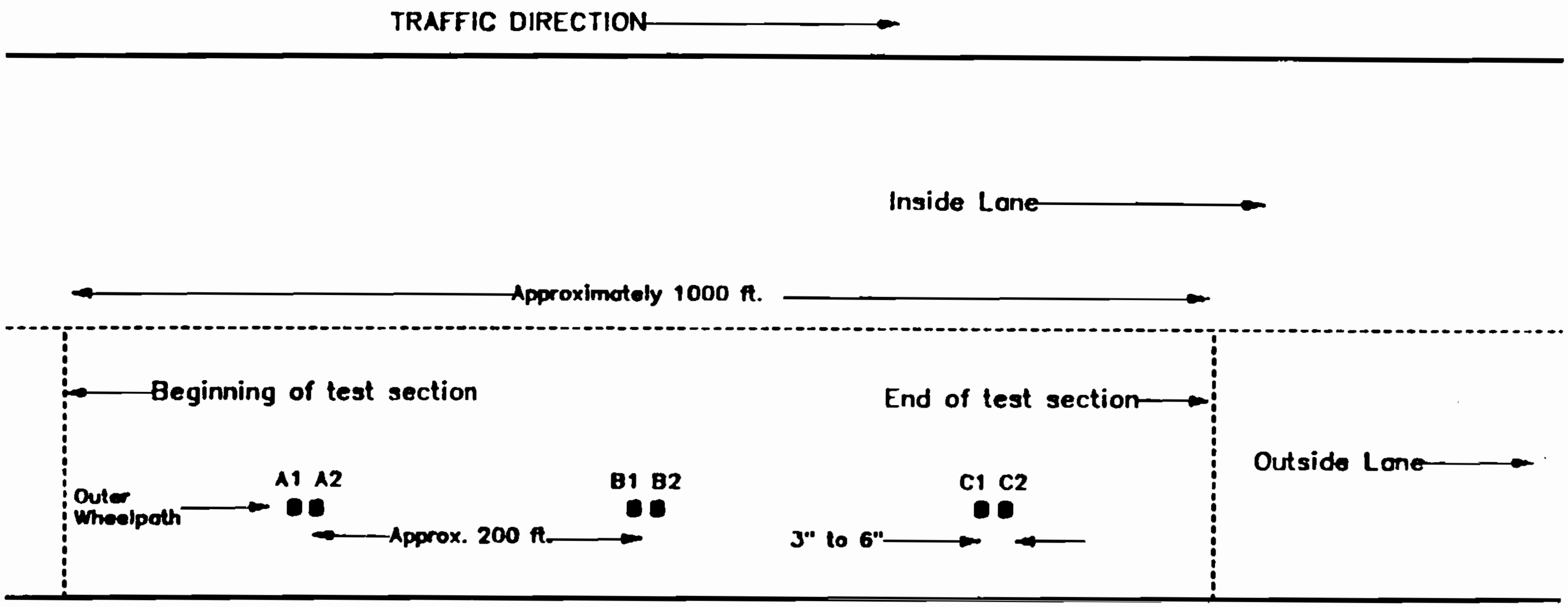
The test sections in seven of the projects were approximately 1000 feet long; in the eighth project (District 1) the test sections were approximately 500 feet long.

An attempt was made to have test sections with low and high air voids as outlined in the experiment design; however, it was difficult to develop the rolling pattern for a particular target void content within the time and distance available. The construction of the projects are described in more detail in the Appendices.

Field Sampling Program

Loose samples of the hot asphalt mixtures utilized in the various test sections were obtained at the asphalt mixing plants. In addition, samples of the asphalt cements, aggregates, hydrated limes, and various antistripping additives were also obtained and shipped to the asphalt research laboratory at The University of Texas at Austin.

Field cores were also taken immediately following construction of the test sections. These cores were approximately 4-inch in diameter and 1 to 2 inches in thickness. Three paired samples were obtained from seven of the eight projects (except Dist. 17) in the wheel path of each test section at approximately 200-foot intervals with the first and last pairs of cores located approximately 300 feet from the beginning and the end of the test section. In the case of District 17, four paired samples were obtained from the wheel path of each test section at approximately 200-foot intervals. The first and last pairs of cores were located approximately 200 feet from the beginning and the end of the test section. The distance between the two paired cores was approximately 3 to 6 inches (Fig 2.3). In the shorter test sections (District 1), the distance between each pair of cores was proportional to the length of the test section. Additional cores will be obtained and tested periodically over a period of approximately five years.



Note: Three pairs of cores are obtained as shown (A1,A2,B1,B2,C1,C2).

Fig 2.3 Coring pattern for paired cores taken immediately after construction.

TEST METHODS

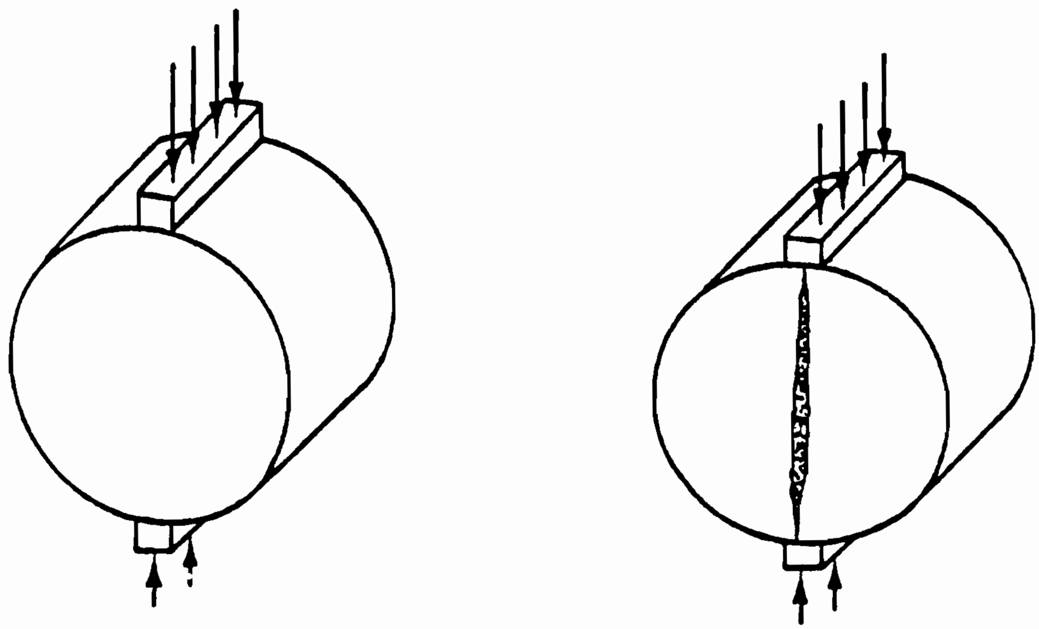
A laboratory test to estimate the moisture damage or stripping potential of an asphalt mixture must test the actual aggregate, asphalt cement, and additive proposed for use in the mixture. The test should also be sensitive enough to differentiate between the effectiveness of different additives and treatment levels used in the mixture (Ref 34). Finally, and probably most important, the test values should relate to actual field performance.

In conjunction with the Materials and Tests Division (D-9), two basic moisture susceptibility test methods were selected for evaluation. These methods were the wet-dry indirect tensile test, often referred to as the Lottman test, and the boiling test. As previously noted, however, there are a number of variations of the wet-dry indirect tensile test. Thus, in cooperation with the Materials and Tests Division, the following specific test methods were selected for evaluation.

Wet-Dry Indirect Tensile Test

The indirect tensile test involves loading a cylindrical specimen with a compressive load acting parallel to and along the vertical diametrical plane (Fig 2.4a). The load is applied through 0.5-inch wide steel loading strips curved to fit the specimen. A fairly uniform tensile stress, perpendicular to the plane of the applied load, causes the specimen ultimately to fail by splitting along the vertical diameter (Fig 2.4b). An estimate of the tensile strength is calculated from the applied load at failure and the specimen dimensions.

Original concept of the indirect tensile test and current test procedure were developed by Kennedy (Refs 48 49) at The University of Texas at Austin and were utilized by Lottman et al (Ref 12) for measuring the potential for moisture damage in asphalt mixtures. Since the initial development of the wet-dry test method by Lottman, several techniques for moisture conditioning have been developed as modifications of the original Lottman procedure. All methods, however, use the indirect tensile test to determine the tensile strength ratio (TSR) of wet and dry specimens as follows:



(a) Compressive load being applied. (b) Specimen failing in tension.

Fig 2.4 Indirect tensile test loading and failure.

$$TSR = \frac{S_T(\text{Conditioned})}{S_T\ (\text{Unconditioned})} \qquad \text{(Eq 2.1)}$$

where, S_T = Indirect Tensile Strength.

The wet-dry indirect tensile test procedures which were selected for evaluation were:

1) The Texas Tex-531-C method, a modified Lottman (Ref 46),
2) A modification of Texas Tex-531-C method,
3) The Original Lottman method (Ref 12),
4) The Tunnicliff-Root method (Ref 29), and
5) A multiple Freeze-Thaw Cyclic method similar to that reported by Scherocman et al (Ref 34).

The test procedures are described below and are summarized in Table 2.5.

Tex-531-C Method. The Tex-531-C method utilizes laboratory compacted specimens with air void contents of approximately 7 percent. A group of specimens are mixed and compacted using the design aggregates and asphalt. Half of the specimens are tested dry or unconditioned. The other half of the specimens are conditioned by vacuum saturation with water. A partial vacuum (approximately 15-17 inches of mercury) is applied long enough to achieve a degree of saturation of about 70 percent.

TABLE 2.5 SUMMARY OF MOISTURE-CONDITIONING PROCEDURE

Test Method			
Tex-531-C Method	Original Lottman	Tunnicliff-Root	Cyclic Freeze-Thaw
.Vacuum saturation to 60-80% filled voids.	.Vacuum saturation using 26-in Hg for 30 min.	.Vacuum saturation to 60-80% filled voids.	.Vacuum saturation to 60-80% voids.
.Freezing at 0 F for 15 hours.	.Conditioning at 77 F (water-bath) for 30 min.	.Soaking at 140 F (water-bath) for 24 hours.	.Freezing at 0 F (air-temperature) for 15 hrs.
.Thawing at 140 F (water-bath) for 24 hours.	.Freezing at 0 F for 15 hours.	.Conditioning at 77 F (water-bath) for 3 hours prior to testing.	.Thawing at 140 F (air temperature for 24 hours.
.Conditioning at 77 F (water-bath) for 3 hours prior to testing.	.Thawing at 140 F (water-bath) for 24 hrs.		.Cooling at 77 F (air temperature) for 9 hours.
	.Conditioning at 77 F (water-bath) for 3 hours prior to testing.		.Repeat the freeze-thaw-cool cycle (48 hours/cycle).
			.Number of cycles: 1,3, 5,7 & 9.
			.Conditioning at 77 F (water bath) for 3 hours prior to testing.

The conditioned specimens are placed in a freezer at 0 F for 15 hours, and then the specimens are taken from the freezer and placed in a 140 F water bath for 24 hours. After a complete freeze-thaw cycle, the moisture-conditioned specimens are cooled to room temperature in a 77 F water bath for approximately three hours prior to testing. All of the specimens are then tested to determine their indirect tensile strength. The ratio of the conditioned strength to the unconditioned (dry) tensile strength is calculated using Equation 2.1.

Modified Tex-531-C Method. The current test method utilized by Texas (Tex-531-C) includes a procedure to account for asphalt absorption. This procedure requires an additional day. Thus, it would be desirable to eliminate this extra time.

The mixing and compaction procedures of the Tex-531-C method, with cure and without cure, are summarized on Table 2.6. In the Tex-531-C method, the aggregate and asphalt are mixed at 300 F, cooled at room temperature (77 F) for 2.5 hours, and then cured at 140 F for 15 hours (overnight). Molding and compacting of the specimens take place the following day using the Texas-Gyratory shear compactor after heating the mix at 250 F for 2 hours. For the modified Tex-531-C method, the mixing and molding of the specimens

TABLE 2.6 SUMMARY OF MIXING AND COMPACTION PROCEDURE

Procedure	Test Method	
	Tex-531-C Method with Cure (Method A)	Modified Tex-531-C Method without Cure (Method B)
Mixing	. Mixing at 300 F . Cooling at room temperature for 2.5 hours . Curing at 140 F for 15 hours	. Mixing at 275 F
Molding	. Heating at 250 F for 2 hours . Compacting specimens to 7.0 ± 1.0% air voids . Cooling the specimens to room temperature	. (Same as Method A)

take place in the same day. The aggregate and asphalt are heated to 275 F, mixed at 275 F, without cure and compacted at 250 F using the Texas-Gyratory shear compactor to 7.0 $\pm$ 1.0% air voids.

The conditioning and testing procedures of the compacted specimens are exactly the same as for the Tex-531-C method.

Original Lottman Method. In the Original Lottman method, the laboratory specimens are fabricated and compacted in the same fashion as for the modified Tex-531-C method. However, half of the specimens are partially saturated under a vacuum of 26-in. of mercury for 30 minutes rather than for a period of time required to achieve a specified degree of saturation. Subsequently, the wet specimens are placed in a 77 F water-bath for 30 minutes before being subjected to a freeze-thaw cycle. The specimen is frozen at 0 F for 15 hours and then thawed at 140 F water bath for 24 hours. After a complete freeze-thaw cycle, the wet specimens are cooled to room temperature in a 77 F water bath for approximately three hours prior to testing. All of the wet and dry specimens are then tested to determine their indirect tensile strength. The tensile strength ratio (TSR) using the wet and dry tensile strength is determined according to Equation 2.1.

<u>Tunnicliff-Root Method.</u> In the Tunnicliff-Root procedure, the freeze cycle (0 F for 16 hours) used in the Tex-531-C method is eliminated since it is felt that the freeze cycle could cause additional specimen damage over and above that produced by the moisture (Ref 29). The laboratory specimens are fabricated and compacted to 7.0 ± 1.0 percent air voids as in the Tex-531-C method. Half of the specimens are partially vacuum-saturated with water to 55 to 80 percent saturation. The conditioned specimens are then soaked at 140 F water bath for 24 hours. The specimens are cooled to room temperature in a 77 F water bath for approximately three hours prior to testing. All of the wet and dry specimens are then tested to determine their indirect tensile strength. A tensile strength ratio (TSR) of the wet and dry tensile strengths is determined (Eq 2.1).

<u>Multiple Freeze-Thaw Cyclic Method.</u> In order to provide a practical and realistic test procedure for accelerated testing of asphalt concrete to predict the moisture and the rate of progression of damage due to the effect of moisture, a modification of the original Lottman cyclic wetting technique is used.

In the Multiple Freeze-Thaw Cycle procedure, the laboratory specimens were fabricated and compacted to 7.0 ± 1.0 percent air voids as in the Tex-531-C method. Half of the specimens were partially vacuum-saturated with water to 60 to 80 percent filled voids. The wet specimens were then immersed in water in a flat-bottom pan, were placed in an automated environmental chamber, and were subjected to repeated freeze-thaw temperature cycles (Fig 2.5). The freeze-thaw cycle starts at the room temperature (77 F) and it usually takes about 30 minutes to reach the freezing air temperature of 0 F depending on the amount of water in the chamber. The air temperature stays at 0 F for about 14.5 hours before it heats up to 140 F. The heating process usually takes about 30 minutes or longer and the air temperature remains at 140 F for about 23.5 hours. At the end of one complete freeze-thaw cycle, the air temperature cools from 140 F to 77 F in less than 30 minutes and stays at 77 F for about 8.5 hours before undergoing another complete freeze-thaw cycle. Prior to testing, the specimens were left in the chamber for three to four hours at 77 F. The wet specimens were then tested to determine their indirect tensile strength. The tensile strength ratio (Eq 2.1) is determined for the specific freeze-thaw cycle. The specified freeze-thaw cycles were 1, 3, 5, 7 and 9.

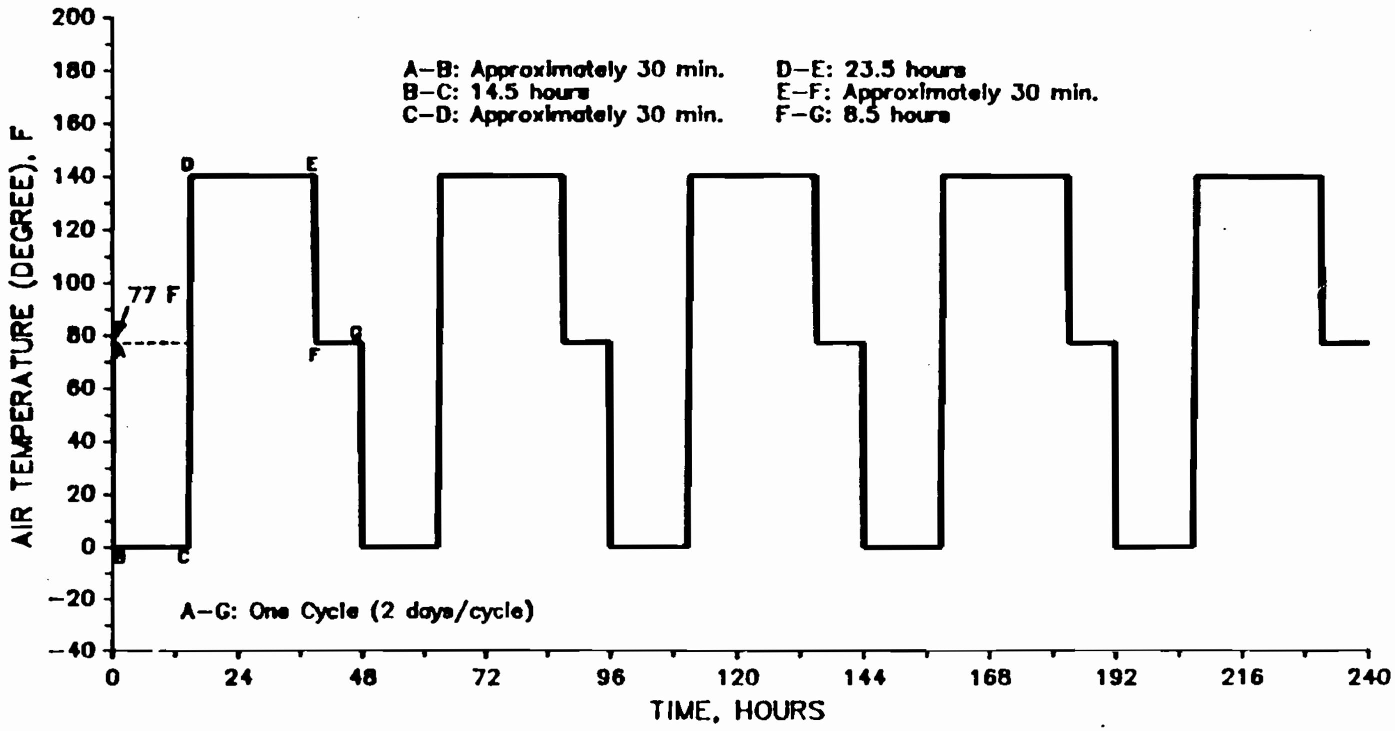


Fig 2.5 Freeze-thaw cycle used in the Multiple Freeze-Thaw Cycle Method.

Boiling Test

This test, which is the Texas Tex-530-C method (Ref 46), involves a visual determination 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.

Approximately 1000 grams of asphalt mix is prepared using the designated type and amount of asphalt and aggregates for the project. The mix is cooled at room temperature for approximately 24 hours prior to performing the stripping test. Two hundred grams of the mix is added to boiling water (distilled) in a stainless steel beaker. The distilled water with the mix contained in the beaker is boiled in an oil bath maintained at 325 to 350 F temperatures for 10 minutes. Then the beaker is removed from the oil bath and stripped asphalt is skimmed from the surface of the water by dipping a paper towel into the beaker. The water is decanted from the beaker and the wet mix is emptied onto a white paper towel. The following day, after the mix has been allowed to dry, the mix is examined to estimate the degree of stripping present in the mixture. The stripping test results are reported as the percent of asphalt retained after boiling.

EXPERIMENTAL PROGRAM

Laboratory tests were performed on mixtures which were: 1) mixed and compacted in the laboratory (laboratory mixtures), 2) mixed in the plant and compacted in the laboratory (plant mixtures), and 3) mixed in the plant and compacted in the field (field cores).

Laboratory Mixed/Laboratory Compacted Mixtures

The asphalt cements, aggregates, liquid antistripping additives and hydrated lime were obtained for each project. These materials were mixed and samples prepared for testing in the laboratory in accordance with the mixture design established for the project. The asphalt content and additive dosage are summarized on Table 2.7 for the laboratory prepared mixtures. The specimens were compacted using a procedure which produced an air void content of 7.0 ± 1.0 percent.

The following tests were conducted on all laboratory mixtures:

TABLE 2.7 SUMMARY OF ASPHALT CONTENT AND ADDITIVE DOSAGE FOR LABORATORY PREPARED MIXTURES

SDHPT District	Additives	Additive Dosage,* %	Asphalt Content,** %
	.Control	0	
	.Lime	1.5	4.9
17	.BA 2000	1.0	
	.Perma-Tac	1.0	
	.Control	0	
	.Lime	1.0	
16	.Aquashield	0.5	4.3
	.Dow	0.41	
	.Pavebond LP	0.5	
	.Control	0	
	.Lime	2.0	5.0
13	.BA 2000	1.0	
	.Perma-Tac	1.0	
	.Control	0	
	.Lime	1.0	
6	.Pavebond LP	1.0	6.2
	.Perma-Tac	1.0	
	.Unichem	1.0	
	.Control	0	
	.Lime	1.0	
25	.Aquashield II	1.0	5.2
	.Fina-A	1.0	
	.Perma-Tac	1.0	
	.Unichem	1.0	
	.Control	0	
	.Lime	1.5	
	.APR-MAZ	0.75	
	.Dow	0.45	6.0
1	.Fina-A	1.0	
	.Indulin AS-1	1.0	
	.Pavebond Special	1.0	
	.Perma-Tac Plus	1.0	
	.Control	0	
	.Lime	1.0	
	.ARR-MAZ	1.0	5.3
19	.Aquashield II	0.8	
	.BA 2000	0.5	
	.Perma-Tac	1.0	
	.Control	0	
	.Lime	1.0	
	.ARR-MAZ	1.0	
	.Aquashield II	0.41	5.2
21	.Dow	0.5	
	.Fina-B	0.41	
	.Pavebond LP	1.0	
	.Perma-Tac	1.0	

* The percentage of hydrated lime is based on the total weight of dry aggregates: the percentage of liquid additive is based on the weight of the asphalt cement.

** Asphalt content is percent by weight of total mixture.

1. Wet-dry indirect tensile test

   Method A Indirect tensile test with modified Lottman conditioning (Tex-531-C method with cure)

   Method B Indirect tensile test with modified Lottman conditioning (Tex-531-C method without cure)

   Method C Indirect tensile test with original Lottman conditioning

   Method D Indirect tensile test with Tunnicliff-Root conditioning

   Method E Indirect tensile test with cyclic freeze-thaw conditioning

2. Texas Boiling Test (Tex-530-C method)

Plant Mixed/Laboratory Compacted Mixtures

Samples of the field mixtures were obtained at the asphalt mixing plant. The samples were transported to the laboratory and subsequently compacted using a compaction procedure which produced an air void content of about 7 percent. It was necessary to reheat the samples to achieve a compaction temperature of 250 F.

Since in plant prepared mixtures there is no option to account for curing, the procedure is the same with cure or without cure. The multiple freeze-thaw cyclic conditioning was not used to evaluate the plant mixtures. Thus, the following tests were used for the plant mixed and laboratory compacted samples:

1. Wet-dry indirect tensile test.

   Method B (or A) Indirect tensile test with modified Lottman conditioning (Tex-531-C method).

   Method C Indirect tensile test with original Lottman conditioning.

   Method D Indirect tensile test with Tunnicliff-Root conditioning.

2. Texas boiling test (Tex-530-C method).

Plant Mixed/Field Compacted Mixtures

Plant mixed and field compacted specimens (4-inch diameter pavement cores) were obtained immediately after construction of the test sections. The field cores were measured and subsequently tested in the laboratory.

Since the number of field cores were limited, only the following two tests were conducted:

1. Wet-dry indirect tensile test

   Method A (or B) Indirect tensile test with modified Lottman conditioning (Tex-531-C method)

2. Texas boiling test (Tex-530-C method)

Testing Program

The treated and untreated mixtures were compacted in the laboratory and the specimens were prepared for the dry and/or wet conditioning. There were 28 laboratory mixed and 12 plant mixed specimens prepared for each test section. The number of specimens for each test method prepared are listed in Table 2.8. If any of the specimens had air voids outside of the 6 to 8 percent range, the specimens were discarded and new specimens were prepared and compacted. Since the amount of material and additives were limited, the number of tested specimens were less than 28 samples for a few test sections.

The Texas boiling test was performed on the laboratory mixture, the plant mixture, and the mixture obtained from the field cores.

Specimen Preparation. For the wet-dry indirect tensile test the laboratory-mixed/laboratory-compacted specimens

TABLE 2.8 TESTING PROGRAM FOR WET-DRY INDIRECT TENSILE TEST PER EACH TREATMENT

Test Methods	Laboratory Mixture		Plant Mixture	
	No. of Dry Specimen	No. of Wet Specimen	No. of Dry Specimen	No. of Wet Specimen
(A) Tex-531-C Method with cure	3	3	-	-
(B) Tex-531-C Method without cure	3	3	3	3
(C) Original Lottman conditioning	-	3	-	3
(D) Tunnicliff-Root Conditioning	-	3	-	3
(E) Cyclic Freeze-Thaw Conditioning				
1 cycle	-	2	-	-
3 cycles	-	2	-	-
5 cycles	-	2	-	-
7 cycles	-	2	-	-
9 cycles	-	2	-	-
Subtotal	6	22	3	9
Total		28		12

consisted of 1000 grams dry weight of aggregate, and were made by using the field job mix formula for each mixture. The appropriate design asphalt content was mixed with the aggregate to produce a cylindrical specimen 4.0-inch in diameter and approximately 2.0-inch in height. Detailed mixing and molding procedures were previously described and summarized on Table 2.6 for each method of the wet-dry indirect tensile test. The plant-mixed/laboratory-compacted specimens consisted of 1000 grams of the actual loose plant mix (asphalt and aggregates) which were reheated to 250 F prior to compaction. Samples were compacted using the Texas-Gyratory shear compactor as described in Texas Test Method Tex-206-F (Ref 46). In order to produce specimens with air voids in the range of 6 to 8 percent, the Texas standard gyratory compaction procedure was modified, and both the number of rotations at 50 psi, and level-up loads at 500 psi, were adjusted by the trial and error.

If antistripping agent was to be evaluated, it was blended with the asphalt. The asphalt was preheated to 275 to 300 F. A proper amount of asphalt and antistripping additive were weighed into a 6-ounce ointment can to yield approximately 100 grams of treated asphalt. The concentration of antistripping additive was expressed as a percent of the treated asphalt. The two materials were immediately mixed by stirring with a small spatula for approximately two minutes.

For the boiling test, approximately 1000 grams of laboratory mix were prepared using the designated asphalt and aggregates. The mix procedure was used according to the Test Method Tex-205-F (Ref 46) with modifications described below. After the preheated asphalt had been added to the aggregate, the material was mixed for 2 minutes. The pan containing the mix was then returned to the oven sufficiently long enough to bring the temperature to 275 ± 5 F. The 2-minute mixing was repeated again. Three cycles of heating and mixing were used, resulting in a total mixing time of six minutes. The mix was then allowed to cool to room temperature for approximately 24 hours prior to performing the stripping test. The field core and the plant mix were reheated to 200-225 F in the oven and approximately 1000 grams of the loosened mix was allowed to cool to room temperature overnight prior to boiling test.

Specimen Conditioning. For the wet-dry indirect tensile test the specimens were tested after either dry or wet conditioning. The dry conditioning consisted of curing the specimen at room temperature (77 F) for at least one day prior to testing. The wet conditioning involved immersing the specimen in distilled water at room temperature, applying a vacuum, and then subjecting the specimen to various types of conditioning as summarized on Table 2.5. The two levels of vacuum discussed below were used to prepare the wet specimens:

1. Twenty-six inches of mercury vacuum while submerged in water for 30 minutes for the original Lottman procedure.
2. Using trial and error method to apply a suitable vacuum pressure to achieve approximately 70 percent (60-80%) degree of saturation for the wet specimens other than the original Lottman procedure. Depending on the type of materials and air void content of the specimens, the vacuum pressure and the duration of vacuum were varied; however, a vacuum pressure of 15-17 inches of mercury with approximately 5-minutes duration usually was sufficient to achieve 70 percent of saturation.

Test Equipment. The test equipment for the wet-dry indirect tensile test was the same as that used in previous studies at the Center for Transportation Research and included a loading frame, loading head, and MTS closed-loop electrohydraulic system to apply load and to control deformation rate (Refs 48 and 49). For the static test the vertical deformations were monitored by a DC linear variable differential transducer (LVDT) positioned on the upper platen. A loading rate of 2 inches per minute was applied at a test temperature of 77 F. The peak loads were obtained by a direct digital readout device.

TEST PROPERTIES ANALYZED

The test properties analyzed were: indirect tensile strength, tensile strength ratio and Boiling Water Stripping test value. The engineering properties and other properties required for analysis are described in the following. Equations used to calculate each property are also included in the sections that follow.

Tensile Strength. The indirect tensile strength is the maximum tensile stress which the specimen attains during destructive testing in indirect tension. For 4-inch diameter specimens and the load-deformation information obtained from the static test, tensile strength can be calculated from the following relationship:

$$S_T = \frac{0.156\,P}{t} \quad \text{(Eq 2.2)}$$

where

S_T = tensile strength, psi,

P = the maximum load carried by the specimen, lb, and

t = thickness or height of the specimen, inch.

Tensile Strength Ratio. In order to evaluate the effect of moisture conditioning on the stripping and non-stripping mixtures, a parameter was defined in terms of tensile strengths of the wet and dry specimens. The tensile strength ratio is defined as follows:

$$TSR = \frac{S_{T_{wet}}}{S_{T_{dry}}} \quad \text{(Eq 2.3)}$$

where

TSR = tensile strength ratio,

$S_{T_{wet}}$ = tensile strength of the wet specimen, psi, and

$S_{T_{dry}}$ = tensile strength of the dry specimen, psi

Boiling Water Stripping Test Value. This value is expressed as the percent of asphalt retained after the boiling water test. The value is visually estimated according to the degree of stripping present in the mixture. The values reported in this report are the opposite of those reported in Texas Test Method Tex-530-C, which uses percent stripping.

Bulk Specific Gravity. The bulk specific gravity is the ratio of the weight of the compacted bituminous mixture specimen to the bulk volume of the specimen. ASTM Designation D 2726-73 was used to determine the actual specific gravity as follows:

$$G_a = \frac{A}{B - C} \qquad \text{(Eq 2.4)}$$

where

G_a = actual specific gravity,

A = weight of the dry specimen in air, g

B = weight of the saturated surface-dry specimen in air, g, and

C = weight of the specimen in water, g

Theoretical Maximum Specific Gravity. The theoretical maximum specific gravity of a specimen occurs when all the air voids are filled. ASTM D 2041-78 or Tex-227-F (Ref 46) was used to determine the maximum specific gravity as follows:

$$G_{rc} = \frac{A}{D + A_{sd} - E} \qquad \text{(Eq 2.5)}$$

Where: G_{rc} = Maximum theoretical specific gravity corrected for water absorption during test

A_{sd} = Weight (grams) of surface dry sample in air

D = Weight (grams) of calibrated pycnometer filled with water

E = Weight (grams) of pycnometer containing sample and filled with water to the calibration level

Percent Air Voids in Specimens. The air voids in a specimen are the small air spaces between the individual aggregate particles. This can be determined by the following equation:

$$AV = \frac{G_{rc} - G_a}{G_{rc}} X\ 100 \qquad \text{(Eq 2.6)}$$

where

AV = air voids in a specimen, percent, and

G_a = actual bulk specific gravity of a specimen.

G_{rc} = Maximum theoretical specific gravity corrected for water absorption

Degree of Saturation. The ratio of the volume of water in a specimen to the total volume of voids is the degree of saturation and is calculated as a percentage:

$$S = \frac{V_W}{V_V} X 100 \qquad \text{(Eq 2.7)}$$

where

S = degree of saturation in wet specimen, percent,

V_W = volume of water in a wet specimen, and

V_V = total volume of voids in a wet specimen.

CHAPTER 3

SUMMARY AND PRESENTATION OF EXPERIMENTAL RESULTS

This chapter summarizes the test results obtained for the laboratory prepared mixtures, the plant mixed-laboratory compacted mixtures, and the field cores taken immediately after construction. All test results are listed and illustrated in the tables and figures in the Appendices A through H. The data are summarized in the following according to two basic types of tests, i.e., the wet-dry indirect tensile test and the Texas boiling test.

WET-DRY INDIRECT TENSILE TEST RESULTS

Laboratory Mixture

Five test methods for the laboratory mixture were:

1) Method A: Tex-531-C method.

2) Method B: Modified Tex-531-C method.

3) Method C: Original Lottman method.

4) Method D: Tunnicliff-Root method.

5) Method E: Multiple freeze-thaw cyclic method.

Tensile strength ratios were obtained for the test methods A through D using the average tensile strength of the three wet specimens divided by the average tensile strength of the three dry specimens. The TSR values are summarized in Tables 3.1 for the test methods A through D. The test results for the multiple freeze-thaw cyclic method are summarized in Table 3.2 where the TSR values represent the average conditioned tensile strength for a specific number of cycles divided by the original average dry tensile strength.

Plant Mixture

Three test methods utilized to evaluate the plant mixture were:

1) Method B: Tex-531-C method.

2) Method C: Original Lottman method.

3) Method D: Tunnicliff-Root method.

Tensile strength ratios were obtained for the test methods B through D using the average tensile strength of the three wet specimens divided by the average tensile

TABLE 3.1 SUMMARY OF TSR TEST RESULTS FOR LABORATORY MIXTURES

District	Additive Name	Tensile Strength Ratio (TSR)				
		Tex-531-C with Cure	Tex-531-C w/o Cure	Original Lottman	Tunnicliff-Root	First Cycle
17	No Additive	0.51	0.51	0.47	0.52	0.49
	Lime	1.18	1.19	1.12	1.23	1.02
	BA 2000	0.82	0.96	0.88	1.09	0.80
	Perma-Tac	0.82	0.94	0.91	0.97	0.77
16	No Additive	0.44	0.47	0.44	0.53	0.61
	Lime	0.74	0.83	0.77	0.93	1.20
	Aquashield	0.56	0.62	0.60	0.70	0.77
	Dow	0.53	0.58	0.45	0.68	0.68
	Pavebond LP	0.60	0.55	0.57	0.67	0.83
13	No Additive	0.43	0.55	0.53	0.70	0.81
	Lime	1.42	1.27	1.22	1.26	1.19
	BA 2000	0.64	0.66	0.79	0.85	1.21
	Perma-Tac	0.61	0.69	0.78	0.88	1.03
6	No Additive	0.20	0.23	0.15	0.32	0.66
	Lime	0.78	0.62	0.58	0.78	1.07
	Pavebond LP	0.40	0.35	0.26	0.42	0.53
	Perma-Tac	0.49	0.37	0.30	0.42	0.51
	Unichem	0.37	0.42	0.30	0.54	0.61
25	No Additive	0.67	0.62	0.46	0.64	0.71
	Lime	1.30	1.23	0.93	1.07	1.17
	Aquashield II	1.19	1.23	0.82	1.01	1.02
	Fina-A	0.98	1.18	0.82	1.01	1.01
	Perma-Tac	1.03	0.97	0.70	0.86	0.83
	Unichem	0.92	1.02	0.72	0.87	1.02
1	No Additive	0.74	0.96	0.80	1.01	0.91
	Lime	1.06	1.22	1.14	1.24	1.26
	ARR-MAZ	1.14	1.26	1.14	1.29	1.24
	Dow	0.70	0.85	0.82	0.95	0.90
	Fina-A	1.10	1.10	1.10	1.20	1.18
	Indulin AS-1	1.07	1.14	1.17	1.22	1.09
	PVBD Special	1.21	1.37	1.50	1.42	1.23
	Perma-Tac Plus	1.15	1.15	0.94	1.13	1.01
19	No Additive	1.12	1.07	0.93	0.98	1.19
	Lime	1.07	1.53	1.45	1.64	1.59
	ARR-MAZ	1.19	1.09	0.99	1.20	1.20
	Aquashield II	1.25	1.24	1.11	1.36	1.31
	BA 2000	1.16	1.07	1.22	1.30	1.29
	Perma-Tac	0.93	1.17	1.03	1.03	1.12
21	No Additive	0.24	0.28	0.22	0.27	0.35
	Lime	1.04	1.06	1.04	1.07	1.19
	ARR-MAZ	0.52	0.48	0.39	0.55	0.63
	Aquashield II	0.73	0.76	0.54	0.74	0.73
	Dow	0.35	0.37	0.30	0.37	0.49
	Fina-B	0.45	0.88	0.59	0.78	0.81
	Pavebond LP	0.51	0.55	0.53	0.58	0.63
	Perma-Tac	0.47	0.52	0.39	0.49	0.64

TABLE 3.2 SUMMARY OF MULTIPLE FREEZE-THAW CYCLIC TEST RESULTS FOR LABORATORY MIXTURES

District	Additive Name	Tensile Strength Ratio (TSR) 1 CYCLE	3 CYCLES	5 CYCLES	7 CYCLES	9 CYCLES
17	No Additive	0.49	0.36	0.28	0.25	0.19
	Lime	1.02	1.03	0.82	0.81	0.84
	BA 2000	0.80	0.81	0.60	0.64	0.54
	Perma-Tac	0.77	0.67	0.62	0.57	0.52
16	No Additive	0.61	0.49	0.37	0.31	0.39
	Lime	1.20	0.99	0.83	0.63	0.67
	Aquashield	0.77	0.79	0.68	0.56	0.67
	Dow	0.68	0.56	0.47	0.33	0.37
	Pavebond LP	0.83	0.60	0.49	0.48	0.46
13	No Additive	0.81	0.57	0.43	0.36	0.33
	Lime	1.19	1.05	1.06	0.92	1.02
	BA 2000	1.21	1.02	1.00	0.54	0.79
	Perma-Tac Plus	1.03	1.05	0.89	0.70	0.90
6	No Additive	0.66	0.22	0.13	0.16	0.13
	Lime	1.07	0.89	0.71	0.54	0.57
	Pavebond LP	0.53	0.47	0.30	0.19	0.24
	Perma-Tac	0.51	0.47	0.32	0.28	0.26
	Unichem	0.61	0.51	0.37	0.30	0.25
25	No Additive	0.71	0.44	0.27	0.28	0.23
	Lime	1.17	1.04	0.86	0.98	0.89
	Aquashield II	1.02	0.85	0.80	0.90	0.71
	Fina-A	1.01	0.80	0.83	0.76	0.79
	Perma-Tac	0.83	0.69	0.62	0.59	0.44
	Unichem	1.02	0.75	0.66	0.62	0.48
1	No Additive	0.91	0.68	0.52	0.47	0.31
	Lime	1.26	1.01	1.00	0.91	0.89
	ARR-MAZ	1.24	1.07	1.06	0.91	0.89
	Dow	0.90	0.70	0.59	0.43	0.32
	Fina-A	1.18	0.99	0.95	0.84	0.85
	Indulin AS-1	1.09	1.00	0.91	0.86	0.80
	PVBD Special	1.23	1.28	1.16	1.04	0.95
	Perma-Tac Plus	1.01	1.00	0.90	0.78	0.56
19	No Additive	1.19	0.66	0.64	0.45	0.48
	Lime	1.59	1.61	1.00	1.06	1.01
	ARR-MAZ	1.20	1.05	0.75	0.70	0.74
	Aquashield II	1.31	1.16	0.99	1.06	1.09
	BA 2000	1.29	1.15	0.94	0.92	0.83
	Perma-Tac	1.12	0.85	0.75	0.61	0.61
21	No Additive	0.35	0.17	0.22	0.18	0.13
	Lime	1.19	1.03	1.00	0.79	0.78
	ARR-MAZ	0.63	0.50	0.50	0.42	0.41
	Aquashield II	0.73	0.61	0.60	0.54	0.49
	Dow	0.49	0.26	0.27	0.23	0.19
	Fina-B	0.81	0.74	0.67	0.62	0.56
	Pavebond LP	0.63	0.47	0.53	0.45	0.46
	Perma-Tac	0.64	0.43	0.40	0.35	0.36

strength of the three dry specimens. The TSR values are summarized in Table 3.3 for the test methods B through D.

Field Core

The field cores were air-dried in the laboratory and the air voids determined before testing. For each pair of field cores, one was tested dry and the other was tested using the Tex-531-C wet conditioning technique. A tensile strength ratio was obtained for each pair of field cores using the tensile strength of the wet specimen divided by the tensile strength of the dry specimen (Eq 2.1). A summary of the average air voids and the average TSR values for the low and high air void test sections of the eight projects are presented in Table 3.4. The average air voids were the average air void content of all of the pairs of field cores from the low and high void test sections. In some cases, the average low and high air voids were reversed compared to the targeted low and high voids test sections. In these cases, the test sections were classified with respect to the actual air voids in the pavement as noted on the table.

TABLE 3.3 SUMMARY OF TSR TEST RESULTS FOR PLANT MIXED-LABORATORY COMPACTED MIXTURES

District	Additive Name	Tensile Strength Ratio (TSR)		
		Tex-531-C Method	Original Tunnicliff-Lottman	Root
17	No Additive	0.64	0.51	0.61
	Lime	1.18	1.01	1.09
	BA 2000	1.07	0.98	1.01
	Perma-Tac	0.51	0.43	0.50
16	No Additive	0.79	0.72	0.87
	Lime	1.02	0.87	1.01
	Aquashield	0.87	0.76	0.87
	Dow	0.75	0.72	0.87
	Pavebond LP	0.77	0.75	0.90
13	No Additive	1.03	1.02	0.98
	Lime	1.03	1.02	0.97
	BA 2000	1.08	0.96	0.99
	Perma-Tac	1.00	0.98	0.96
6	No Additive	0.47	0.38	0.54
	Lime	0.54	0.43	0.66
	Pavebond LP	0.83	0.66	0.80
	Perma-Tac	0.78	0.65	0.85
	Unichem	0.64	0.61	0.78
25	No Additive	0.60	0.44	0.64
	Lime	0.89	0.76	0.90
	Aquashield II	0.60	0.48	0.63
	Fina-A	0.85	0.79	0.96
	Perma-Tac	0.76	0.63	0.76
	Unichem	0.75	0.67	0.78
1	No Additive	1.06	0.97	1.07
	Lime	1.12	1.27	1.12
	ARR-MAZ	1.10	1.23	1.16
	Dow	0.97	0.95	0.96
	Fina-A	1.12	1.20	1.15
	Indulin AS-1	1.10	1.22	1.19
	PVBD Special	1.15	1.24	1.19
	Perma-Tac Plus	1.02	1.07	1.12
19	No Additive	0.73	0.75	0.80
	Lime	1.11	1.16	1.21
	ARR-MAZ	1.12	1.08	1.08
	Aquashield II	1.16	1.24	1.17
	BA 2000	1.21	1.26	1.27
	Perma-Tac	1.01	1.14	1.15
21	No Additive	0.23	0.28	0.26
	Lime	0.17	0.19	0.19
	ARR-MAZ	0.39	0.41	0.40
	Aquashield II	0.47	0.53	0.50
	Dow	0.30	0.30	0.29
	Fina-B	0.56	0.65	0.56
	Pavebond LP	0.51	0.59	0.51
	Perma-Tac	0.42	0.49	0.44

TABLE 3.4 SUMMARY OF TSR (TEX-531-C) TEST RESULTS FOR FIELD CORES

SDHPT District	Additive Name	Test Section High/Low Voids	Air Voids (AVG)	Tensile Strength Ratio (AVG)
17	No Additive	Low Voids High Voids	5.2 6.4	0.58 0.63
	Lime	Low Voids High Voids	2.8 4.6	1.01 0.99
	BA 2000	Low Voids High Voids	6.2 7.3	0.94 0.92
	Perma-Tac Plus	High Voids* Low Voids*	7.1 4.8	0.54 1.02
16	No Additive	High Voids* Low Voids*	9.6 9.5	0.66 0.71
	Lime	Low Voids High Voids	8.6 8.7	0.86 0.93
	Pavebond LP	High Voids* Low Voids*	10.8 10.2	0.85 0.69
	Aquashield	High Voids* Lowh Voids*	10.6 9.8	0.76 0.84
	Dow	Low Voids High Voids	8.7 9.6	0.76 0.63
13	No Additive	Low Voids High Voids	5.6 6.2	0.87 0.82
	Lime	High Voids* Low Voids*	5.5 5.2	0.82 1.07
	BA 2000	Low Voids High Voids	5.8 6.1	0.93 0.88
	Perma-Tac Plus	Low Voids High Voids	4.3 5.5	0.90 1.08
6	No Additive	Low Voids High Voids	8.2 11.1	0.52 0.44
	Lime	Low Voids High Voids	8.5 10.7	0.50 0.44
	Pavebond LP	Low Voids High Voids	9.2 10.6	0.72 0.64
	Perma-Tac	High Voids* Low Voids*	9.5 8.0	0.60 0.67
	Unichem	High Voids* Low Voids*	9.8 9.7	0.65 0.65

TABLE 3.4 (Continued)

SDHPT District	Additive Name	Test Section High/Low Voids	Air Voids (AVG)	Tensile Strength Ratio (AVG)
25	No Additive	Low Voids	9.9	0.53
		High Voids	11.2	0.64
	Lime	High Voids*	8.3	1.00
		Low Voids*	7.9	0.99
	Aquashield II	Low Voids	9.2	0.63
		High Voids	10.1	0.96
	Fina-A	Low Voids	8.4	1.11
		High Voids	10.3	1.02
	Perma-Tac	Low Voids	8.0	0.80
		High Voids	8.7	0.94
	Unichem	Low Voids	8.7	0.84
		High Voids	9.4	0.60
1	No Additive	Low Voids	5.6	0.91
		High Voids	9.5	0.88
	Lime	Low Voids	6.6	1.31
		High Voids	6.6	1.20
	ARR-MAZ	Low Voids	6.7	1.18
		High Voids	8.8	1.36
	Dow	High Voids*	8.8	1.07
		Low Voids*	8.4	1.01
	Fina-A	High Voids*	6.0	0.99
		Low Voids*	5.8	1.11
	INDULIN AS-1	Low Voids	5.5	1.12
		High Voids	8.1	1.19
	Pavebond Special	Low Voids	6.2	1.03
		High Voids	9.3	1.02
	Perma-Tac Plus	Low Voids	6.6	1.13
		High Voids	9.4	1.13
19	No Additive	High Voids*	9.9	0.79
		Low Voids*	8.1	0.87
	Lime	Low Voids	6.2	1.10
		High Voids	7.8	1.23
	ARR-MAZ	High Voids*	8.4	1.12
		Low Voids*	7.7	1.24
	Aquashield II	High Voids*	8.8	1.36
		Low Voids*	8.4	1.70

TABLE 3.4 (Continued)

SDHPT District	Additive Name	Test Section High/Low Voids	Air Voids (AVG)	Tensile Strength Ratio (AVG)
	BA 2000	Low Voids	7.2	1.09
		High Voids	7.8	1.12
	Perma-Tac	Low Voids	8.0	1.05
		High Voids	8.3	1.04
21	No Additive	Low Voids	8.3	0.56
		High Voids	9.7	0.53
	Lime	Low Voids	10.9	0.77
		High Voids	11.9	1.21
	ARR-MAZ	Low Voids	8.2	0.80
		High Voids	10.4	0.73
	Aquashield II	Low Voids	6.7	0.73
		High Voids	7.9	0.95
	Dow	Low Voids	8.8	0.62
		High Voids	12.0	0.53
	Fina-B	Low Voids	7.1	0.76
		High Voids	7.9	0.75
	Pavebond LP	Low Voids	9.1	0.80
		High Voids	11.9	0.73
	Perma-Tac	Low Voids	8.9	0.99
		High Voids	12.5	0.68

*Note: The low and high voids test sections represent the actual air void content of field test sections rather than the targeted values.

TEXAS BOILING TEST RESULTS

Laboratory Mixture

Approximately 1000 grams of treated and untreated asphalt-aggregate mixtures were prepared in the laboratory and a portion of the mixture, 200 grams, was used for the boiling test. The boiled mixture was examined the following day after it had been allowed to dry. The percent of asphalt retained after boiling was estimated independently by two operators at different times. The average value of the two ratings was reported as the asphalt retained in the mixture. The test results are summarized on Table 3.5.

Plant Mixture

Approximately 1000 grams of loose plant mixtures were heated at 140 F temperature in the oven and 200 grams of the loose plant mixtures were used for the boiling test. The same procedure was followed as described above for the laboratory mixture. The test results are also summarized in Table 3.5.

TABLE 3.5 SUMMARY OF BOILING (TEX-530-C) TEST RESULTS

District	Additive Name	Asphalt Retained After Boiling, %		
		Lab Mix	Plant Mix	Field Core
17	No Additive	50.0	52.5	50.0
	Lime	85.0	94.0	92.5
	BA 2000	92.5	92.5	92.5
	Perma-Tac	90.0	50.0	90.0
16	No Additive	77.5	82.5	75.0
	Lime	75.0	82.5	77.5
	Aquashield	77.5	85.0	82.5
	Dow	77.5	85.0	75.0
	Pavebond LP	77.5	85.0	72.5
13	No Additive	77.5	77.5	82.5
	Lime	96.5	96.5	90.0
	BA 2000	97.5	96.5	92.5
	Perma-Tac	96.5	95.0	92.5
6	No Additive	50.0	70.0	60.0
	Lime	72.5	72.5	60.0
	Pavebond LP	60.0	85.0	87.5
	Perma-Tac	65.0	80.0	75.0
	Unichem	67.5	85.0	90.0
25	No Additive	50.0	77.5	72.5
	Lime	85.0	87.5	85.0
	Aquashield II	96.5	77.5	72.5
	Fina-A	94.0	94.0	92.5
	Perma-Tac	90.0	92.5	87.5
	Unichem	94.0	87.5	77.5
1	No Additive	82.5	90.0	91.5
	Lime	92.5	92.5	95.0
	AkR-MAZ	90.0	97.5	95.0
	Dow	82.5	91.5	92.5
	Fina-A	92.5	95.0	97.5
	Indulin AS-1	92.5	96.5	95.0
	PVBD Special	92.5	95.0	97.5
	Perma-Tac Plus	92.5	95.0	95.0
19	No Additive	85.0	85.0	87.5
	Lime	94.0	90.0	85.0
	ARR-MAZ	92.5	90.0	90.0
	Aquashield II	92.5	94.0	90.0
	BA 2000	92.5	96.5	90.0
	Perma-Tac	92.5	90.0	90.0
21	No Additive	37.5	25.0	25.0
	Lime	81.0	37.5	45.0
	ARR-MAZ	55.0	57.5	50.0
	Aquashield II	77.5	67.5	67.5
	Dow	57.5	52.5	47.5
	Fina-B	80.0	75.0	65.0
	Pavebond LP	65.0	67.5	62.5
	Perma-Tac	55.0	61.0	60.0

Field Core

A field core was randomly selected and was heated at 140 F temperature in oven. Two hundred grams of the loosened mixture was used for the boiling test. The procedure was the same as described above. The test results for the field cores are summarized on Table 3.5.

ANOMALIES IN TEST RESULTS

A few anomalies were identified during the analysis of the test data. These anomalies are discussed below.

District 17

One discrepancy was concerned with the plant mixture of the Perma-Tac which showed the percent asphalt retained after boiling was extremely low, even as low as the control materials (Table 3.5). The tensile strength ratios of the high voids test section where the loose plant mixtures were taken were also as low as the control (Table 3.4); however, the tensile strength ratios of the low voids test section were much higher than that of the control.

In order to investigate the presence of the Perma-Tac in the mixtures, infrared spectrascopy tests were performed on the field cored mixtures taken from both the low and high voids test sections supposedly containing Perma-Tac. It was confirmed by infrared spectroscopy that the Perma-Tac was present in both the low and the high voids test sections. Due to some unknown reasons, the treated materials from the low voids test section had much higher TSR values than the materials from the high voids test section.

District 25

An anomaly was identified with the plant mixture and the field core from the low voids test section of the Aquashield II (Tables 3.3, 3.4, and 3.5). The boiling test was run on the field core and the plant mixture taken from the low voids test section. The percent asphalt retained after boiling was very low for both the field core and the plant mixture (Table 3.5). The tensile strength ratio for the plant mixed-laboratory compacted mixture was also low (Table 3.3). However, the tensile strength ratios of the field core from the high voids test section were much higher than that from the low voids test section (Table 3.4).

Again, infrared spectroscopy tests were performed on the field cored mixtures taken from both the low and high voids test sections supposedly containing Aquashield II. It was also confirmed by infrared spectroscopy that the Aquashield II was present in both the low and the high voids test sections. Nevertheless, the two test sections behaved differently in terms of the resistance to moisture susceptibility.

District 21

The problem was concerned with the plant mixture and the field core from the lime treated test sections. There was a significant difference in moisture resistance between the laboratory prepared mixture and the plant prepared mixture for the hydrated lime (Tables 3.1, 3.3, and 3.5). The hydrated lime was added in slurry form to the aggregates prior to entering into the drum mixer, whereas in the laboratory the lime slurry was added to the dry aggregates and mixture was oven-dried prior to mixing with the asphalt cement. The mixing procedures were the same as for the other projects such as Districts 17, 16, 13, and 25; however, for some unknown reasons, the difference between the data obtained for the laboratory mixture and the plant mixture were very pronounced for both the boiling test

(Table 3.5) and the wet-dry indirect tensile test (Tables 3.1 and 3.3).

During laboratory testing, an observation was made that some clayey materials in the plant-mixed/laboratory-prepared samples showed some signs of swelling upon moisture conditioning. The contained clay materials might be detrimental to the wet specimens; thus, the wet tensile strength was greatly reduced for the lime treated mixtures.

Lime Treated Mixtures

An apparent anomaly is the lime treated mixtures that exhibited higher wet tensile strength compared to the dry tensile strength, i.e., the tensile strength ratio exceeding 1.0 for the lime treated mixtures. This behavior has been observed by many other researchers (Refs 5, 12, 29, 34, and 44) but has not been thoroughly investigated. Thus, further research is needed to better understand the interactions of hydrated lime, asphalt, and aggregate.

CHAPTER 4

ANALYSIS OF LABORATORY AND PLANT MIXTURES TEST RESULTS

The test results and analysis of the laboratory and plant mixtures are discussed in this chapter. The following analyses were conducted

1) To evaluate the relationships between various moisture damage test values,
2) To compare the differences and similarities between the laboratory mixture and the plant mixture, and
3) To determine the effectiveness of hydrated lime and various liquid additives.

The multiple freeze-thaw cycle test results were also analyzed to determine the effect of freeze-thaw cycles on the moisture resistance of the treated and untreated mixtures.

COMPARISON OF MOISTURE DAMAGE TEST VALUES

Five wet-dry indirect tensile test methods were used for the laboratory mixtures and three test methods were used for the plant mixtures. The boiling test results are also analyzed and correlated with the TSR values.

Effect of Curing for Modified Lottman (Tex-531-C) Procedure

The results from the Tex-531-C method with and without curing are compared in Figure 4.1 for each of the eight projects. The test values for all laboratory mixtures are compared in Figure 4.2. Test values from the Tex-531-C method with cure and the Tex-531-C method without cure are essentially equal with the exception of the values for the lime treated mixtures in District 19. The linear regression relationship between the two sets of TSR values approximates the line of equality and the R-squared value of 0.86 indicates a reasonably good correlation.

Thus, the time required for testing in the laboratory can possibly be shortened significantly. Nevertheless additional aggregates with a wider range of absorption probably should be tested.

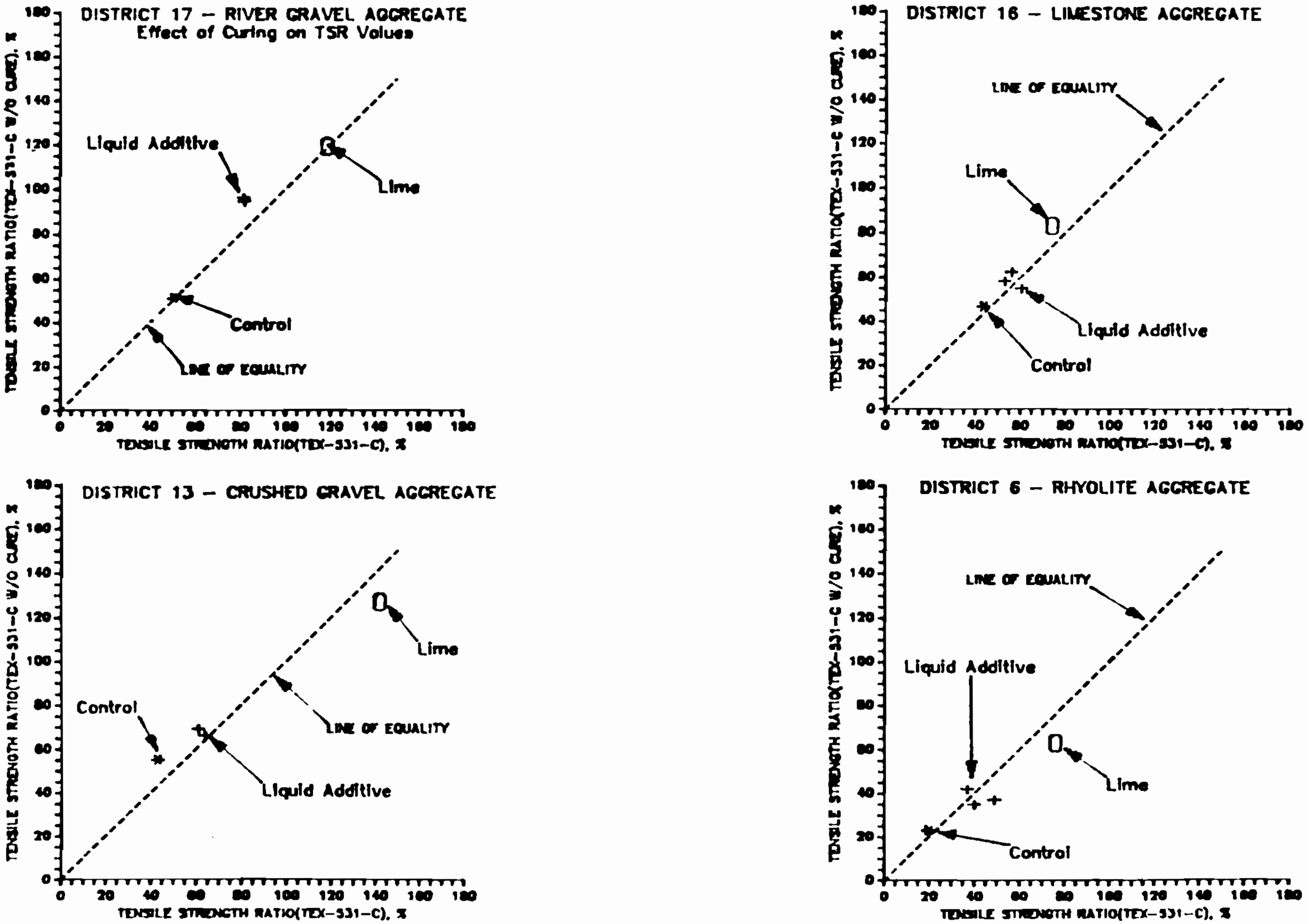


Fig. 4.1 Effect of curing on TSR values for modified Lottman (Tex-531-C) procedure.

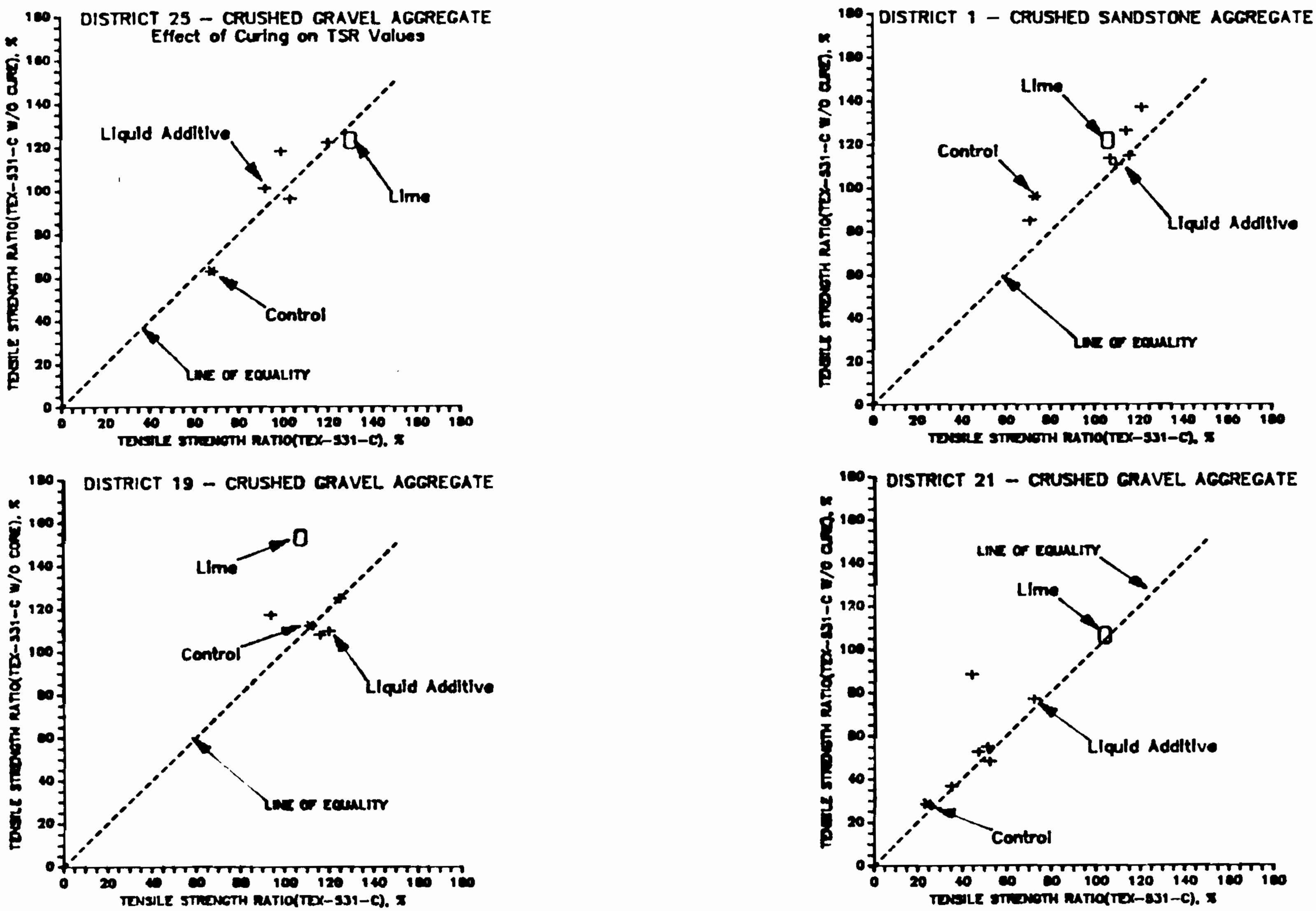


Fig. 4.1 Effect of curing on TSR values for modified Lottman (Tex-531-C) procedure - continued.

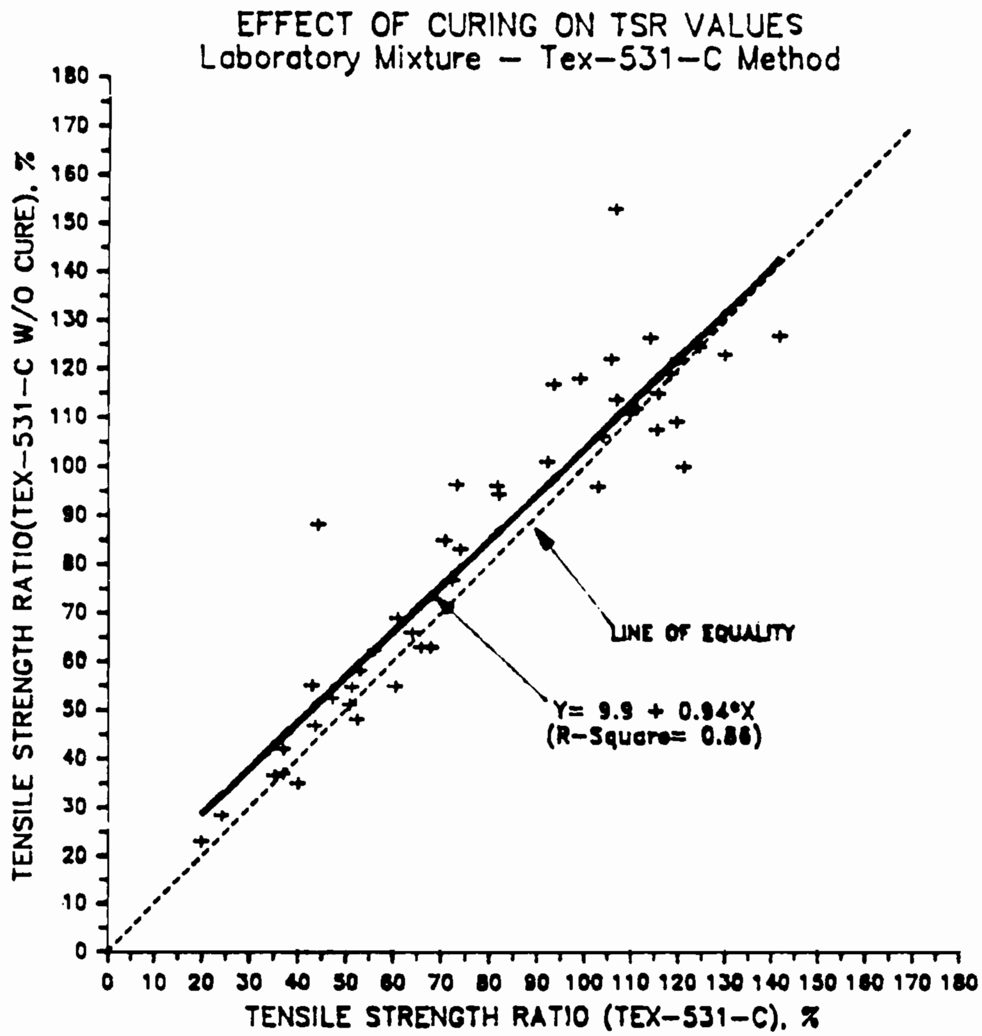


Fig 4.2 Effect of curing on TSR values for modified Lottman (Tex-531-C) procedure for all projects.

Comparison of Tensile Strength Ratios

Comparisons of the TSR values for laboratory and plant mixtures are shown in Figures 4.3 and 4.4. All tests are compared to the modified Lottman procedure (Tex-531-C) which is utilized by the Texas SDHPT.

The original Lottman test procedure was more severe than the other test methods evaluated as evidenced by the lower TSR values. The TSR values for the Tunnicliff-Root procedure tended to be approximately equal to or slightly less than the TSR values for the modified Lottman (Tex-531-C) procedure. The first cycle of the multiple freeze-thaw cycle procedure was the least severe (Fig 4.3). Thus, the test methods, ranked in decreasing order of severity, are

(1) Original Lottman,

(2) Modified Lottman (Tex-531-C), and

(3) Tunnicliff-Root.

The severity of the original Lottman is attributed to high degree of saturation of the specimens produced by the vacuum saturation procedure. In the modified Lottman procedure (Tex-531-C), the degree of saturation is controlled between 60 and 80 percent resulting in less damage. In the Tunnicliff-Root method, the degree of

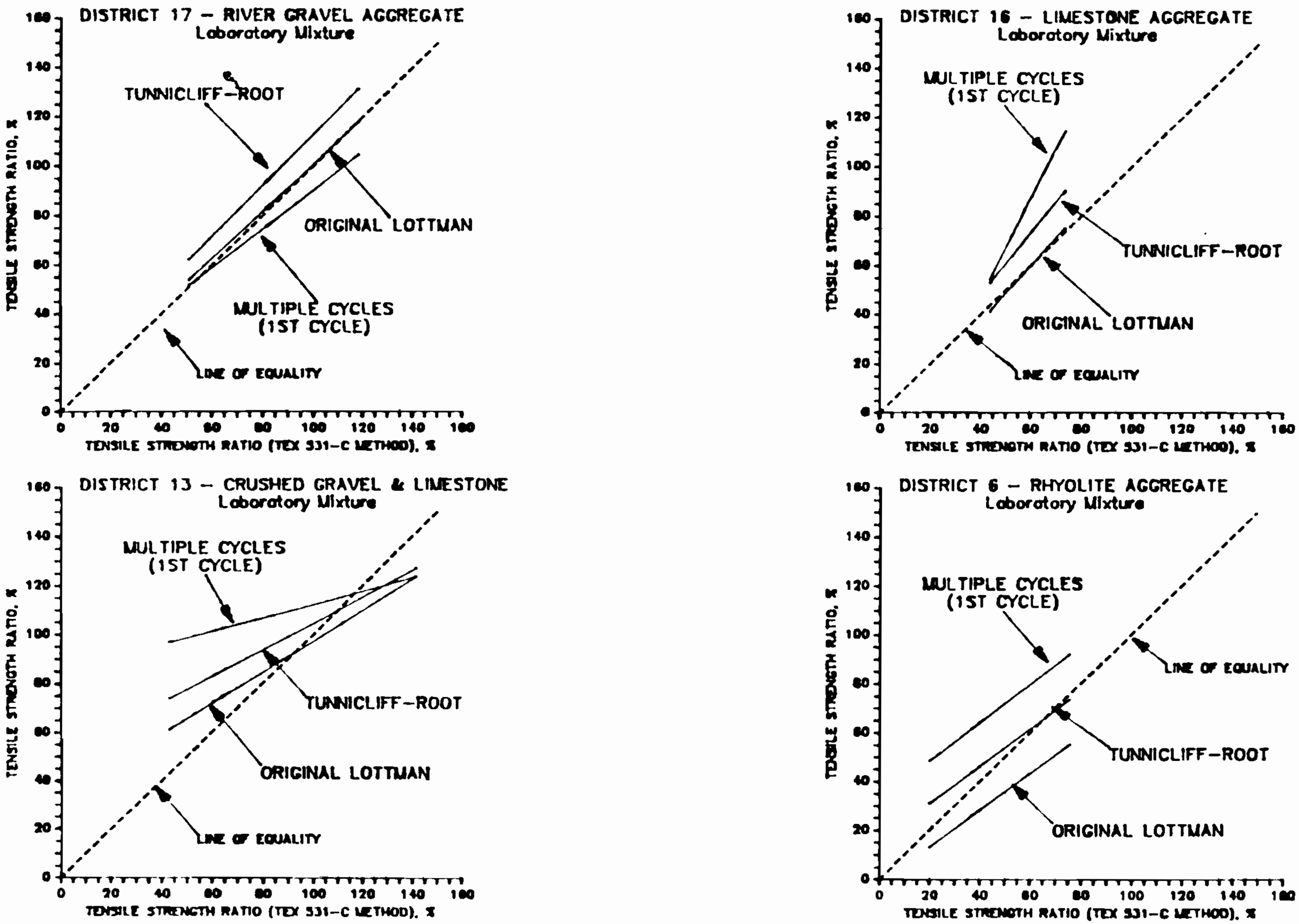


Fig. 4.3 Comparison of TSR values for laboratory mixtures.

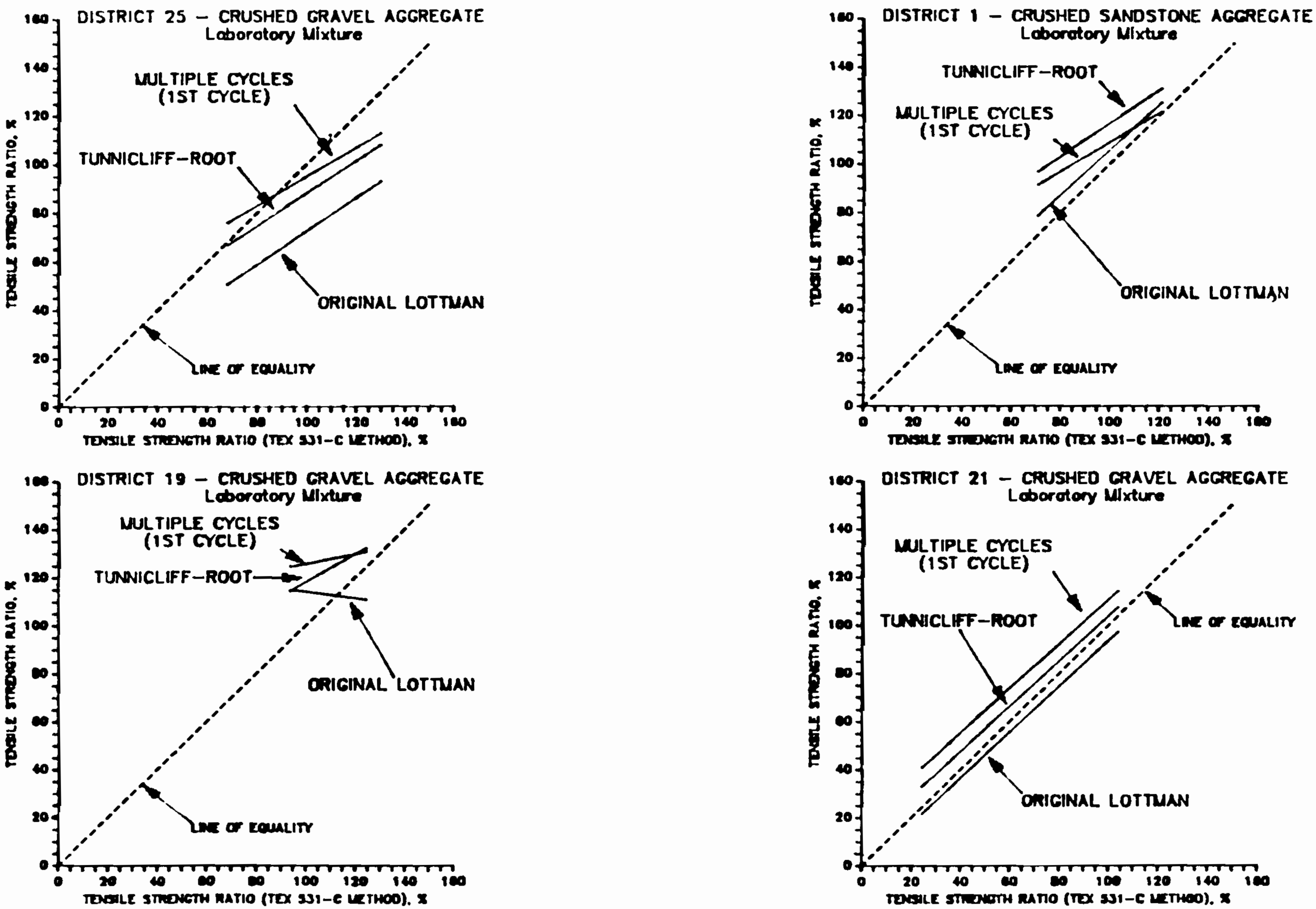


Fig. 4.3 Comparison of TSR values for laboratory mixtures - continued.

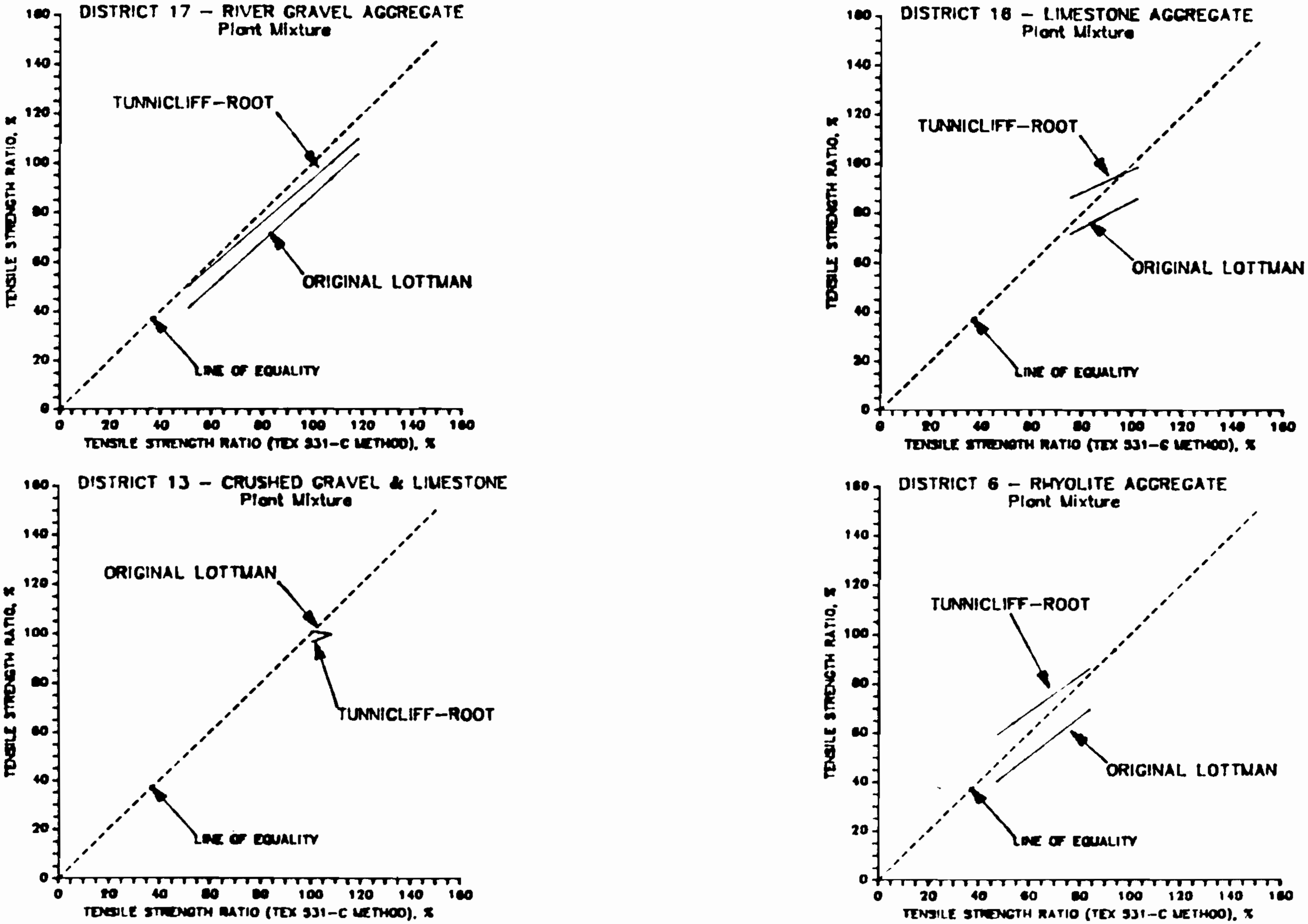


Fig. 4.4 Comparison of TSR values for plant mixtures.

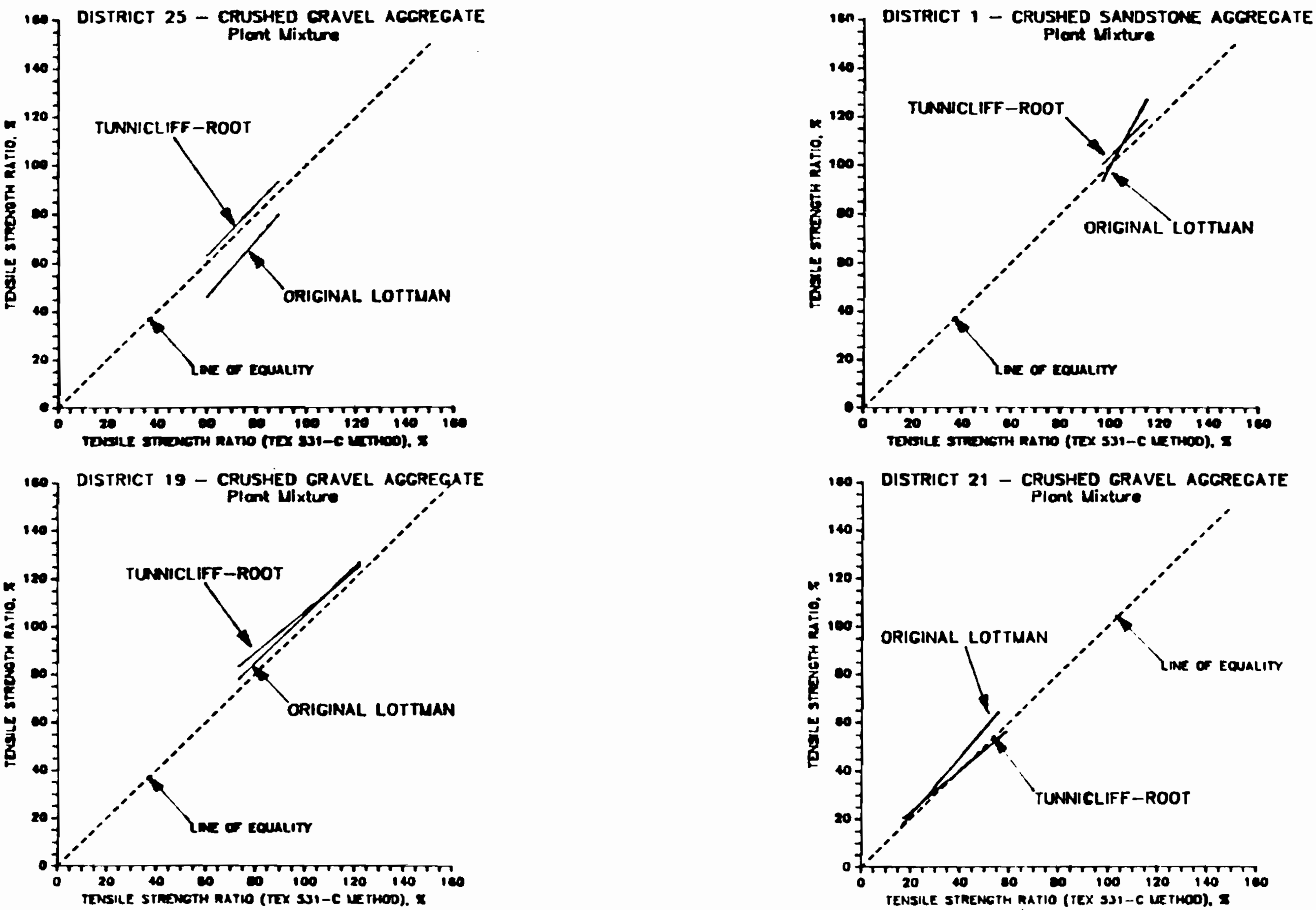


Fig. 4.4 Comparison of TSR values for plant mixtures - continued.

saturation is also controlled between 55 and 80 percent, but, in addition no freeze cycle is used and the specimens are conditioned with only a warm (140 F) water-bath soak; thus, damage due to freezing is eliminated. In the cyclic Freeze-Thaw test, the specimens were immersed in water and subjected to repeated freeze-thaw cycles.

Correlations of TSR Values with Modified Lottman TSR Values

The previous analysis establishes the relative severity of the tests and indicates that the methods provide different TSR values. Thus, the TSR values were analyzed to establish possible correlations.

Laboratory mixtures. The laboratory mixture TSR values for the different test procedures were correlated with the TSR values obtained from the modified Lottman (Tex-531-C) procedure as shown in Figures 4.5a, b, and c. For each comparison, e.g., the original Lottman versus the modified Lottman, there are two correlation relationships shown for the data set; one which regressed the original Lottman data on the modified Lottman (Tex-531-C) data and the second which regressed the modified Lottman (Tex-531-C) data on the original Lottman data.

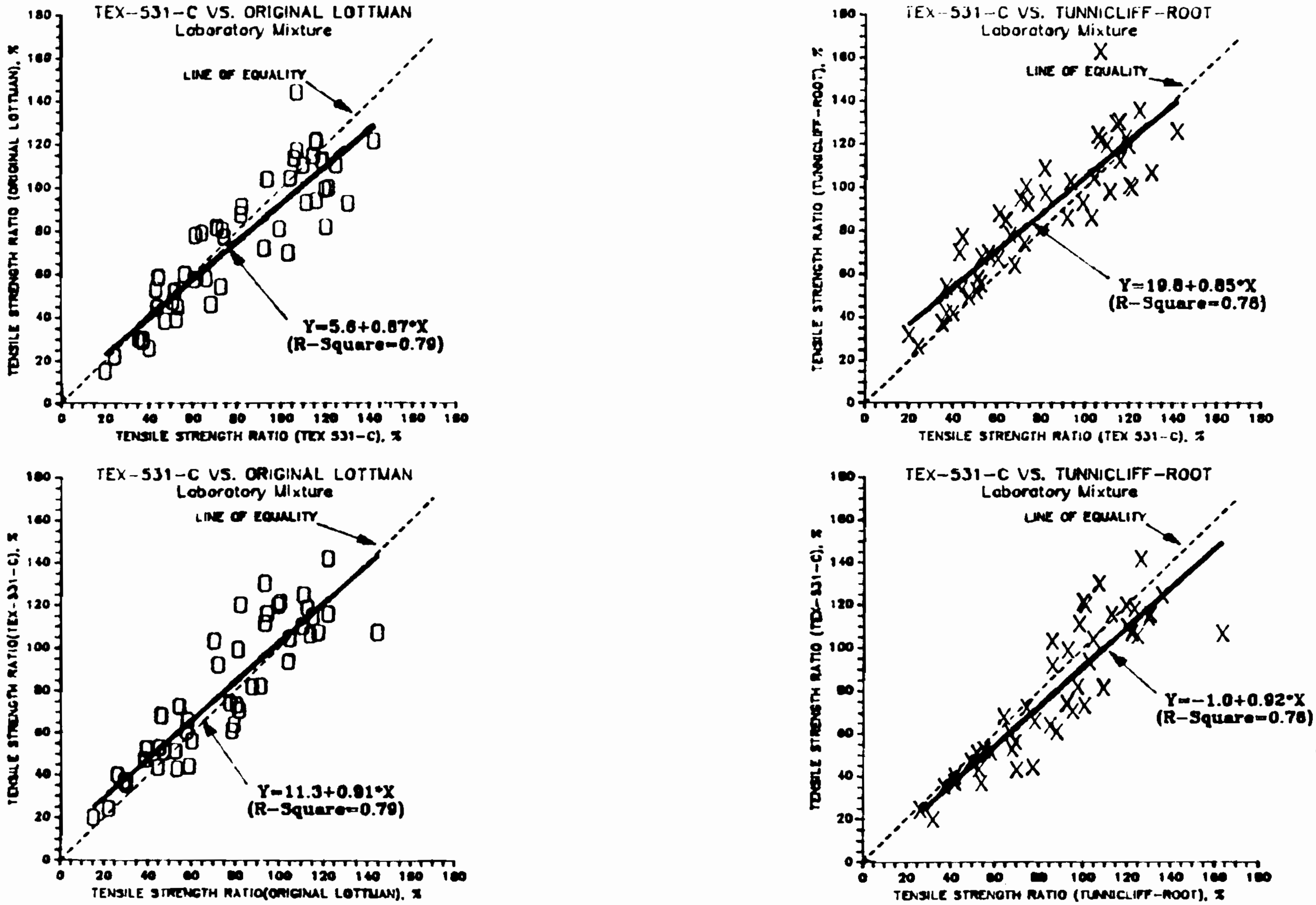
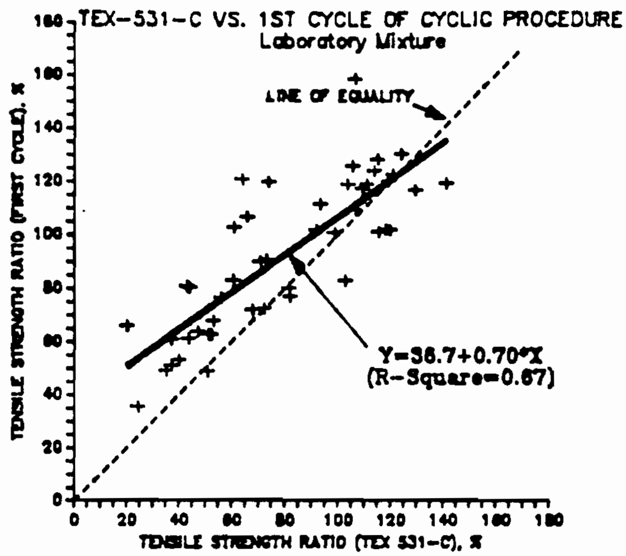


Fig. 4.5 Correlation of TSR values with modified Lottman (Tex-531-C) TSR values for laboratory mixtures.



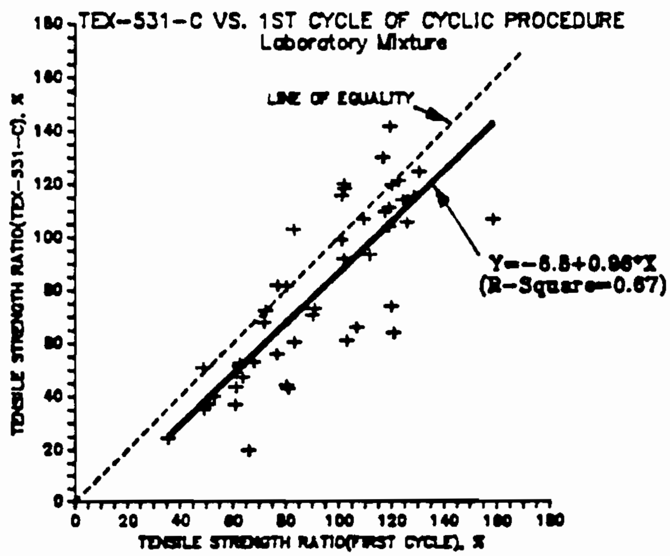


Fig 4.5 Correlation of TSR values with modified Lottman (Tex-531-C) TSR values for laboratory mixtures - continued.

Thus, the X and Y values for the two equations are different. These correlations are reasonably good with R^2 values ranging from 0.67 to 0.79 with the lower value associated with the test procedure involving the first cycle of the multiple freeze-thaw cycle procedure.

Plant mixtures. The TSR values for the original Lottman and Tunnicliff-Root procedures are compared with the modified Lottman (Tex-531-C) TSR values as shown in Figure 4.6. For each comparison, two regression equations are shown as previously discussed. The R^2 values are very high ranging from 0.91 to 0.95 indicating excellent correlations were obtained between the modified Lottman (Tex-531-C) and both the original Lottman and the Tunnicliff-Root procedures for the plant mixtures.

Laboratory and Plant Mixtures. Combining the TSR values from the laboratory and field mixtures for all eight projects, produce correlations between the TSR values for both the original Lottman and Tunnicliff-Root procedures and the modified Lottman (Tex-531-C) values as shown in Figure 4.7. The correlation equations are also summarized in Table 4.1 for the comparisons between the modified Lottman (Tex-531-C) and both the original Lottman and the Tunnicliff-Root procedures. The R^2 values ranged from 0.84 to 0.85. Thus, the TSR values for the modified Lottman

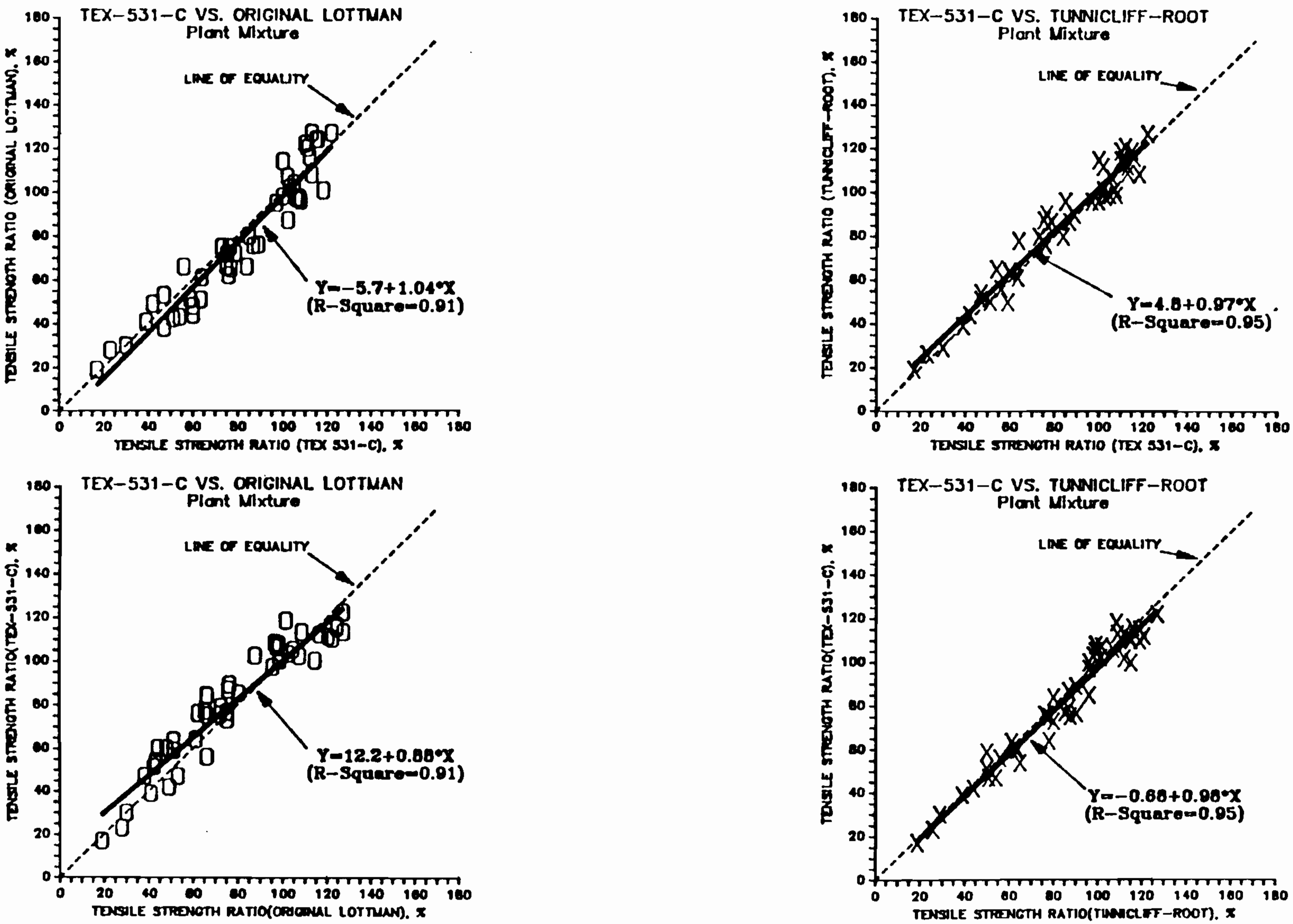


Fig. 4.6 Correlation of TSR values with modified Lottman (Tex-531-C) TSR values for plant mixtures.

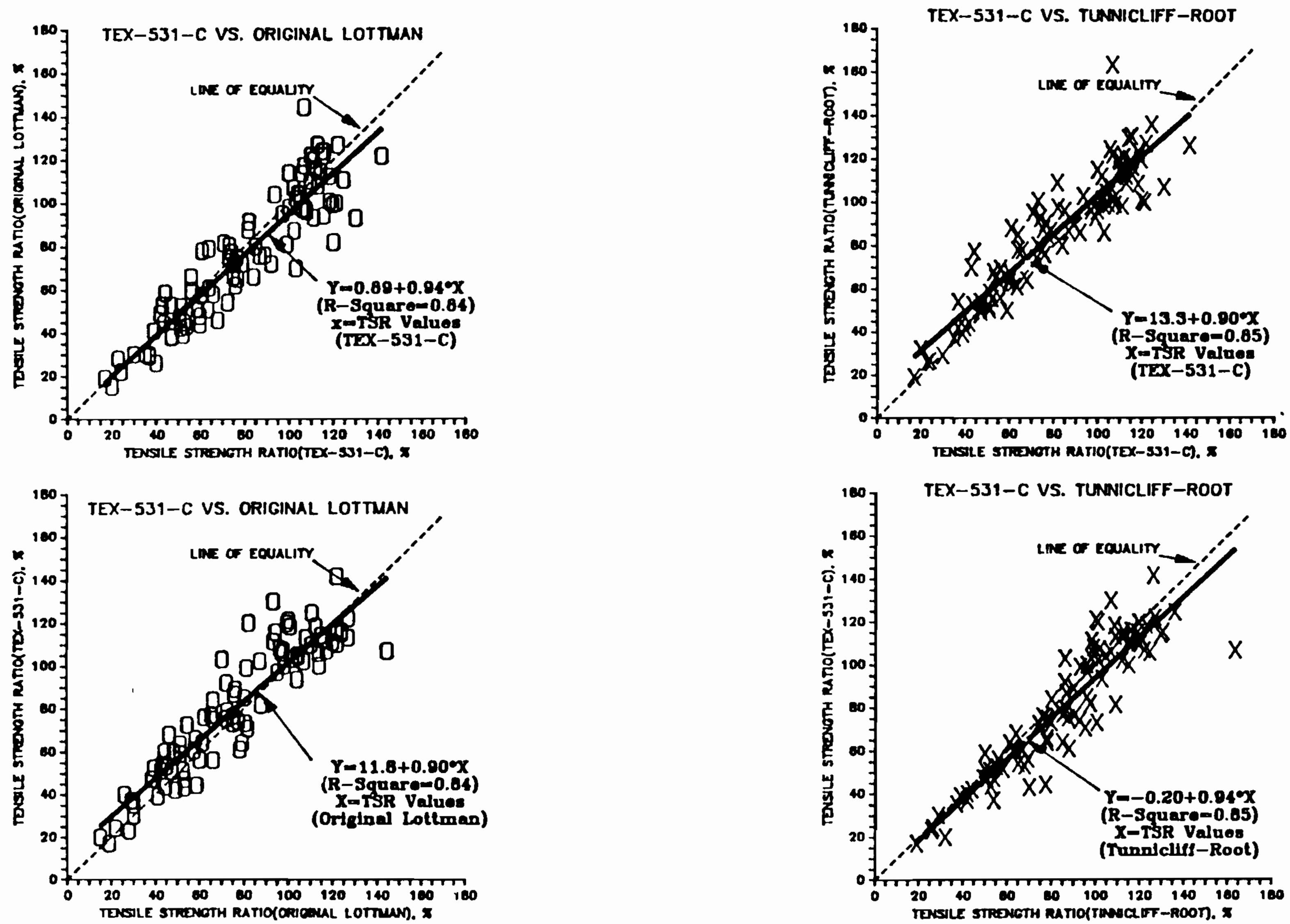


Fig. 4.7 Correlation of TSR values with modified Lottman (Tex-531-C) TSR values for all projects.

(Tex-531-C) can be estimated from the TSR values obtained by either the original Lottman or the Tunnicliff-Root procedures, or vise versa using the equations listed in Table 4.1. This would also allow critical values from one test method to be transferred into an equivalent value for another test method.

Correlation of Boil Values with TSR Values

Two types of correlations were developed between the boiling test results and the TSR values; the first regressed the TSR values on the boil values (Figures 4.8a and 4.9a) and the second regressed the boil values on the TSR values (Figures 4.8b and 4.9b). The correlation relationships were developed using the natural logarithm of the TSR data and correlating it with the boil values using linear regression. Other transformations were investigated, but did not improve the correlation.

Laboratory Mixtures. The relationships between the boiling test results and each of the four TSR test methods for the laboratory mixture are shown in Figures 4.8a and 4.8b. The R^2 values range from 0.63 to 0.76.

TABLE 4.1 SUMMARY OF CORRELATION EQUATIONS OF TSR VALUES FOR VARIOUS TEST METHODS

Correlation	Correlation Equation	R^2 Value
Original Lottman	C (TSR) = 0.89 + 0.94* A (TSR)	0.84
vs.	or	
Modified Lottman*	A (TSR) = 11.8 + 0.90* C (TSR)	0.84
Tunnicliff-Root	D (TSR) = 13.3 + 0.90* A (TSR)	0.85
vs.	or	
Modified Lottman*	A (TSR) = 0.20 + 0.94* D (TSR)	0.85
Multiple Freeze-Thaw Cycle (First Cycle)	E (TSR) = 36.7 + 0.70* A (TSR)	0.67
vs.	or	
Modified Lottman**	A (TSR) = -8.8 + 0.96* E (TSR)	0.67

Where,

A(TSR) = TSR values of the modified Lottman (Tex-531-C) method, %

C(TSR) = TSR values of the Original Lottman method, %

D(TSR) = TSR values of the Tunnicliff-Root method, %

E(TSR) = TSR values of first cycle of the multiple freeze-thaw cycle method, %.

* Laboratory and Plant Mixtures

** Laboratory Mixtures

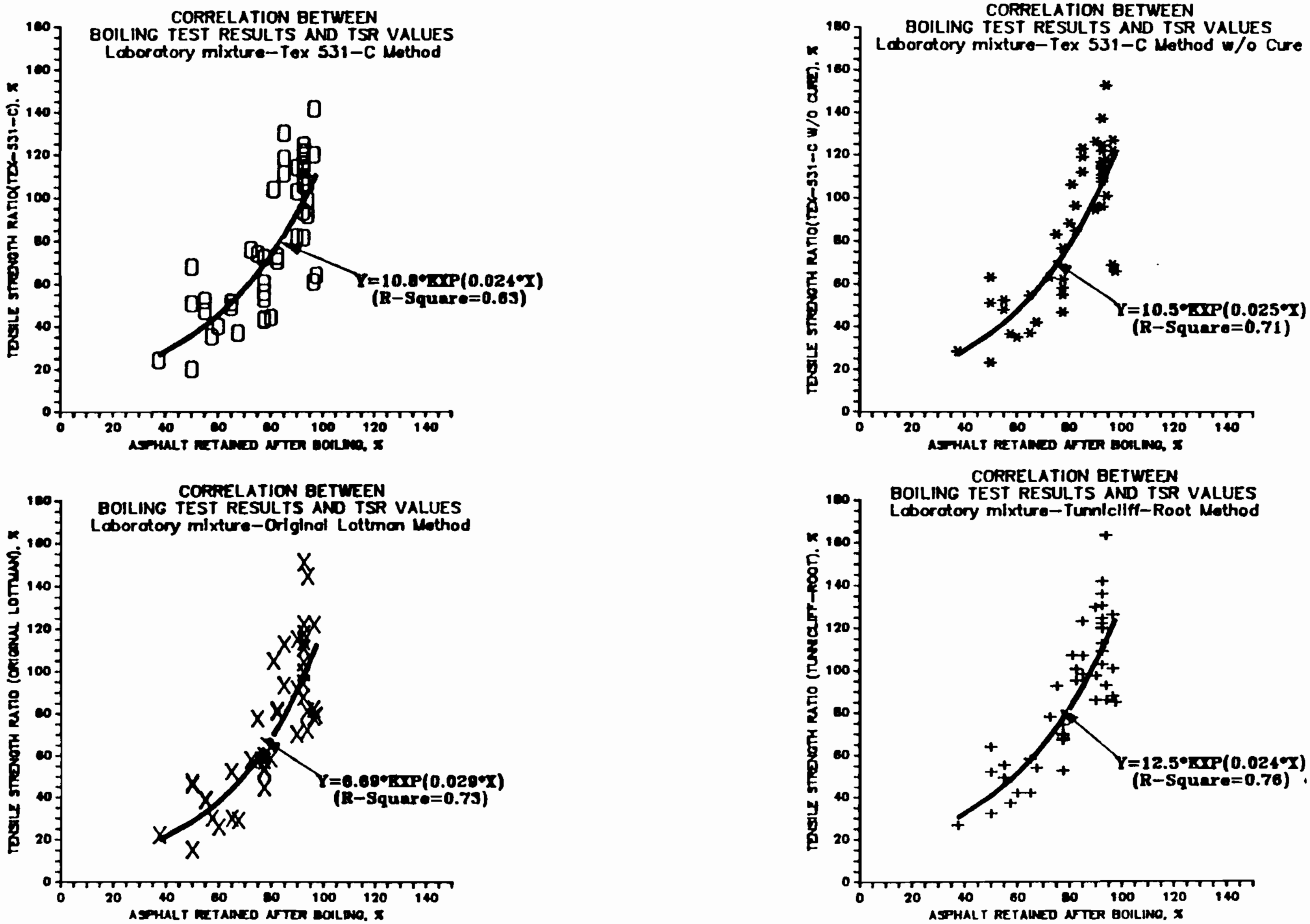


Fig. 4.8a Correlation of boiling test results with TSR values for laboratory mixture.

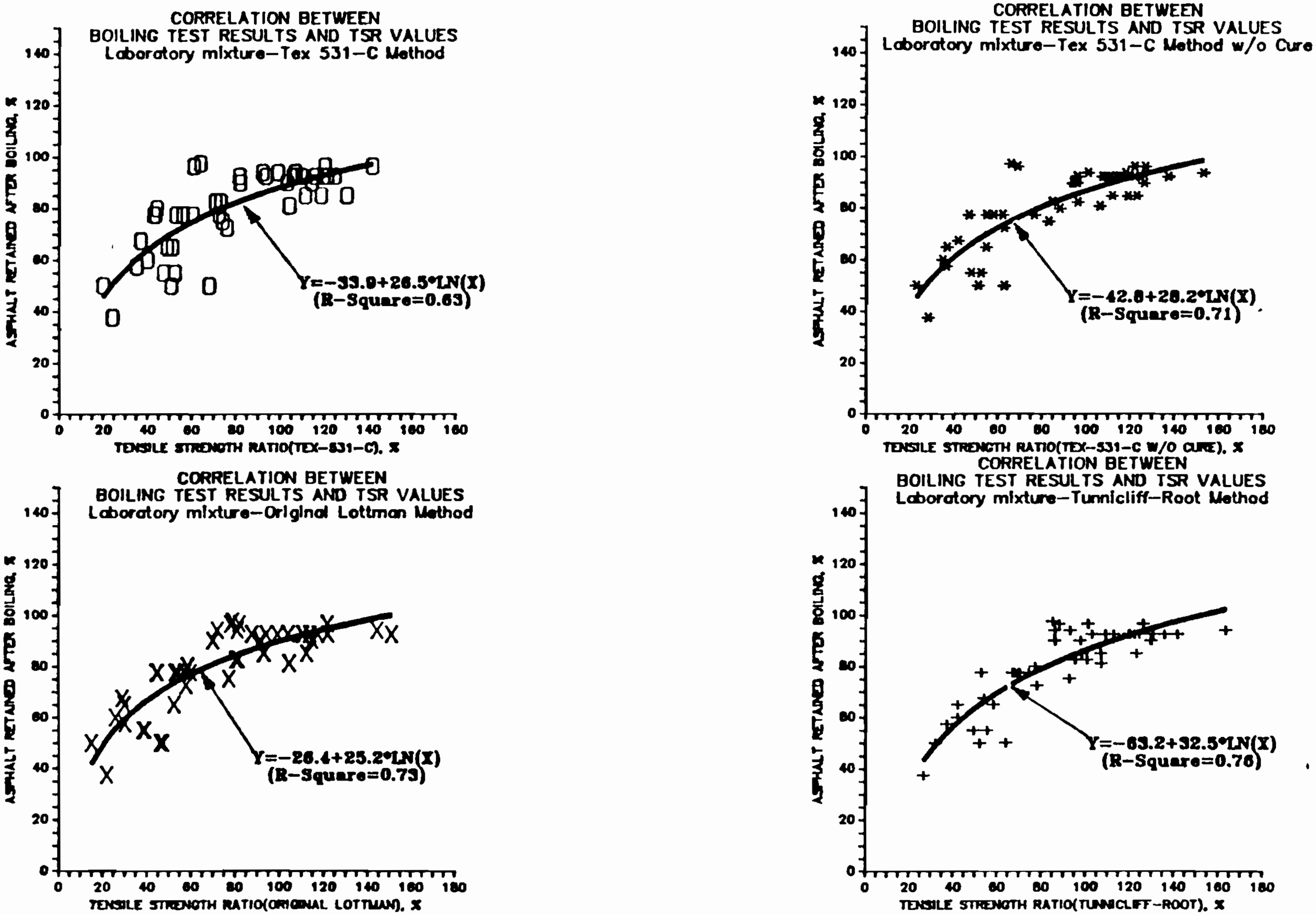


Fig. 4.8b Correlation of TSR values with boiling test results for laboratory mixtures.

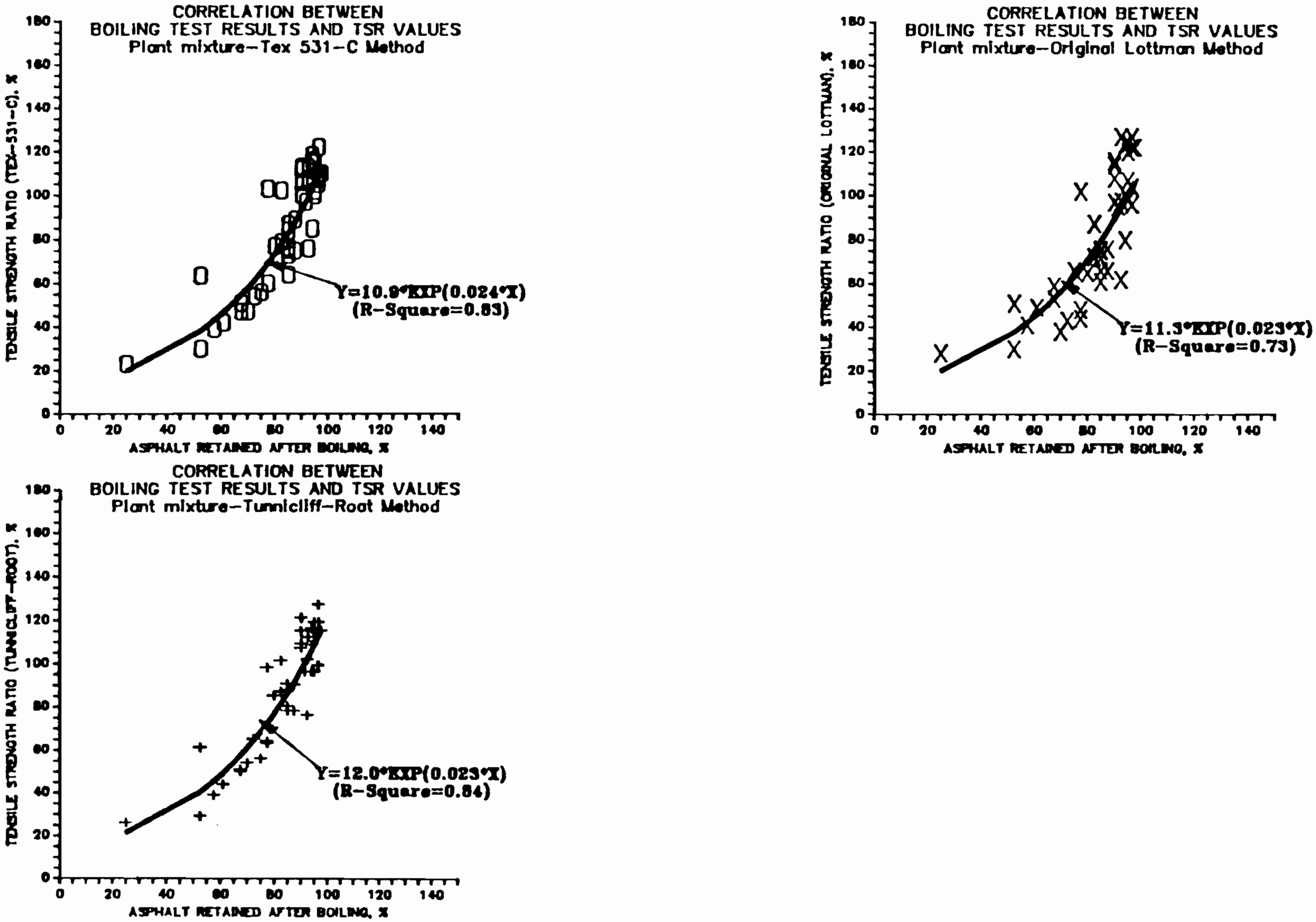


Fig. 4.9a Correlation of boiling test results with TSR values for plant mixtures.

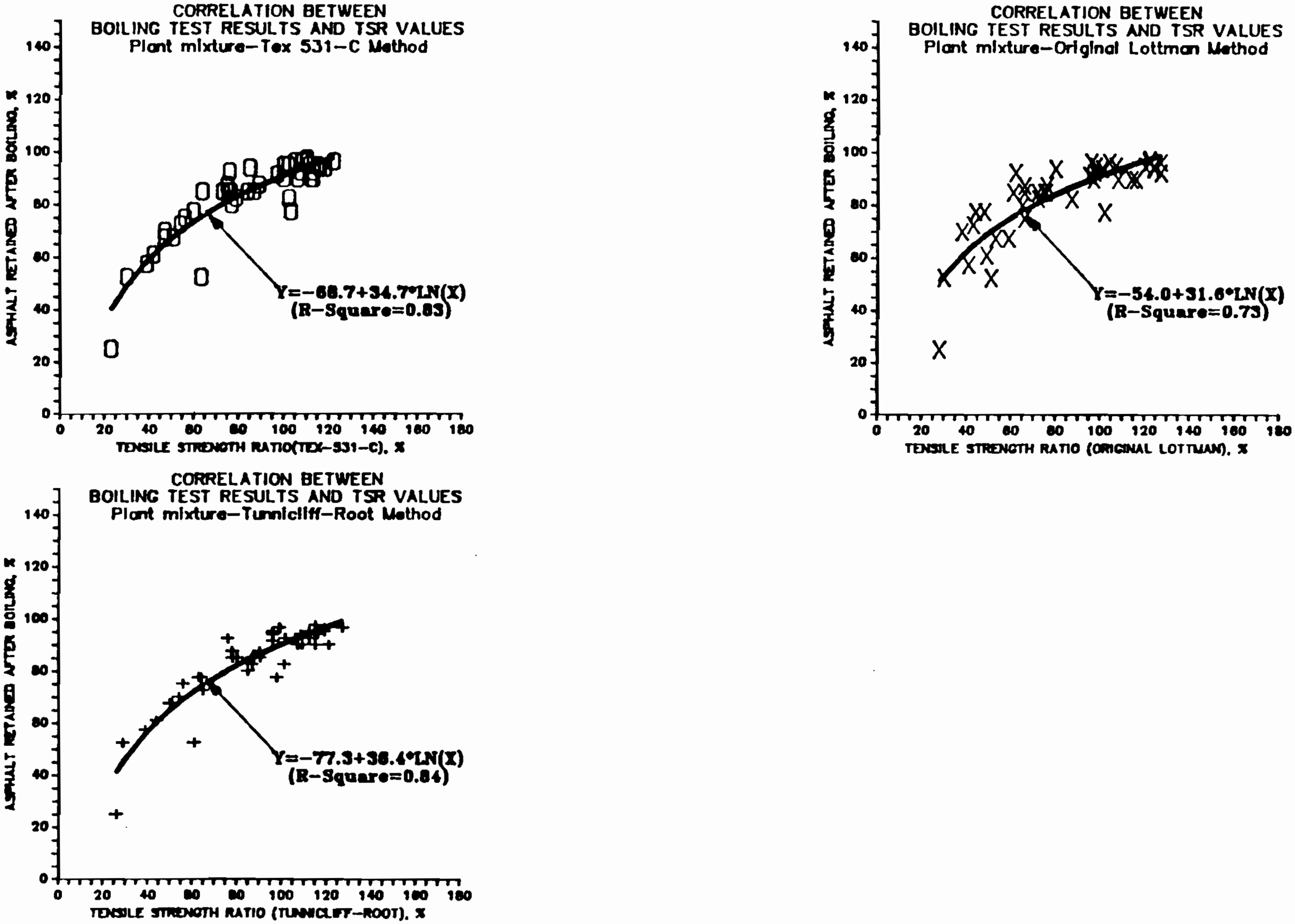


Fig. 4.9b Correlation of TSR values with boiling test resulsts for plant mixtures.

Plant Mixtures. The relationships between the boiling test results and each of the three TSR test methods are shown in Figures 4.9a and 4.9b. The R^2 values range from 0.73 to 0.84.

Laboratory and Plant Mixtures. The correlations between the boiling test results and the TSR values were developed using the test values from both the laboratory and plant mixtures for all eight projects. The correlations are shown in Figures 4.10 and 4.11. The R^2 values range from 0.71 to 0.79 indicating a reasonably good correlation between the TSR values and the boil values. These correlation equations can provide estimates of the boil values based on the wet-dry indirect tensile test results or the TSR values based on the boiling test results. Again critical values approximating the same level of damage can be estimated. For example a TSR value (Tex-531-C) of 70 would correspond to a boil value of 79 percent retained.

COMPARISON BETWEEN LABORATORY MIXTURE AND PLANT MIXTURE

The data obtained for the laboratory mixtures were compared with the data obtained for the plant mixtures to determine whether the values were the same or different. The amount of aggregate and asphalt are the same for both

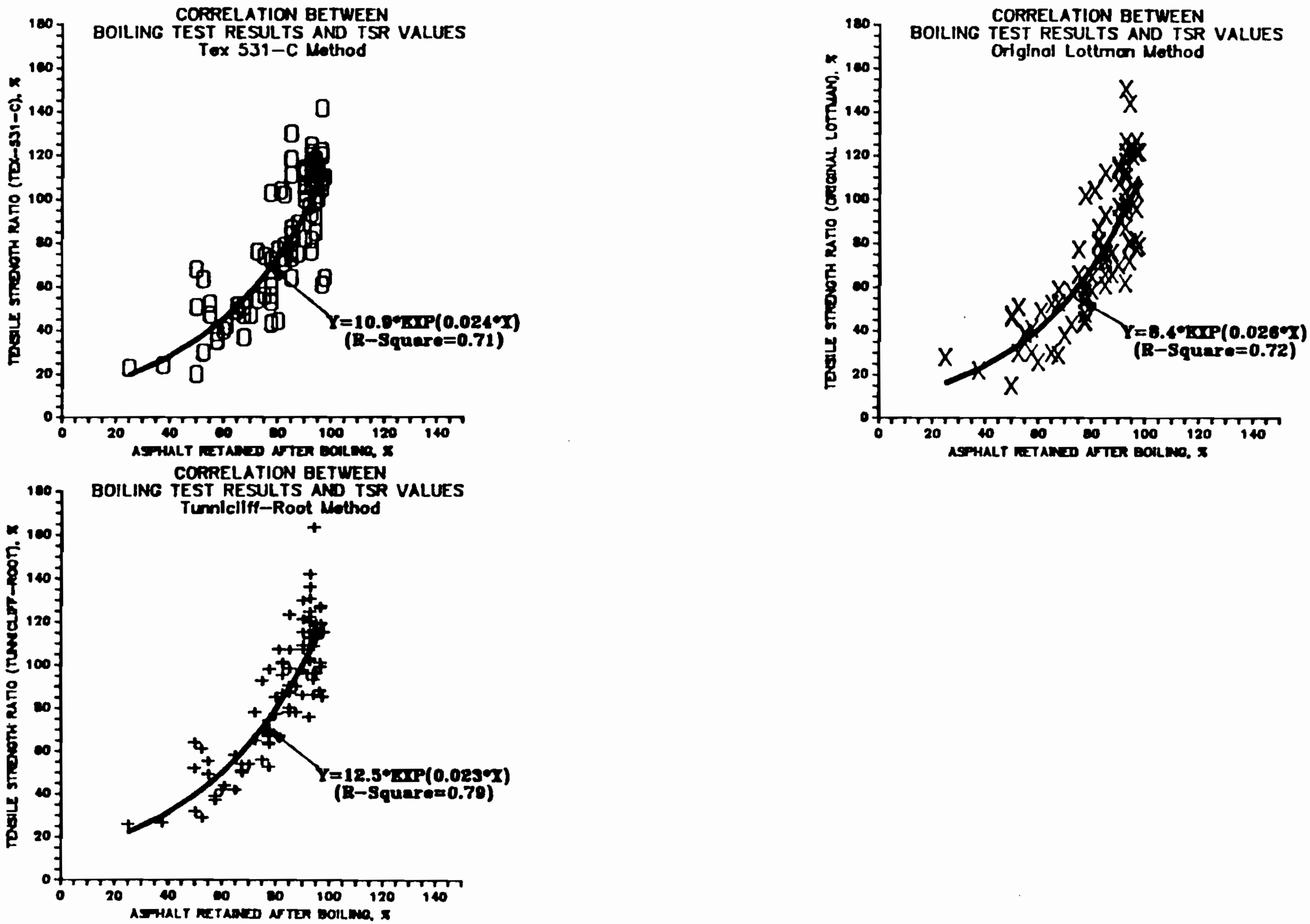


Fig. 4.10 Correlation of boiling test results with TSR values for all projects.

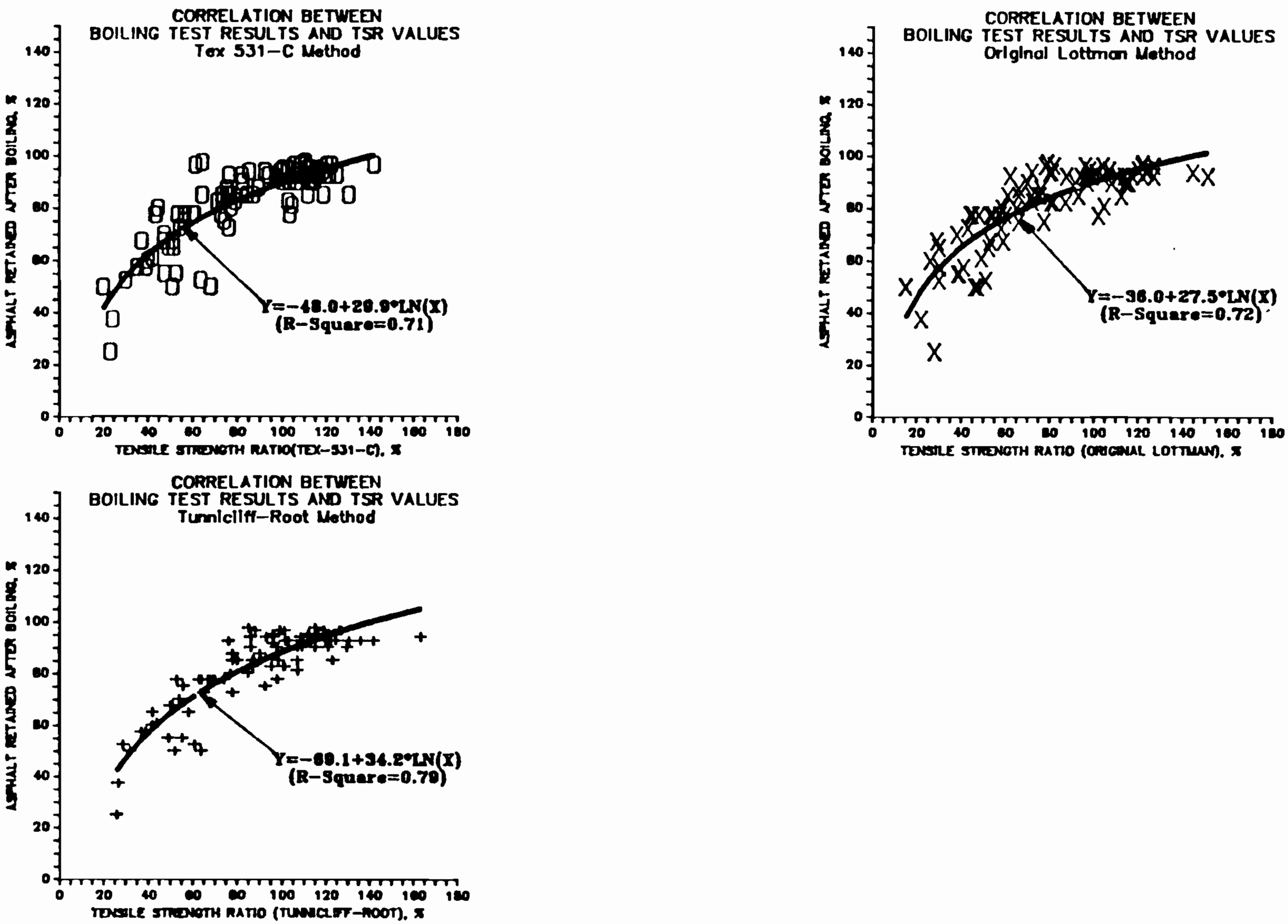


Fig. 4.11 Correlation of TSR values with boiling test results for all projects.

the laboratory mixture and the plant mixture; except for the three projects in Districts 1, 16, and 19. The tests were conducted on the preliminary laboratory designed mixtures prior to construction and the plant mixtures were the actual paving mixture as adjusted in the field. In addition, in a few cases the suppliers of antistripping additives had trouble introducing their product in the field.

Comparison of Dry Tensile Strength

The dry tensile strength of the laboratory mixture and the plant mixture are compared in Figure 4.12 for each individual project and in Figure 4.13 for all projects. Except for the District 6 project (rhyolite aggregate) the dry strengths of the plant mixtures were greater than or approximately equal to that of the laboratory mixtures (Fig 4.12).

For either the laboratory or the plant mixtures of each individual project, the dry strengths of the lime treated mixture, the mixtures containing liquid additives, and the control mixture were approximately equal although in a few cases, the mixtures containing liquid additives tended to be stronger than the control. However, the hydrated lime and liquid antistripping additive apparently did not have a

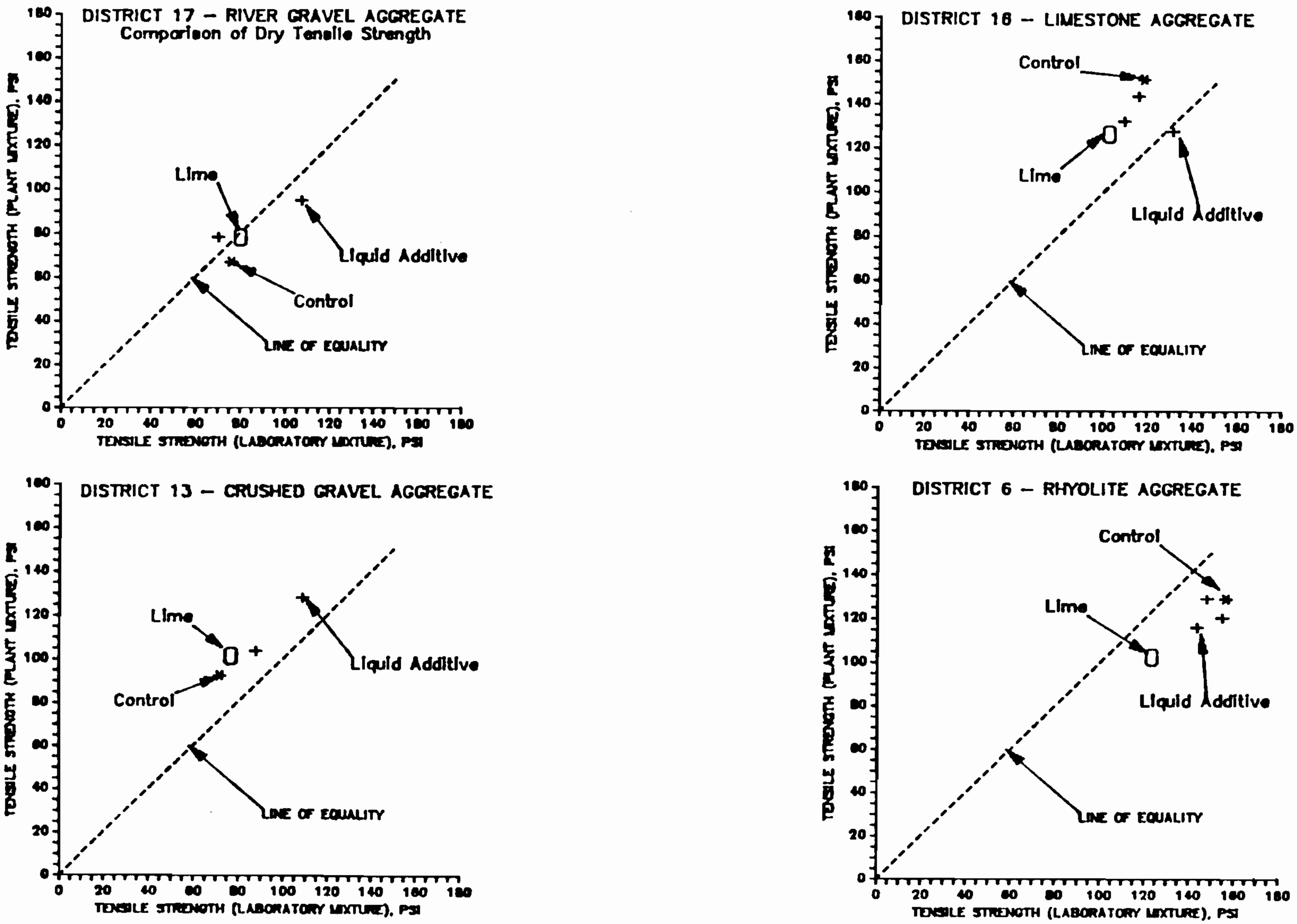


Fig. 4.12 Comparison of dry tensile strengths between laboratory and plant mixtures.

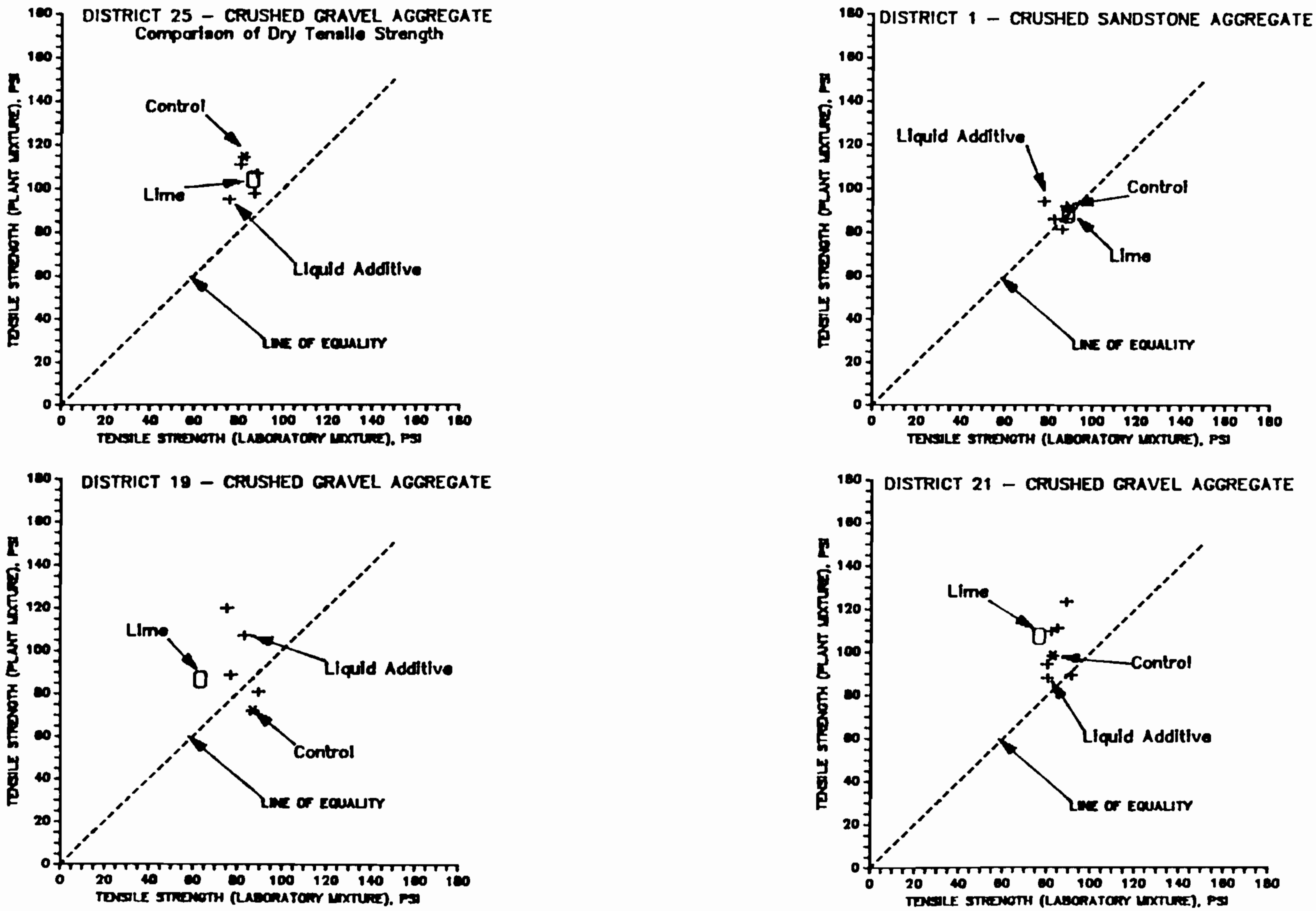


Fig. 4.12 Comparison of dry tensile strengths between laboratory and plant mixtures - continued.

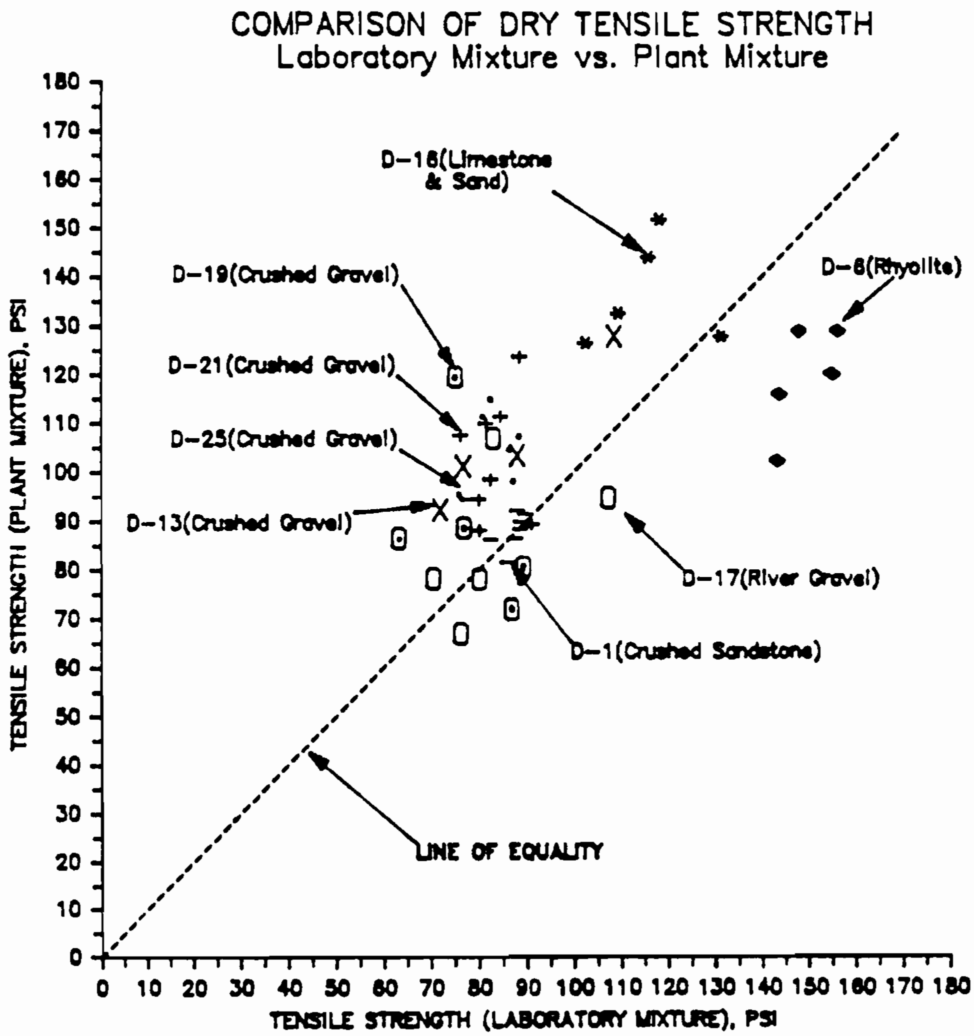


Fig 4.13 Comparison of dry tensile strengths between laboratory and plant mixtures for all materials.

significant or consistent effect on the dry strengths of the mixtures.

Figure 4.13 compares the dry tensile strengths of the laboratory and plant mixtures for all eight projects. Regardless of the type of mixtures, the river gravel aggregates tended to have lower dry tensile strength, whereas the limestone and rhyolite materials had the higher dry tensile strength; however, the data are very limited.

Comparison of Wet Tensile Strength

The wet tensile strength of the laboratory mixture and the plant mixture are compared in Figure 4.14 for each individual project and in Figure 4.15 for all projects. Except for mixtures treated with lime, the wet strengths of the plant mixtures were greater than or equal to the wet strengths of the laboratory mixtures. As for the lime-treated mixtures, in most cases the wet strengths of the plant mixtures were approximately equal to the wet strengths of the laboratory mixtures (Districts 17, 13, 25, 1, and 19). However, the lime treated plant mixture had higher wet tensile strength than the laboratory mixture for Districts 16 and 21, whereas the reverse was true for District 6.

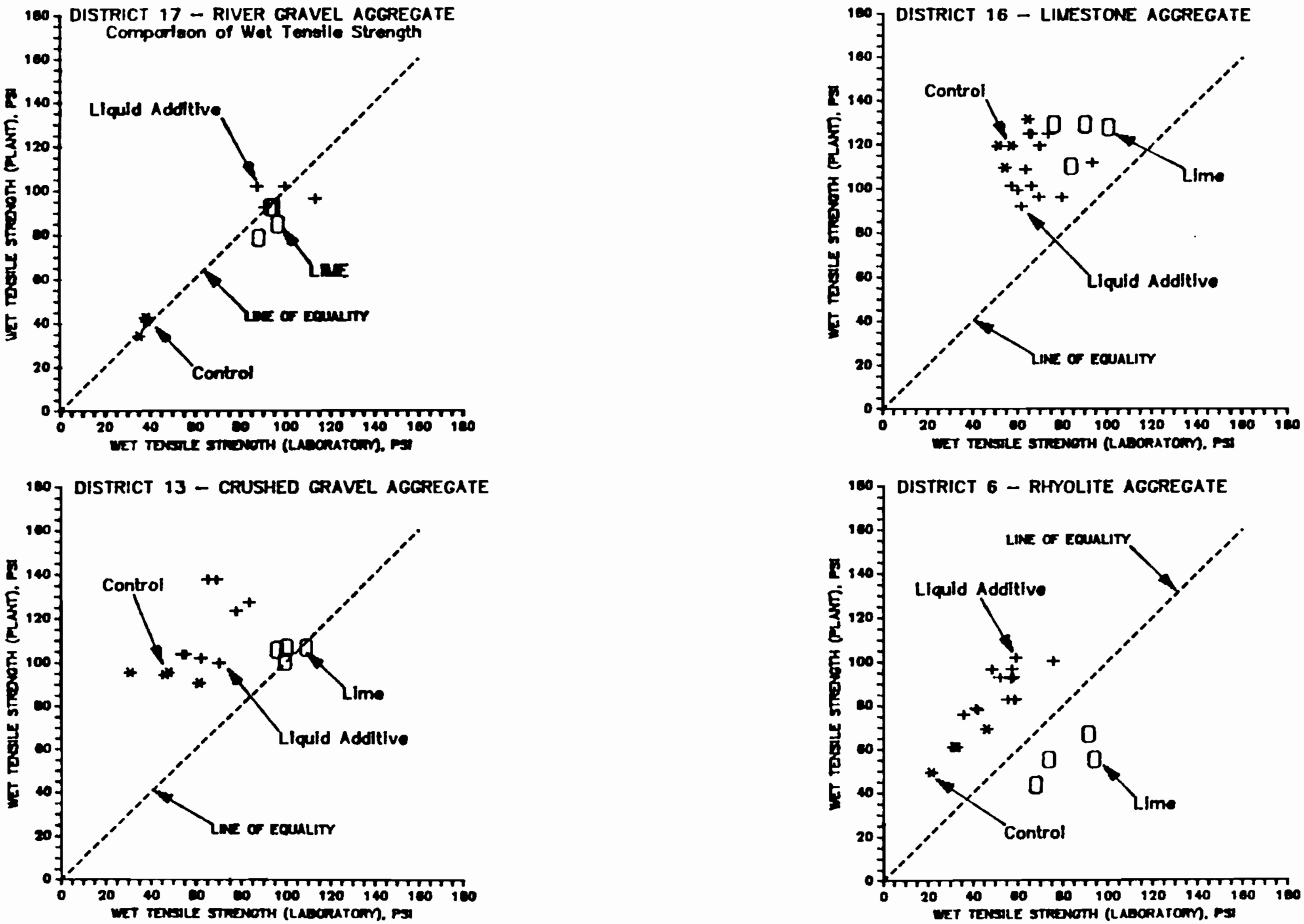


Fig. 4.14 Comparison of wet tensile strengths between laboratory and plant mixtures.

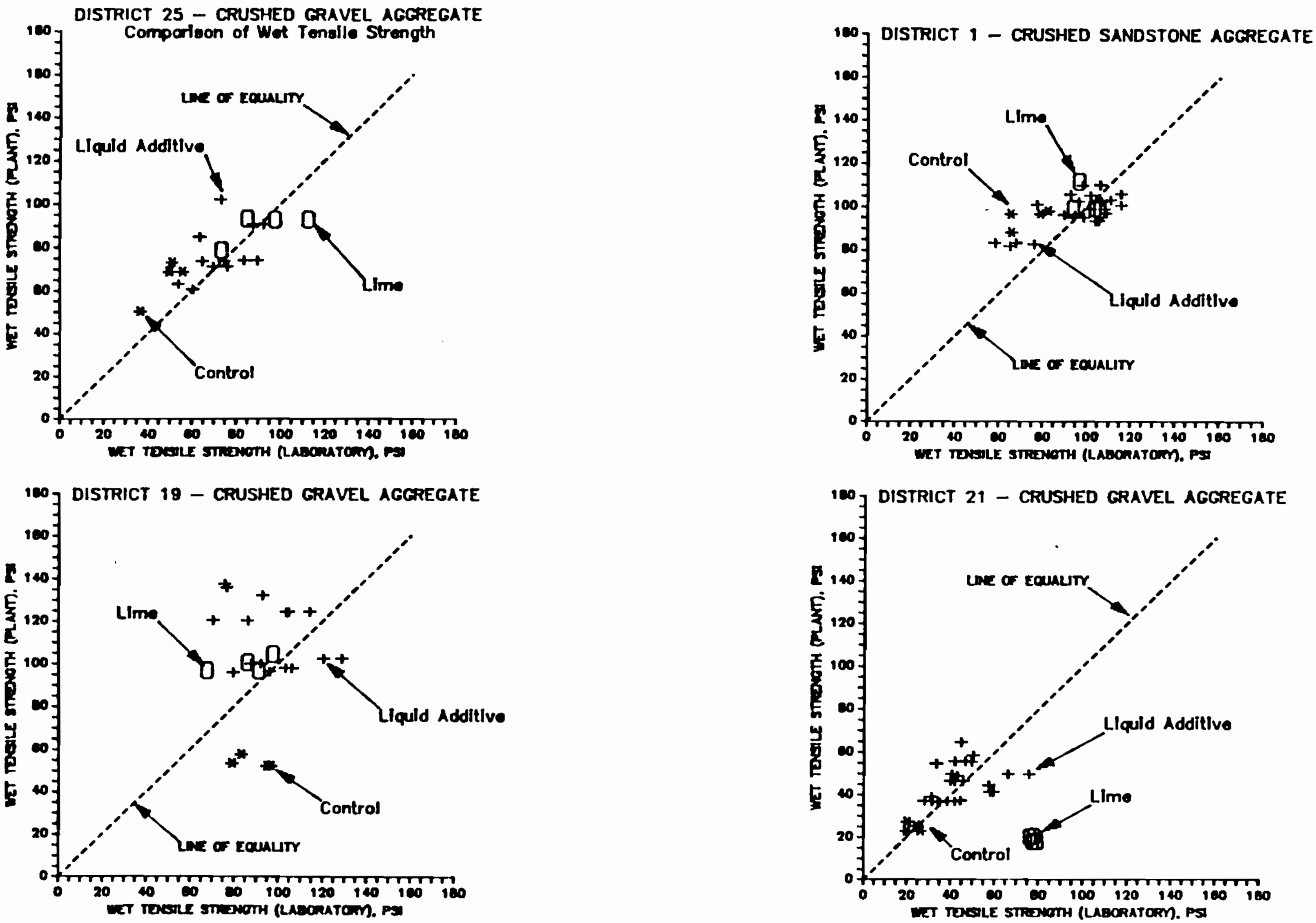


Fig. 4.14 Comparison of wet tensile strengths between laboratory and plant mixtures - continued.

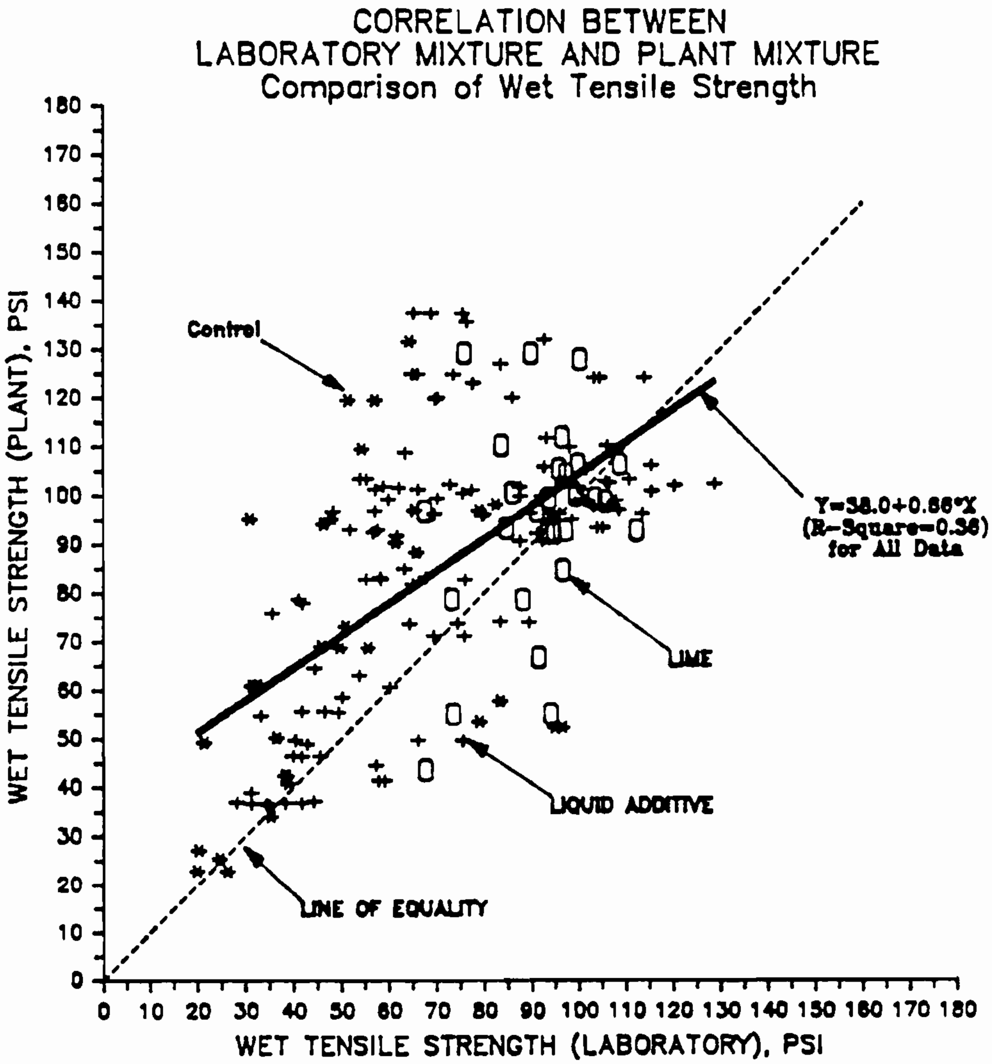


Fig 4.15 Comparison of wet tensile strengths between laboratory and plant mixtures for all projects.

The wet tensile strengths for both the laboratory and plant mixtures from all eight projects is compared in Figure 4.15. A linear correlation line is shown for the overall data. The low R^2 value of 0.36 indicates a poor correlation between the wet strengths of the laboratory mixtures and plant mixtures. Generally, the wet strength of the plant mixtures were greater than that of the laboratory mixtures.

Comparison of Tensile Strength Ratio

The tensile strength ratios for the laboratory mixture and the plant mixture are compared in Figure 4.16 for each individual project. Except for lime treated mixtures the tensile strength ratios of the plant mixtures were approximately equal to (Districts 17, 25, 1, 19, and 21), or greater than (Districts 16, 13, and 6) the TSR values for the laboratory mixtures. In contrast, for the lime treated materials, the plant mixtures had lower TSR values for Districts 6, 13, 19, 21, and 25, higher TSR values for District 16 and equal values for Districts 17 and 1.

The comparison of the TSR values for both laboratory and plant mixtures for all eight projects is shown in Figure 4.17. Correlation equation was developed for the overall data. The plant mixture exhibited higher TSR values than

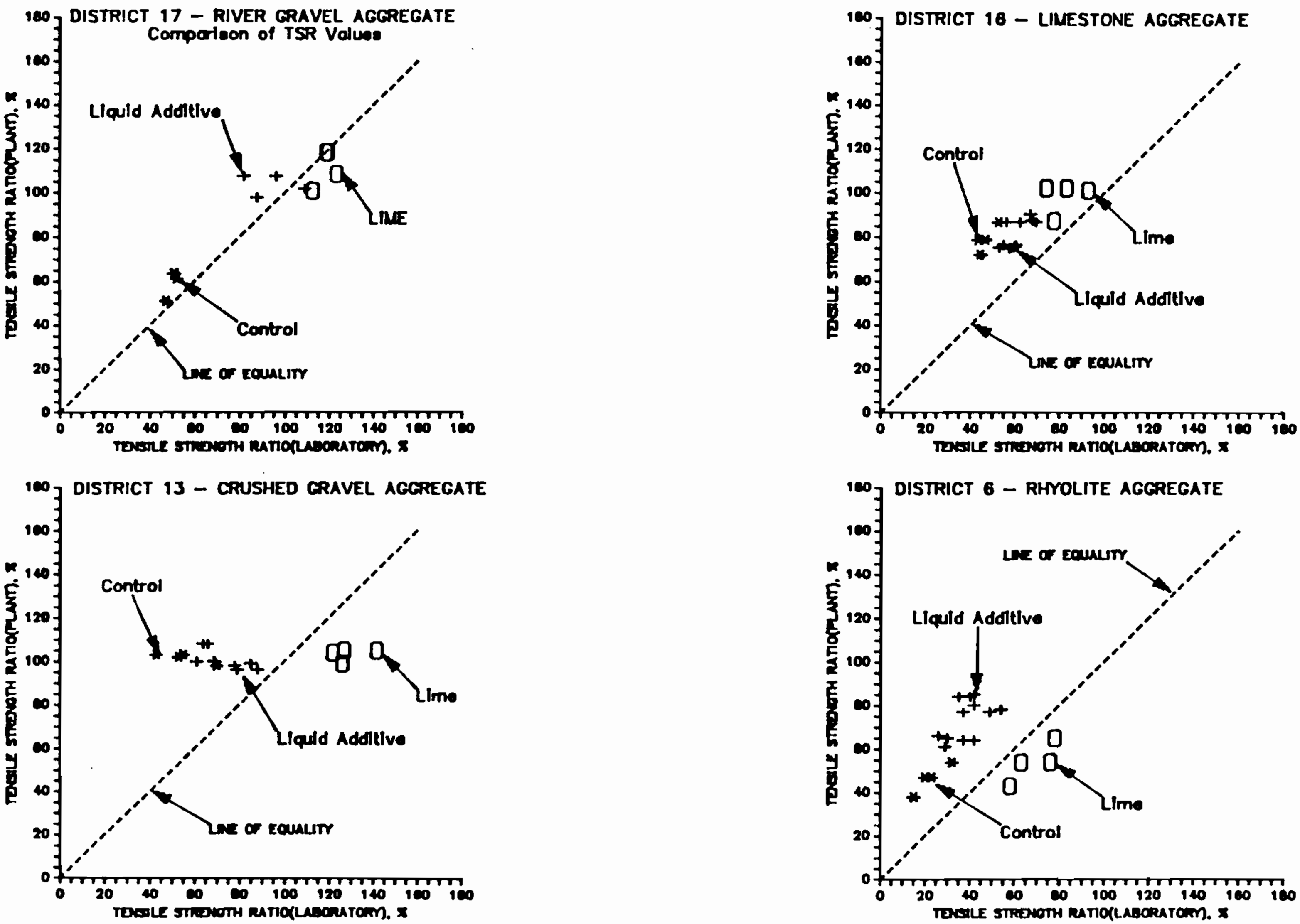


Fig. 4.16 Comparison of tensile strength ratios between laboratory and plant mixtures.

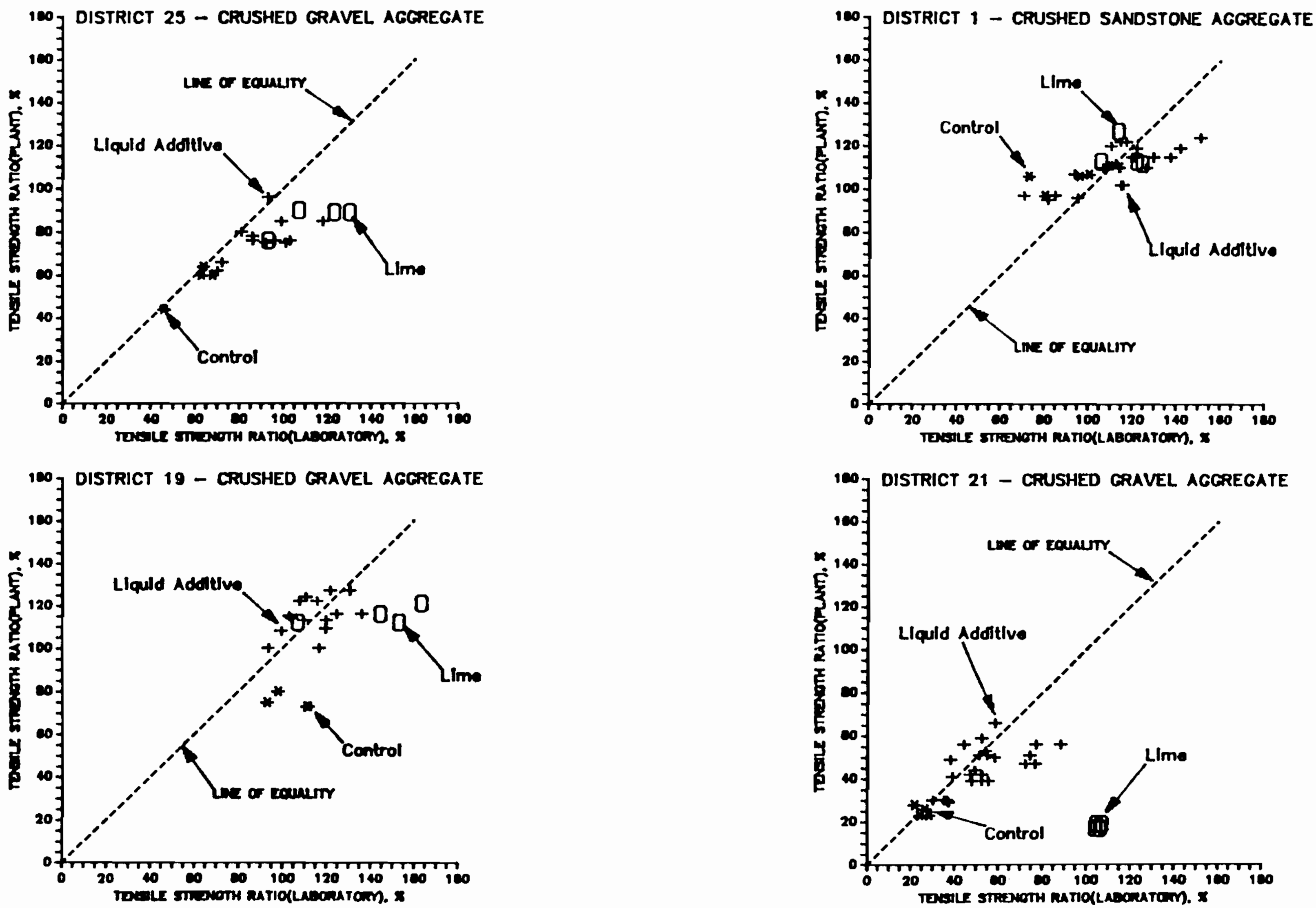


Fig. 4.16 Comparison of tensile strength ratios between laboratory and plant mixtures - continued.

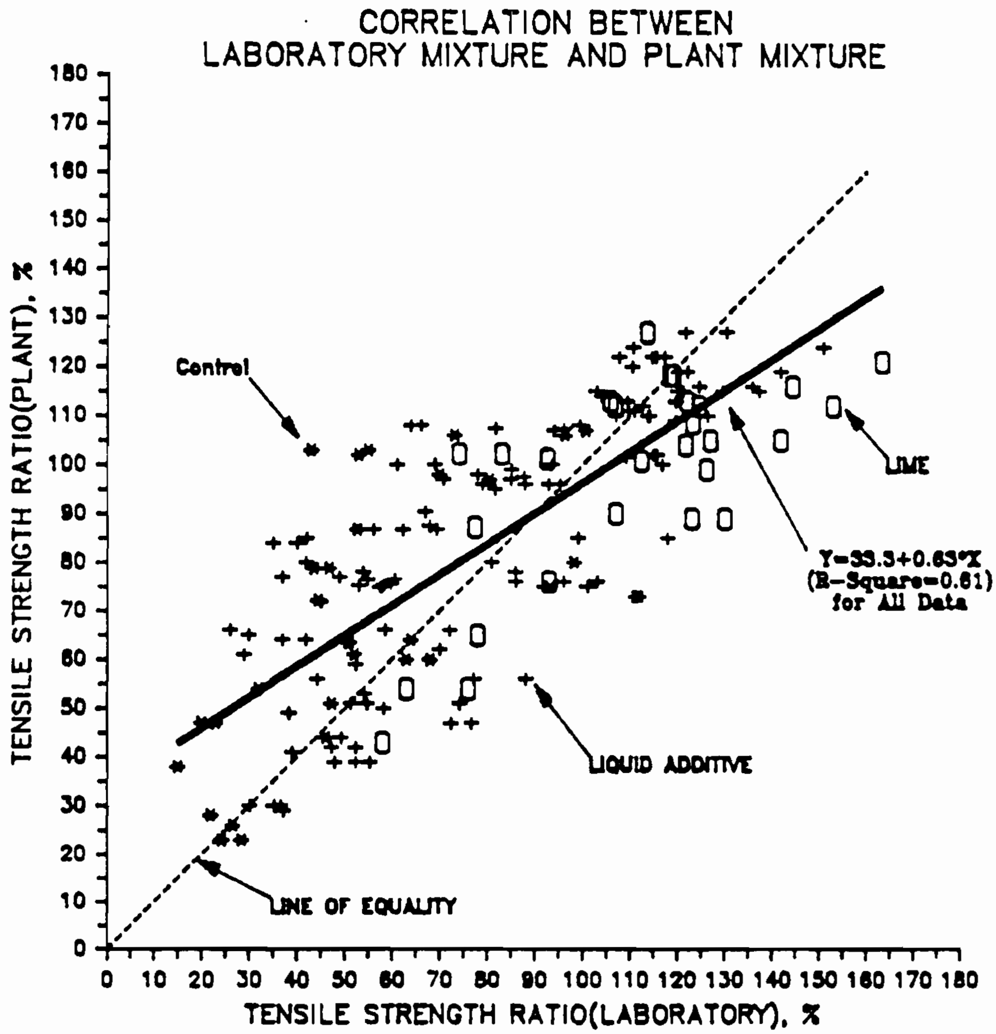


Fig 4.17 Comparison of tensile strength ratios between laboratory and plant mixtures for all projects.

the laboratory mixture for laboratory TSR values less than about 90 percent; however, the amount of data are limited.

Comparison of Boiling Test Results

The boiling test results for the laboratory and plant mixtures for each project are compared in Figure 4.18. Generally the boil values for the laboratory and plant mixtures were approximately equal (Districts 17, 13, 25, 1, 19, and 21); however, two plant mixtures had higher boil values (percent asphalt retained) than the laboratory mixtures (Districts 16 and 6).

The comparisons of boil test values for the laboratory and plant mixtures for all eight projects is shown in Figure 4.19. As previously noted, Figure 4.19 illustrates that the boil values for the plant and laboratory mixtures were essentially equal except for about 5 data points. The correlation equation was reasonably good with an R^2 value of 0.71.

EFFECTIVENESS OF VARIOUS ADDITIVES

The effectiveness of the various liquid antistripping additives and hydrated lime was evaluated in terms of the

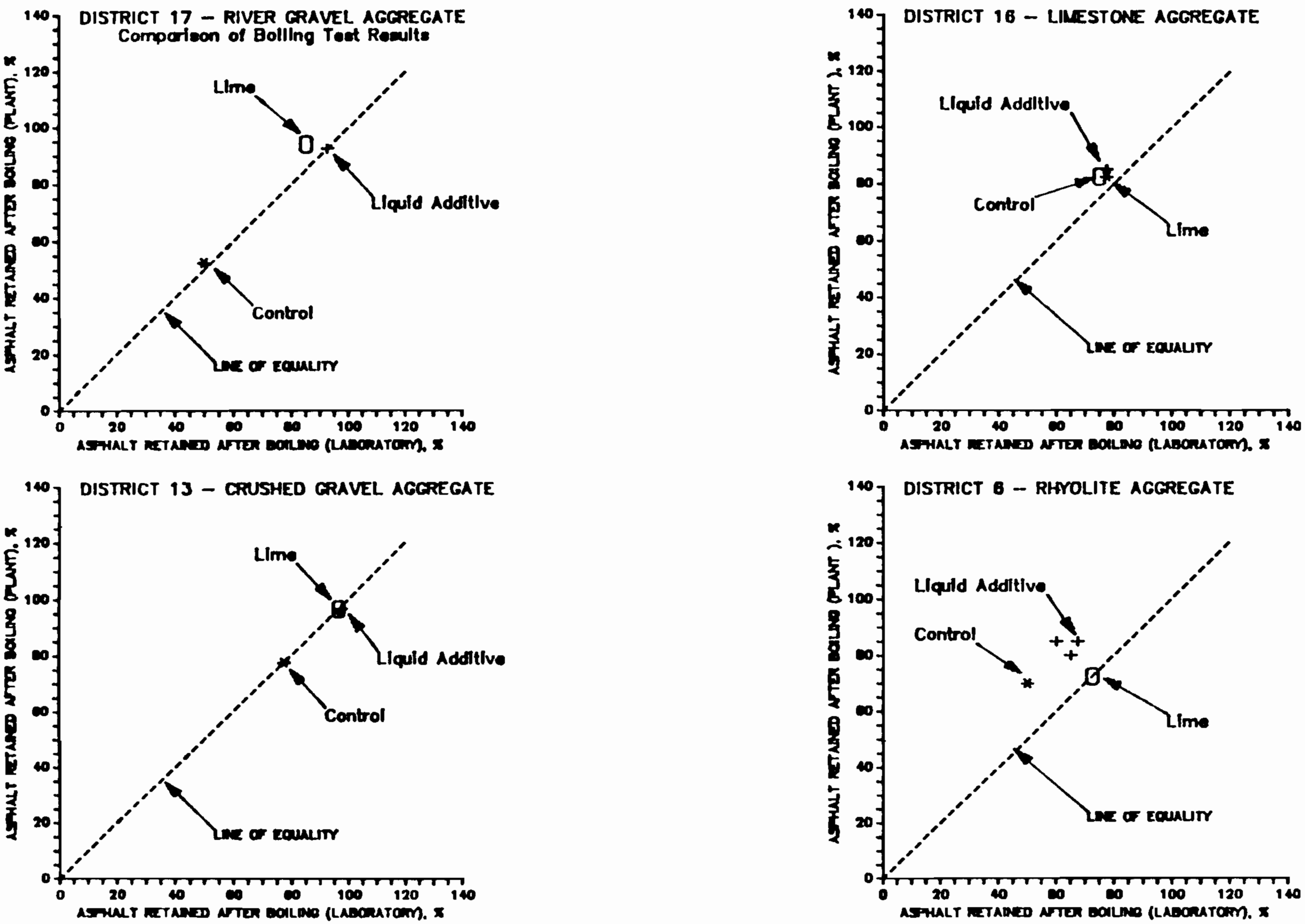


Fig. 4.18 Comparison of boil values between laboratory and plant mixtures.

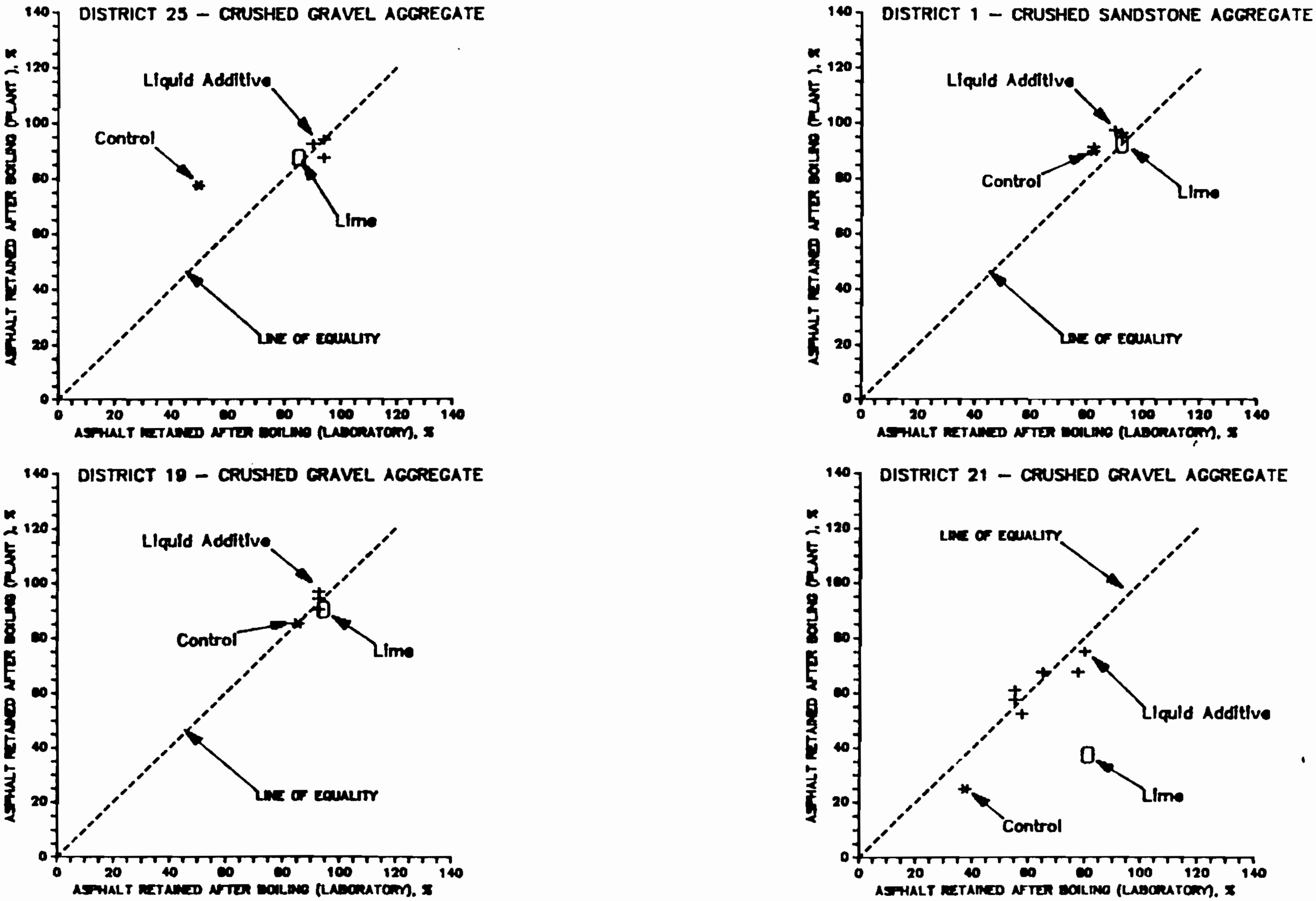


Fig. 4.18 Comparison of boil values between laboratory and plant mixtures - continued.

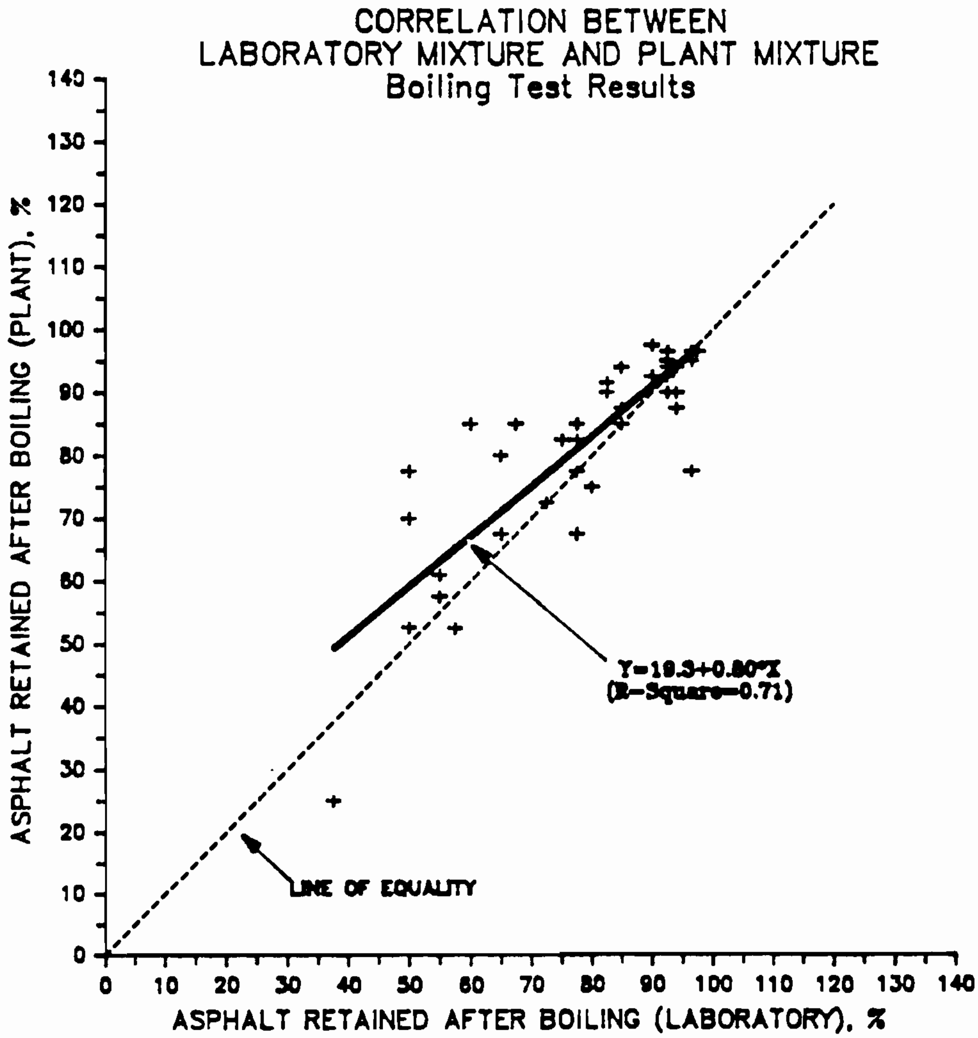


Fig 4.19 Comparison of boil values between laboratory and plant mixtures for all projects.

tensile strength ratio (TSR) and the boiling test results. A detailed description of the statistical analyses and comparisons utilized in the evaluation is presented in Appendix I. The evaluations based on the statistical comparisons are summarized in the following.

Evaluation of Effectiveness Using Tensile Strength Ratios

The TSR values for the laboratory mixtures and the plant mixtures are shown in Figures 4.20 and 4.21, respectively. The effectiveness of the hydrated lime and the various antistripping additives was estimated using the TSR values. The statistical analyses for TSR values are contained in Appendix I and summarized below.

An α-level of 5 percent and the Bonferroni method (Ref 52) for multiple comparisons were used to test the statistical significance between the difference of two TSR values. The Bonferroni method for multiple comparisons was to reset the α-level to α/N, where N was the number of comparisons, and used Student-t table entries for the significance level of α/N. Because the probability exists that one of the N multiple comparisons may exceed the 5 percent level. Therefore, to achieve the α-level of 5 percent error rate, the t-value of $t_{0.05/N}$ from the t-table

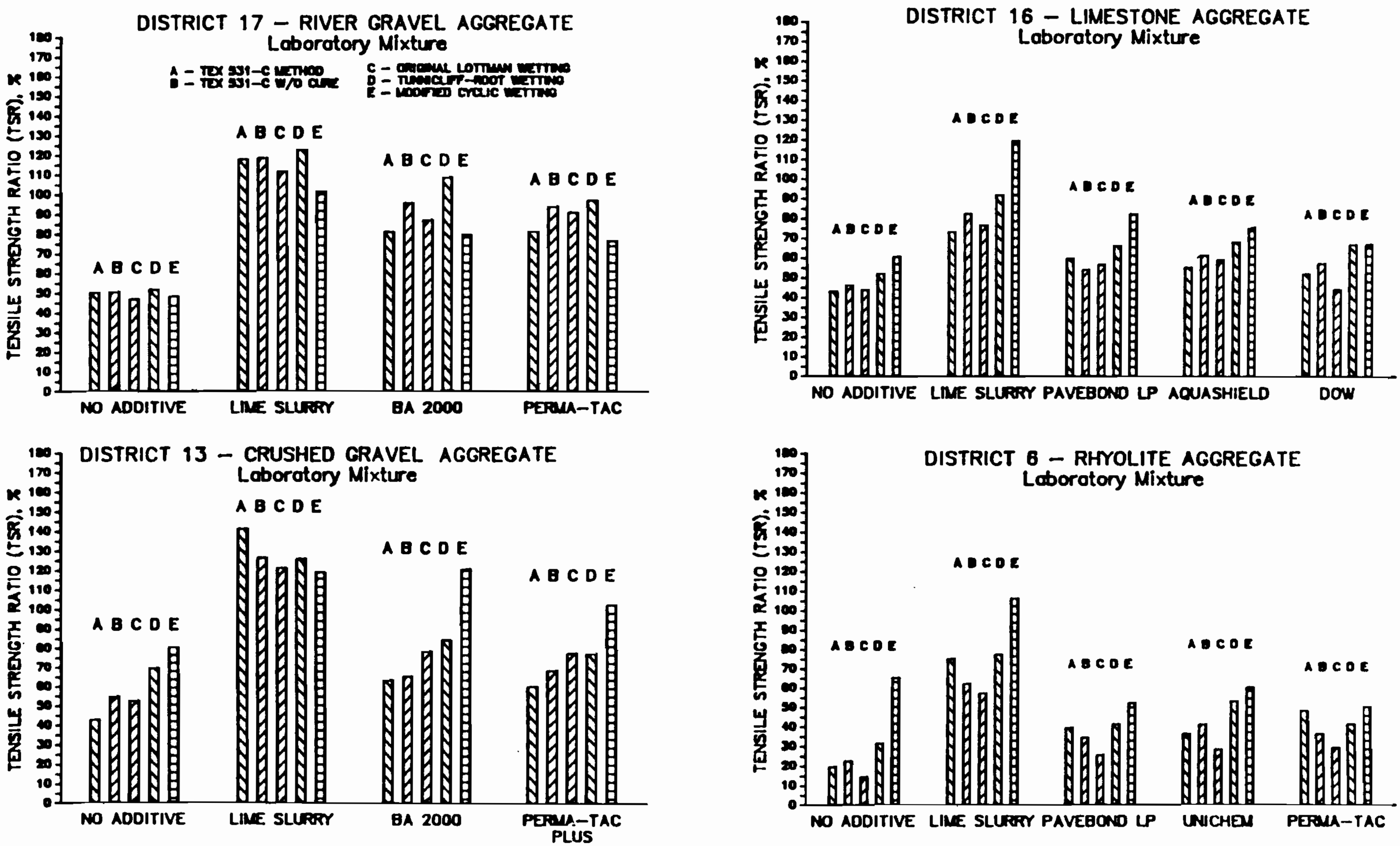


Fig. 4.20 Wet-dry indirect tensile test results for laboratory mixtures.

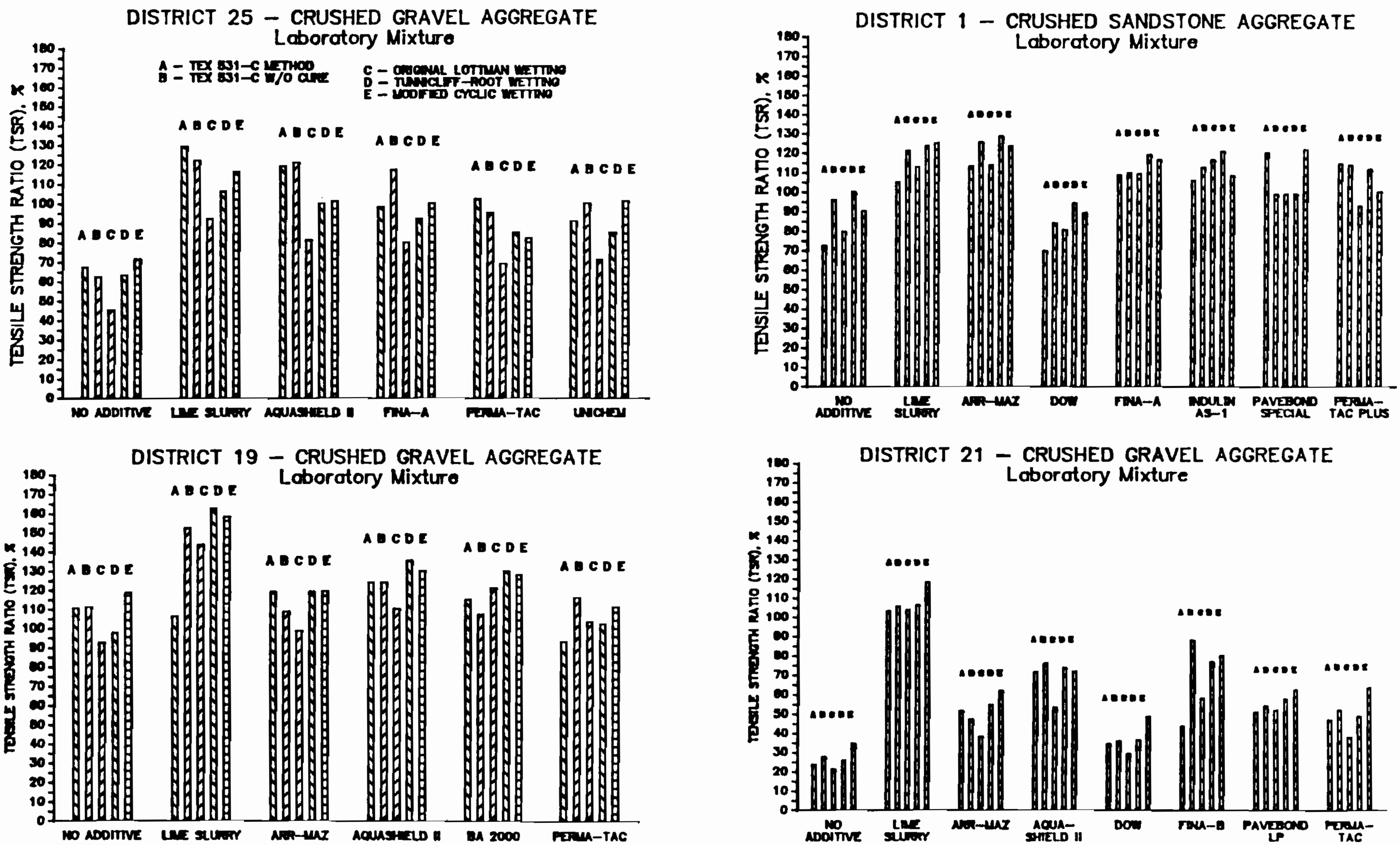


Fig. 4.20 Wet-dry indirect tensile test results for laboratory mixtures - continued.

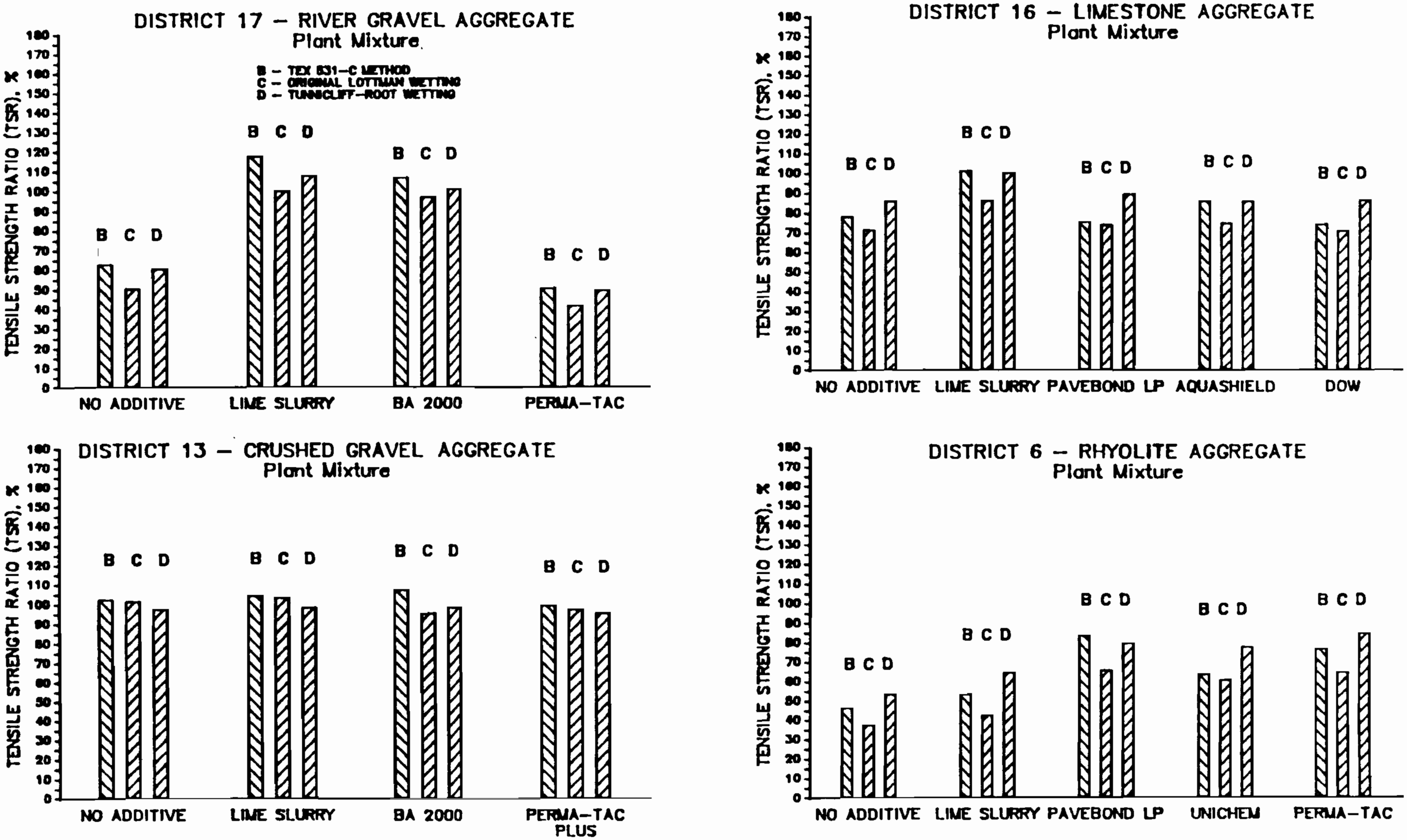


Fig. 4.21 Wet-dry indirect tensile test results for plant mixtures.

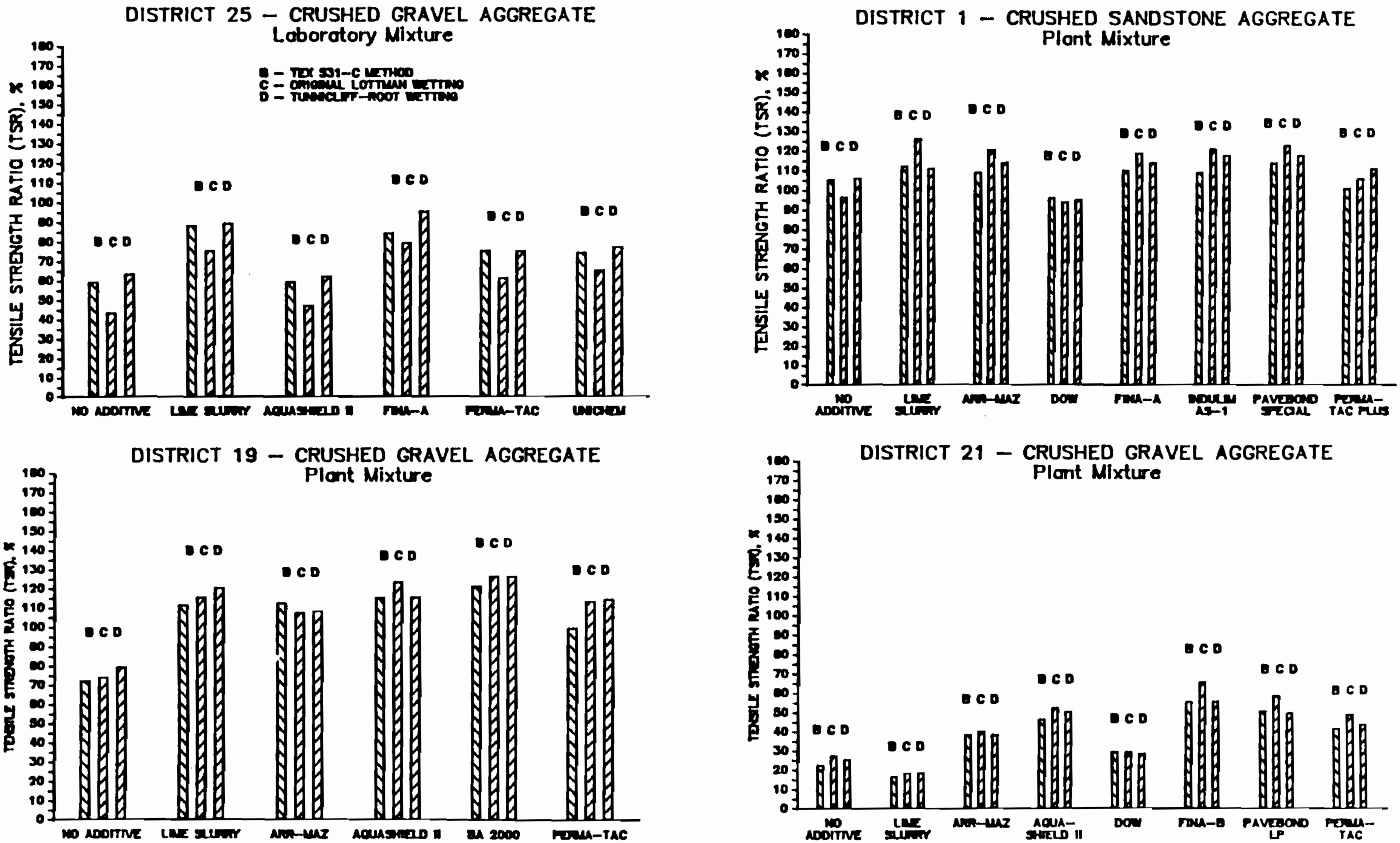


Fig. 4.21 Wet-dry indirect tensil test results for plant mixtures - continued.

should be used with appropriate degrees of freedom to test the statistical significance for N multiple comparisons.

The detailed test results of the pairwise comparisons using the TSR values are presented in the Appendix I (Figures I.1 through I.16) for the laboratory mixture and the plant mixture for each of the eight projects. From the outcomes shown in Figures I.1 through I.16, the two test criteria may not necessarily achieve the same conclusion in statistical significance. The criterion using the Bonferroni method is more stringent than the customary 5 percent level of error rate, i.e., the Bonferroni method will achieve less difference in statistical significance among the additives (or control) than the 5 percent level of error rate. However, the differences between the two test criterions are not very noticeable in evaluating the effectiveness of the various additives (or control). Therefore, the advantage of using the Bonferroni method over the 5 percent error rate is not significant in this study.

The effectiveness of the antistripping additives (or control) at 5 percent significance level is summarized on Table 4.2 based on the pairwise comparisons of the TSR values. The brackets indicate that the additives are not statistically different within the same bracket. The

TABLE 4.2 SUMMARY OF EFFECTIVENESS OF ANTISTRIPPING ADDITIVES BASED ON PAIRWISE COMPARISONS OF TENSILE STRENGTH RATIOS AT 5% SIGNIFICANCE LEVEL

SDHPT District	Effectiveness of Antistripping Additives or Control *(In Decreasing Order of Effectiveness)					
	Tex-531-C Method		Original Lottman Method		Tunnicliff-Root Method	
	Lab	Plant	Lab	Plant	Lab	Plant
17	Lime BA 2000 Perma-Tac Control	Lime BA 2000 Control Perma-Tac+	Lime BA 2000 Perma-Tac Control	Lime BA 2000 Control Perma-Tac+	Lime BA 2000 Perma-Tac Control	Lime BA 2000 Control Perma-Tac+
16	Lime P.B. LP Aquashield Dow Control	Lime Aquashield Control P.B. LP Dow	Lime Aquashield P.B. LP Dow Control	Lime Aquashield P.B. LP Dow Control	Lime Aquashield Dow P.B. LP Control	Lime P.B. LP Dow Aquashield Control
13	Lime BA 2000 P.T. Plus Control	BA 2000 Lime Control P.T. Plus	Lime BA 2000 P.T. Plus Control	Lime Control P.T. Plus BA 2000	Lime P.T. Plus BA 2000 Control	BA 2000 Control Lime P.T. Plus
6	Lime Perma-Tac P.B. LP Unichem Control	P.B. LP Perma-Tac Unichem Lime Control	Lime Unichem Perma-Tac P.B. LP Control	P.B. LP Perma-Tac Unichem Lime Control	Lime Unichem Perma-Tac P.B. LP Control	Perma-Tac P.B. LP Unichem Lime Control
25	Lime AS II Perma-Tac Fina-A Unichem Control	Lime Fina-A Perma-Tac Unichem A.S. II++ Control	Lime A.S. II Fina-A Unichem Perma-Tac Control	Fina-A Lime Unichem Perma-Tac A.S. II++ Control	Lime A.S. II Fina-A Unichem Perma-Tac Control	Fina-A Lime Unichem Perma-Tac A.S. II++ Control
1	P.B. Special P.T. Plus ARR-MAZ Fina-A Indulin AS-1 Lime Control Dow	P.B. Special Fina-A Lime Indulin AS-1 ARR-MAZ Control P. T. Plus Dow	P.B. Special Indulin AS-1 ARR-MAZ Lime Fina-A P.T. Plus Control Dow	Lime P.B. Special ARR-MAZ Indulin AS-1 Fina-A P.T. Plus Control Dow	P.B. Special ARR-Maz Lime Indulin AS-1 Fina-A P.T. Plus Control Dow	P.B. Special Indulin AS-1 ARR-MAZ Fina-A P.T. Plus Lime Control Dow
19	A.S. II ARR-MAZ BA 2000 Control Lime Perma-Tac	BA 2000 A.S. II ARR-MAZ Lime Perma-Tac Control	Lime BA 2000 A.S. II Perma-Tac ARR-MAZ Control	BA 2000 A.S. II Lime Perma-Tac ARR-MAZ Control	Lime A.S. II BA 2000 ARR-MAZ Perma-Tac Control	BA 2000 Lime A.S. II Perma-Tac ARR-MAZ Control
21	Lime A.S. II ARR-MAZ P.B.LP Perma-Tac Fina-B Dow Control	Fina-B P.B. LP A.S. II Perma-Tac ARR-MAZ Dow Control Lime	Lime Fina-B A.S. II P.B. LP Perma-Tac ARR-MAZ Dow Control	Fina-B P.B. LP A.S. II Perma-Tac ARR-MAZ Dow Control Lime	Lime Fina-B A.S. II P.B. LP ARR-MAZ Perma-Tac Dow Control	Fina-B P.B. LP A.S. II Perma-Tac ARR-MAZ Dow Control Lime

* The bracket indicates that the additives are not statistically different within the same bracket.

\+ The Perma-Tac was taken from the high voids test section.

++ The Aquashield II was taken from the low voids test section.

discussions are made in the following with regard to the effectiveness of the hydrated lime and the liquid antistripping additives.

Hydrated Lime. The hydrated lime was effective as compared to control on the laboratory mixtures as well as on most of the plant mixtures as summarized on Table 4.3; however, the lime was not effective on the plant mixtures of Districts 13, 6, and 21. For the plant mixture of District 13, there were essentially no differences among the various additives including the lime. For the plant mixture of District 6, the dry lime was added in layers to the coarse aggregate stockpile. Twelve hours prior to use, water was placed on the stockpile. Therefore, the hydrated lime may not have been mixed well with the rhyolite aggregates. For the District 21 material, the hydrated lime slurry was very effective on the laboratory mixture, but there was no significant difference between the TSR values of the lime treated and the untreated plant mixture. As previously discussed, the problem was associated either with the raw material itself or with the field application technique of the lime.

Liquid Antistripping Additives. Most liquid additives were effective as compared to control as measured by the TSR

TABLE 4.3 EFFECTIVENESS* OF ANTISTRIPPING ADDITIVES AS COMPARED TO CONTROL USING WET-DRY INDIRECT TENSILE TEST RESULTS

Additives	Laboratory/Plant Mixture	SDHPT District No. 17	16	13	6	25	1	19	21
Hydrated Lime	Lab	E	E	E	E	E	E	E	E
	Plant	E	E	N	N	E	E	E	N
Aquashield	Lab		E						
	Plant		N						
Aquashield II	Lab					E		E	E
	Plant					N		E	E
ARR-MAZ	Lab						E	E	E
	Plant						E	E	E
BA 2000	Lab	E		E				E	
	Plant	E		N				E	
Dow	Lab		E[1]				N		E
	Plant		N				N		E
Fina-A	Lab					E	E		
	Plant					E	E		
Fina-B	Lab								E
	Plant								E
Indulin AS-1	Lab						E		
	Plant						E		
Pavebond LP	Lab		E		E[2]				E
	Plant		N		E				E
Pavebond Special	Lab						E		
	Plant						E		
Perma-Tac	Lab	E			E[2]	E		N	E
	Plant	N			E	E		E	E
Perma Tac Plus	Lab			E			N[3]		
	Plant			N			N[4]		
Unichem	Lab				E	E			
	Plant				E	E			

* At 5 percent significance level
E - Effective at 5% significance level as compared to control for all test methods except as noted.
N - Not effective at 5% significance level as compared to control for all test methods except as noted.
1 - Not effective according to the Original Lottman Method.
2 - Not effective according to the Tunnicliff-Root Method.
3 - Effective according to the Tex-531-C Method.
4 - Effective according to the Tunnicliff-Root Method.

values (Table 4.3). However, a few treated materials were not significantly different from the untreated raw materials. The liquid additives were effective on the gravel materials such as the river gravels in Districts 17, 19, 21 and 25 and were fairly effective for treating the rhyolite material in District 6. The liquid additives were not very effective on the limestone material from District 16.

Evaluation of Effectiveness Using Boiling Test Results

The effectiveness of the hydrated lime and the various antistripping additives was evaluated using the percent of asphalt retained after boiling (Fig 4.22). The statistical analyses and comparisons were similar to that used to evaluate effectiveness based on TSR values.

The detailed test results of the statistical comparisons using the boil test values are shown in the Appendix I (Figures I.17 through I.24) for the laboratory and plant mixtures of each for each of the eight projects. The -level of 5 percent error rate and the Bonferroni method for multiple comparisons were also used to test the statistical significance of the various additives. The Bonferroni method is more strict than the α-level of 5

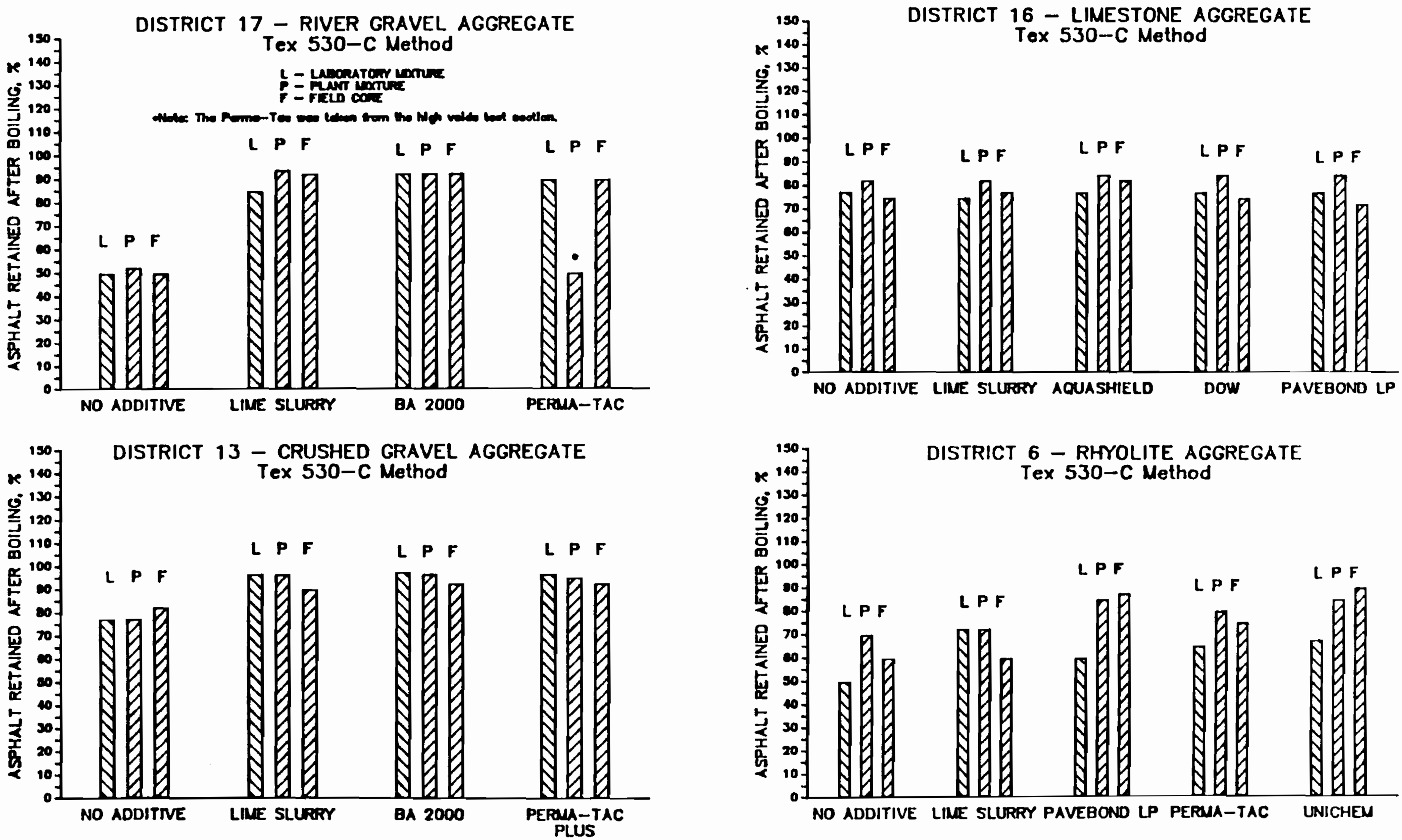


Fig. 4.22 Texas boiling test results.

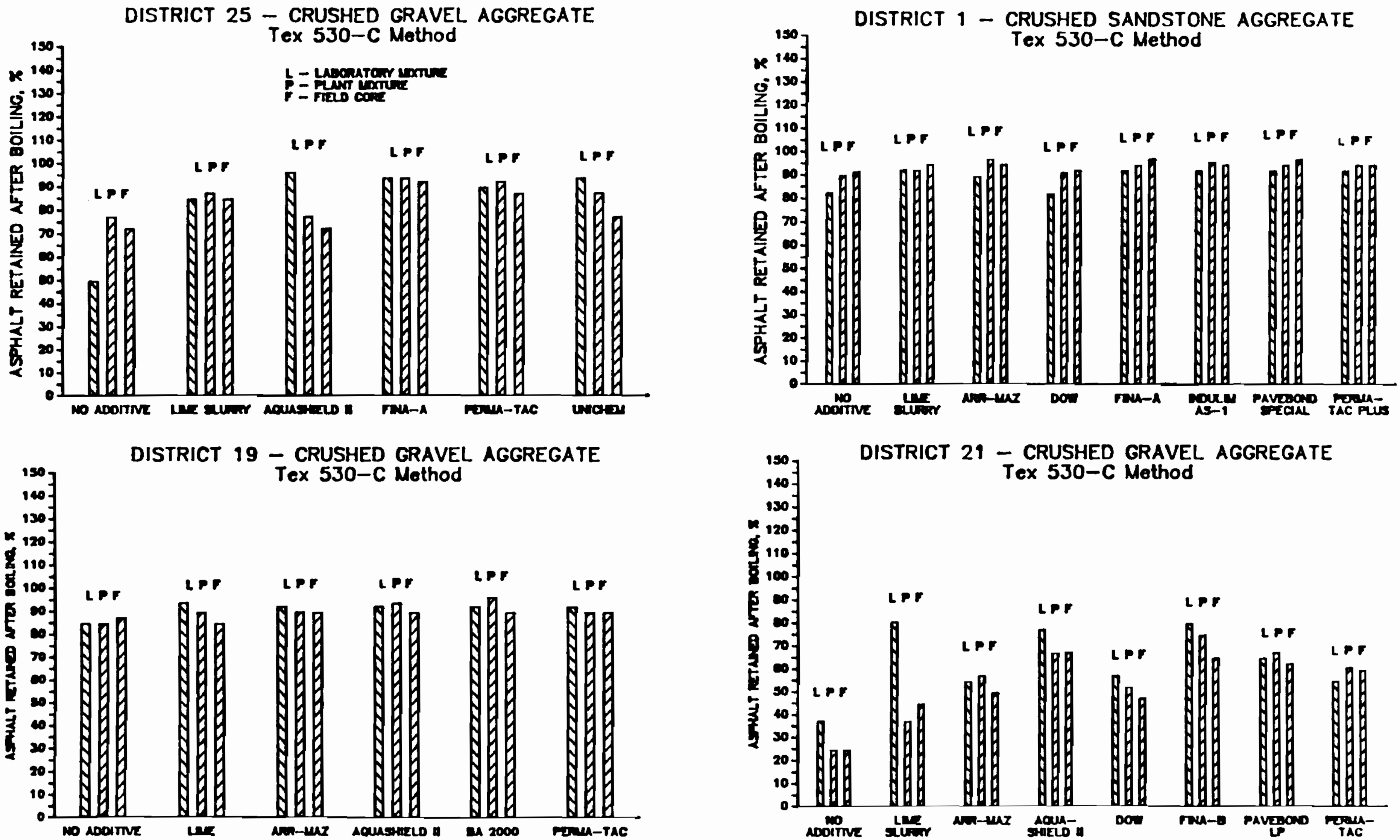


Fig. 4.22 Texas boiling test results - continued.

percent error rate; nevertheless, the two test criteria did not provide major differences with regard to the effectiveness of the various additives (or control).

The effectiveness of the various additives (or control) at 5 percent significance level is summarized on Table 4.4 for the laboratory and plant mixtures based on the pairwise comparisons of the boil test values.

Hydrated Lime. The hydrated lime was effective compared to the control for most of the laboratory mixtures as summarized in Table 4.5; however, the lime was not significantly better than the control for the limestone material (District 16) and the crushed gravel aggregates (Districts 1 and 9). The reason was probably due to the high boil values of the control mixtures (Districts 16, 1, and 19); thus, the boil values of the lime treated mixtures were not significantly different from the control mixtures for the laboratory mixtures. As for the plant mixtures, in most cases the hydrated lime was not effective (Table 4.5). In addition to the materials which were not effective for the lime treated laboratory mixtures (Districts 1, 16, and 19), the lime was not effective on the plant mixtures of Districts 6, 25, and 21. For the plant mixture of District 6, the lime was probably not mixed well with the rhyolite aggregates in the plant as described previously. For the

TABLE 4.4 SUMMARY OF EFFECTIVENESS OF ANTISTRIPPING ADDITIVES BASED ON PAIRWISE COMPARISONS OF BOILING TEST RESULTS AT 5% SIGNIFICANCE LEVEL

SDHPT District	Effectiveness of Antistripping Additives or Control (In Decreasing Order of Effectiveness) — Lab	Plant
17	BA 2000 Perma-Tac Lime Control	Lime BA 2000 Perma-Tac+ Control
16	Aquashield Dow Pavebond LP Control Lime	Aquashield Dow Pavebond LP Lime Control
13	BA 2000 Perma-Tac Lime Control	Lime BA 2000 Perma-Tac Control
6	Lime Unichem Perma-Tac Pavebond LP Control	Pavebond LP Unichem Perma-Tac Lime Control
25	Aquashield II Fina-A Unichem Perma-Tac Lime Control	Fina-A Perma-Tac Lime Unichem Aquashield II++ Control
1	Lime Fina-A Indulin AS-1 P.B. Special P.T. Plus ARR-MAZ Control Dow	ARR-MAZ Indulin AS-1 Fina-A P.B. Special P.T. Plus Lime Dow Control
19	Lime ARR-MAZ Aquashield II BA 2000 Perma-Tac Control	BA 2000 Aquashield II Lime ARR-MAZ Perma-Tac Control
21	Lime Fina-B Aquashield II Pavebond LP Dow ARR-MAZ Perma-Tac Control	Fina-B Aquashield II Pavebond LP Perma-Tac ARR-MAZ Dow Lime Control

* The bracket indicates that the additives are not statistically different within the same bracket.

\+ The Perma-Tac was taken frm the high voids test section.

++ The Aquashield II was taken from the low voids test section.

TABLE 4.5 EFFECTIVENESS* OF ANTISTRIPPING ADDITIVES AS COMPARED TO CONTROL USING BOILING TEST RESULTS

Additives	Laboratory/Plant Mixture	SDHPT District No. 17	16	13	6	25	1	19	21
Hydrated Lime	Lab	E	N	E	E	E	N	N	E
	Plant	E	N	E	N	N	N	N	N
Aquashield	Lab		N						
	Plant		N						
Aquashield II	Lab					E		N	E
	Plant					N		N	E
ARR-MAZ	Lab						N	N	E
	Plant						N	N	E
BA 2000	Lab	E		E				N	
	Plant	E		E				N	
Dow	Lab		N				N		E
	Plant		N				N		E
Fina-A	Lab					E	N		
	Plant					N	N		
Fina-B	Lab								E
	Plant								E
Indulin AS-1	Lab						N		
	Plant						N		
Pavebond LP	Lab		N		N				E
	Plant		N		N				E
Pavebond Special	Lab						N		
	Plant						N		
Perma-Tac	Lab	E			N	E		N	E
	Plant	N			N	N		N	E
Perma Tac Plus	Lab			E			N		
	Plant			E			N		
Unichem	Lab				E	E			
	Plant				N	N			

* At 5 percent significance level.
E - Effective at 5% significance level as compared to control.
N - Not effective at 5% significance level as compared to control.

District 25 material, the plant mixed control material had a fairly high boil value (Figure 4.22); therefore, the lime treated mixture was not significantly different from the control material. As for the District 21 material, the problem was associated either with the raw material itself or with the field application technique of the lime as described previously.

Liquid Antistripping Additives. Most liquid additives were effective on preventing moisture damage using the boil values for Districts 17, 13, 25 (except plant mixture), and 21 (all with gravel aggregates.)

However, the liquid additives were not effective for Districts 16 (limestone), 6 (rhyolite), 1 (sandstone), and 19 (crushed gravel). The reason was possibly due to the high boil test values for control materials for the Districts 16, 1, and 19 (Figure 4.22). For District 6, only the Unichem was effective on the laboratory mixture, whereas the other additives were not effective on the rhyolite material.

EFFECTIVENESS BASED MULTIPLE FREEZE-THAW CYCLES

The average cyclic freeze-thaw test results are summarized in Figure 4.23 in terms of the number of

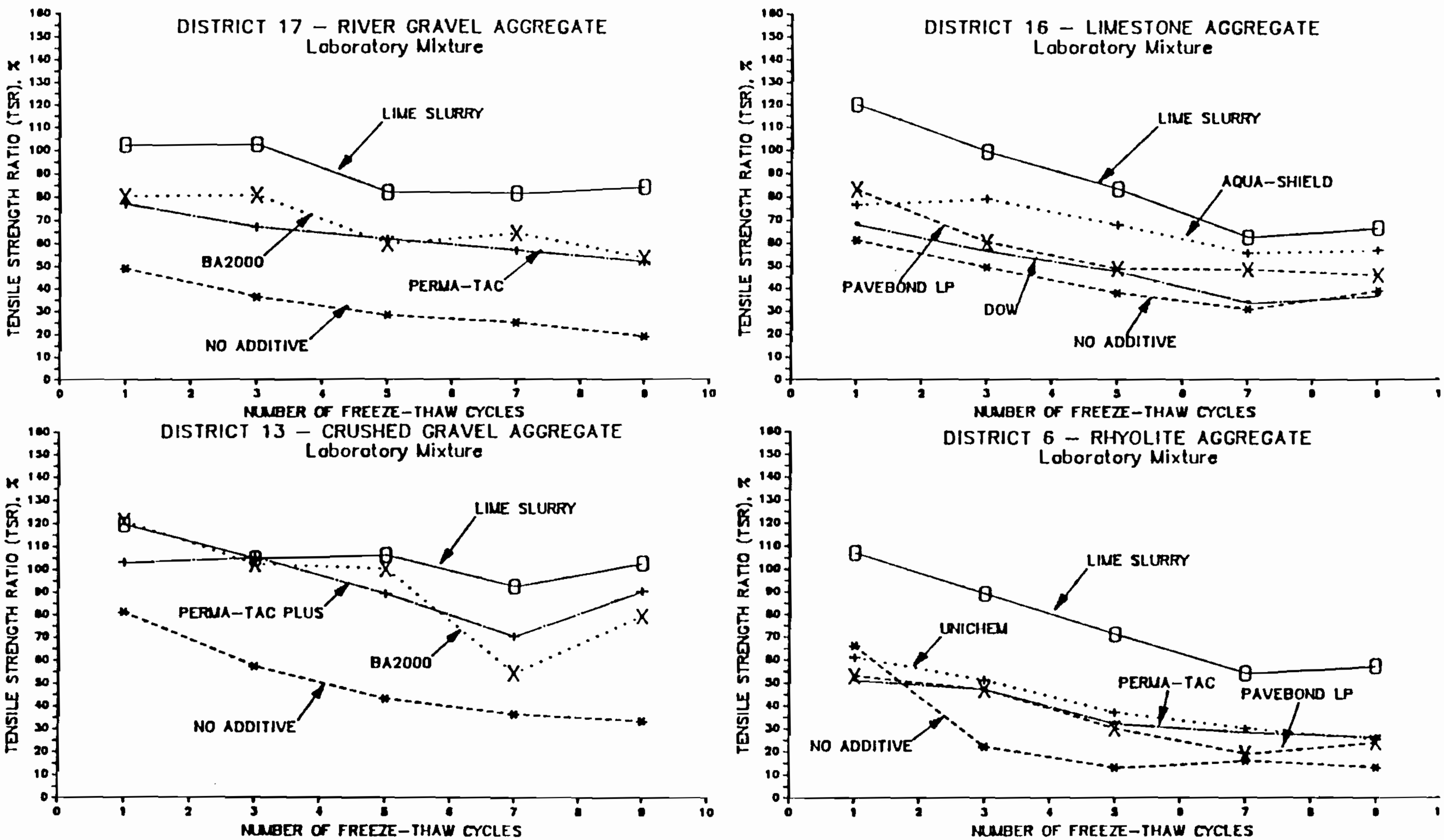


Fig. 4.23 Multiple freeze-thaw cyclic test results for laboratory mixtures.

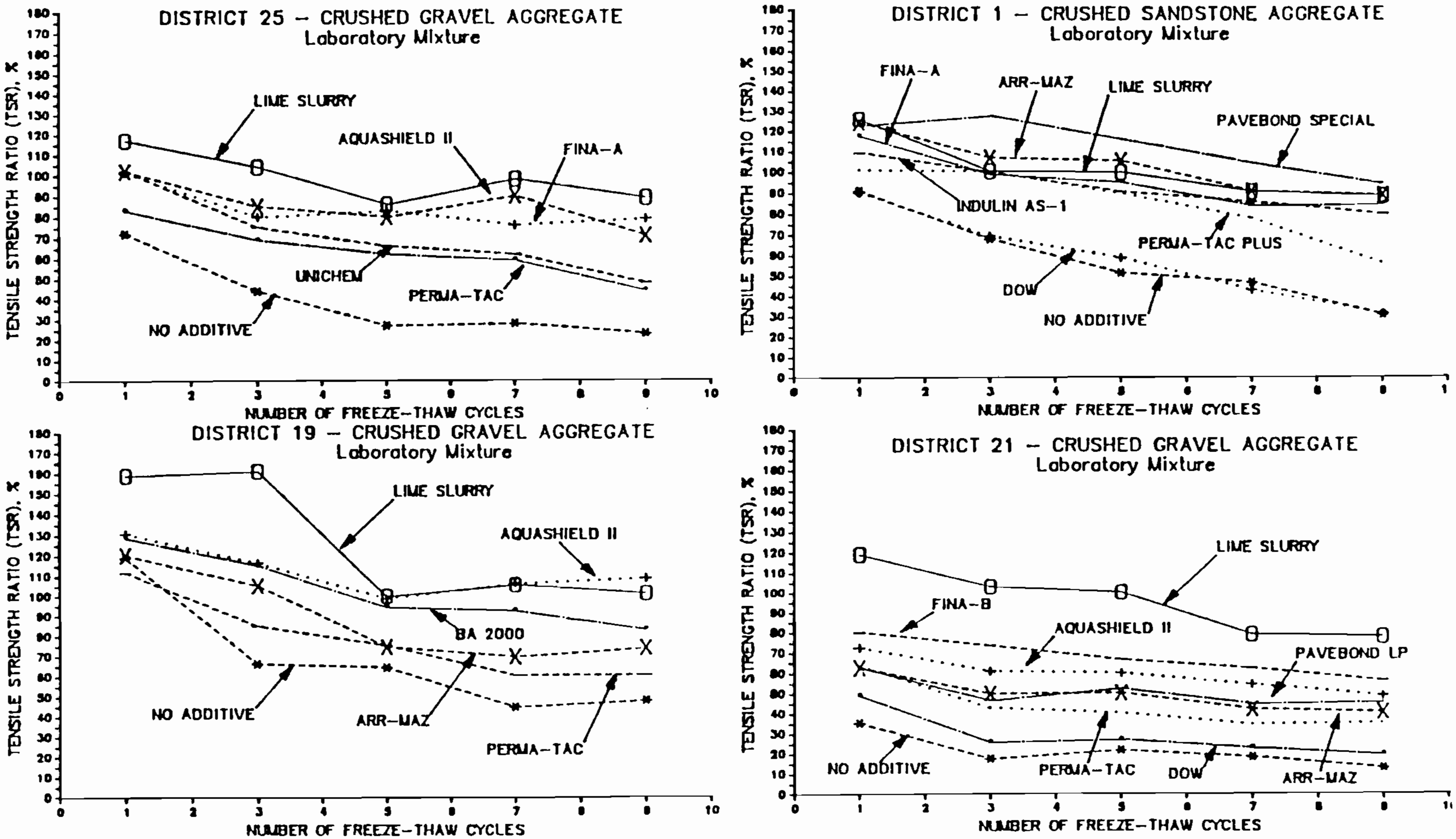


Fig. 4.23 Multiple freeze-thaw cyclic test results for laboratory mixtures - continued.

freeze-thaw cycles versus the tensile strength ratio (TSR) where TSR represents the average conditioned tensile strength for a specific number of cycles divided by the original average dry tensile strength. Linear regression relationships for the relationships shown in Figure 4.23 are presented in Figure 4.24 for the eight districts.

Some general trends were observed from the relationships shown in Figure 4.24. The TSR values decreased with an increased number of freeze-thaw cycles and the mixtures with higher initial TSR values at cycle one had higher TSR values at the end of nine freeze-thaw cycles. The slopes of the linear regression lines, i.e., the rate of deteriorations, for treated and untreated mixtures were approximately equal. Next, the hydrated lime generally had a much higher TSR value at cycle one and the TSR value was still higher than the other liquid additives at the end of nine freeze-thaw cycles. Finally, the raw material with no additive exhibited the lowest TSR values under the multiple freeze-thaw cyclic testing condition.

For ease of comparison, the slopes, the associated intercept TSR values at cycle one, and the standard error estimates for the linear regression analysis are summarized in Table 4.6. These results of the slopes and the intercept values at cycle one are also shown in Figure 4.25 for the

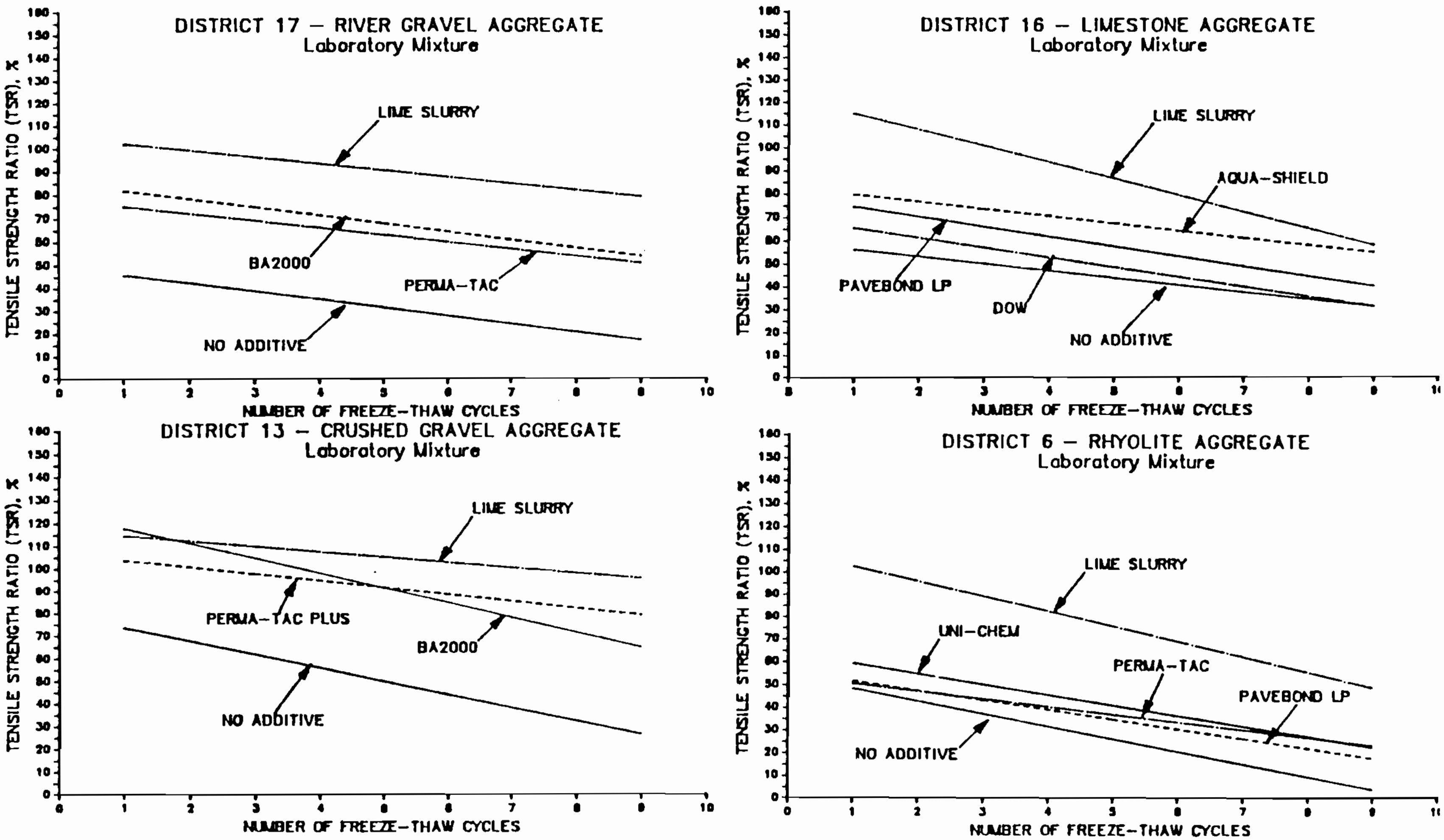


Fig. 4.24 Linear regression analysis of cyclic test results for laboratory mixtures.

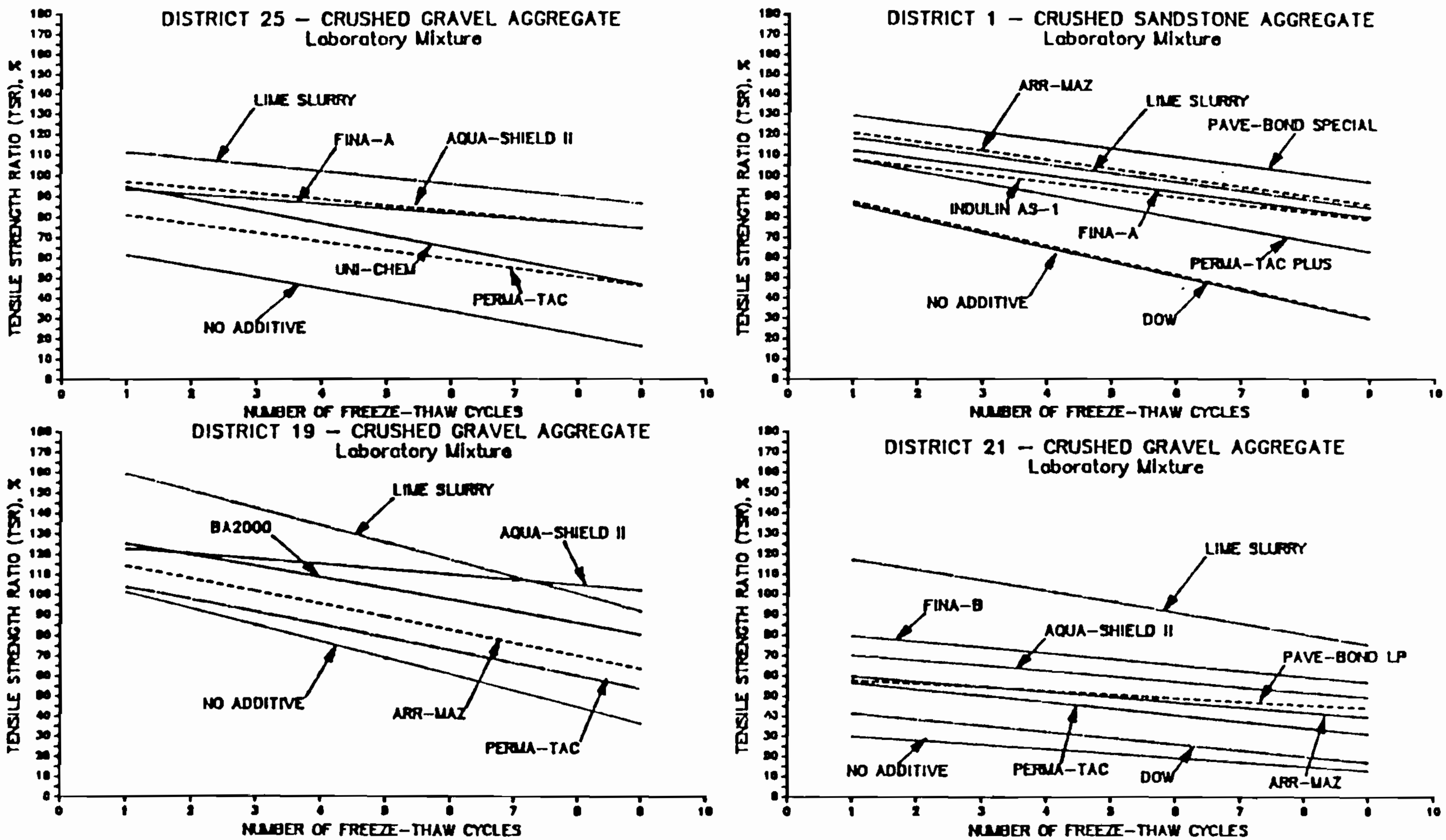


Fig. 4.24 Linear regression analysis of cyclic test results for laboratory mixtures - continued.

TABLE 4.6 SUMMARY OF RESULTS OF LINEAR REGRESSION ANALYSIS FOR MULTIPLE FREEZE-THAW CYCLIC TEST

District	Additive Name	% TSR at Cycle One: TSR, %	% TSR at Cycle One: Standard Error	Rate of Deterioration: TSR, %/Cycle	Rate of Deterioration: Standard Error	R-Square
	No Additive	46	2.87	3.57	0.499	0.94
	Lime	102	6.44	2.88	1.122	0.69
17	BA 2000	82	5.61	3.50	0.977	0.81
	Perma-Tac	75	1.68	3.05	0.292	0.97
	No Additive	56	6.75	3.14	1.175	0.70
	Lime	115	7.55	7.14	1.314	0.91
16	Aquashield	80	4.54	3.13	0.790	0.84
	Dow	65	4.59	4.26	0.799	0.90
	Pavebond LP	75	7.63	4.32	1.329	0.78
	No Additive	73	6.94	5.85	1.208	0.89
	Lime	114	6.74	2.33	1.173	0.57
13	BA 2000	118	15.49	6.60	2.696	0.67
	Perma-Tac Plus	104	10.66	3.05	1.855	0.47
	No Additive	48	14.83	5.60	2.581	0.61
	Lime	103	6.97	6.75	1.213	0.91
6	Pavebond LP	52	5.97	4.30	1.039	0.85
	Perma-Tac	51	3.58	3.45	0.624	0.91
	Unichem	59	2.77	4.65	0.482	0.97
	No Additive	62	9.60	5.70	1.671	0.79
	Lime	111	8.03	3.10	1.398	0.62
	Aquashield II	97	7.57	2.85	1.318	0.61
25	Fina-A	93	6.72	2.40	1.170	0.58
	Perma-Tac	81	3.27	4.40	0.569	0.95
	Unichem	95	6.36	6.05	1.107	0.91
	No Additive	86	4.94	7.09	0.860	0.96
	Lime	118	6.83	4.21	1.188	0.81
	ARR-MAZ	121	4.25	4.29	0.740	0.92
	Dow	87	2.56	7.20	0.446	0.99
1	Fina-A	112	5.15	4.02	0.896	0.87
	Indulin AS-1	108	1.82	3.63	0.317	0.98
	Pavebond Special	129	5.20	4.00	0.906	0.87
	Perma-Tac Plus	108	6.11	5.60	1.064	0.90
	No Additive	101	15.71	8.16	2.734	0.75
	Lime	159	17.41	8.53	3.031	0.73
	ARR-MAZ	114	10.54	6.40	1.834	0.80
19	Aquashield II	123	9.14	2.68	1.591	0.49
	BA 2000	125	5.12	5.70	0.891	0.93
	Perma-Tac	104	7.38	6.32	1.284	0.89
	No Additive	30	5.20	2.20	0.904	0.66
	Lime	117	4.82	5.34	0.839	0.93
	ARR-MAZ	60	3.21	2.60	0.558	0.89
	Aquashield II	70	2.37	2.70	0.412	0.93
21	Dow	41	6.61	3.10	1.151	0.71
	Fina-B	80	0.77	2.97	0.135	0.99
	Pavebond LP	58	5.14	1.80	0.896	0.57
	Perma-Tac	56	6.29	3.25	1.096	0.75

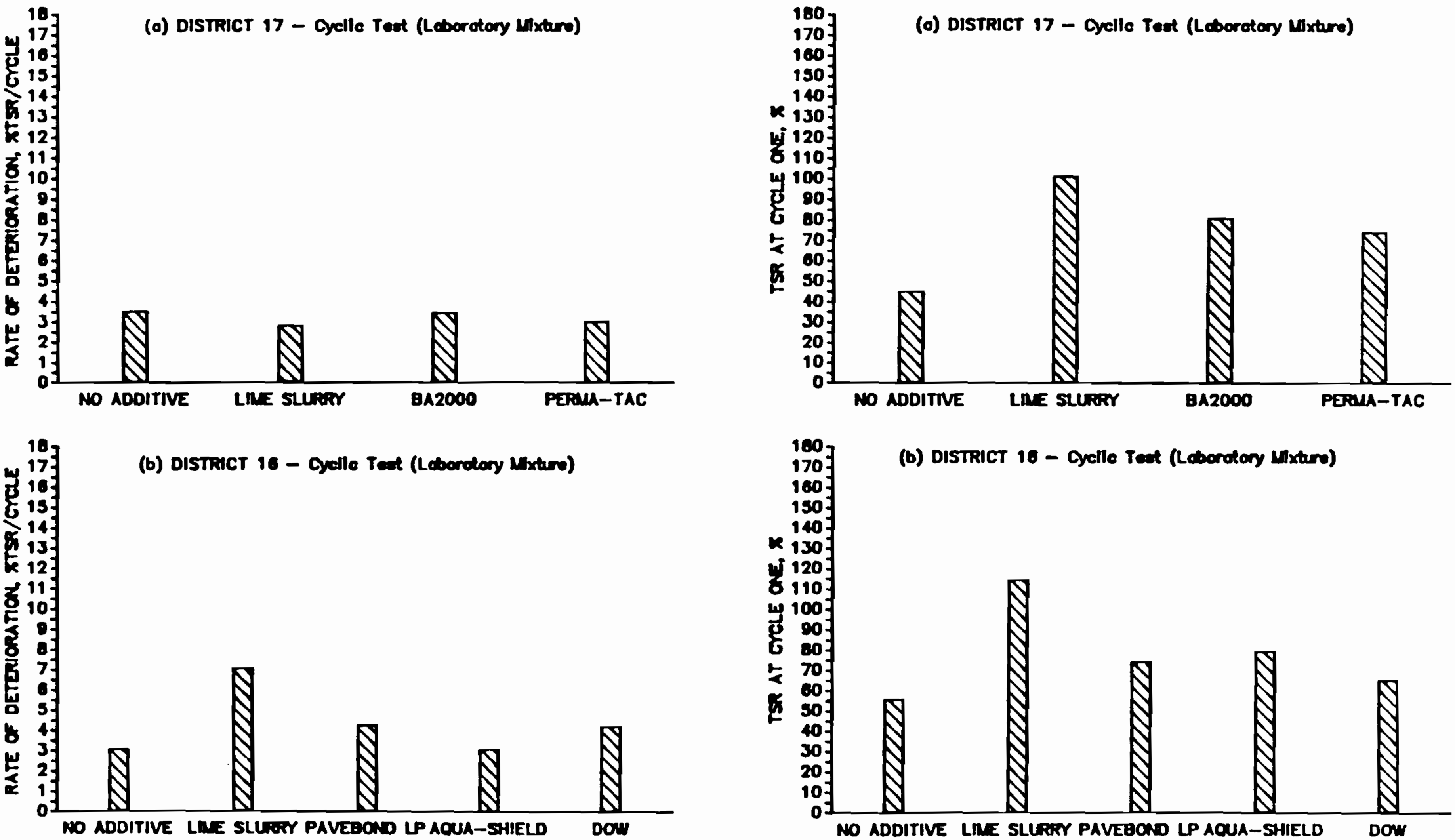


Fig. 4.25 The effect of additive on estimated rate of deterioration and initial TSR value.

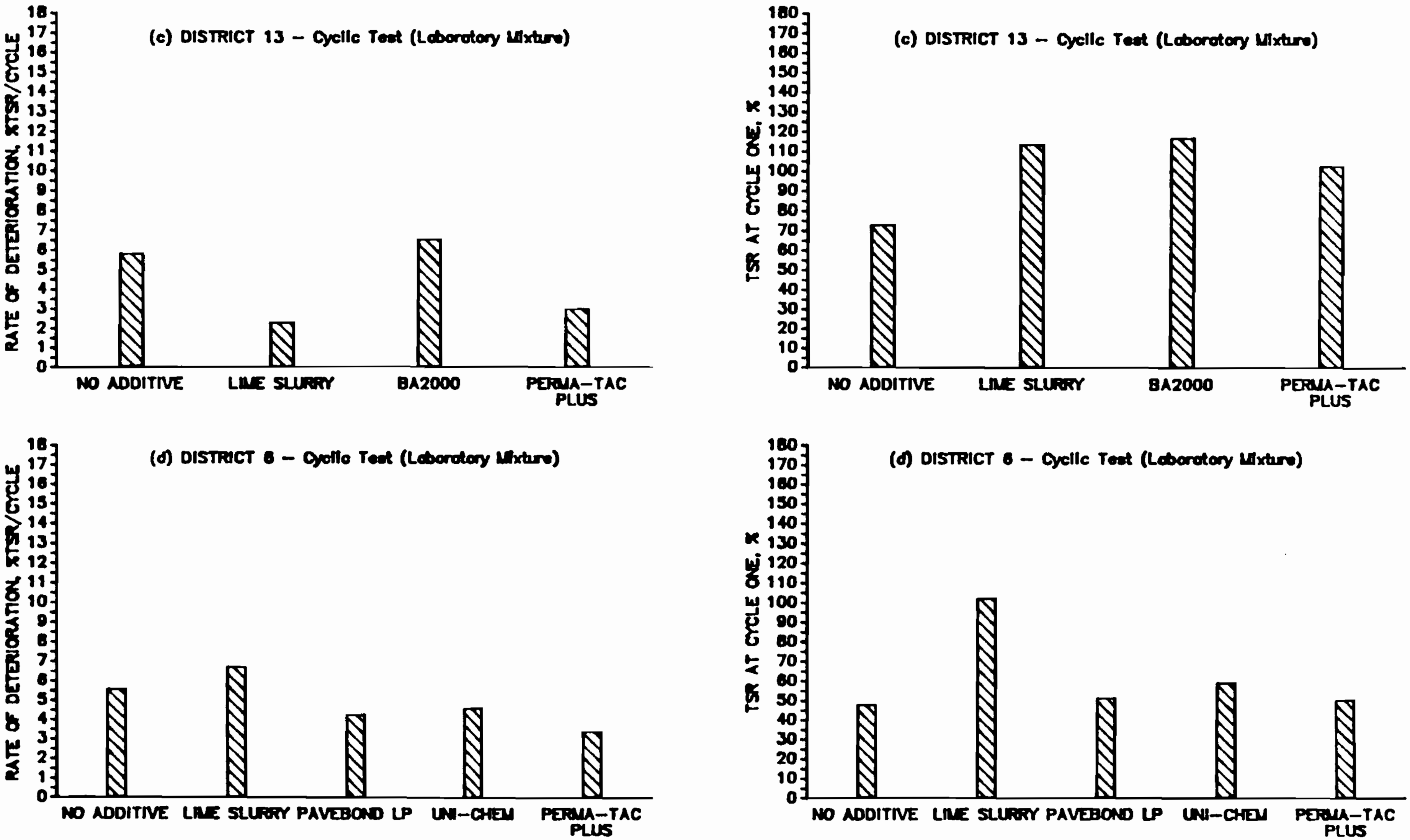


Fig. 4.25 The effect of additive on estimated rate of deterioration and initial TSR value - continued.

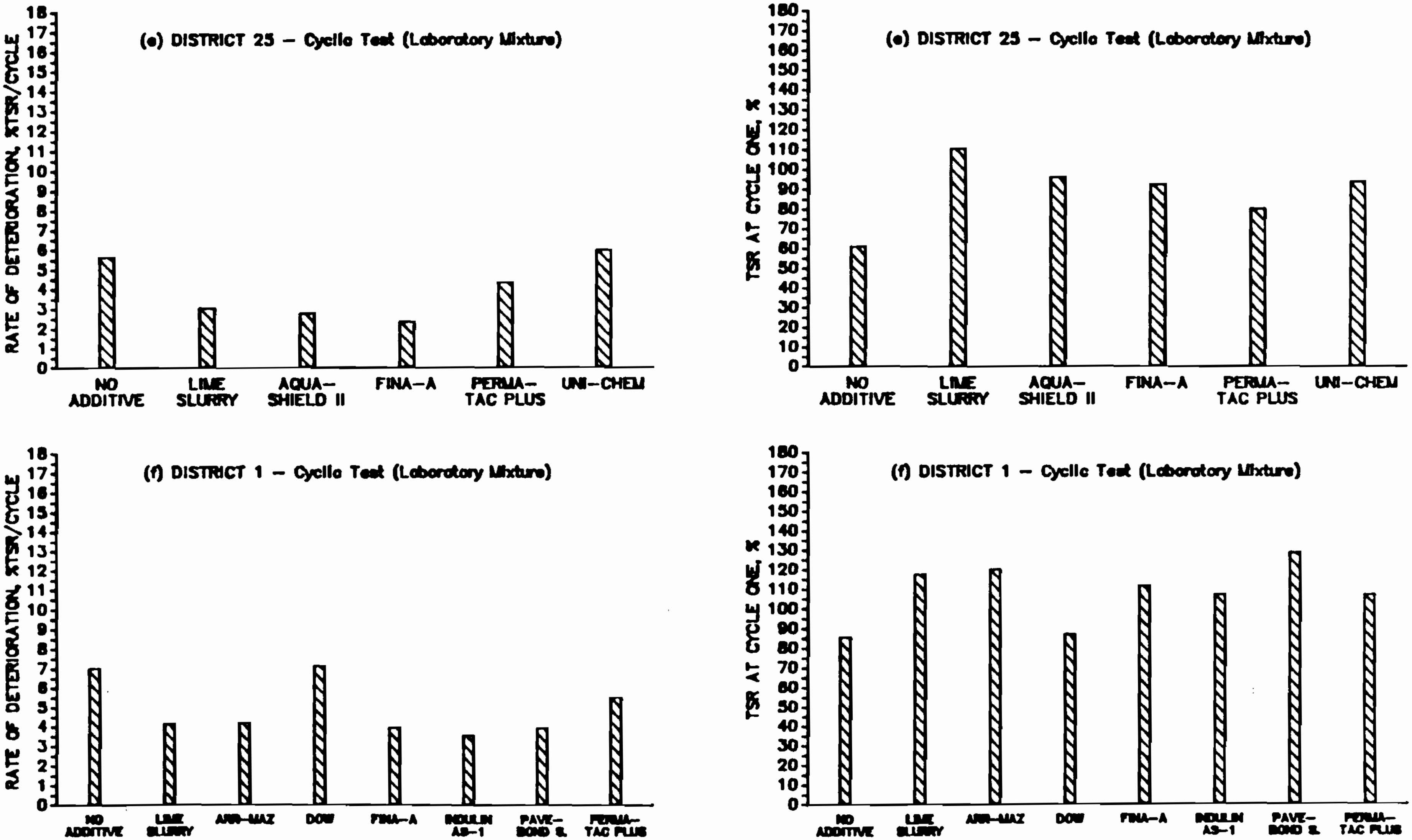


Fig. 4.25 The effect of additive on estimated rate of deterioration and initial TSR value - continued.

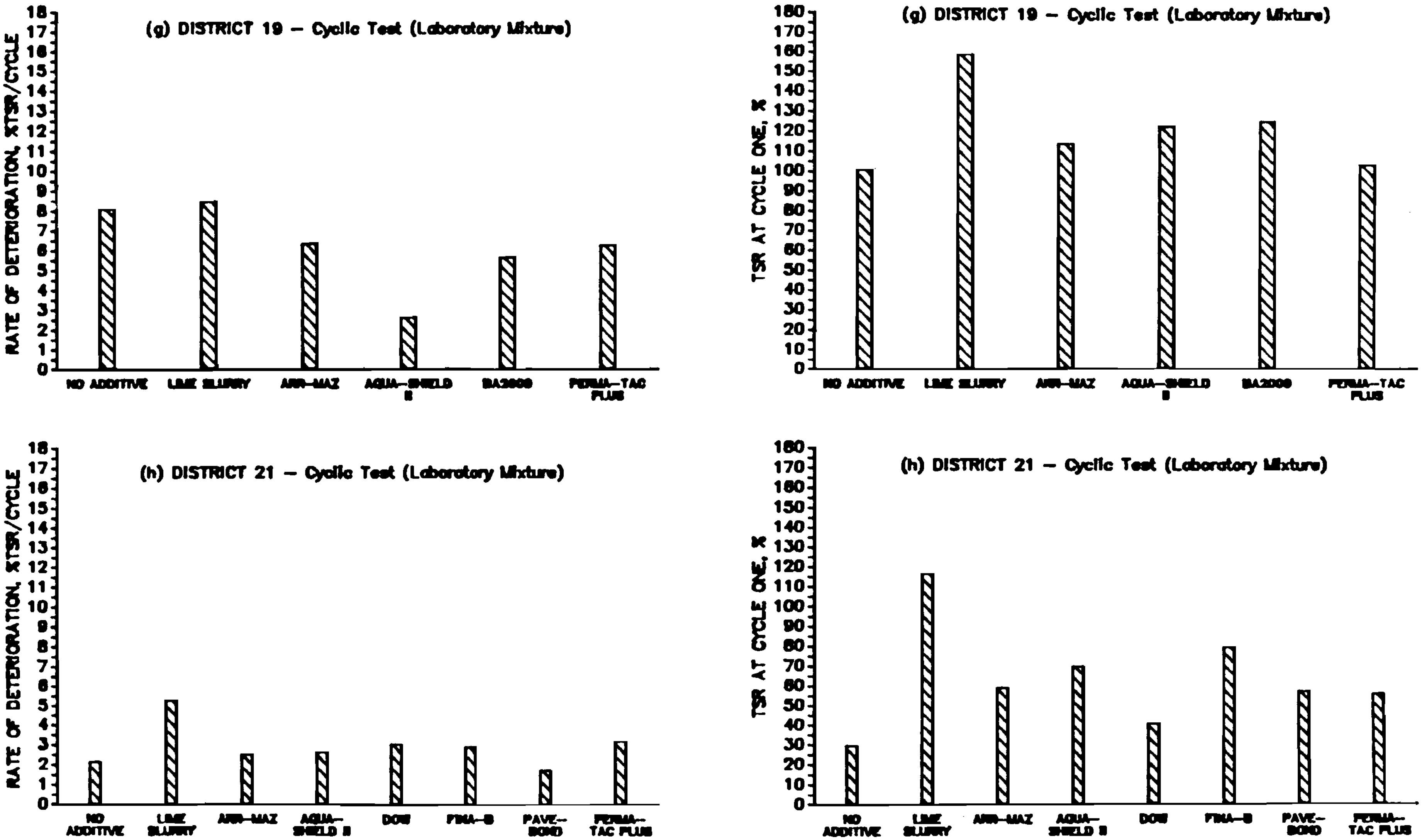


Fig. 4.25 The effect of additive on estimated rate of deterioration and initial TSR value - continued.

eight projects.

As illustrated in Figure 4.25, the rates of deterioration (slopes) were not much different from one another. To confirm that the rates of deterioration (slopes) were not significantly different from one another, statistical analysis was performed to do the comparison. The detailed analysis of the statistical pairwise comparisons for the rates of deterioration is summarized in the Appendix I. The significance levels were the 5 percent error rate and the Bonferroni method for multiple comparisons.

The above analyses indicated there were no differences between the slopes for seven out of the eight projects. The exception was District 1. For District 1, the slopes of the untreated material and the Dow pellets were significantly different from the ARR-MAZ and Indulin AS-1 at the 5% error rate (Figure 4.25f); however, they were not significantly different from one another using the Bonferroni Method of comparison.

Since the rates of deterioration are approximately equal for untreated and treated mixtures under the multiple freeze-thaw cyclic condition, those treated mixtures with higher initial TSR values at cycle one will essentially retain their edge of higher TSR at the end of multiple freeze-thaw cycles. The effect of additive on the estimated initial TSR value is shown in Figure 4.25 for all additives and controls. The estimated and the measured TSR values at cycle one are compared as shown in Figure 4.26. The correlation is excellent with an R^2 value of 0.97. Therefore, the estimated initial TSR values (Figure 4.25) are representative of the actual TSR values at cycle one for the untreated and treated mixtures.

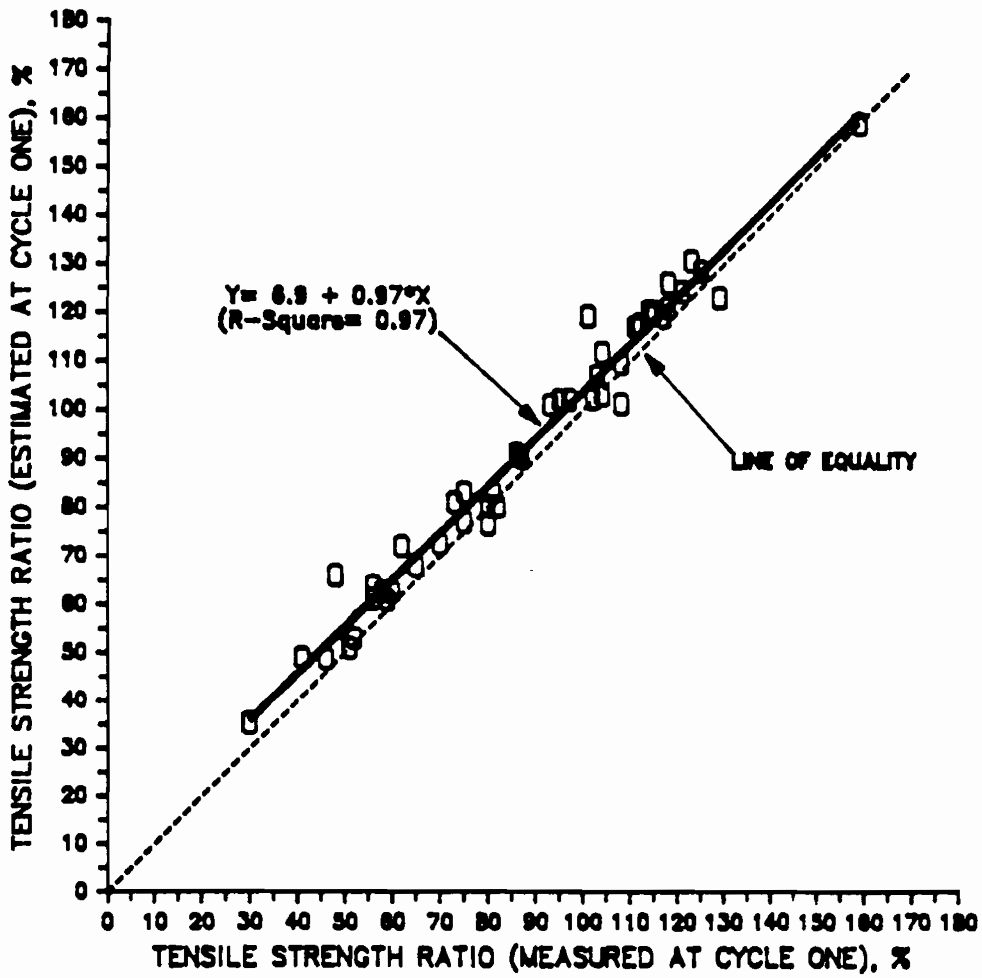


Fig 4.26 Comparison of estimated and measured initial TSR values at cycle one for multiple freeze-thaw cyclic test.

CHAPTER 5

ANALYSIS OF FIELD CORE TEST RESULTS

Field cores were obtained immediately after construction. These cores were analyzed to estimate air voids. In addition, two types of tests were conducted on the cores, i.e., the boiling test (Tex-530-C) and the modified Lottman procedure (Tex-531-C).

AIR VOIDS

The average air void contents of field cores from the test sections are summarized in Figure 5.1. In some cases the targeted air void contents for the low and high void test sections were not achieved. Primarily because in the time available it was not possible to develop the rolling pattern required to achieve a specified air void content. Thus in many cases there was little difference between the

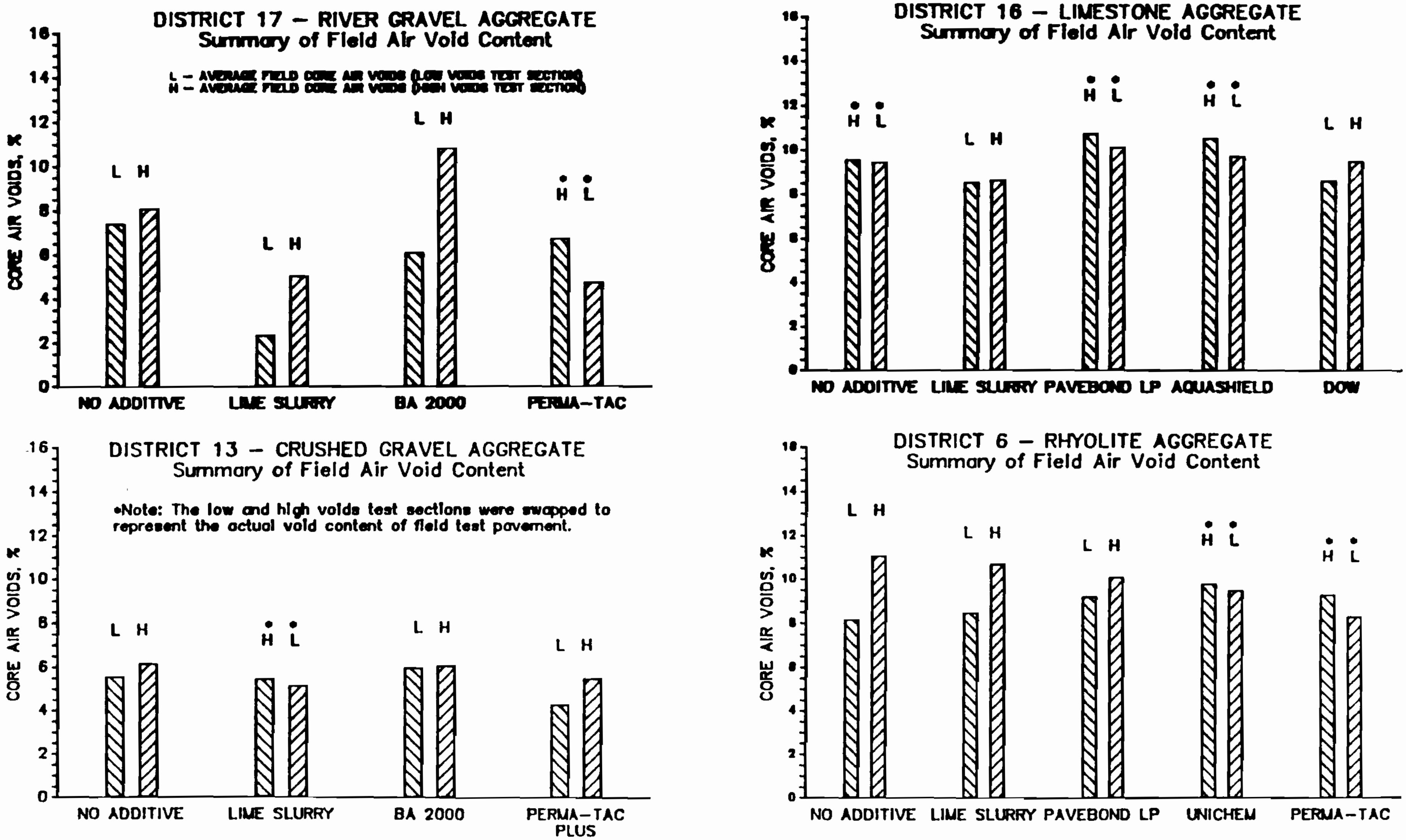


Fig. 5.1 Average air void content of field cores from low and high voids test sections.

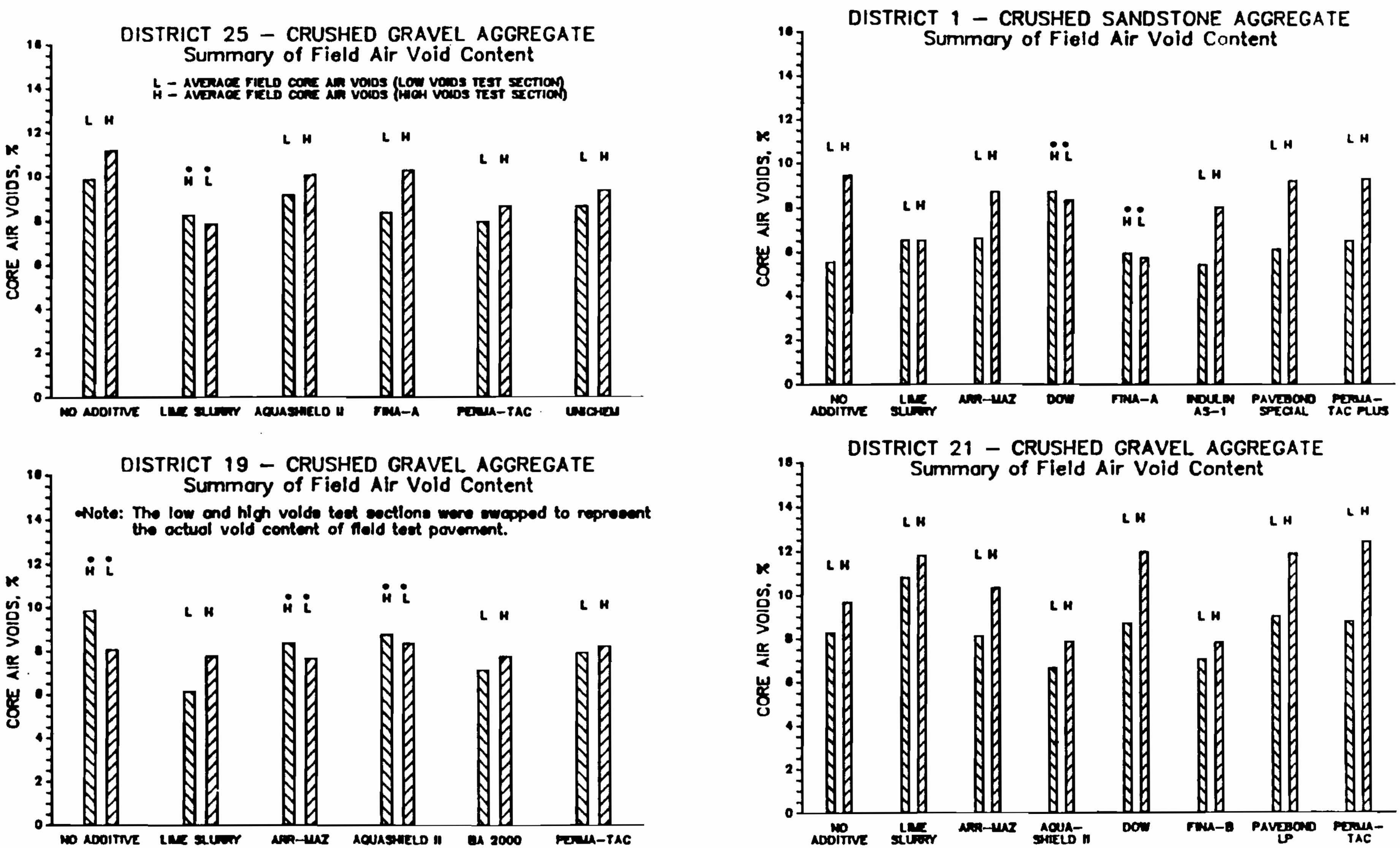


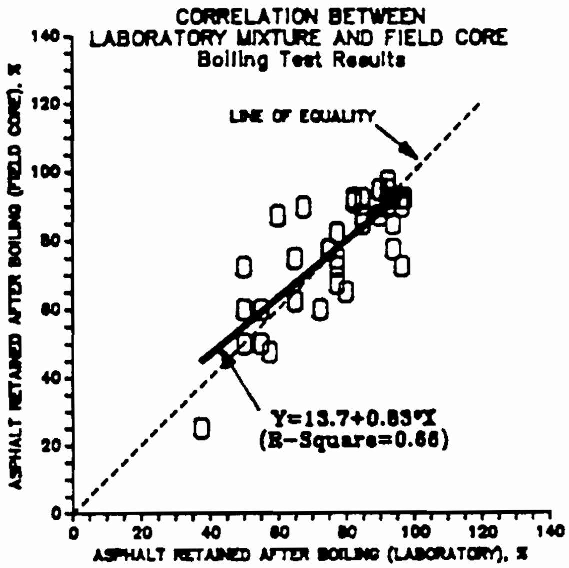
Fig. 5.1 Average air void content of field cores from low and high voids test sections - continued.

high and low voids, and in some cases the relative void contents were reversed, i.e., the high void content section had the lower air void content. In these cases where the high and low air voids were reversed, the actual air void content of the field test pavement was used as illustrated in Figure 5.1.

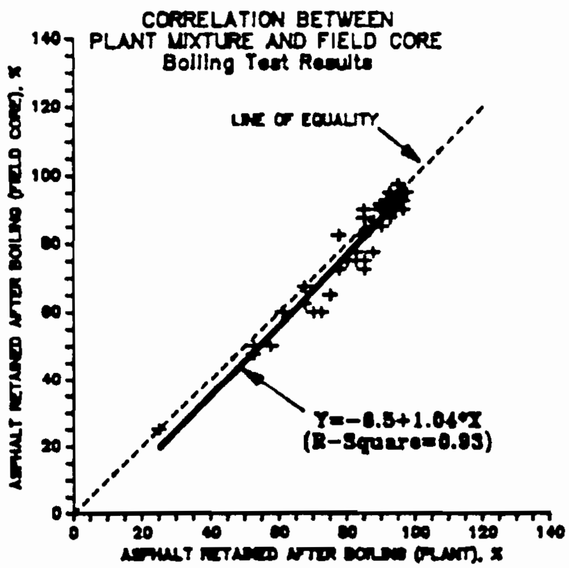
BOILING TEST RESULTS ON FIELD CORE

The results of the boiling test for the field cores are shown in Figure 4.38 together with the results for the laboratory and plant mixtures. Figure 5.2 illustrates the relationships between the boil test results for mixtures obtained by coring and the results obtained for both the laboratory and plant mixtures. The relationship between boiling test results for the field cored mixture and the results for the laboratory mixture was essentially the same as the relationship between boiling test results for the plant mixtures and the laboratory mixtures (Fig 4.19).

Both the plant and field cored mixtures retained more asphalt than the laboratory mixtures, i.e., both the field core and the plant mixture were more resistant to moisture damage. Excellent correlation (R^2 = 0.93) was obtained between boiling test results for the field cored mixture and



(a) Laboratory mixtures



(b) Plant mixtures

Fig 5.2 Relationships between boiling test results for field cored mixture and the results for both laboratory and plant mixtures.

the results for the plant mixture (Fig 5.2). The slope of the correlation line was approximately equal to 1.0 and the data exhibited minimum scatter. Therefore, the boiling test results of the field mixture can best be estimated by the results obtained by tests on the plant mixture.

MODIFIED LOTTMAN TEST RESULTS ON FIELD CORE

The modified Lottman test procedure (Tex-531-C) was conducted on each pair of the field cores. Due to a wide range of the air void content on the field cores, the TSR test results can not be readily compared with the laboratory test values. Since the TSR is a function of the air voids and the TSR values are compared at 7 percent air voids, the relationship between the TSR values and the core air voids must be established to obtain a TSR value at approximately 7 percent air voids. A similar approach was used previously to determine the dry and wet tensile strength at 7 percent air voids (Ref 53). The relationships between TSR and air voids are shown in Figure 5.3. The results of the linear regression analysis are summarized in Table 5.1.

Generally the TSR values decreased as the air voids increased (Figure 5.3). However, most regression lines are

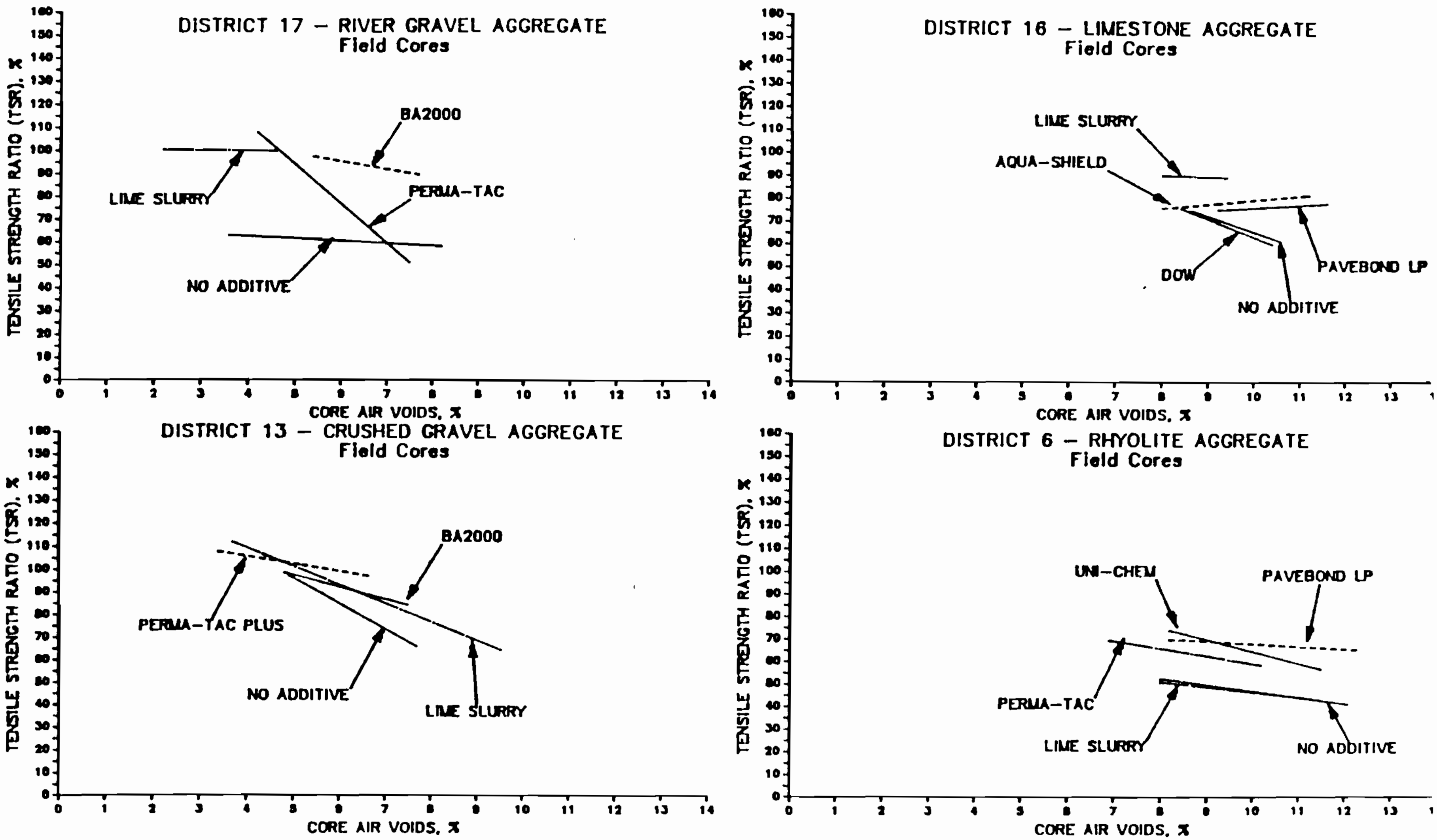


Fig. 5.3 Relationship between tensile strength ratio and air voids for field cores.

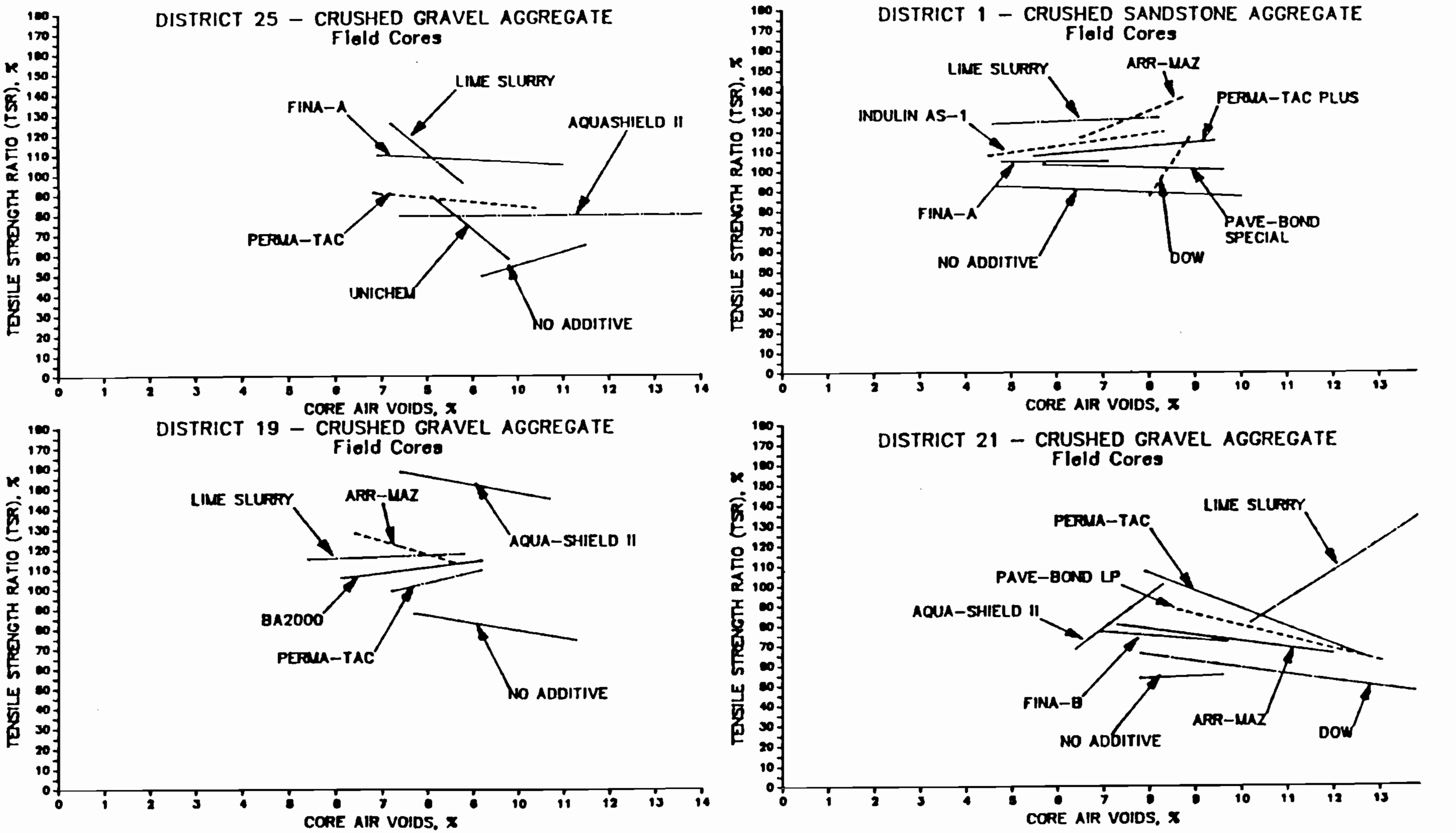


Fig. 5.3 Relationship between tensile strength ratio and air voids for field cores - continued.

RELATIONSHIP OF TSR VALUES(TEX-531-C) AND AIR VOIDS
FOR FIELD CORES

District	Additive Name	Intercept TSR Value, %	Slope, %/%	R-Square	Sample Size, n	Remarks (ANOVA Results)
	No Additive	67.1	-1.10	0.02	8	F=0.13, p=0.7356
	Lime	101.0	-0.24	0.00	6	F=0.01, p=0.9256
17	BA 2000	115.9	-3.43	0.04	7	F=0.22, p=0.6605
	PERMA-TAC	180.6	-17.29	0.75	8	F=18.47, p=0.0051*
	No Additive	134.8	-6.95	0.33	6	F=1.93, p=0.2373
	Lime	97.1	-0.86	0.00	6	F=0.02, p=0.9042
16	Aquashield	60.6	1.90	0.03	6	F=0.12, p=0.7504
	Dow	142.1	-7.91	0.20	6	F=0.99, p=0.3770
	Pavebond LP	63.0	1.32	0.01	6	F=0.04, p=0.8477
	No Additive	152.1	-11.17	0.45	6	F=3.21, p=0.1477
	Lime	142.0	-8.13	0.82	5	F=14.11, p=0.0330*
13	BA 2000	124.0	-5.30	0.22	6	F=1.15, p=0.3436
	P.T. Plus	118.9	-3.29	0.05	9	F=0.35, p=0.5752
	No Additive	74.5	-2.79	0.40	6	F=2.71, p=0.1749
	Lime	68.8	-2.25	0.15	6	F=0.68, p=0.4553
6	Pavebond LP	79.1	-1.15	0.07	6	F=0.32, p=0.6000
	Perma-Tac	92.8	-3.40	0.17	6	F=0.83, p=0.4132
	Unichem	117.0	-5.27	0.55	6	F=4.95, p=0.0901
	No Additive	-10.5	6.53	0.68	6	F=8.35, p=0.0444*
	Lime	262.2	-18.90	0.70	6	F=9.37, p=0.0376*
	Aquashield II	78.3	0.11	0.00	6	F=0.001, p=0.9819
25	Fina-A	118.8	-1.30	0.04	6	F=0.17, p=0.7024
	Perma-Tac	105.6	-2.19	0.11	6	F=0.47, p=0.5298
	Unichem	240.1	-18.60	0.45	6	F=3.29, p=0.1437
	No Additive	97.3	-0.98	0.02	6	F=0.10, p=0.7650
	Lime	120.3	0.86	0.02	6	F=0.06, p=0.8162
	ARR-MAZ	58.1	9.07	0.41	6	F=2.73, p=0.1739
	Dow	-187.5	34.40	0.51	6	F=4.18, p=0.1103
1	Fina-A	104.6	0.10	0.00	6	F=0.00, p=0.9848
	Indulin AS-1	93.8	3.20	0.37	6	F=2.34, p=0.2012
	P.B. Special	107.1	-0.65	0.01	6	F=0.05, p=0.8308
	P.T. Plus	97.2	2.00	0.07	6	F=0.29, p=0.6179
	No Additive	117.3	-3.83	0.26	6	F=1.43, p=0.2977
	Lime	110.9	0.78	0.00	6	F=0.01, p=0.9107
	ARR-MAZ	170.7	-6.69	0.27	6	F=1.51, p=0.2862
19	Aquashield II	188.7	-4.14	0.04	6	F=0.15, p=0.7166
	BA 2000	88.4	2.83	0.42	6	F=2.90, p=0.1636
	Perma-Tac	60.3	5.38	0.30	6	F=1.74, p=0.2581
	No Additive	46.1	0.94	0.01	6	F=0.04, p=0.8562
	Lime	-66.5	14.50	0.38	6	F=2.43, p=0.1938
	ARR-MAZ	102.7	-3.10	0.29	6	F=1.65, p=0.2688
	Aquashield II	-41.6	17.10	0.38	6	F=2.43, p=0.1939
21	Dow	90.6	-3.21	0.26	6	F=1.38, p=0.3050
	Fina-B	90.3	-1.95	0.10	6	F=0.42, p=0.5516
	Pavebond LP	138.0	-5.85	0.33	6	F=1.98, p=0.2321
	Perma-Tac	178.2	-9.00	0.87	6	F=27.90, p=0.0062*

*Note: Statistically Significant at 5% level.

relatively flat with very low R^2 values. The analysis of variance (ANOVA) for the linear regression was conducted to evaluate the significance of the relationships with the air voids. The results of ANOVA are summarized in the Table 5.1. In most cases, the regression lines were not significant at the 5% level, although, in a few cases, the regression lines were statistically significant. The problems are with small sample size as well as short range of air voids. The field cores are limited in number such that large sample size can not be obtained. In addition, the range of air voids between the lowest and the highest value for each field test section was quite small.

COMPARISON OF TSR VALUES AT APPROXIMATELY 7 PERCENT AIR VOIDS

For the purpose of comparison, the relationships between the TSR values and the core air voids were interpolated or extrapolated to provide an estimated TSR value corresponding to the same air voids content as the laboratory and plant mixtures. These estimated core TSR values are summarized on Table 5.2 and TSR values of the laboratory and plant mixtures.

TABLE 5.2 SUMMARY OF TSR VALUES(TEX-531-C) AT APPROXIMATELY 7% AIR VOIDS FOR FIELD CORES

District	Additive Name	Lab Mixture AIR VOID, %	Lab Mixture TSR, %	Lab Mixture CORE TSR, %	Plant Mixture AIR VOID, %	Plant Mixture TSR, %	Plant Mixture CORE TSR, %	Remarks
17	No Additive	6.9	50.8	59.5	7.4	63.5	59.0	
	Lime	6.3	118.4	99.5	7.0	118.3	99.3	
	BA 2000	6.9	81.6	92.2	6.7	107.4	92.9	
	PERMA-TAC	7.5	82.0	50.9	7.6	51.2	49.2	Values not reliable.
16	No Additive	6.4	44.0	90.3	6.8	78.8	87.5	
	Lime	7.2	74.1	90.9	6.8	102.2	91.3	
	Aquashield	7.1	56.1	74.1	6.5	86.8	73.0	
	Dow	6.2	53.0	93.1	7.5	75.3	82.8	
	Pavebond LP	7.2	60.5	72.5	7.7	76.5	73.2	
13	No Additive	7.3	43.0	70.6	6.8	103.0	76.1	
	Lime	7.3	141.7	82.7	7.1	105.0	84.3	
	BA 2000	6.5	64.0	89.6	6.1	108.0	91.7	
	P.T. Plus	7.4	61.0	94.6	6.0	100.0	99.2	
6	No Additive	6.5	20.0	56.4	6.9	47.0	55.2	
	Lime	6.0	76.0	55.3	6.8	54.0	53.5	
	Pavebond LP	6.7	40.0	71.4	6.4	84.0	71.7	
	Perma-Tac	6.4	49.0	71.0	6.7	77.0	70.0	
	Unichem	6.3	37.0	83.8	7.0	64.0	80.1	
25	No Additive	7.1	68.0	35.9	6.9	60.0	34.6	
	Lime	6.5	130.0	139.4	7.1	89.0	128.0	
	Aquashield II	6.9	120.0	79.1	6.4	60.0	79.0	Values not reliable.
	Fina-A	7.0	99.0	109.7	7.3	85.0	109.3	
	Perma-Tac	6.6	103.0	91.1	7.2	76.0	89.8	
	Unichem	7.6	92.0	98.7	7.1	75.0	108.0	
1	No Additive	7.3	73.1	90.1	6.9	106.0	90.5	
	Lime	6.8	105.8	126.1	6.4	113.0	125.8	
	ARR-MAZ	7.0	114.1	121.6	6.9	110.0	120.7	
	Dow	7.1	70.7	56.7	6.9	97.0	49.9	Values not reliable.
	Fina-A	7.1	109.7	105.3	6.6	111.0	105.3	
	Indulin AS-1	6.9	106.9	115.9	7.2	110.0	116.8	
	P.B. Special	6.4	121.2	102.9	7.2	115.0	102.4	
	P.T. Plus	6.8	115.7	110.8	7.4	102.0	112.0	
19	No Additive	6.8	111.2	91.3	7.8	73.0	87.4	
	Lime	7.3	106.8	116.6	7.4	112.0	116.7	
	ARR-MAZ	6.2	119.7	129.2	6.5	113.0	127.2	
	Aquashield II	6.9	124.6	160.1	6.9	116.0	160.1	
	BA 2000	7.2	115.5	108.8	6.4	122.0	106.5	
	Perma-Tac	7.1	93.5	98.5	6.8	100.0	96.9	
21	No Additive	7.4	24.2	53.1	6.8	23.0	52.5	
	Lime	7.3	104.0	39.4	7.9	17.0	48.1	Values not reliable.
	ARR-MAZ	6.9	52.4	81.3	7.5	39.0	79.5	
	Aquashield II	6.8	72.4	74.7	7.6	47.0	88.4	
	Dow	6.8	35.2	68.8	7.2	30.0	67.5	
	Fina-B	6.8	44.3	77.0	7.1	56.0	76.5	
	Pavebond LP	7.4	51.4	94.7	7.3	51.0	95.3	
	Perma-Tac	6.7	47.2	117.9	7.2	42.0	113.4	Values not reliable.

Figure 5.4 compares the laboratory and core TSR values for each of the eight projects. Generally, the core TSR values were larger than the values for laboratory mixture. The TSR values of the lime-treated mixtures were not consistent possibly due to different application techniques. All of the lime was added and mixed in slurry form in the laboratory whereas, in two cases, the dry lime was added on the wet coarse aggregates at the plant (Districts 6 and 19). The relationships between all core and laboratory TSR values are shown in Figure 5.5. The correlation was extremely poor for the lime. The correlation for the liquid additives was fair with an R-square value of 0.61. The relationship also suggests that the field mixtures were more resistant to moisture damage than the laboratory mixtures.

The comparisons of plant and core TSR values are shown in Figure 5.6 for each of the eight districts. With exception of District 21 data, the TSR values for the field core were in general agreement with the TSR values for the plant mixture. The data from all eight projects were plotted to establish the relationships between the plant mixture and the field core (Figure 5.7). The correlation for all the data points was fair with R-square value of 0.48. The data still indicate that the field cored mixtures are less susceptible to moisture damage than the

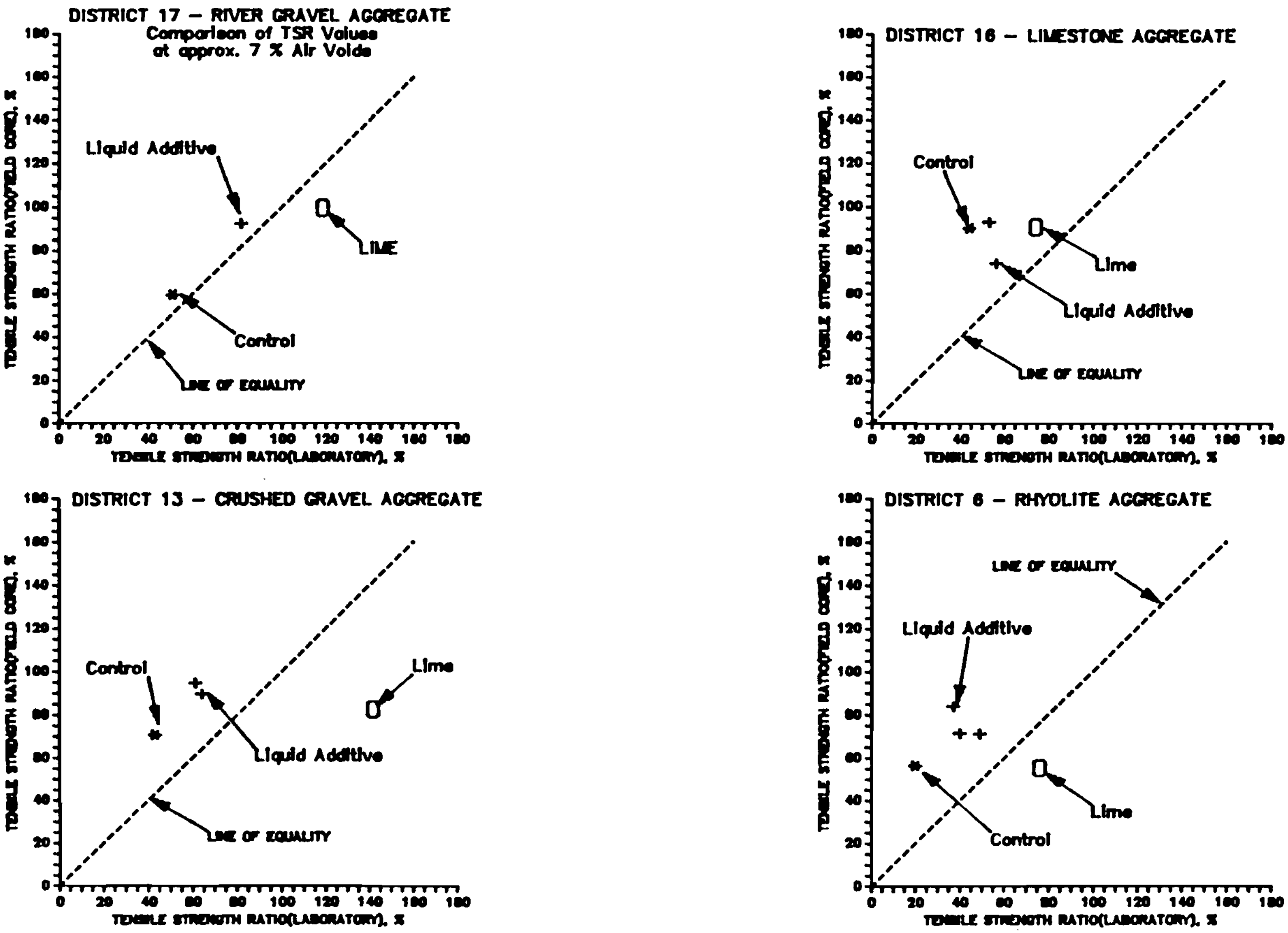


Fig. 5.4 Comparison of TSR values at approximately 7 percent air voids between laboratory mixture and field cored mixture.

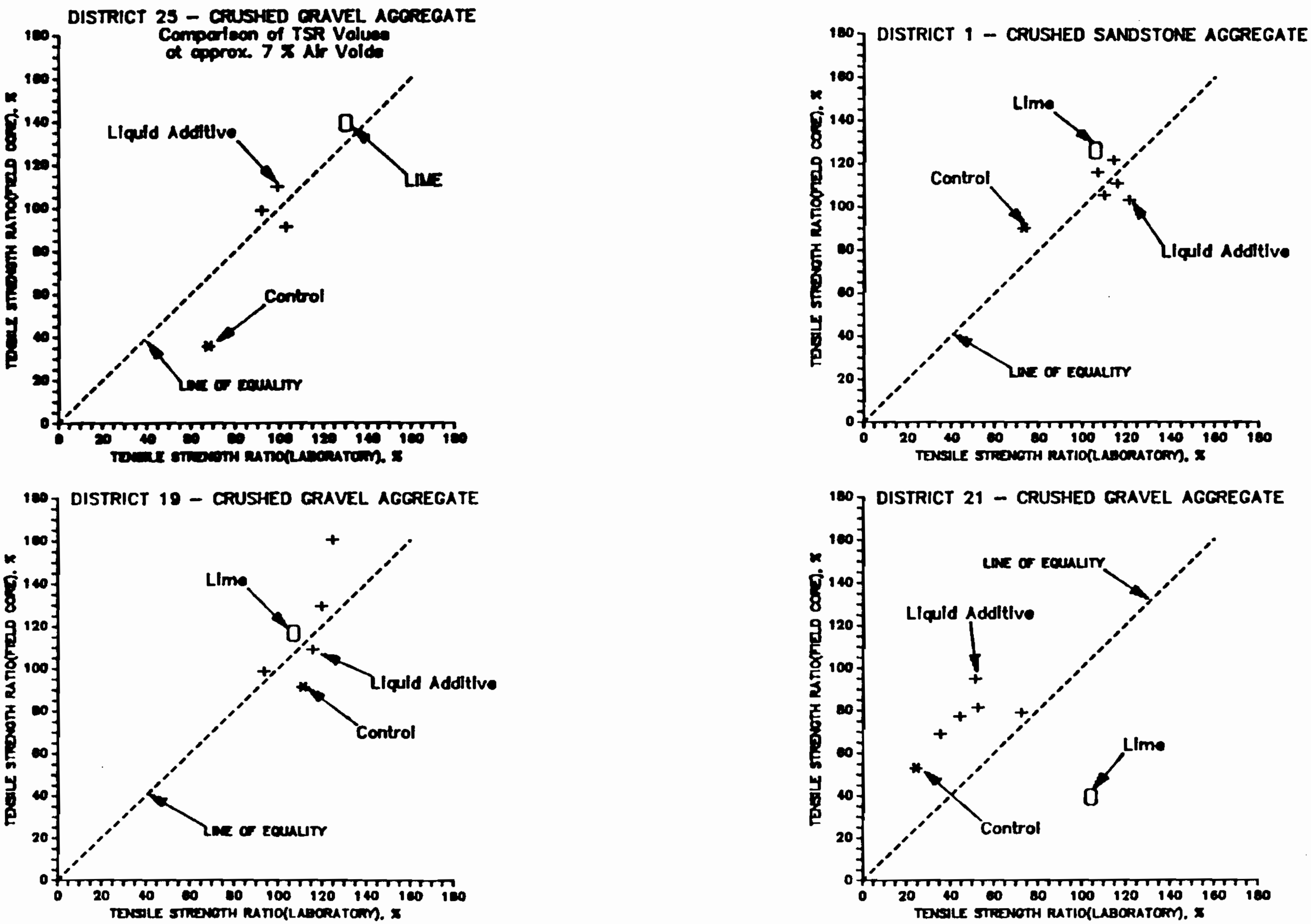


Fig. 5.4 Comparison of TSR values at approximately 7 percent air voids between laboratory mixture and field cored mixtures - continued.

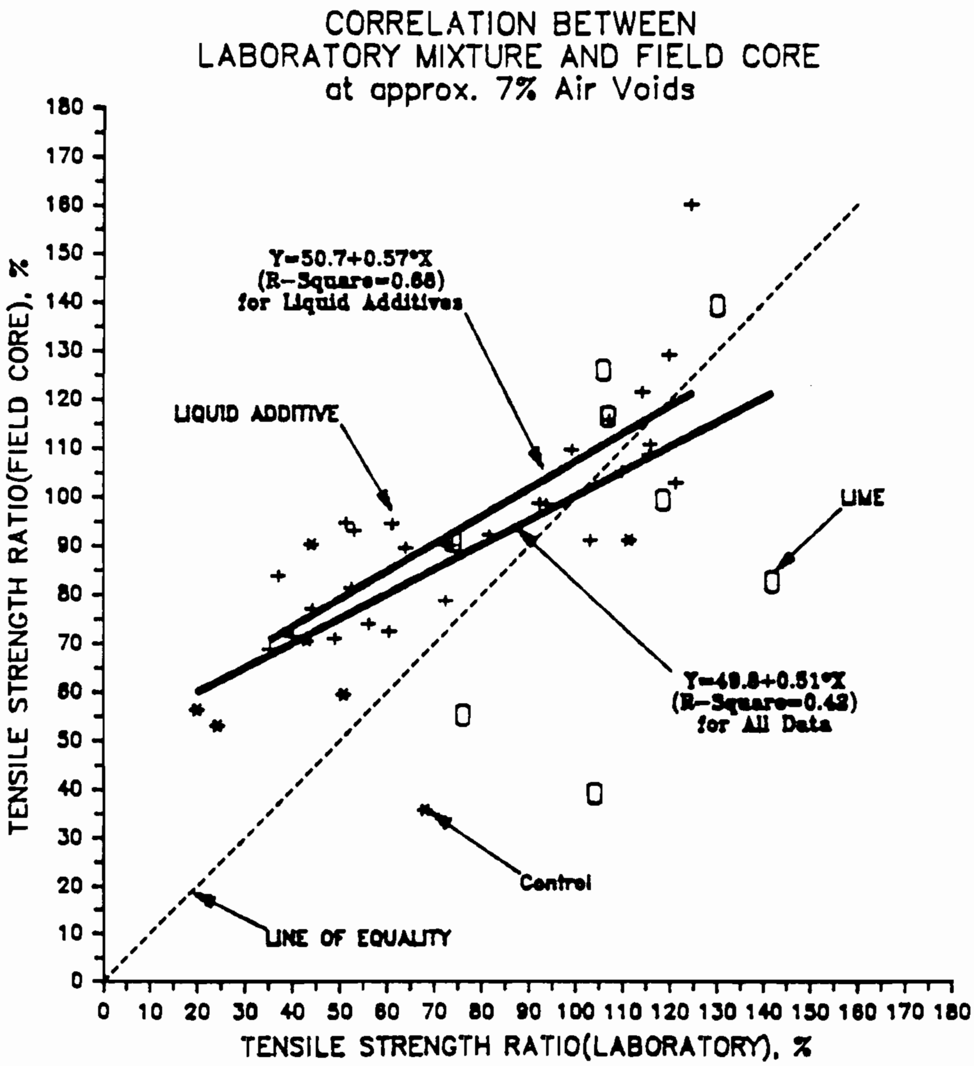


Fig 5.5 Comparison of TSR values at approximately 7 percent air voids between laboratory mixture and field cored mixture for all eight projects.

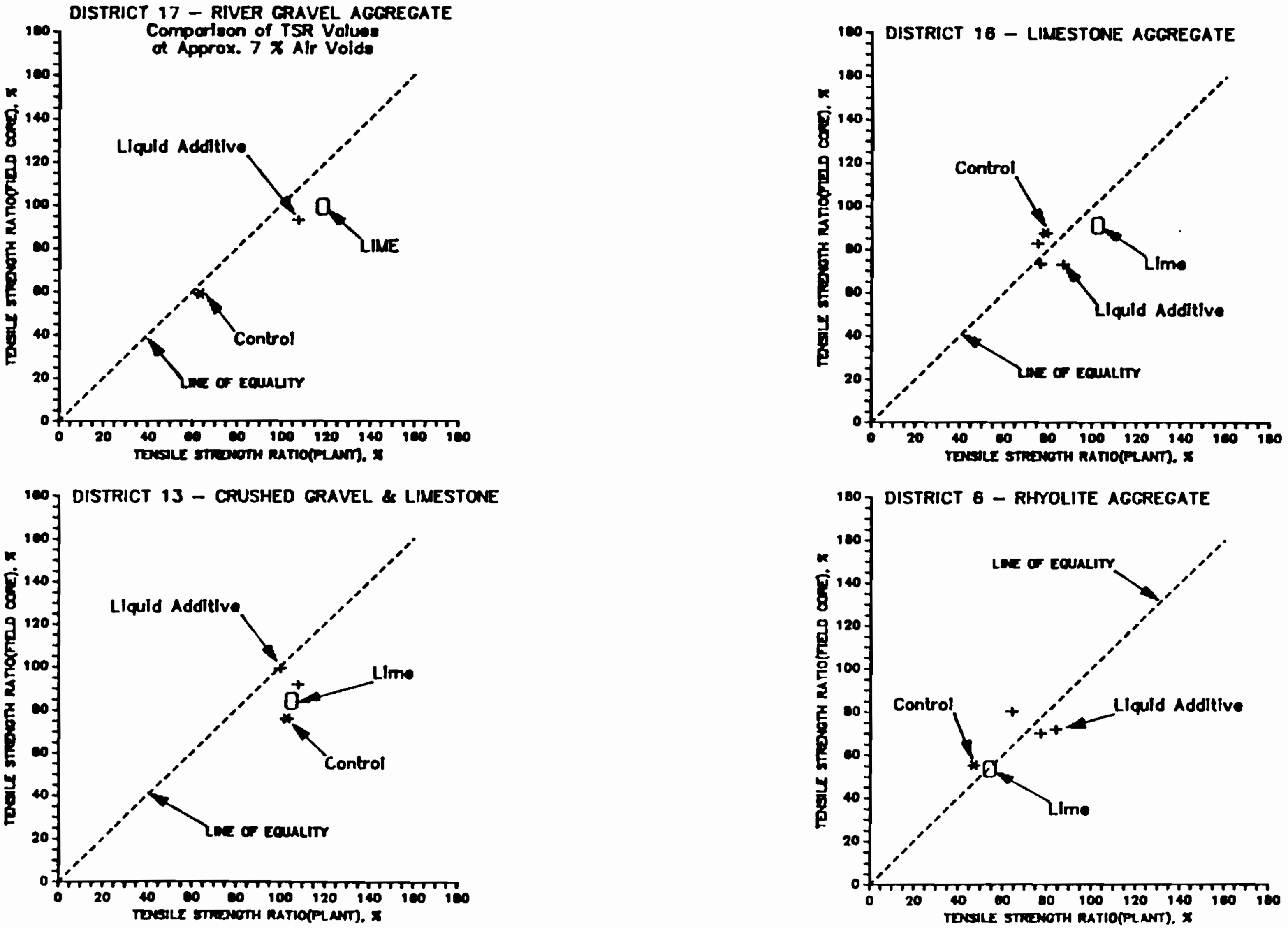


Fig. 5.6 Comparison of tSR values at approximately 7 percent air voids between plant mixture and field cored mixture.

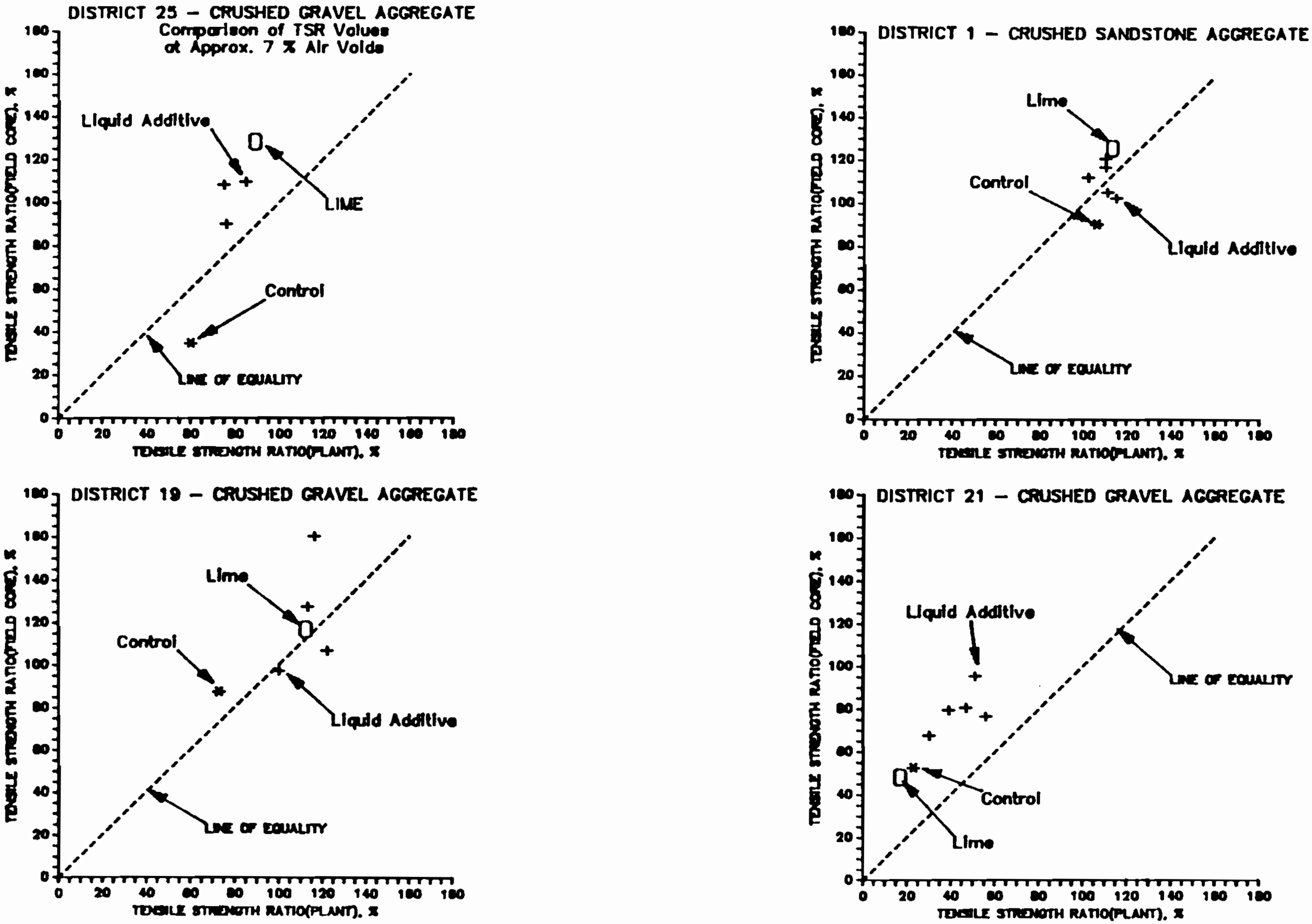


Fig. 5.6 Comparison of TSR values at approximately 7 percent air voids between plant mixture and field cored mixtures - continued.

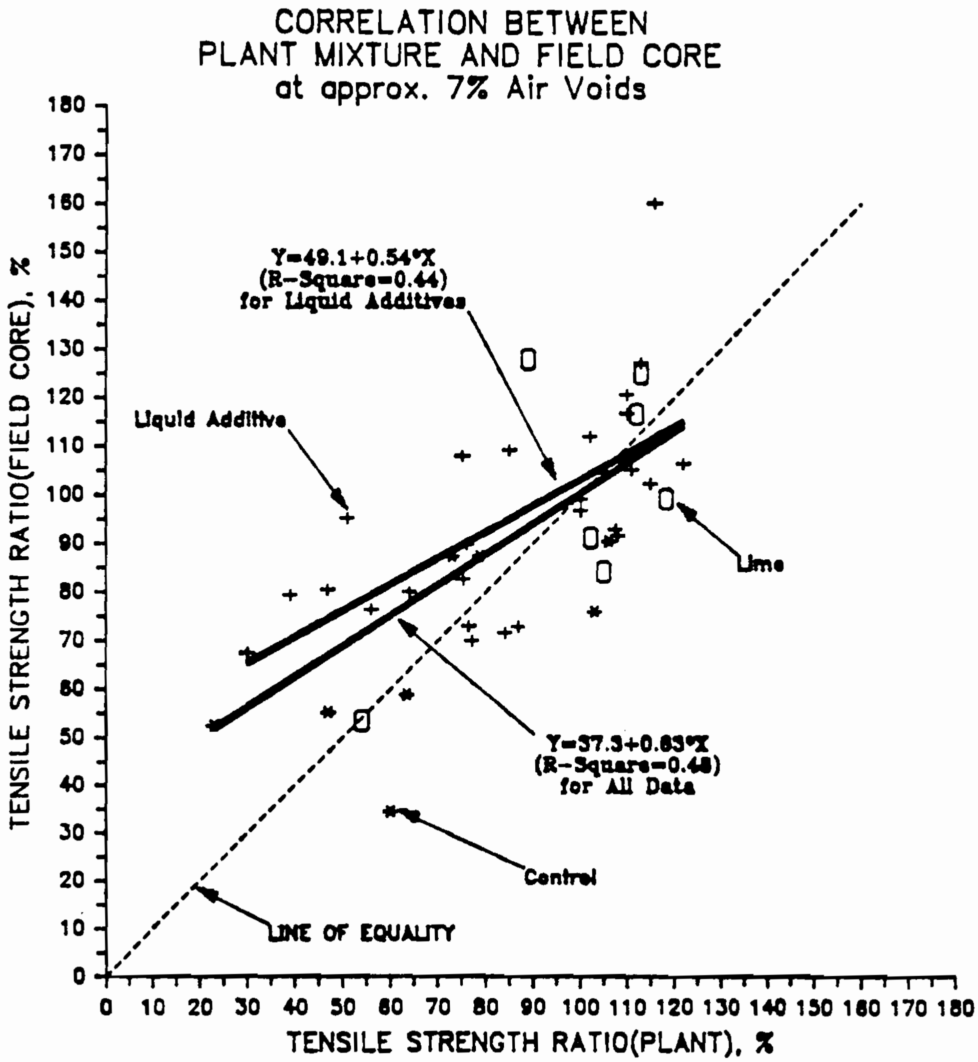


Fig 5.7 Comparison of TSR values at approximately 7 percent air voids between plant mixture and field cored mixture for all eight projects.

plant mixtures at approximately 7 percent air void content.

Because of the problem with District 21 data, the correlation was reanalyzed for the treatments (and control) without the District 21 data. The results are shown in Figure 5.8. This suggests that test results based on the plant mixtures can be used to predict the results for cores taken from the pavement immediately after construction.

COMPARISON OF BOIL VALUES WITH TSR VALUES AT APPROXIMATELY 7 PERCENT AIR VOIDS

The relationships between the boiling test results and the estimated TSR values of the field core at approximately 7 percent air voids are shown in Figure 5.9. The correlation (without the District 21 data) is fair with an R^2 value of 0.47; however, at best the data are scattered.

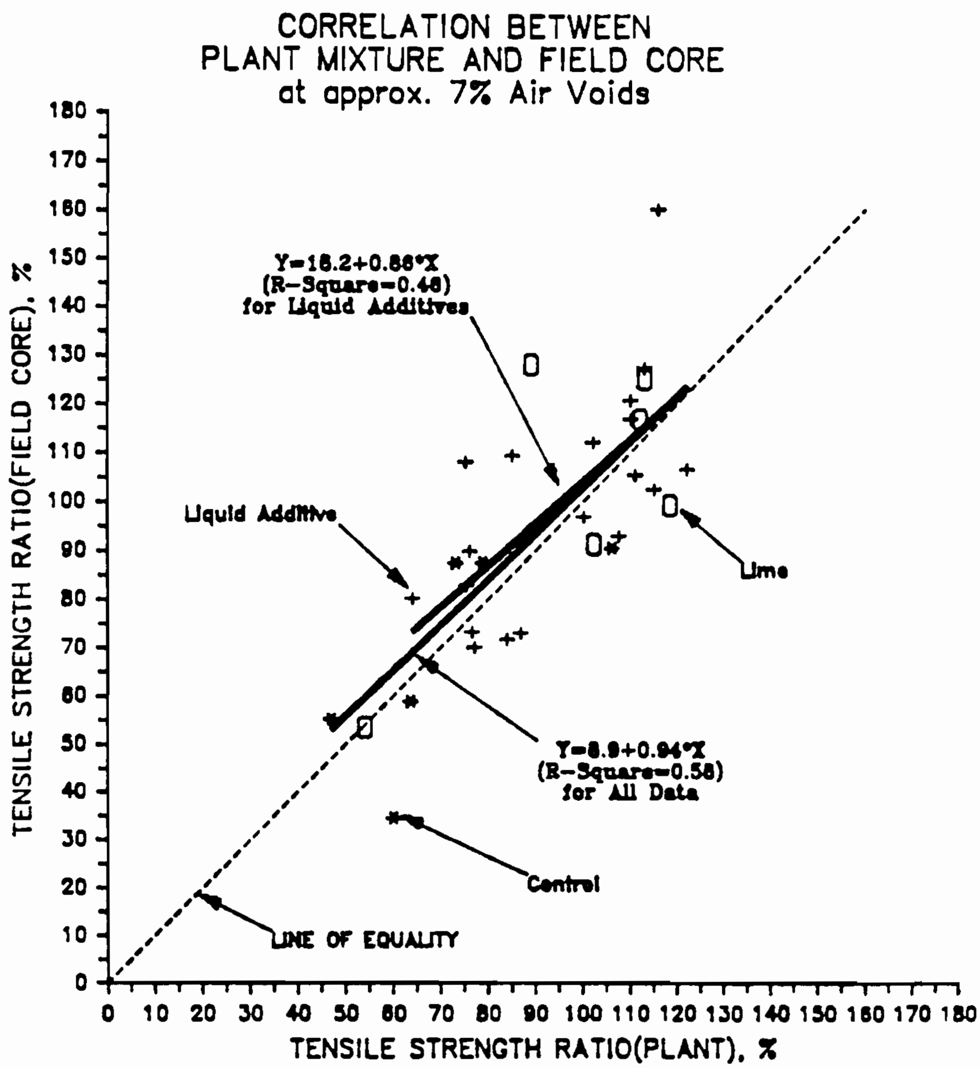


Fig 5.8 Comparison of TSR values at approximately 7 percent air voids between plant mixture and field cored mixture for 7 districts (excluding District 21 data).

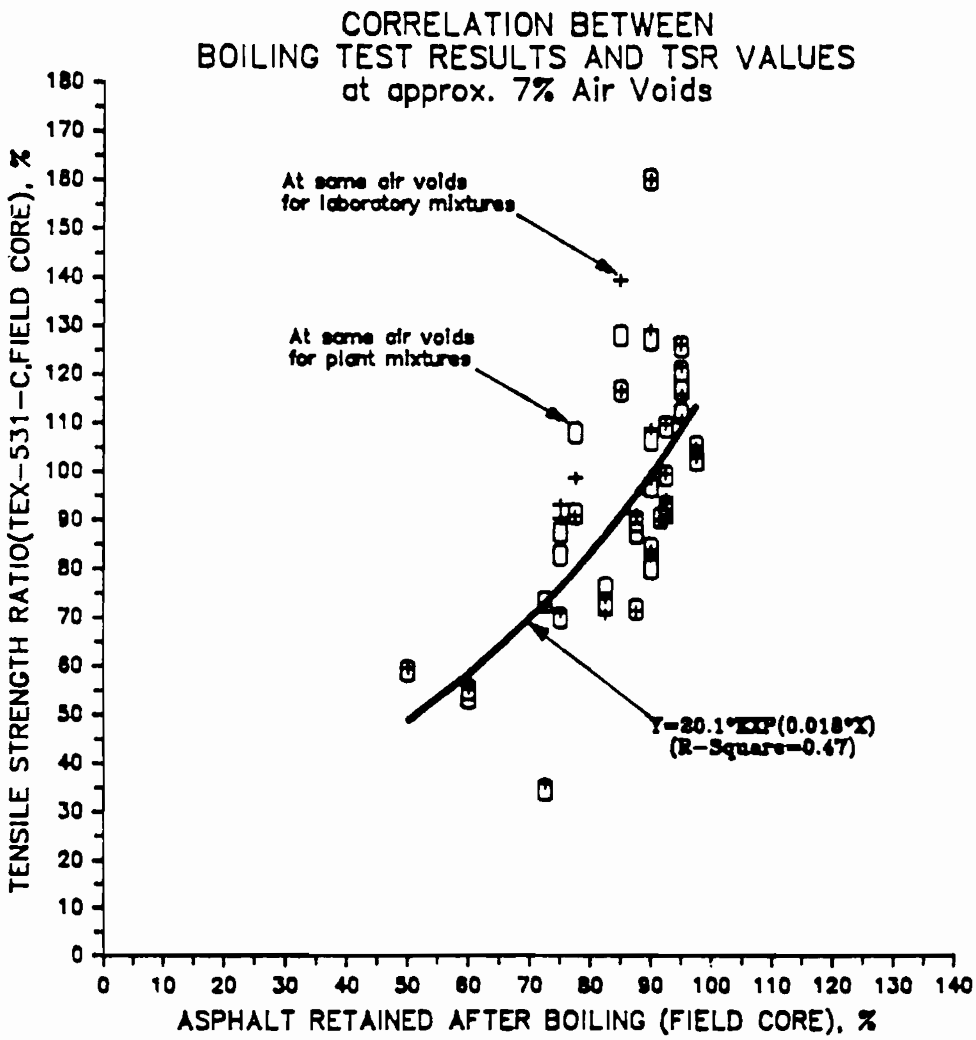


Fig 5.9 Comparison of boiling test results with TSR values at approximately 7 percent air voids for field cored mixture.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations based on the data and analyses from this study are summarized below.

CONCLUSIONS

Comparison of Moisture Damage Test Values

1. The moisture susceptibility test methods used in this study were:
   a. Original Lottman method
   b. Tex-531-C method
   c. Tunnicliff-Root method
2. Good correlations were obtained between the TSR values of the modified Lottman (Tex-531-C) and both the original Lottman and the Tunnicliff-Root procedures. The R^2 values ranged from 0.84 to 0.85.
3. With regard to the asphalt absorption during the

mixing stage of sample preparation in the laboratory, the effect of curing on TSR values specified by the modified Lottman (Tex-531-C) procedure was not significant. Thus, the time required for testing of moisture damage could probably be shortened significantly.

4. The correlations between the boiling test results and the TSR values were reasonably good. The R^2 values ranged from 0.71 to 0.79.

Comparison Between Laboratory Mixture and Plant Mixture

1. The dry tensile strength of the plant mixtures generally were equal to or higher than that of the laboratory mixtures.
2. On the average the wet strength of the plant mixtures was higher than that of the laboratory mixtures.
3. Generally the plant mixtures had higher TSR values than the laboratory mixtures. Comparisons of the tensile strength ratios between the laboratory mixtures and the plant mixtures were dependent on the types of asphalt-aggregate combinations, the antistripping additives, and the testing methods.

4. The percentage of asphalt retained after boiling of the plant mixtures generally were higher than that of the laboratory mixtures.

Effectiveness of Various Antistripping Additives

1. The hydrated lime was effective on treating the moisture susceptible materials from stripping; however, the field application techniques had strong influence on the performance of the lime treated materials in the field. The slurry form of adding the hydrated lime worked very well both in the laboratory and in the field.
2. The liquid additives in general were not very effective on treating the limestone as well as the sandstone materials. However, most liquid additives were effective for the river gravels.
3. Boiling test results were in favor of the liquid additives, whereas the tensile strength ratios were in favor of the hydrated lime. However, both the boiling test and the wet-dry indirect tensile test could be used to estimate the moisture susceptibility of treated materials.

Multiple Freeze-Thaw Cyclic Test Results

1. The hydrated lime usually started with a much higher TSR value at cycle one and the value was still higher than most of the liquid additives at the end of nine freeze-thaw cycles.
2. The raw materials with no additive obtained the lowest TSR values under the cyclic testing condition.
3. The rates of deterioration for the treated and untreated materials were not significantly different under the multiple freeze-thaw cyclic testing condition.
4. The estimated initial TSR values at cycle one were representative of the measured TSR values at cycle one for the untreated and treated mixtures.

Field Cores

1. The boiling test results for the field cores were about equal to the results for the plant mixtures, i.e., the field core data could best be represented by the data obtained from the plant mixture.
2. The relationships between the TSR values of the

field cores and the core air voids generally were not statistically significant at the 5% level using the linear regression; however, the sample size and the range of air void were small.

3. The field core data were compared with the laboratory data on the same basis of air voids at approximately 7 percent. A good correlation was obtained between the plant mixture and the field cored mixture. Therefore, the test results based on the plant mixtures could be used to estimate the results from the field cored mixtures.

RECOMMENDATIONS

1. Ultimately, the effectiveness of the antistripping agents and usefulness of the laboratory test methods must be related to the field test results. Thus, the field test sections should be monitored periodically to evaluate the long-term performance of the selected liquid additives and the hydrated lime.
2. The laboratory test methods should be verified and correlated to the field performance in stripping and moisture damage. A predictive performance

model based on the actual field evaluation should be developed to improve the laboratory tests in the future.

3. Realistic failure indices or specifications may be developed based on the field performance in the future.

APPENDIX A

FIELD AND LABORATORY EXPERIMENTAL PROGRAM - DISTRICT 17

The objective of Appendix A is twofold: (1) to describe the site specific (District 17) field operations of the test sections along with a description of the materials, additives and construction techniques used for this field project, (2) to present the laboratory test results of the laboratory mixed and plant mixed asphalt mixtures along with the zero-aged (immediately after construction) pavement cores for the field experimental study at District 17 (Figure A-1)of the Texas State Department of Highways and Public Transportation (SDHPT).

FIELD EXPERIMENTAL PROGRAM

The test pavements were constructed on FM 485 in Hearne, Texas, in July 1986, and involved pavement overlay to both lanes of the highway. The test sections were installed as the surface course in the eastbound and westbound lanes as shown schematically in Figure A-2. Each test section was approximately two inches thick, 12 feet wide, and 1000 feet long. A total of eight (8) test sections were constructed and two liquid antistripping additives were used in addition to the hydrated lime and the control materials. The composition of the eight test sections are as follows:

Test Section 1. Control Section - No additive, low air voids.

Test Section 2. Control Section - No additive, high air voids.

Test Section 3. Hot mix with 1% BA 2000, low air voids.

Test Section 4. Hot mix with 1% BA 2000, high air voids.

Test Section 5. Hot mix with 1.5% Lime Slurry, low air voids.

Test Section 6. Hot mix with 1.5% Lime Slurry, high air voids.

Test Section 7. Hot mix with 1.0% Perma-Tac, low air voids.

Test Section 8. Hot mix with 1.0% Perma-Tac, high air voids.

The field construction was conducted by District 17 of the SDHPT and was assisted by the Center for Transportation Research, The University of Texas at Austin. The average daily traffic (ADT) is estimated at 2000 vehicles for the test pavement.

MATERIALS AND PAVING MIXTURE

An AC-20 asphalt cement from the Texas Gulf refinery was used throughout this project. Four aggregates--a processed gravel, a washed sand, a coarse field sand and a fine field sand, were combined to produce the project gradation. Gradations of the individual aggregates, the project gradation, percentages of each aggregate combined, and the specification are given on Table A-1. The project gradation is plotted on a 0.45 power graph in Figure A-3.

The asphalt concrete mixture used in this study met the SDHPT specifications of Item 340, Type D (Modified) fine graded surface course (Ref 45). Preliminary test results for this mixture design are given below:

Asphalt Content	-	4.9%
Average Density	-	96 percent of theoretical maximum density
Air Void Content	-	4 percent
Hveem Stability	-	35%
Cohesiometer Value	-	59

FIELD OPERATIONS

A drum mix plant was used to prepare hot mixed asphalt mixtures containing lime slurry and liquid antistripping additives. Identical raw material sources (asphalt cement and aggregates) were utilized throughout the experiment. Two commercially available liquid antistripping additives were used for the test sections, i.e., BA 2000 and Perma-Tac.

The hydrated lime was mixed and added in slurry form to the aggregates on the cold feed belt of the drum dryer. The BA 2000 and Perma-Tac were metered into the asphalt in-line injection system of the plant.

Compaction of each test section was achieved using a vibratory roller, a pneumatic roller, and a steel wheel roller. The field air voids were controlled using a Troxler Thin Layer Asphalt Gauge. After several passes were made using a 15-ton vibratory roller, the Troxler gauge was placed on top of the pavement to measure the density of the in-place asphalt layer. A trial and error method of increasing or decreasing the number of passes by the vibratory roller was used to achieve the desired field density (i.e., the desired air voids of the test sections). Final rolling involved using the pneumatic roller.

The field cores were obtained soon after the construction. Three to four pairs of samples were cored from each test section with each pair approximately 200 feet apart. The sample size was approximately 4-inches in diameter and 1 to 2 inches in thickness. The coring process was in accordance with the general coring layout procedure described in the main text of this report (Chapter 2). The field cores were transported to the Center for Transportation Research laboratory immediately after sampling.

LABORATORY TESTING PROGRAM

Laboratory tests were performed on mixtures which were 1) mixed and compacted in the laboratory, 2) mixed in the plant and compacted in the laboratory, and 3) mixed in the plant and compacted in the field (i.e., field cores). Based on a literature review and previous project findings (as discussed in Chapter 2 of the main text), the following tests were used to evaluate the moisture susceptibility of the treated and untreated mixtures for the laboratory mixed and compacted samples:

I. Wet-dry indirect tensile test.

Method A Indirect tensile test with modified Lottman conditioning (Tex-531-C method with cure).

Method B Indirect tensile test with modified Lottman conditioning (Tex-531-C method without cure).

Method C Indirect tensile test with original Lottman conditioning.

Method D Indirect tensile test with Tunnicliff-Root conditioning.

Method E Indirect tensile test with cyclic freeze-thaw conditioning.

II. Texas boiling test (Tex-530-C method).

For the plant mixed and laboratory compacted samples, the following tests were used:

I. Wet-dry indirect tensile test.

Method B (or A) Indirect tensile test with modified Lottman conditioning (Tex-531-C method).

Method C Indirect tensile test with original Lottman conditioning.

Method D Indirect tensile test with Tunnicliff-Root conditioning.

II. Texas boiling test (Tex-530-C method).

It should be noted here that Method B is the same as Method A since the loose mixtures were mixed at the plant prior to shipping to the laboratory for reheating and compaction, so the curing process is irrelevant for the plant mixed loose mixtures.

The following tests were used for the field cores:

I. Wet-dry indirect tensile test

Method A (or B) Indirect tensile test with modified Lottman conditioning (Tex-531-C method).

II. Texas boiling test (Tex-530-C method).

The laboratory compacted specimens were made at such a compactive effort as to provide an approximately 7.0 $\pm$ 1.0% air void content. Two liquid antistripping additives were used in addition to the raw material and the hydrated lime slurry. The additives and the dosage are given below:

a. Hydrated lime slurry (1.5% by weight of aggregate).

b. BA 2000 (1.0% by weight of asphalt).

c. Perma-Tac (1.01% by weight of asphalt).

The experimental design of the laboratory testing program was discussed in Chapter 2 and was carried out through the duration of this study. Sample preparation, conditioning, test procedures and engineering properties analyzed for the test methods were also discussed in Chapter 2.

PRESENTATION OF TEST RESULTS

Laboratory Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables A-2 through A-5. The data are plotted in Figure A-4 for laboratory mixtures using Methods A through E. The cyclic freeze-thaw test results are shown in Figures A-5 and A-6.

Plant Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables A-6 through A-9. The data are also plotted in Figure A-7 for plant mixtures using Methods B through D.

Plant Mixed/Field Compacted Mixtures (Field Cores)

Summary of the test results are presented on Table A-10. The achieved field compaction to have the low and high air voids are summarized in Figure A-8 which shows the average air void content of the field cores from the low and high voids test sections in the field. The average TSR values are shown in Figure A-9 for the low and high voids test sections.

Texas Boiling Test Results

The Texas boiling test results are presented on Table A-11 and plotted in Figure A-10 for the laboratory mixture, the plant mixture, and the field core.

APPENDIX A SUMMARY OF DATA FOR DISTRICT 17

TABLE A-1 AGGREGATE GRADATION (DISTRICT 17)

SIEVE SIZE	PROCESSED GRAVEL SIEVE ANALYSIS	PROCESSED GRAVEL 55%	WASHED SAND SIEVE ANALYSIS	WASHED SAND 25%	COARSE FIELD SAND SIEVE ANALYSIS	COARSE FIELD SAND 10%	FINE FIELD SAND SIEVE ANALYSIS	FINE FIELD SAND 10%	COMBINED GRADATION	SDHPT SPECIFICATIONS
Plus 1/2 in.									0	0
1/2 to 3/8 in.	1.3	0.7							0.7	0-15
3/8 to No. 4	53.5	29.4							29.4	21-53
No. 4 to No. 10	42.2	23.2	14.4	3.6					26.8	11-32
Plus No. 10									(56.9)	54-74
No. 10 to No. 40	2.1	1.2	48.1	12.0	1.3	0.1	4.3	0.4	13.7	6-32
No. 40 to No. 80	0.5	0.3	31.5	7.9	60.8	6.1	24.5	2.5	16.8	4-27
No. 80 to No.200	0.2	0.1	5.5	1.4	34.1	3.4	58.2	5.8	10.7	3-27
Minus No. 200	0.2	0.1	0.5	0.1	3.8	0.4	13.0	1.3	1.9	1-8
TOTAL	100.0	55.0	100.0	25.0	100.0	10.0	100.0	10.0	100.0	

TABLE A-2 TEST RESULTS FOR LABORATORY MIXTURES (D-17)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 4.9 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.9	140.9	73	
	A2	DRY	6.5	141.5	84	
	A3	DRY	7.3	140.3	72	
		DRY AVG	6.9	140.9	76	
	A4	WET	6.8	141.1	37	
	A5	WET	6.8	141.1	44	
	A6	WET	7.1	140.6	35	
		WET AVG	6.9	140.9	39	0.51
B	B1	DRY	6.6	141.4	74	
	B2	DRY	6.2	142.1	77	
	B3	DRY	6.5	141.5	74	
		DRY AVG**	6.4	141.6	75	
	B4	WET	6.8	141.1	33	
	B5	WET	6.6	141.5	41	
	B6	WET	6.4	141.6	41	
		WET AVG	6.6	141.4	38	0.51
C	C1	WET	6.5	141.5	35	
	C2	WET	6.6	141.3	33	
	C3	WET	6.4	141.7	38	
		WET AVG	6.5	141.5	35	
		DRY AVG**	6.4	141.6	75	0.47
D	D1	WET	6.8	141.1	43	
	D2	WET	7.3	140.3	36	
	D3	WET	6.9	140.9	37	
		WET AVG	7.0	140.8	39	
		DRY AVG**	6.4	141.6	75	0.52

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE A-2 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.1	140.7	38	
	E2	1 CYCLE	6.9	140.9	35	
		WET AVG	7.0	140.8	37	
		DRY AVG**	6.4	141.6	75	
						0.49
	E3	3 CYCLES	6.6	141.4	26	
	E4	3 CYCLES	6.8	141.1	28	
		WET AVG	6.7	141.2	27	
		DRY AVG**	6.4	141.6	75	
						0.36
E						
	E5	5 CYCLES	6.7	141.3	22	
	E6	5 CYCLES	6.3	141.9	20	
		WET AVG	6.5	141.6	21	
		DRY AVG**	6.4	141.6	75	
						0.28
	E7	7 CYCLES	6.1	142.2	20	
	E8	7 CYCLES	6.5	141.6	18	
		WET AVG	6.3	141.9	19	
		DRY AVG**	6.4	141.6	75	
						0.25
	E9	9 CYCLES	6.3	141.9	15	
	E10	9 CYCLES	6.4	141.7	13	
		WET AVG	6.4	141.8	14	
		DRY AVG**	6.4	141.6	75	
						0.19

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE A-3 TEST RESULTS FOR LABORATORY MIXTURES (D-17)
ADDITIVE: LIME SLURRY (1.5% BY WT OF AGGREGATE)
ASPHALT CONTENT = 4.9 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.3	141.4	83	
	A2	DRY	6.6	141.0	78	
		DRY AVG	6.4	141.2	81	
	A4	WET	6.4	141.3	94	
	A5	WET	6.0	141.9	89	
	A6	WET	6.5	141.2	101	
		WET AVG	6.3	141.5	95	
						1.18
B	B1	DRY	6.7	140.8	79	
	B2	DRY	6.1	141.7	79	
	B3	DRY	6.4	141.3	77	
		DRY AVG**	6.4	141.3	78	
	B4	WET	6.9	140.5	94	
	B5	WET	6.5	141.1	93	
		WET AVG	6.7	140.8	94	
						1.19
C	C1	WET	6.7	140.9	92	
	C2	WET	6.8	140.6	84	
		WET AVG	6.8	140.7	88	
		DRY AVG**	6.4	141.3	78	
						1.12
D	D1	WET	6.3	141.5	99	
	D2	WET	6.1	141.8	94	
	D3	WET	6.3	141.5	97	
		WET AVG	6.2	141.6	97	
		DRY AVG**	6.4	141.3	78	
						1.23

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE A-3 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.2	141.6	77	
	E2	1 CYCLE	6.2	141.6	83	
		WET AVG	6.2	141.6	80	
		DRY AVG**	6.4	141.3	78	1.02
	E3	3 CYCLES	6.6	141.0	79	
	E4	3 CYCLES	6.2	141.6	82	
		WET AVG	6.4	141.3	80	
		DRY AVG**	6.4	141.3	78	1.03
E	E5	5 CYCLES	6.1	141.7	66	
	E6	5 CYCLES	6.4	141.3	63	
		WET AVG	6.2	141.5	64	
		DRY AVG**	6.4	141.3	78	0.82
	E7	7 CYCLES	6.9	140.6	65	
	E8	7 CYCLES	6.3	141.4	63	
		WET AVG	6.6	141.0	64	
		DRY AVG**	6.4	141.3	78	0.81
	E9	9 CYCLES	6.6	141.0	65	
	E10	9 CYCLES	6.7	140.8	67	
		WET AVG	6.7	140.9	66	
		DRY AVG**	6.4	141.3	78	0.84
****	A3	DRY	5.7	142.4	85	
	B6	DRY	5.7	142.3	83	
	B7	DRY	5.9	142.0	80	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE A-4 TEST RESULTS FOR LABORATORY MIXTURES (D-17)
ADDITIVE: BA 2000 (1.0%)
ASPHALT CONTENT = 4.9 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	7.2	140.4	103	
	A2	DRY	6.5	141.5	109	
	A3	DRY	6.5	141.4	109	
		DRY AVG	6.7	141.1	107	
A	A4	WET	6.6	141.2	92	
	A5	WET	7.2	140.3	78	
	A6	WET	6.9	140.9	92	
		WET AVG	6.9	140.8	87	
						0.82
	B1	DRY	6.5	141.4	103	
	B2	DRY	6.4	141.5	105	
	B3	DRY	6.7	141.1	105	
		DRY AVG**	6.5	141.4	104	
B	B4	WET	6.5	141.5	100	
	B5	WET	6.3	141.7	100	
		WET AVG	6.4	141.6	100	
						0.96
	C1	WET	6.7	141.1	94	
	C2	WET	7.2	140.4	89	
		WET AVG	6.9	140.8	92	
C		DRY AVG**	6.5	141.4	104	
						0.88
	D1	WET	6.0	142.2	121	
	D2	WET	6.8	141.0	106	
		WET AVG	6.4	141.6	114	
D		DRY AVG**	6.5	141.4	104	
						1.09

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE A-4 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	6.2	141.9	89	
	E2	1 CYCLE	6.9	140.8	78	
		WET AVG	6.5	141.4	83	
		DRY AVG**	6.5	141.4	104	0.80
	E3	3 CYCLES	6.3	141.7	86	
	E4	3 CYCLES	6.5	141.5	82	
		WET AVG	6.4	141.6	84	
		DRY AVG**	6.5	141.4	104	0.81
	E5	5 CYCLES	6.8	141.0	59	
	E6	5 CYCLES	6.8	140.9	65	
		WET AVG	6.8	141.0	62	
		DRY AVG**	6.5	141.4	104	0.60
	E7	7 CYCLES	6.2	141.8	70	
	E8	7 CYCLES	6.6	141.2	64	
		WET AVG	6.4	141.5	67	
		DRY AVG**	6.5	141.4	104	0.64
	E9	9 CYCLES	7.0	140.6	59	
	E10	9 CYCLES	6.9	140.8	52	
		WET AVG	7.0	140.7	56	
		DRY AVG**	6.5	141.4	104	0.54
****	B6	DRY	5.8	142.5	115	
	B7	DRY	5.7	142.7	121	
	B8	DRY	5.6	142.9	125	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE A-5 TEST RESULTS FOR LABORATORY MIXTURES (D-17)
ADDITIVE: PERMA-TAC (1.0%)
ASPHALT CONTENT = 4.9 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.1	140.7	69	
	A2	DRY	7.4	140.2	69	
	A3	DRY	7.0	140.9	73	
		DRY AVG	7.2	140.6	70	
	A4	WET	7.7	139.8	56	
	A5	WET	7.1	140.6	61	
	A6	WET	7.5	140.1	57	
		WET AVG	7.5	140.2	58	0.82
B	B1	DRY	6.9	141.1	72	
	B2	DRY	6.9	141.0	70	
	B3	DRY	7.3	140.5	71	
		DRY AVG**	7.0	140.8	71	
	B4	WET	6.7	141.2	64	
	B5	WET	6.6	141.4	69	
	B6	WET	6.7	141.4	68	
		WET AVG	6.7	141.3	67	0.94
C	C1	WET	6.7	141.2	62	
	C2	WET	6.8	141.1	66	
	C3	WET	7.1	140.7	66	
		WET AVG	6.9	141.0	65	
		DRY AVG**	7.0	140.8	71	0.91
D	D1	WET	6.8	141.2	68	
	D2	WET	6.8	141.2	70	
	D3	WET	6.5	141.6	68	
		WET AVG	6.7	141.3	69	
		DRY AVG**	7.0	140.8	71	0.97

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE A-5 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.3	140.4	55	
	E2	1 CYCLE	7.4	140.3	54	
		WET AVG	7.3	140.3	55	
		DRY AVG**	7.0	140.8	71	0.77
	E3	3 CYCLES	8.0	139.4	48	
	E4	3 CYCLES	7.3	140.4	47	
		WET AVG	7.6	139.9	47	
		DRY AVG**	7.0	140.8	71	0.67
E	E5	5 CYCLES	7.1	140.7	43	
	E6	5 CYCLES	7.3	140.5	45	
		WET AVG	7.2	140.6	44	
		DRY AVG**	7.0	140.8	71	0.62
	E7	7 CYCLES	7.2	140.6	38	
	E8	7 CYCLES	7.0	140.8	43	
		WET AVG	7.1	140.7	40	
		DRY AVG**	7.0	140.8	71	0.57
	E9	9 CYCLES	6.8	141.1	39	
	E10	9 CYCLES	6.3	141.9	34	
		WET AVG	6.6	141.5	37	
		DRY AVG**	7.0	140.8	71	0.52

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE A-6 TEST RESULTS FOR PLANT MIXTURES (D-17)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 4.9 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.1	141.1	68	
	B2	DRY	7.4	140.7	63	
	B3	DRY	7.4	140.8	69	
		DRY AVG**	7.3	140.9	67	
	B4	WET	7.4	140.8	42	
	B5	WET	7.5	140.6	41	
	B6	WET	7.2	141.0	44	
		WET AVG	7.4	140.8	42	0.64
C	C1	WET	7.5	140.6	35	
	C2	WET	7.4	140.8	35	
	C3	WET	7.5	140.5	32	
		WET AVG	7.5	140.6	34	
		DRY AVG**	7.3	140.9	67	0.51
D	D1	WET	7.0	141.4	41	
	D2	WET	7.1	141.2	38	
	D3	WET	7.6	140.4	43	
		WET AVG	7.2	141.0	41	
		DRY AVG**	7.3	140.9	67	0.61

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE A-7 TEST RESULTS FOR PLANT MIXTURES (D-17)
ADDITIVE: LIME SLURRY (1.5% BY WT OF AGGREGATE)
ASPHALT CONTENT = 4.9 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	7.4	140.9	75	
	B2	DRY	6.8	141.9	79	
	B3	DRY	7.0	141.5	80	
		DRY AVG**	7.1	141.4	78	
B						
	B4	WET	6.8	141.8	94	
	B5	WET	7.1	141.4	90	
	B6	WET	7.1	141.4	93	
		WET AVG	7.0	141.6	92	
						1.18
	C1	WET	7.0	141.6	82	
	C2	WET	7.0	141.5	75	
	C3	WET	6.6	142.2	80	
		WET AVG	6.9	141.8	79	
C						
		DRY AVG**	7.1	141.4	78	
						1.01
	D1	WET	6.9	141.7	93	
	D2	WET	7.2	141.3	81	
	D3	WET	7.2	141.2	80	
		WET AVG	7.1	141.4	85	
D						
		DRY AVG**	7.1	141.4	78	
						1.09

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE A-8 TEST RESULTS FOR PLANT MIXTURES (D-17)
ADDITIVE: BA 2000 (1.0%)
ASPHALT CONTENT = 4.9 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.2	141.5	93	
	B2	DRY	7.0	141.8	95	
	B3	DRY	7.1	141.6	97	
		DRY AVG**	7.1	141.6	95	
	B4	WET	6.6	142.3	102	
	B5	WET	6.8	142.1	105	
	B6	WET	6.7	142.3	98	
		WET AVG	6.7	142.2	102	
						1.07
C	C1	WET	7.1	141.5	94	
	C2	WET	6.7	142.2	93	
	C3	WET	6.9	141.9	91	
		WET AVG	6.9	141.9	93	
		DRY AVG**	7.1	141.6	95	
						0.98
D	D1	WET	6.4	142.6	96	
	D2	WET	7.1	141.6	100	
	D3	WET	7.0	141.7	93	
		WET AVG	6.9	142.0	96	
		DRY AVG**	7.1	141.6	95	
						1.01

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE A-9 TEST RESULTS FOR PLANT MIXTURES (D-17)
ADDITIVE: PERMA-TAC (1.0%)
ASPHALT CONTENT = 4.9 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.8	141.8	78	
	B2	DRY	7.2	142.7	82	
	B3	DRY	7.6	142.1	74	
		DRY AVG**	7.5	142.2	78	
	B4	WET	7.5	142.2	42	
	B5	WET	7.3	142.6	38	
	B6	WET	7.8	141.8	40	
		WET AVG	7.6	142.2	40	0.51
C	C1	WET	7.5	142.3	35	
	C2	WET	7.9	141.7	31	
	C3	WET	7.7	141.9	34	
		WET AVG	7.7	142.0	33	
		DRY AVG**	7.5	142.2	78	0.43
D	D1	WET	7.5	142.3	39	
	D2	WET	7.4	142.4	37	
	D3	WET	7.4	142.4	41	
		WET AVG	7.5	142.3	39	
		DRY AVG**	7.5	142.2	78	0.50

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)Tensile Strength(Dry Avg)

TABLE A-10 TEST RESULTS FOR FIELD CORES
DISTRICT 17
ASPHALT CONTENT = 4.9 %

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		1A	WET	3.6	148.1	87	
		1B	DRY	4.2	147.1	115	
							0.76
	LOW	2A	DRY	7.4	142.2	124	
	AIR	2B	WET	7.0	142.8	59	
	VOIDS						0.47
	SECTION	3A	WET	5.5	145.1	53	
		3B	DRY	5.7	144.7	116	
							0.46
		4A	DRY	4.1	147.3	125	
		4B	WET	4.3	146.9	78	
							0.62
				--------			-------
NO ADDITIVE		(AVG VOIDS)		5.2		(AVG TSR)	0.58
(CONTROL)		5A	WET	5.5	145.0	63	
		5B	DRY	4.2	147.1	119	
							0.53
	HIGH	6A	DRY	6.3	144.0	98	
	AIR	6B	WET	6.0	144.4	66	
	VOIDS						0.67
	SECTION	7A	WET	6.3	143.9	55	
		7B	DRY	7.2	142.5	89	
							0.62
		8A	DRY	7.3	142.4	85	
		8B	WET	8.2	141.0	61	
							0.72
				--------			-------
		(AVG VOIDS)		6.4		(AVG TSR)	0.63
		9A	WET	2.2	149.4	106	
		9B	DRY	3.1	148.0	107	
	LOW						0.99
	AIR	10A	DRY	2.8	148.4	102	
	VOIDS	10B	WET	2.4	149.0	106	
	SECTION						1.04
		11A	WET	2.9	148.3	119	
		11B	DRY	3.1	147.9	117	
							1.01
				--------			-------
		(AVG VOIDS)		2.8		(AVG TSR)	1.01
LIME SLURRY		12A	DRY	5.1	145.0	109	
		12B	WET	4.6	145.6	117	
	HIGH						1.07
	AIR	13A	WET	3.6	147.2	109	
	VOIDS	13B	DRY	4.8	145.4	113	
	SECTION						0.97
		14A	DRY	4.9	145.1	97	
		14B	WET	4.4	146.0	90	
							0.94
				--------			-------

TABLE A-10 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		(AVG VOIDS)		4.6		(AVG TSR)	0.99
		15A	WET	6.1	145.4	123	
		15B	DRY	6.6	144.6	126	
							0.98
	LOW AIR VOIDS SECTION	16A	DRY	8.5	141.7	107	
		16B	WET	6.9	144.2	90	
							0.85
		17A	WET	5.4	146.5	131	
		17B	DRY	4.7	147.5	142	
							0.92
		18A	DRY	5.7	145.9	117	
		18B	WET	5.6	146.1	120	
							1.03
		(AVG VOIDS)		6.2		(AVG TSR)	0.94
BA 2000		19A	WET	6.5	144.7	109	
		19B	DRY	6.6	144.7	123	
	HIGH AIR VOIDS SECTION						0.89
		20A	DRY	7.8	142.8	98	
		20B	WET	7.5	143.3	115	
							1.18
		21A	WET	7.7	142.9	79	
		21B	DRY	7.6	144.6	113	
							0.70
		(AVG VOIDS)		7.3		(AVG TSR)	0.92
		22A	WET	7.0	144.1	43	
		22B	DRY	6.5	144.7	89	
							0.49
	LOW AIR VOIDS SECTION	23A	DRY	7.4	143.3	95	
		23B	WET	7.5	143.2	56	
							0.59
		24A	WET	7.0	144.0	61	
		24B	DRY	5.6	146.2	93	
							0.66
		25A	DRY	8.3	141.9	91	
		25B	WET	7.4	143.3	37	
							0.412
		(AVG VOIDS)		7.1		(AVG TSR)	0.54
PERMA-TAC PLUS		26A	WET	4.8	147.4	90	
		26B	DRY	5.2	146.7	85	
							1.06
	HIGH AIR VOIDS SECTION	27A	DRY	4.4	147.9	75	
		27B	WET	4.2	148.4	65	
							0.87
		28A	WET	4.6	147.7	88	
		28B	DRY	4.9	147.3	88	
							1.00
		29A	DRY	5.3	146.6	82	

TABLE A-10 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		29B	WET	5.0	147.1	95	
							1.16
				--------			-------
		(AVG VOIDS)		4.8		(AVG TSR)	1.02

*TSR = Tensile Strength Ratio
= Tensile Strength (Wet)/Tensile Strength (Dry)

TABLE A-11 BOILING TEST RESULTS
DISTRICT 17

TYPE OF MIXTURE	TYPE OF ADDITIVE	ASPHALT RETAINED AFTER BOILING, %		
		RATING 1	RATING 2	AVG
LABORATORY	NO ADDITIVE	50	50	50.0
	LIME	80	90	85.0
	BA 2000	95	90	92.5
	PERMA-TAC	90	90	90.0
PLANT	NO ADDITIVE	55	50	52.5
	LIME	98	90	94.0
	BA 2000	95	90	92.5
	PERMA-TAC*	50	50	50.0
FIELD CORE	NO ADDITIVE	50	50	50.0
	LIME	95	90	92.5
	BA 2000	95	90	92.5
	PERMA-TAC**	95	85	90.0

*Note: The loose mixture was sampled from the first truck leaving the plant for the low voids test section.

**Note: The field cores were obtained from the high voids test section.

APPENDIX A LIST OF FIGURES

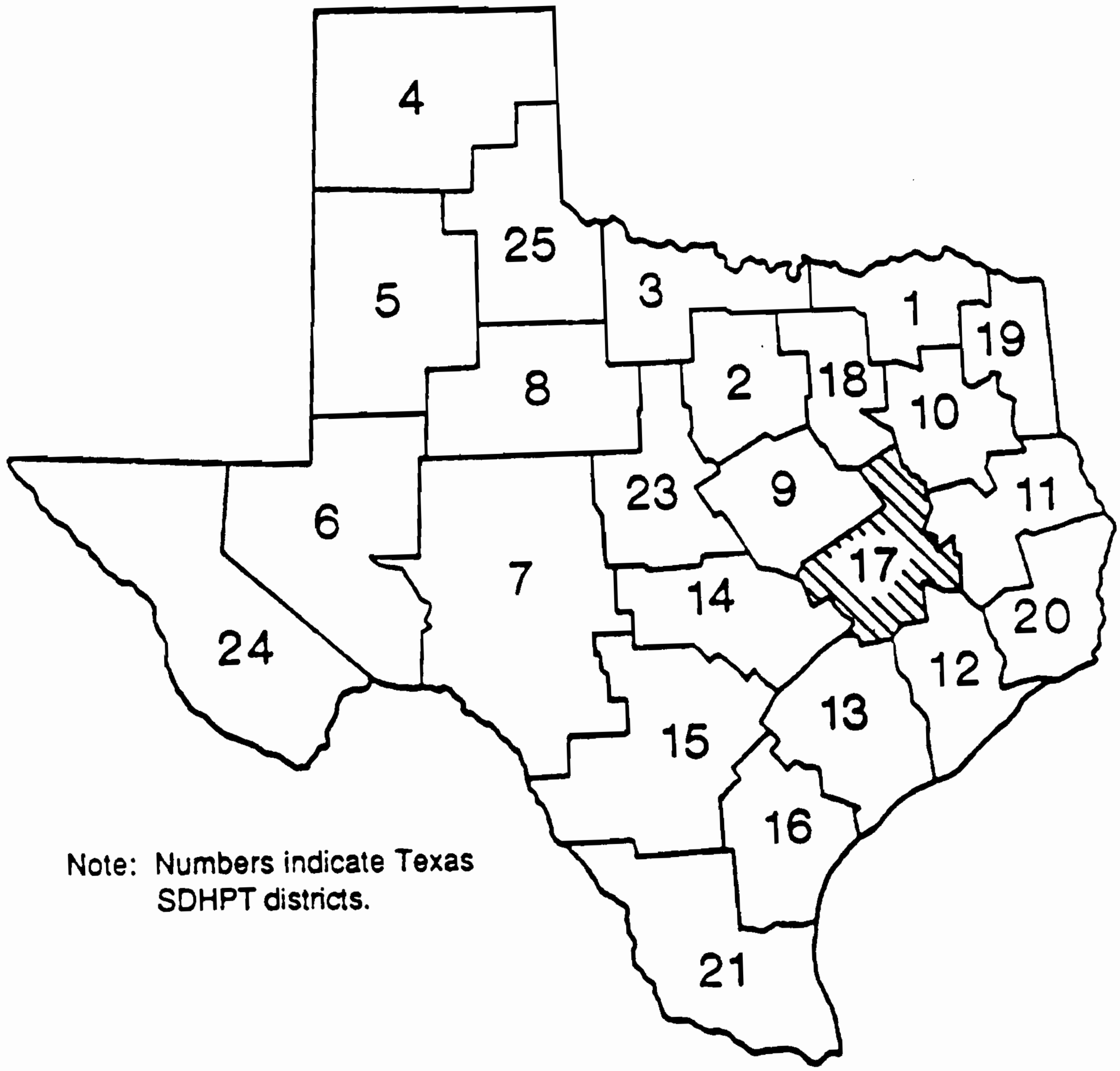
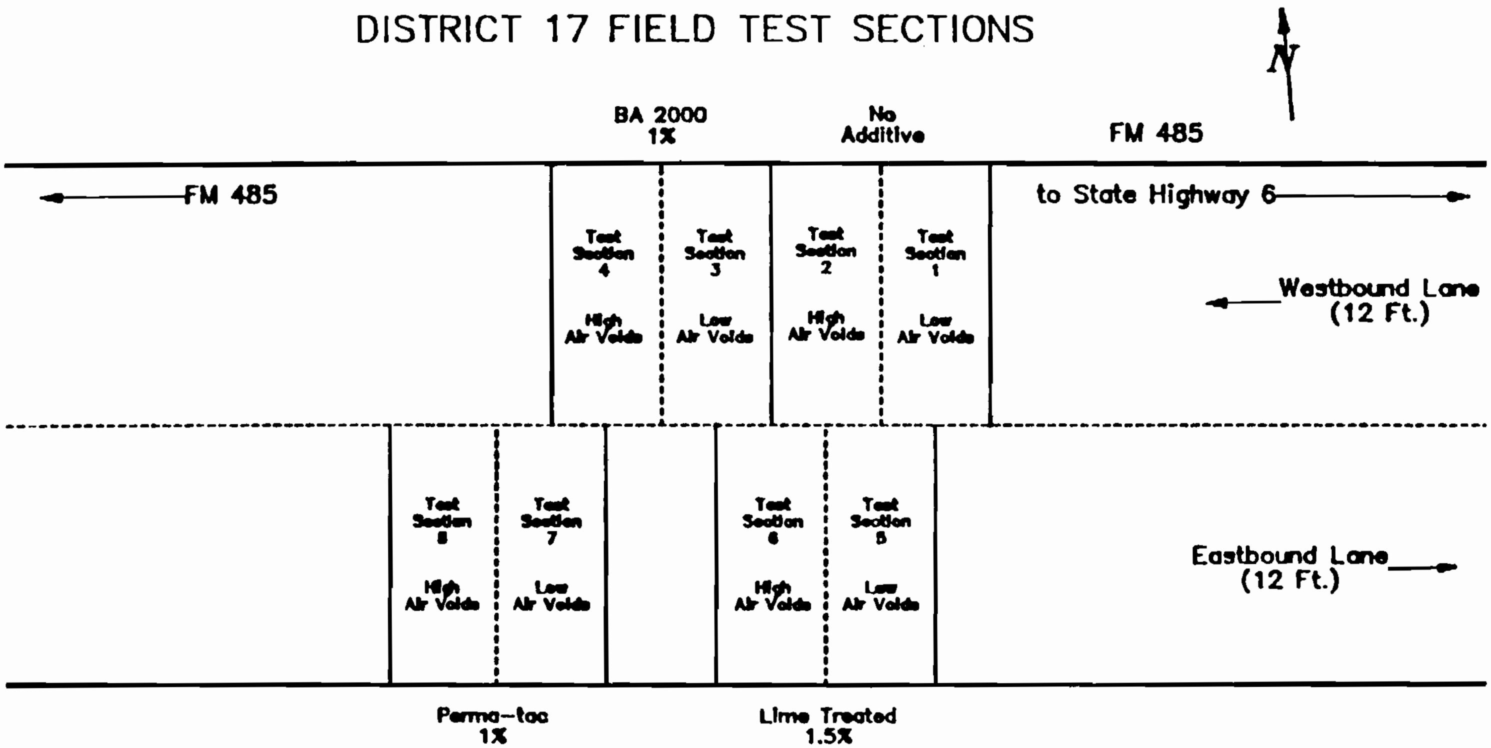


Figure A-1. Location of Field Test Sections (District 17).



Note: Each test section is approximately 1000 feet in length.

Fig A-2 Schematic Illustration of Field Test Sections

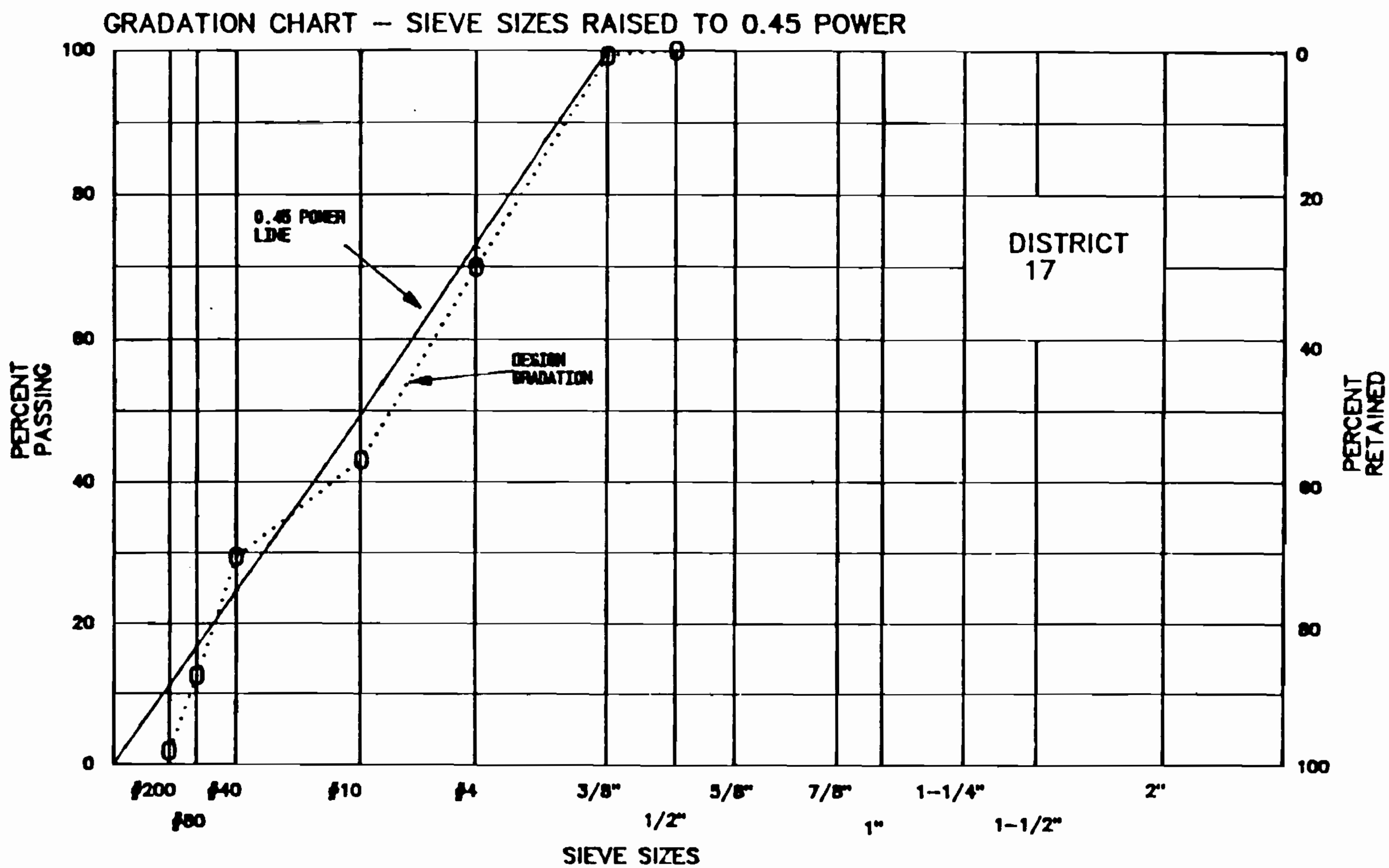


Fig A-3 Aggregate Gradation Chart.

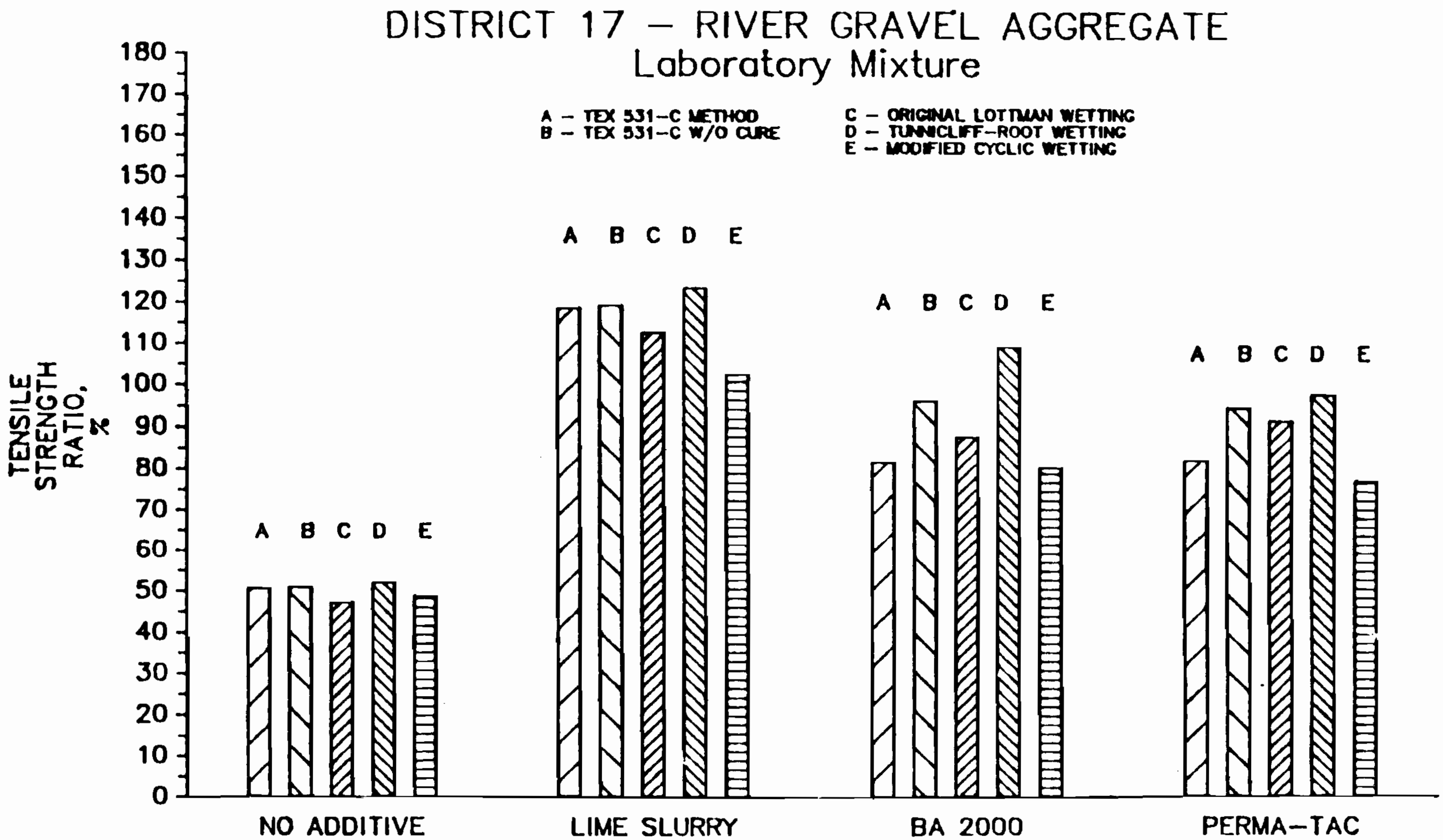


Fig A-4 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

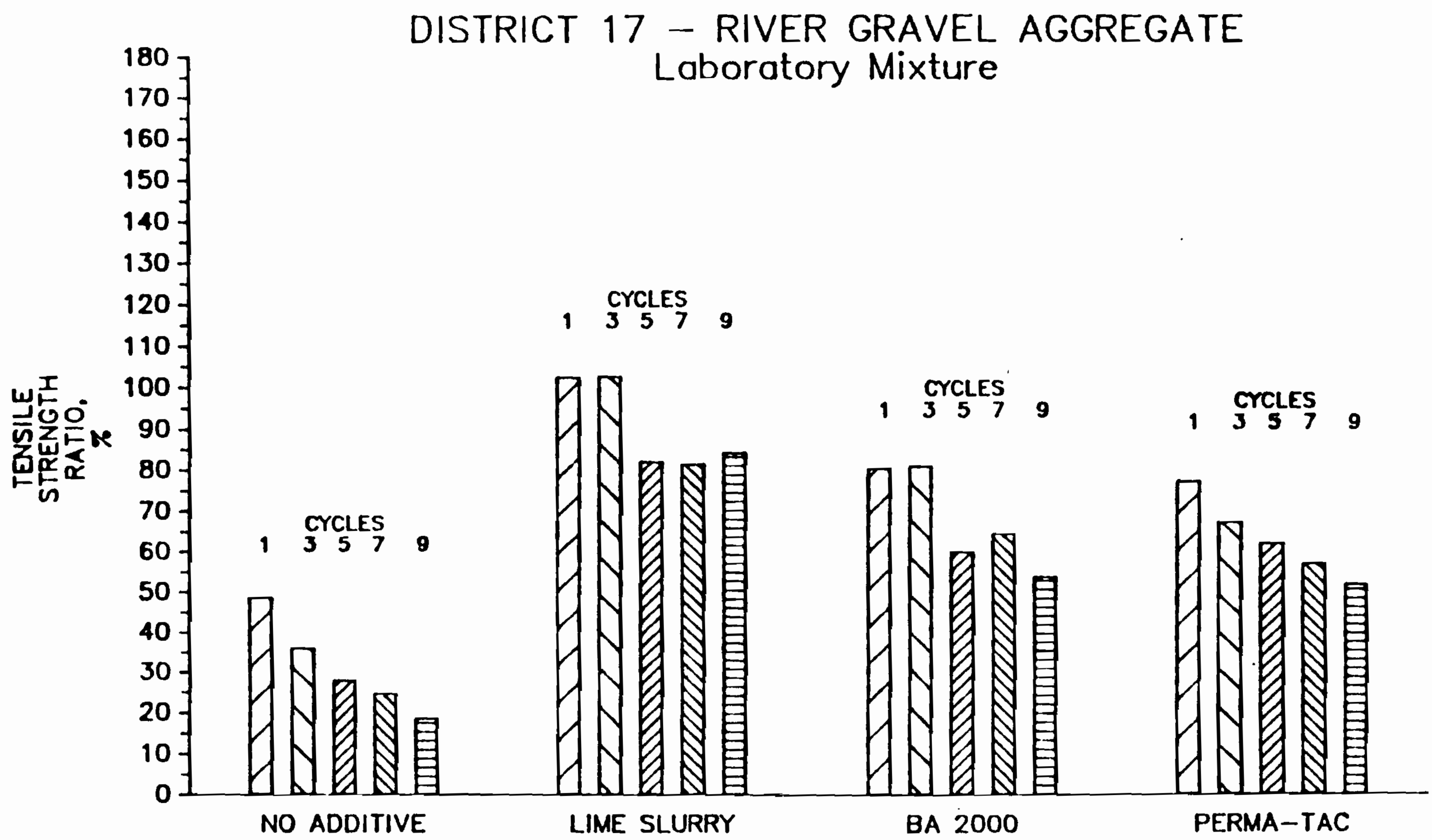


Fig A-5 Wet-Dry Indirect Tensile Cyclic Freeze-Thaw Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

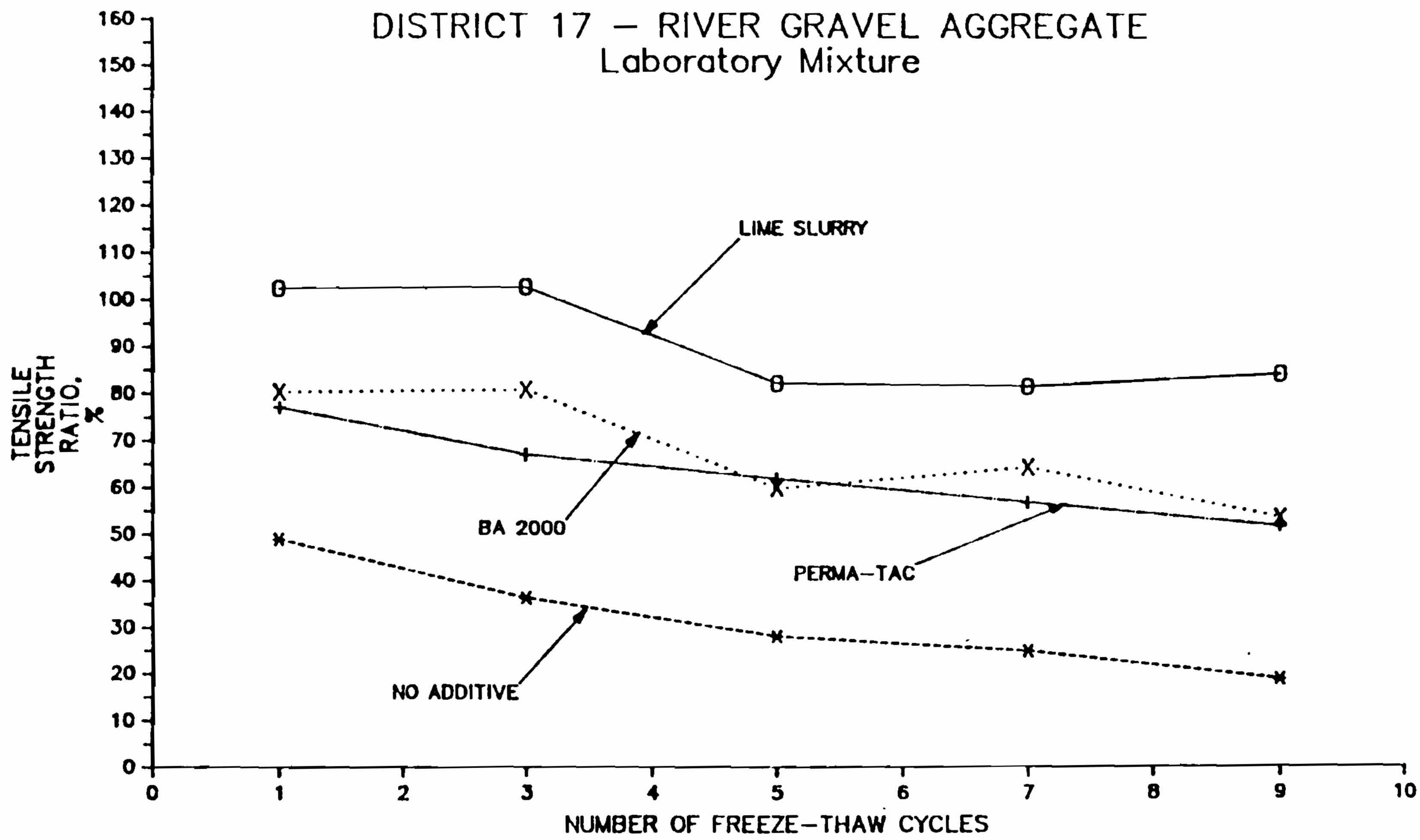


Fig A-6 Tensile Strength Ratio (TSR) Vs. Number of Freeze-Thaw Cycles for Laboratory Mixtures.

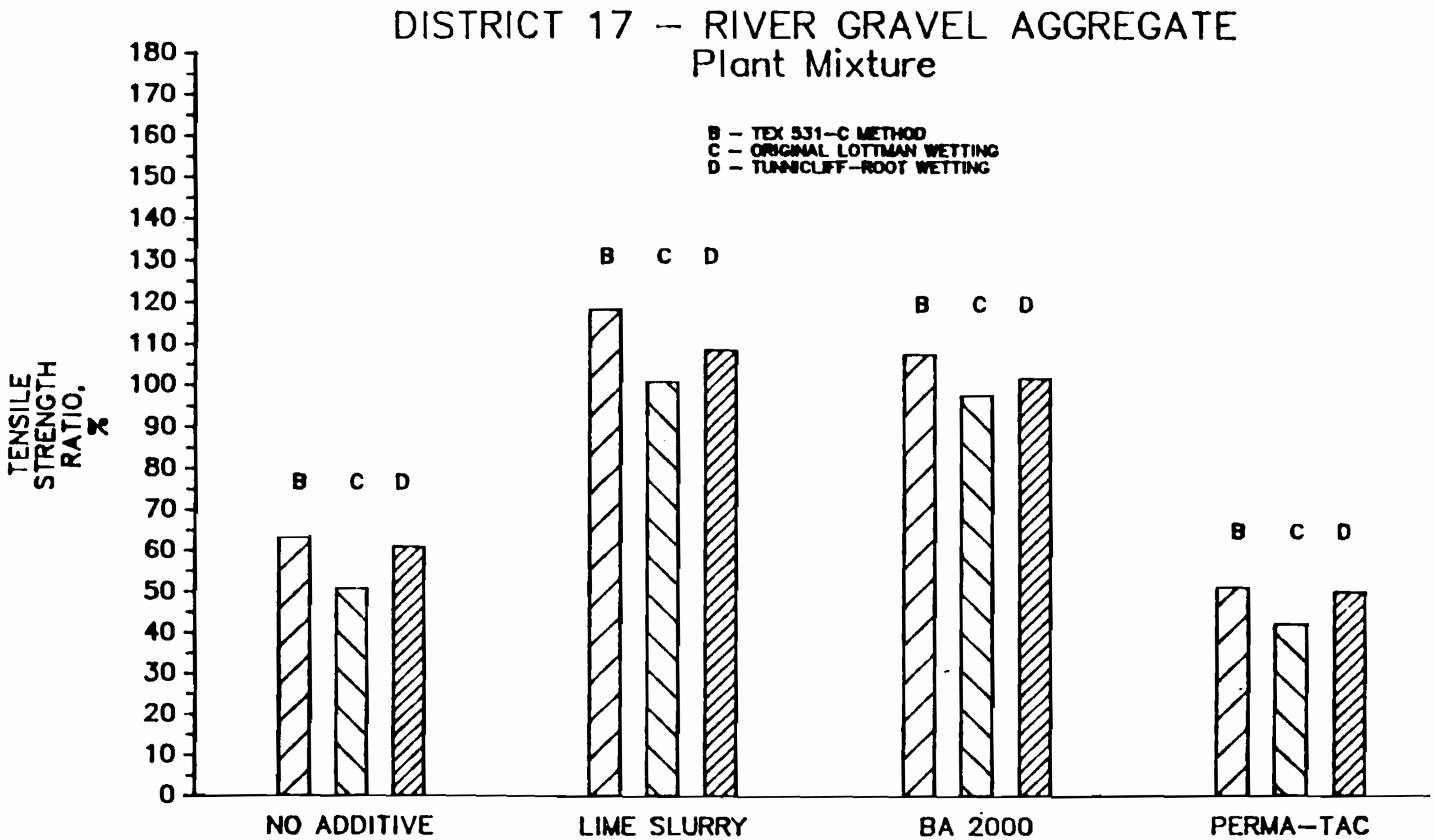


Fig A-7 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Plant Mixtures.

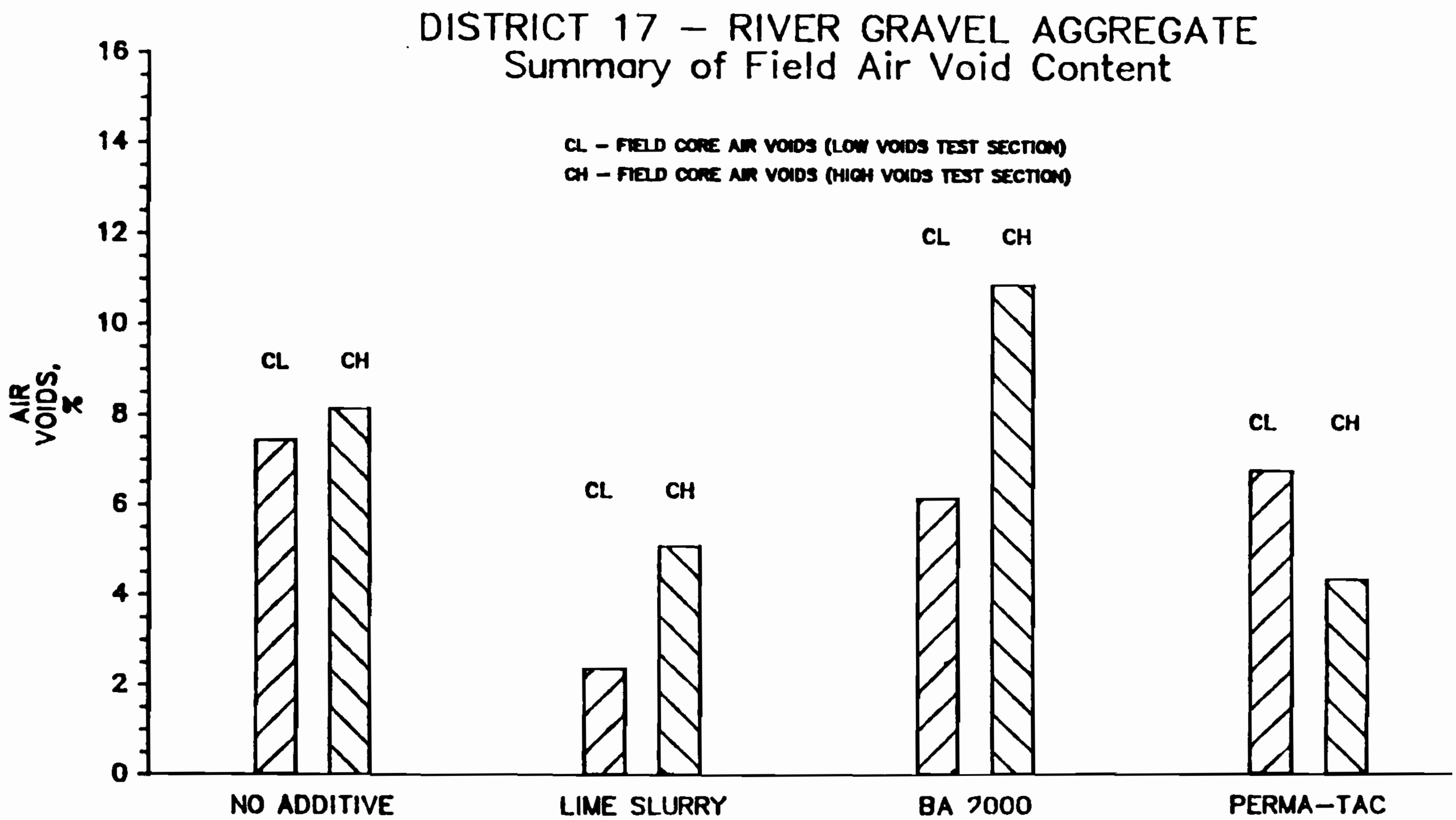


Fig A-8 Summary of Field Core Air Void Content.

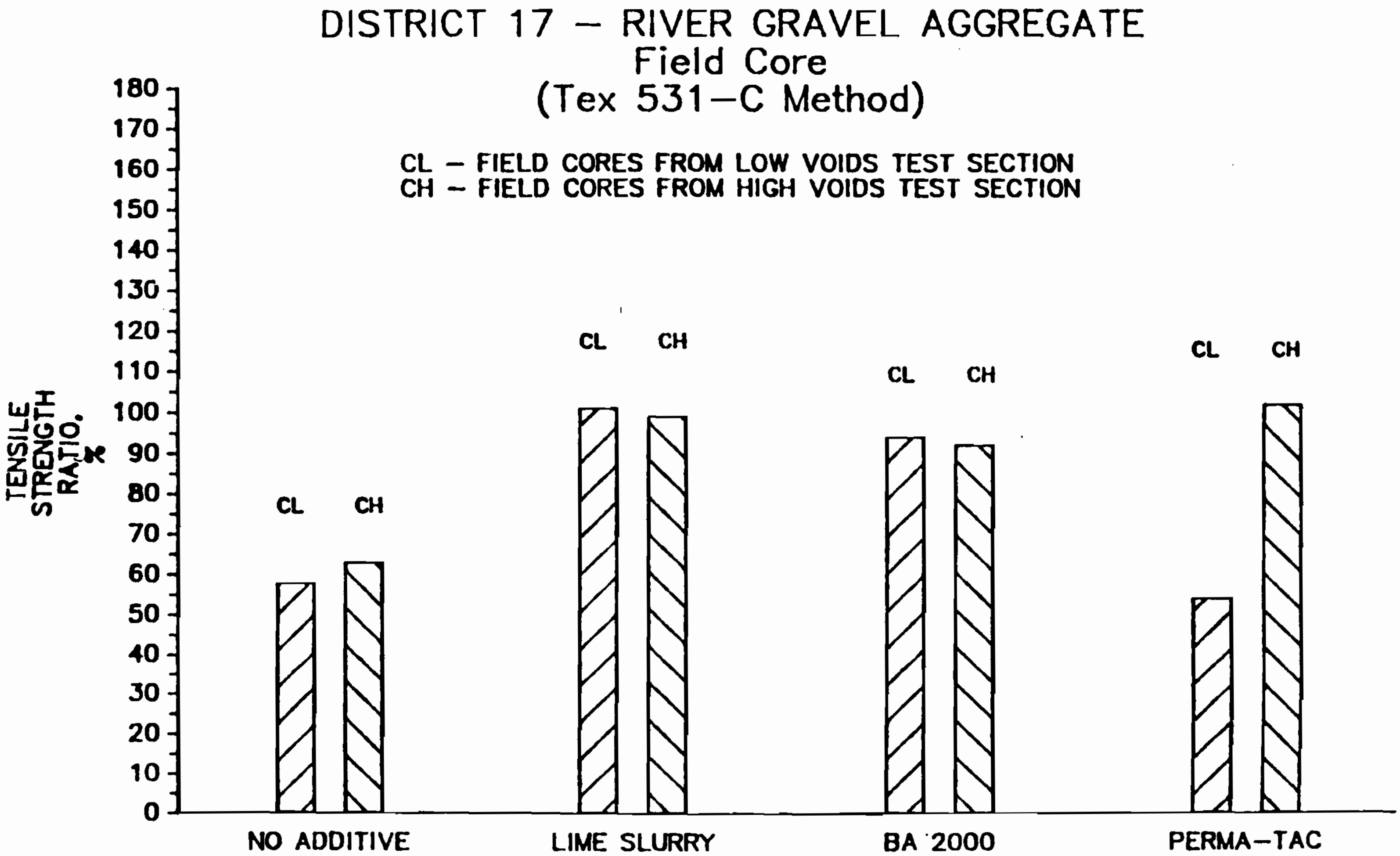


Fig A-9 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Field Cores.

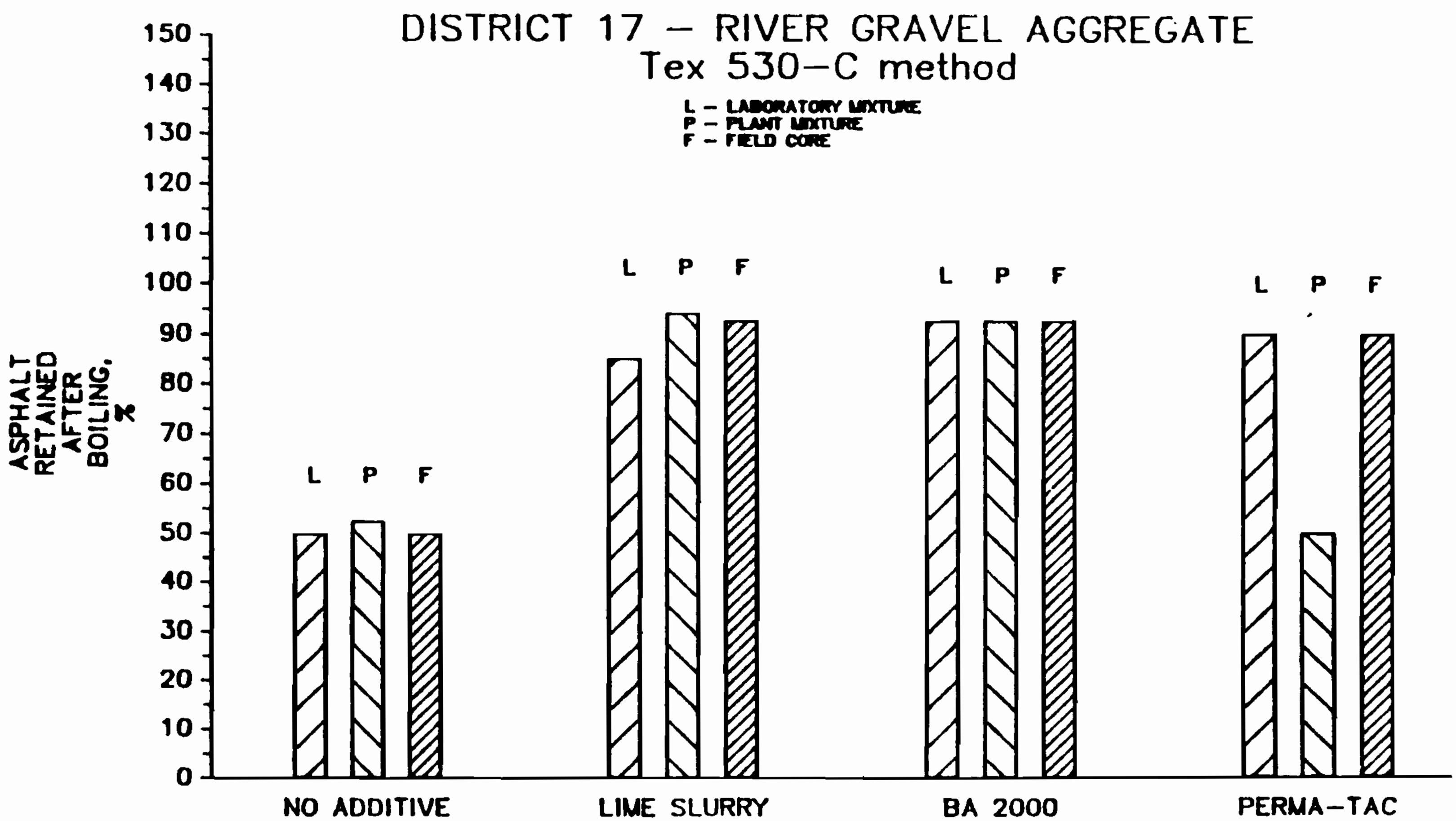


Fig A-10 Texas Boiling Test Results.

APPENDIX B

FIELD AND LABORATORY EXPERIMENTAL PROGRAM - DISTRICT 16

The objective of Appendix B is twofold: (1) to describe the site specific (District 16) field operations of the test sections along with a description of the materials, additives and construction techniques used for this field project, (2) to present the laboratory test results of the laboratory mixed and plant mixed mixtures along with the zero-aged (immediately after construction) pavement cores for the field experimental study at District 16 (Figure B-1) of the Texas State Department of Highways and Public Transportation (SDHPT).

FIELD EXPERIMENTAL PROGRAM

The test pavements were constructed on US 71 in Odom, Texas, in August 1986, and involved pavement overlay to one lane of the highway. The test sections were installed as the surface course in the outside northbound main travel lane as shown schematically in Figure B-2. Each test section was approximately two and one-half (2.5) inches thick, 12 thick, 12 feet wide, and 1000 feet long. A total of ten (10) test sections were constructed and three liquid antistripping additives were used in addition to the hydrated lime and the control materials. The composition of the ten test sections are as follows:

Test Section 1. Control Section - No additive, low air voids.

Test Section 2. Control Section - No additive, high air voids.

Test Section 3. Hot mix with 1% lime slurry, low air voids.

Test Section 4. Hot mix with 1% lime slurry, high air voids.

Test Section 5. Hot mix with 0.5% Pavebond LP, low air voids.

Test Section 6. Hot mix with 0.5% Pavebond LP, high air voids.

Test Section 7. Hot mix with 0.5% Aquashield, low air voids.

Test Section 8. Hot mix with 0.5% Aquashield, high air voids.

Test Section 9. Hot mix with 0.41% Dow Polyethylene, low air voids.

Test Section 10. Hot mix with 0.41% Dow Polyethylene, high air voids.

The field construction was conducted by District 16 of the SDHPT and was assisted by the Center for Transportation Research, The University of Texas at Austin. The average daily traffic (ADT) is estimated at 11,800 vehicles for the test pavement.

MATERIALS AND PAVING MIXTURE

An AC-20 asphalt cement from the Gulf States refinery in Corpus Christi, Texas was used throughout this project. Three aggregates--a limestone coarse aggregate, a limestone screening, and a field sand, were combined to produce the project gradation. Gradations of the individual aggregates, the project gradation, percentages of each aggregate combined, and the specification are given on Table B-1. The project gradation is plotted on a 0.45 power graph in Figure B-3.

The asphalt concrete mixture used in this study met the SDHPT specifications of Item 340, Type D (Modified) fine graded surface course (Ref 45). Preliminary laboratory test results for this mixture design are given below:

Asphalt Content	-	4.3%
Average Density	-	97 percent of theoretical maximum density
Air Void Content	-	3 percent
Hveem Stability	-	55%

FIELD OPERATIONS

A drum mix plant was used to prepare hot mixed asphalt mixtures containing lime slurry and liquid antistripping additives. Identical raw material sources (asphalt cement and aggregates) were utilized throughout the experiment. Three commercially available liquid antistripping additives were used for the test sections, i.e., Pavebond LP, Aquashield, and Dow Anti-Strip.

The hydrated lime was mixed and added in slurry form to the aggregates on the cold feed belt of the drum dryer. The Pavebond LP and Aquashield were metered into the asphalt in-line injection system of the plant. The Dow Polyethylene pellets were mixed with the asphalt cement in a separate storage tank 12 hours prior to use. Depending on the mixing time and the rate of dissolution, the dosage of Dow antistripping additive was difficult to determine immediately. The percentage of the dosage was determined by analyzing a sample of the pre-mixed asphalt cement from the plant storage tank in Dow Chemical's laboratory.

Compaction of each test section was achieved using a vibratory roller, a pneumatic roller, and a steel wheel roller. An attempt was made to achieve the desired air voids by changing the plant mixing temperature. The low air void test sections were placed at 300 F, and the high air void test sections were placed at 275 F. The field air voids during compaction were also controlled using a Troxler Thin Layer Asphalt Gauge. After several passes were made using a vibratory roller, the Troxler gauge was placed on top of the pavement to measure the density of the in-place asphalt layer. A trial and error method of increasing or decreasing the number of passes by the vibratory roller was used to achieve the desired field density (i.e., the desired air voids of the test sections). Final rolling involved using the pneumatic roller.

The field cores were obtained soon after the construction. Three to four pairs of samples were cored from each test section with each pair approximately 200 feet apart. The sample size was approximately 4-inches in diameter and 2 to 2.5-inches in thickness. The coring process was in accordance with the general coring layout procedure described in the main text of this report (Chapter 2). The field cores were transported to the Center for Transportation Research laboratory immediately after sampling.

LABORATORY TESTING PROGRAM

The laboratory compacted specimens were made at such a compactive effort as to provide an approximately 7.0 ± 1.0% air void content. Three liquid antistripping additives were used in addition to the raw material and the hydrated lime. The additives and the dosage are given below:

a. Hydrated lime slurry (1.0% by weight of aggregate).

b. Aquashield (0.5% by weight of asphalt).

c. Dow Anti-Strip (0.41% by weight of asphalt).

d. Pavebond LP (0.5% by weight of asphalt).

The laboratory testing program was discussed in Chapter 2 of the main text and Appendix A, and it was carried out through the duration of this study. Sample preparation, conditioning, test procedures and engineering properties analyzed for the test methods were also discussed in Chapter 2.

PRESENTATION OF TEST RESULTS

Laboratory Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables B-2 through B-6. The data are plotted in Figure B-4 for laboratory mixtures using Methods A through E. The cyclic freeze-thaw test results are shown in Figures B-5 and B-6.

Plant Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables B-7 through B-11. The data are also plotted in Figure B-7 for plant mixtures using Methods B through D.

Plant Mixed/Field Compacted Mixtures (Field Cores)

Summary of the test results are presented on Table B-12. The achieved field compaction to have the low and high air voids are summarized in Figure B-8 which shows the average air void content of the field cores from the low and high voids test sections in the field. The average TSR values are shown in Figure B-9 for the low and high voids test sections.

Texas Boiling Test Results

The Texas boiling test results are presented on Table B-13 and plotted in Figure B-10 for the laboratory mixture, the plant mixture, and the field core.

APPENDIX B SUMMARY OF DATA FOR DISTRICT 16

TABLE B-1 AGGREGATE GRADATIONS (DISTRICT 16)

SIEVE SIZE	FIELD SAND SIEVE ANALYSIS	FIELD SAND 20%	LIMESTONE SCREENINGS SIEVE ANALYSIS	LIMESTONE SCREENINGS 22%	LIMESTONE "D" SIEVE ANALYSIS	LIMESTONE "D" 58%	COMBINED GRADATION	SDHPT SPECIFICATIONS
Plus 1/2 in.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1/2 to 3/8 in.	0.0	0.0	0.0	0.0	10.4	6.0	6.0	0-15
3/8 to No. 4	0.0	0.0	3.8	0.8	61.0	35.4	36.2	21-53
No. 4 to No. 10	0.0	0.0	31.1	6.8	20.1	11.7	18.5	11-32
Plus No. 10							60.7	54-74
No. 10 to No. 40	2.7	0.5	39.9	8.9	4.2	2.4	11.8	6-32
No. 40 to No. 80	56.7	11.3	6.2	1.4	0.8	0.5	13.2	4-27
No. 80 to No. 200	37.2	7.5	6.1	1.3	0.9	0.5	9.3	3-27
Minus No. 200	3.4	0.7	12.9	2.8	2.6	1.5	5.0	1-8
TOTAL	100.0	20.0	100.0	22.0	100.0	58.0	100.0	

TABLE B-2 TEST RESULTS FOR LABORATORY MIXTURES (D-16)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 4.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	7.1	140.8	127	
	A2	DRY	7.2	140.7	130	
	A3	DRY	6.7	141.5	97	
		DRY AVG	7.0	141.0	118	
A						
	A4	WET	6.2	142.1	45	
	A5	WET	6.6	141.6	59	
	A6	WET	6.4	141.8	51	
		WET AVG	6.4	141.9	52	
						0.44
	B1	DRY	7.0	141.0	118	
	B2	DRY	6.9	141.1	126	
	B3	DRY	7.2	140.6	124	
		DRY AVG**	7.0	140.9	123	
B						
	B4	WET	6.1	142.4	74	
	B5	WET	7.0	140.9	54	
	B6	WET	7.6	140.0	44	
		WET AVG	6.9	141.1	57	
						0.47
	C1	WET	7.7	140.0	48	
	C2	WET	7.1	140.9	59	
	C3	WET	6.6	141.6	56	
		WET AVG	7.1	140.8	54	
C						
		DRY AVG**	7.0	140.9	123	
						0.44
	D1	WET	6.5	141.7	64	
	D2	WET	7.0	141.0	69	
	D3	WET	7.3	140.5	61	
		WET AVG	6.9	141.1	65	
D						
		DRY AVG**	7.0	140.9	123	
						0.53

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE B-2 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.7	139.9	68	
	E2	1 CYCLE	6.6	141.6	81	
		WET AVG	7.1	140.7	75	
		DRY AVG**	7.0	140.9	123	
						0.61
	E3	3 CYCLES	7.6	140.1	61	
	E4	3 CYCLES	7.1	140.8	60	
		WET AVG	7.3	140.5	60	
		DRY AVG**	7.0	140.9	123	
						0.49
E	E5	5 CYCLES	7.2	140.7	52	
	E6	5 CYCLES	7.6	140.1	41	
		WET AVG	7.4	140.4	46	
		DRY AVG**	7.0	140.9	123	
						0.37
	E7	7 CYCLES	6.8	141.3	42	
	E8	7 CYCLES	7.8	139.7	33	
		WET AVG	7.3	140.5	38	
		DRY AVG**	7.0	140.9	123	
						0.31
	E9	9 CYCLES	7.1	140.8	44	
	E10	9 CYCLES	6.7	141.4	52	
		WET AVG	6.9	141.1	48	
		DRY AVG**	7.0	140.9	123	
						0.39

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE B-3 TEST RESULTS FOR LABORATORY MIXTURES (D-16)
ADDITIVE: LIME SLURRY (1.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 4.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.0	140.4	103	
	A2	DRY	7.1	140.2	102	
	A3	DRY	7.9	139.1	102	
		DRY AVG	7.3	139.9	102	
	A4	WET	7.6	139.5	78	
	A5	WET	6.7	140.8	79	
	A6	WET	7.1	140.2	70	
		WET AVG	7.2	140.1	76	
						0.74
B	B1	DRY	7.4	139.7	111	
	B2	DRY	7.1	140.3	112	
	B3	DRY	7.2	140.1	102	
		DRY AVG**	7.2	140.0	108	
	B4	WET	7.0	140.4	80	
	B5	WET	7.4	139.7	97	
	B6	WET	7.1	140.2	93	
		WET AVG	7.2	140.1	90	
						0.83
C	C1	WET	7.9	139.0	79	
	C2	WET	6.8	140.6	91	
	C3	WET	7.1	140.2	80	
		WET AVG	7.3	139.9	83	
		DRY AVG**	7.2	140.0	108	
						0.77
D	D1	WET	6.8	140.7	95	
	D2	WET	6.8	140.7	101	
	D3	WET	6.7	140.8	105	
		WET AVG	6.8	140.8	100	
		DRY AVG**	7.2	140.0	108	
						0.93

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE B-3 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.5	141.1	139	
	E2	1 CYCLE	7.7	139.4	121	
		WET AVG	7.1	140.3	130	
		DRY AVG**	7.2	140.0	108	1.20
	E3	3 CYCLES	7.0	140.3	110	
	E4	3 CYCLES	6.9	140.5	121	
		WET AVG	7.0	140.4	107	
		DRY AVG**	7.2	140.0	108	0.99
E	E5	5 CYCLES	6.7	140.8	89	
	E6	5 CYCLES	7.4	139.8	91	
		WET AVG	7.1	140.3	90	
		DRY AVG**	7.2	140.0	108	0.83
	E7	7 CYCLES	8.0	138.9	68	
	E8	7 CYCLES	6.6	141.0	68	
		WET AVG	7.3	140.0	68	
		DRY AVG**	7.2	140.0	108	0.63
	E9	9 CYCLES	7.5	139.7	73	
	E10	9 CYCLES	7.8	139.2	72	
		WET AVG	7.6	139.4	72	
		DRY AVG**	7.2	140.0	108	0.67

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE B-4 TEST RESULTS FOR LABORATORY MIXTURES (D-16)
ADDITIVE: AQUASHIELD (0.5%)
ASPHALT CONTENT = 4.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	7.8	139.2	116	
	A2	DRY	6.4	141.3	123	
	A3	DRY	7.4	139.7	108	
		DRY AVG	7.2	140.1	116	
A	A4	WET	6.3	141.4	69	
	A5	WET	7.3	140.0	73	
	A6	WET	7.6	139.4	53	
		WET AVG	7.1	140.3	65	
						0.56
	B1	DRY	6.9	140.5	109	
	B2	DRY	7.0	140.4	108	
	B3	DRY	7.9	139.1	101	
		DRY AVG**	7.3	140.0	106	
B	B4	WET	7.1	140.2	66	
	B5	WET	7.1	140.2	65	
	B6	WET	6.7	140.9	67	
		WET AVG	7.0	140.4	66	
						0.62
	C1	WET	8.0	138.9	61	
	C2	WET	7.6	139.5	63	
	C3	WET	6.9	140.5	67	
		WET AVG	7.5	139.6	64	
C		DRY AVG**	7.3	140.0	106	
						0.60
	D1	WET	7.1	140.2	75	
	D2	WET	7.4	139.7	75	
	D3	WET	8.0	138.8	72	
		WET AVG	7.5	139.6	74	
D		DRY AVG**	7.3	140.0	106	
						0.70

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE B-4 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	6.8	140.7	87	
	E2	1 CYCLE	7.0	140.4	75	
		WET AVG	6.9	140.5	81	
		DRY AVG**	7.3	140.0	106	0.77
	E3	3 CYCLES	6.5	141.2	84	
	E4	3 CYCLES	7.1	140.3	83	
		WET AVG	6.8	140.7	84	
		DRY AVG**	7.3	140.5	106	0.79
	E5	5 CYCLES	6.0	141.9	77	
	E6	5 CYCLES	7.4	139.8	67	
		WET AVG	6.7	140.9	72	
		DRY AVG**	7.3	140.0	106	0.68
	E7	7 CYCLES	7.8	139.1	57	
	E8	7 CYCLES	7.2	140.1	61	
		WET AVG	7.5	139.6	59	
		DRY AVG**	7.3	140.0	106	0.56
	E9	9 CYCLES	7.6	139.5	57	
	E10	9 CYCLES	7.5	139.6	64	
		WET AVG	7.5	139.6	61	
		DRY AVG**	7.3	140.0	106	0.67

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE B-5 TEST RESULTS FOR LABORATORY MIXTURES (D-16)
ADDITIVE: DOW ANTI-SRIP (0.41%)
ASPHALT CONTENT = 4.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.0	142.0	151	
	A2	DRY	6.5	141.2	121	
	A3	DRY	6.7	141.0	123	
		DRY AVG	6.4	141.4	131	
	A4	WET	6.6	141.1	64	
	A5	WET	6.2	141.8	76	
	A6	WET	6.0	142.1	69	
		WET AVG	6.2	141.6	70	0.53
B	B1	DRY	6.0	142.0	138	
	B2	DRY	6.4	141.5	148	
	B3	DRY	7.0	140.6	126	
		DRY AVG**	6.5	141.3	137	
	B4	WET	6.6	141.1	88	
	B5	WET	6.8	140.8	69	
	B6	WET	6.8	140.8	84	
		WET AVG	6.7	140.9	80	0.58
C	C1	WET	7.5	139.8	56	
	C2	WET	6.6	141.1	70	
	C3	WET	6.8	140.7	60	
		WET AVG	7.0	140.5	62	
		DRY AVG**	6.5	141.3	137	0.45
D	D1	WET	6.0	142.0	100	
	D2	WET	6.2	141.7	97	
	D3	WET	6.3	141.5	83	
		WET AVG	6.2	141.7	93	
		DRY AVG**	6.5	141.3	137	0.68

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE B-5 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.1	141.9	107	
	E2	1 CYCLE	6.9	140.7	80	
		WET AVG	6.5	141.3	93	
		DRY AVG**	6.5	141.3	137	
						0.68
	E3	3 CYCLES	7.4	139.9	67	
	E4	3 CYCLES	6.6	141.2	87	
		WET AVG	7.0	140.6	77	
		DRY AVG**	6.5	141.3	137	
						0.56
E						
	E5	5 CYCLES	7.2	140.2	60	
	E6	5 CYCLES	6.0	142.0	70	
		WET AVG	6.6	141.1	65	
		DRY AVG**	6.5	141.3	137	
						0.47
	E7	7 CYCLES	6.8	140.9	47	
	E8	7 CYCLES	6.3	141.6	44	
		WET AVG	6.5	141.2	46	
		DRY AVG**	6.5	141.3	137	
						0.33
	E9	9 CYCLES	7.1	140.4	53	
	E10	9 CYCLES	6.8	140.8	48	
		WET AVG	6.9	140.6	50	
		DRY AVG**	6.5	141.3	137	
						0.37

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE B-6 TEST RESULTS FOR LABORATORY MIXTURES (D-16)
ADDITIVE: PAVEBOND LP (0.5%)
ASPHALT CONTENT = 4.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	6.8	140.4	113	
	A2	DRY	6.5	140.8	115	
	A3	DRY	6.5	140.9	101	
		DRY AVG	6.6	140.7	110	
A	A4	WET	6.7	140.6	58	
	A5	WET	7.5	139.4	77	
	A6	WET	7.3	139.6	63	
		WET AVG	7.2	139.9	66	
						0.60
	B1	DRY	6.8	140.5	100	
	B2	DRY	6.0	141.6	117	
	B3	DRY	6.5	140.8	97	
		DRY AVG**	6.4	141.0	105	
B	B4	WET	7.1	140.1	54	
	B5	WET	6.2	141.3	63	
	B6	WET	7.4	139.5	56	
		WET AVG	6.9	140.3	58	
						0.55
	C1	WET	6.2	141.3	62	
	C2	WET	7.7	139.0	57	
	C3	WET	6.7	140.5	61	
		WET AVG	6.9	140.3	60	
C		DRY AVG**	6.4	141.0	105	
						0.57
	D1	WET	6.7	140.7	76	
	D2	WET	6.9	140.3	62	
	D3	WET	6.8	140.5	72	
		WET AVG	6.8	140.5	70	
D		DRY AVG**	6.4	141.0	105	
						0.67

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE B-6 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.3	141.2	101	
	E2	1 CYCLE	6.7	140.6	72	
		WET AVG	6.5	140.9	87	
		DRY AVG**	6.4	141.0	105	
						0.83
	E3	3 CYCLES	6.5	140.9	64	
	E4	3 CYCLES	7.0	140.2	61	
		WET AVG	6.7	140.5	63	
		DRY AVG**	6.4	141.0	105	
						0.60
E	E5	5 CYCLES	7.1	140.1	52	
	E6	5 CYCLES	7.0	140.1	49	
		WET AVG	7.0	140.1	51	
		DRY AVG**	6.4	141.0	105	
						0.49
	E7	7 CYCLES	6.9	140.3	53	
	E8	7 CYCLES	7.0	140.2	48	
		WET AVG	7.0	140.2	50	
		DRY AVG**	6.4	141.0	105	
						0.48
	E9	9 CYCLES	7.7	139.1	49	
	E10	9 CYCLES	6.8	140.5	47	
		WET AVG	7.2	139.8	48	
		DRY AVG**	6.4	141.0	105	
						0.46

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE B-8 TEST RESULTS FOR PLANT MIXTURES (D-16)
ADDITIVE: LIME SLURRY (1.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.8	140.7	124	
	B2	DRY	6.8	140.6	131	
	B3	DRY	6.8	140.7	124	
		DRY AVG**	6.8	140.7	126	
	B4	WET	6.8	140.7	119	
	B5	WET	6.8	140.6	127	
	B6	WET	6.7	140.7	142	
		WET AVG	6.8	140.7	129	
						1.02
C	C1	WET	6.8	140.6	105	
	C2	WET	6.7	140.7	120	
	C3	WET	7.0	140.3	106	
		WET AVG	6.9	140.5	110	
		DRY AVG**	6.8	140.7	126	
						0.87
D	D1	WET	6.7	140.7	141	
	D2	WET	6.7	140.8	132	
	D3	WET	7.2	140.0	111	
		WET AVG	6.9	140.5	128	
		DRY AVG**	6.8	140.7	126	
						1.01

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE B-9 TEST RESULTS FOR PLANT MIXTURES (D-16)
ADDITIVE: AQUASHIELD (0.5%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.4	141.7	141	
	B2	DRY	6.4	141.7	144	
	B3	DRY	6.7	141.3	146	
		DRY AVG**	6.5	141.6	144	
	B4	WET	6.5	141.7	128	
	B5	WET	6.6	141.5	114	
	B6	WET	6.4	141.8	133	
		WET AVG	6.5	141.7	125	0.87
C	C1	WET	6.2	142.1	110	
	C2	WET	6.4	141.8	111	
	C3	WET	6.3	141.8	105	
		WET AVG	6.3	141.9	109	
		DRY AVG**	6.5	141.6	144	0.76
D	D1	WET	6.7	141.3	123	
	D2	WET	6.5	141.6	123	
	D3	WET	6.3	141.9	129	
		WET AVG	6.5	141.6	125	
		DRY AVG**	6.5	141.6	144	0.87

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE B-10 TEST RESULTS FOR PLANT MIXTURES (D-16)
ADDITIVE: DOW ANTI-STRIP (0.41%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	7.4	140.2	131	
	B2	DRY	7.6	139.9	117	
	B3	DRY	7.1	140.6	135	
		DRY AVG**	7.4	140.2	128	
B	B4	WET	7.7	139.7	91	
	B5	WET	7.2	140.5	100	
	B6	WET	7.5	140.0	98	
		WET AVG	7.5	140.1	96	
						0.75
	C1	WET	7.1	140.6	92	
	C2	WET	7.3	140.4	98	
	C3	WET	7.5	140.0	86	
		WET AVG	7.3	140.3	92	
C		DRY AVG**	7.4	140.2	128	
						0.72
	D1	WET	7.5	140.1	123	
	D2	WET	7.1	140.6	107	
	D3	WET	7.5	140.1	105	
		WET AVG	7.3	140.3	112	
D		DRY AVG**	7.4	140.2	128	
						0.87

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE B-11 TEST RESULTS FOR PLANT MIXTURES (D-16)
ADDITIVE: PAVEBOND LP (0.5%)
ASPHALT CONTENT = 5.1 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.9	140.1	134	
	B2	DRY	8.0	139.9	134	
	B3	DRY	8.0	140.0	129	
		DRY AVG**	8.0	140.0	132	
	B4	WET	7.6	140.5	105	
	B5	WET	7.7	140.4	105	
	B6	WET	7.8	140.3	94	
		WET AVG	7.7	140.4	101	0.77
C	C1	WET	8.0	140.0	102	
	C2	WET	8.0	140.0	99	
	C3	WET	7.6	140.6	97	
		WET AVG	7.8	140.2	99	
		DRY AVG**	8.0	140.0	132	0.75
D	D1	WET	7.6	140.6	119	
	D2	WET	7.8	140.3	119	
	D3	WET	8.0	139.9	121	
		WET AVG	7.8	140.3	120	
		DRY AVG**	8.0	140.0	132	0.90

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE B-12 TEST RESULTS FOR FIELD CORES
DISTRICT 16
ASPHALT CONTENT = 5.1 %

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		1A	WET	10.1	135.9	47	
		1B	DRY	9.8	136.5	87	
	LOW						0.54
	AIR	2A	DRY	9.3	137.1	86	
	VOIDS	2B	WET	8.8	137.9	69	
	SECTION						0.80
		3A	WET	10.2	135.8	61	
		3B	DRY	9.4	137.1	94	
							0.64
NO		(AVG VOIDS)		9.6		(AVG TSR)	0.66
ADDITIVE							
(CONTROL)		4A	DRY	10.7	135.0	86	
		4B	WET	10.5	135.3	62	
	HIGH						0.72
	AIR	5A	WET	9.2	137.3	68	
	VOIDS	5B	DRY	9.2	137.4	108	
	SECTION						0.63
		6A	DRY	9.0	137.7	108	
		6B	WET	8.6	138.3	84	
							0.77
		(AVG VOIDS)		9.5		(AVG TSR)	0.71
		7A	WET	8.8	137.7	89	
		7B	DRY	9.2	137.1	105	
	LOW						0.85
	AIR	8A	DRY	7.8	139.2	116	
	VOIDS	8B	WET	8.0	138.9	90	
	SECTION						0.78
		9A	WET	8.9	137.4	96	
		9B	DRY	8.9	137.5	101	
							0.95
		(AVG VOIDS)		8.6		(AVG TSR)	0.86
LIME							
SLURRY		10A	DRY	8.6	137.9	102	
		10B	WET	8.0	138.9	102	
	HIGH						1.00
	AIR	11A	WET	9.4	136.7	84	
	VOIDS	11B	DRY	9.6	136.5	96	
	SECTION						0.88
		12A	DRY	8.3	138.3	110	
		12B	WET	8.1	138.6	102	
							0.93
		(AVG VOIDS)		8.7		(AVG TSR)	0.93
		13A	WET	10.8	135.7	72	
		13B	DRY	10.8	135.7	93	
							0.77
		14A	DRY	11.3	135.0	89	

TABLE B-12 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
	LOW AIR VOIDS SECTION	14B	WET	11.1	135.2	75	
							0.84
		15A	WET	10.2	136.6	84	
		15B	DRY	10.8	135.7	89	
							0.94
		(AVG VOIDS)		10.8		(AVG TSR)	0.85
PAVEBOND LP	HIGH AIR VOIDS SECTION	16A	DRY	10.2	136.6	102	
		16B	WET	10.6	136.1	75	
							0.74
		17A	WET	9.2	138.1	79	
		17B	DRY	8.8	138.7	122	
							0.65
		18A	DRY	10.7	135.8	86	
		18B	WET	11.6	134.4	59	
							0.68
		(AVG VOIDS)		10.2		(AVG TSR)	0.69
	LOW AIR VOIDS SECTION	19A	WET	11.3	136.1	59	
		19B	DRY	10.3	137.7	102	
							0.58
		20A	DRY	8.9	139.8	119	
		20B	WET	9.2	139.3	93	
							0.78
		21A	WET	11.1	136.4	72	
		21B	DRY	12.9	133.7	79	
							0.91
		(AVG VOIDS)		10.6		(AVG TSR)	0.76
AQUA-SHIELD	HIGH AIR VOIDS SECTION	22A	DRY	12.3	134.6	82	
		22B	WET	10.8	136.9	82	
							1.00
		23A	WET	9.7	138.5	88	
		23B	DRY	10.3	137.6	113	
							0.78
		24A	DRY	7.9	141.3	135	
		24B	WET	8.0	141.2	98	
							0.73
		(AVG VOIDS)		9.8		(AVG TSR)	0.84
	LOW AIR VOIDS SECTION	25A	WET	8.6	138.3	80	
		25B	DRY	9.0	137.8	93	
							0.86
		26A	DRY	9.1	137.6	112	
		26B	WET	8.8	138.1	66	
							0.59
		27A	WET	8.4	138.7	87	
		27B	DRY	8.6	138.4	103	
							0.85

TABLE B-12 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		(AVG VOIDS)		8.7		(AVG TSR)	0.76
DOW ANTI-STRIP	HIGH AIR VOIDS SECTION	28A	DRY	9.2	137.5	101	
		28B	WET	9.4	137.2	66	
							0.65
		29A	WET	9.2	137.4	64	
		29B	DRY	9.0	137.8	114	
							0.56
		30A	DRY	10.2	135.9	96	
		30B	WET	10.4	135.7	65	
							0.68
		(AVG VOIDS)		9.6		(AVG TSR)	0.63

*TSR = Tensile Strength Ratio
= Tensile Strength (Wet)/Tensile Strength (Dry)

TABLE B-13 BOILING TEST RESULTS
DISTRICT 16

TYPE OF MIXTURE	TYPE OF ADDITIVE	ASPHALT RETAINED AFTER BOILING, % RATING 1	RATING 2	AVG
LABORATORY	NO ADDITIVE	75	80	77.5
	LIME	70	80	75.0
	AQUASHIELD	75	80	77.5
	DOW	75	80	77.5
	PAVEBOND LP	75	80	77.5
PLANT	NO ADDITIVE	80	85	82.5
	LIME	80	85	82.5
	AQUASHIELD	85	85	85.0
	DOW	85	85	85.0
	PAVEBOND LP	85	85	85.0
FIELD CORE	NO ADDITIVE	70	80	75.0
	LIME	75	80	77.5
	AQUASHIELD	80	85	82.5
	DOW	70	80	75.0
	PAVEBOND LP	65	80	72.5

APPENDIX B LIST OF FIGURES

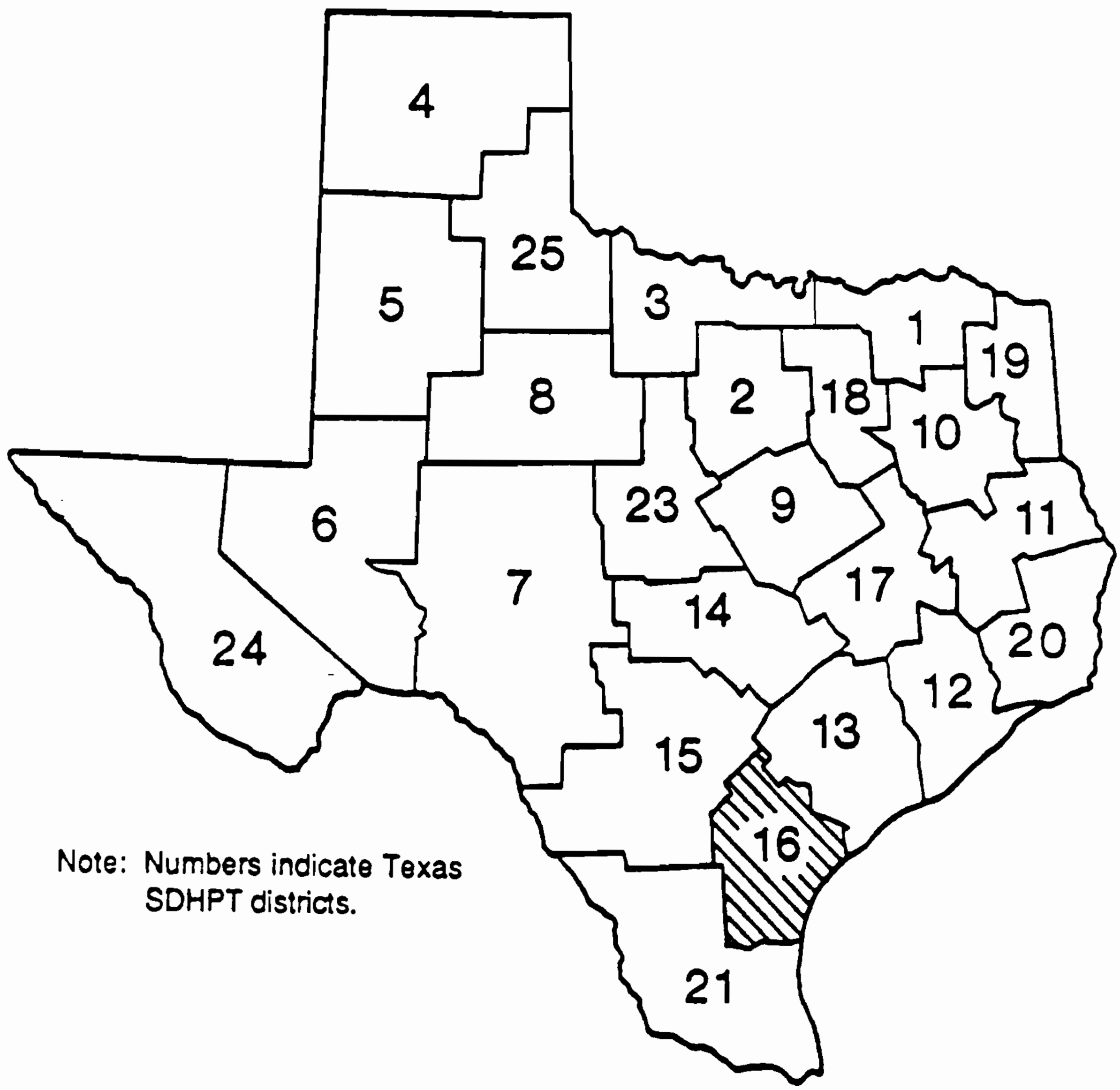
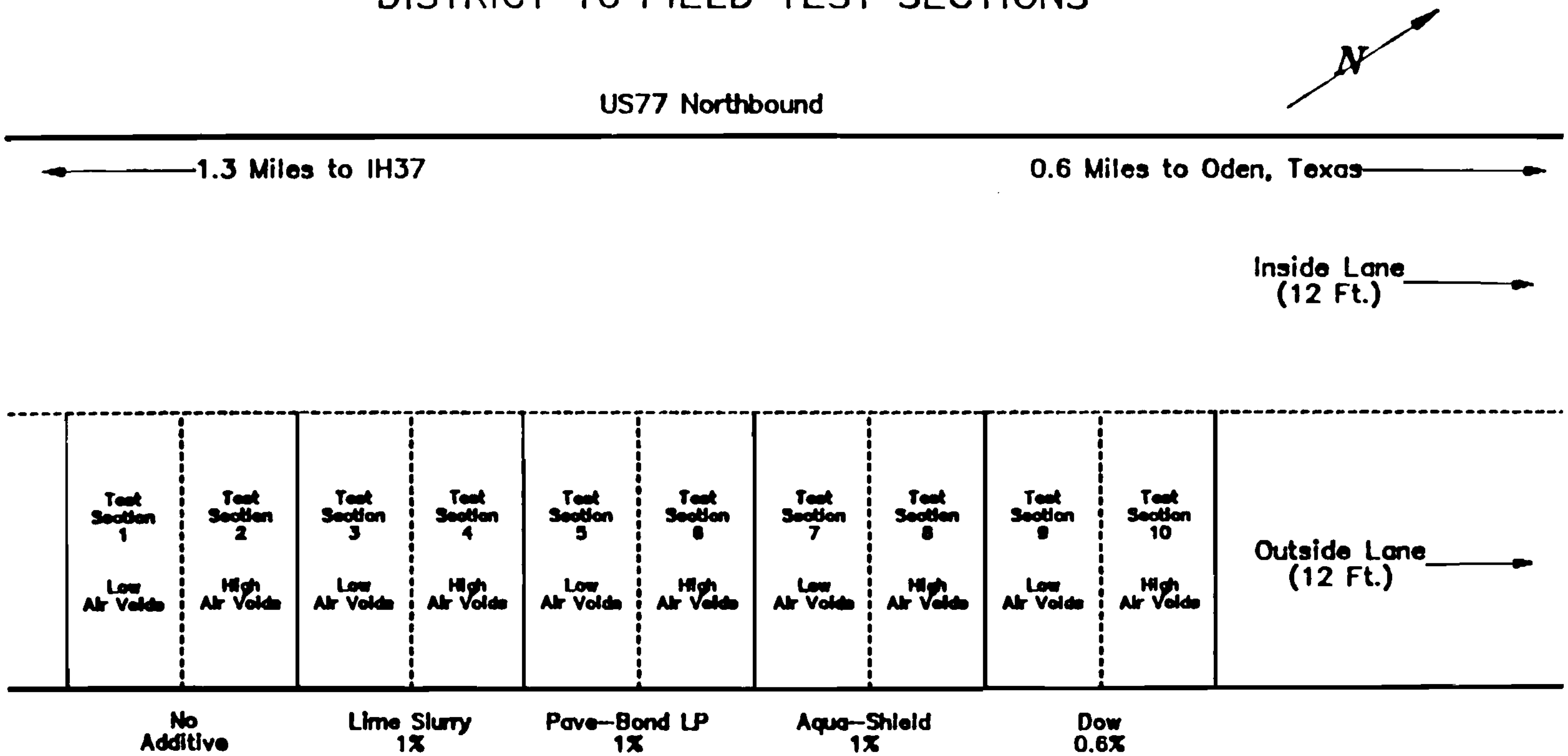


Figure B-1. Location of Field Test Sections (District 16).

DISTRICT 16 FIELD TEST SECTIONS



Note: Each test section is approximately 1000 feet in length.

Fig B-2 Schematic Illustration of Field Test Sections.

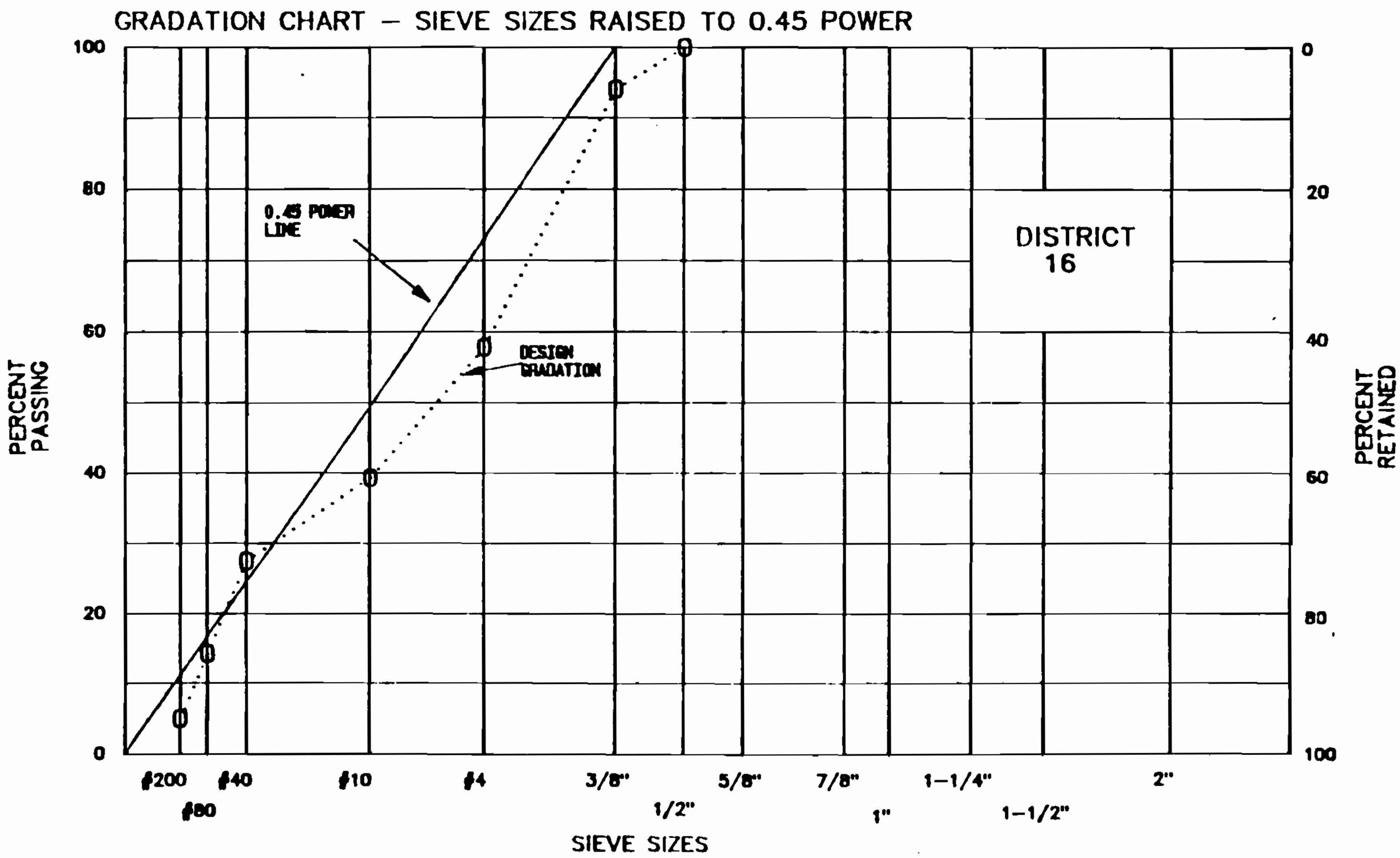


Fig B-3 Aggregate Gradation Chart.

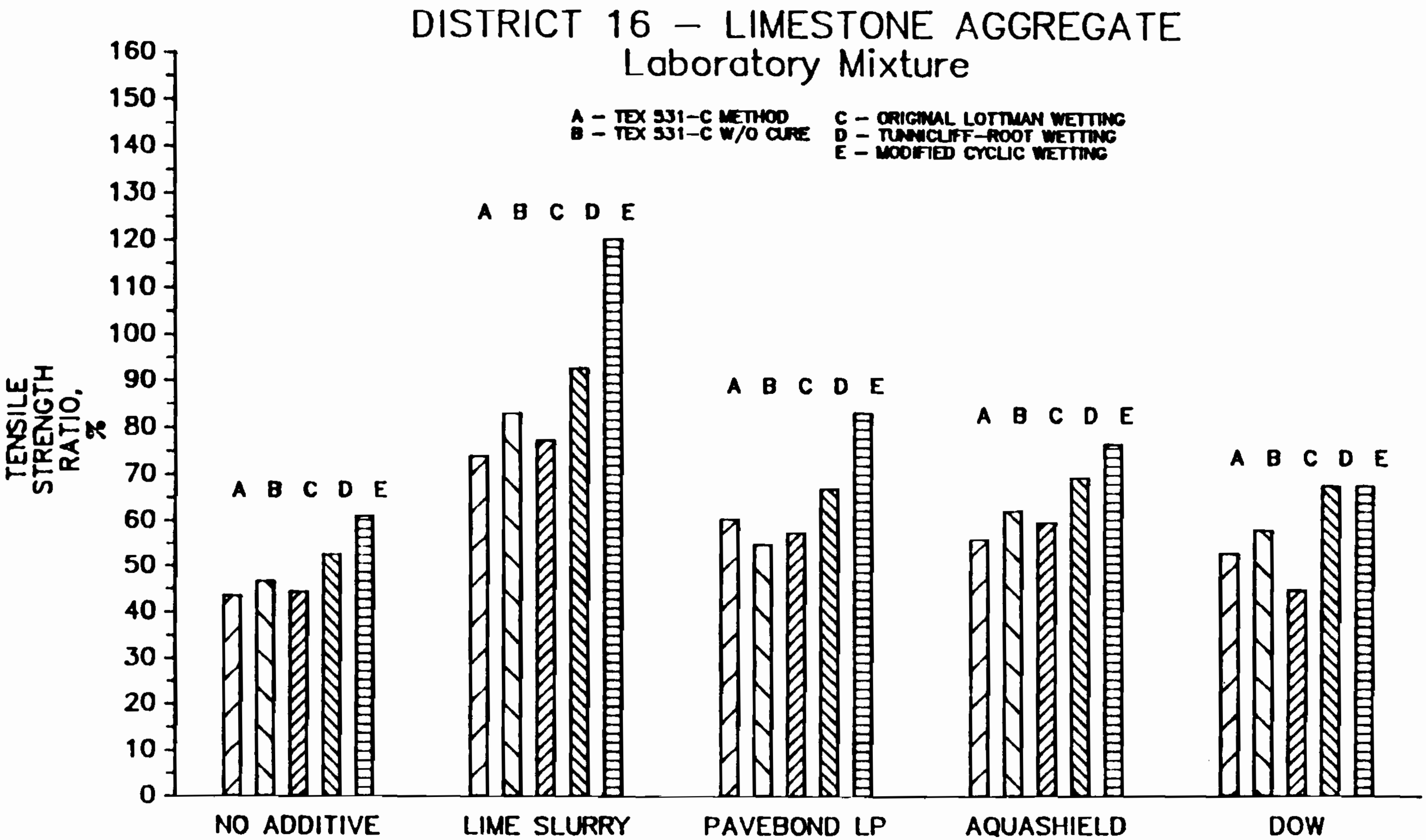


Fig B-4 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

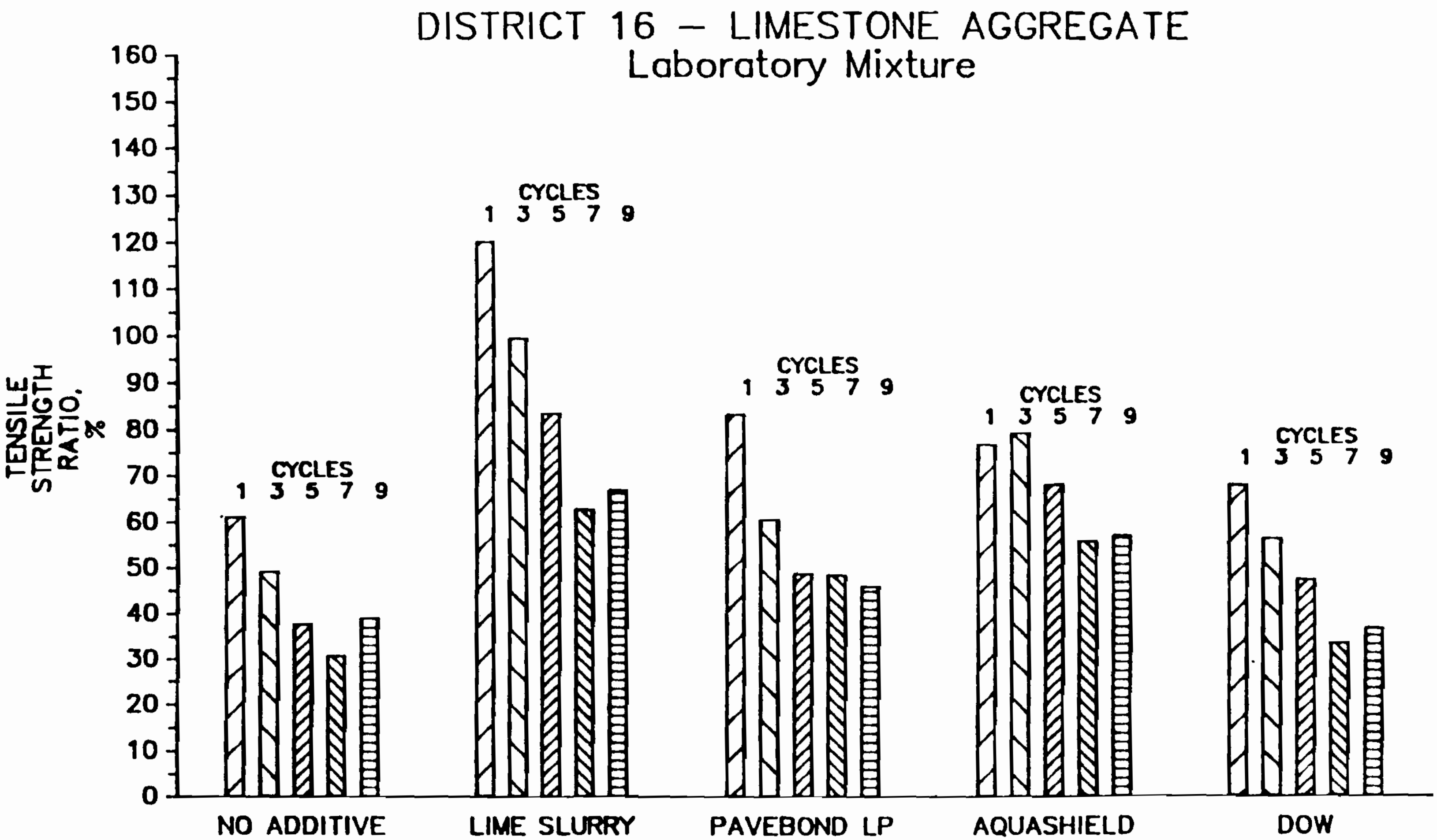


Fig B-5 Wet-Dry Indirect Tensile Cyclic Freeze-Thaw Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

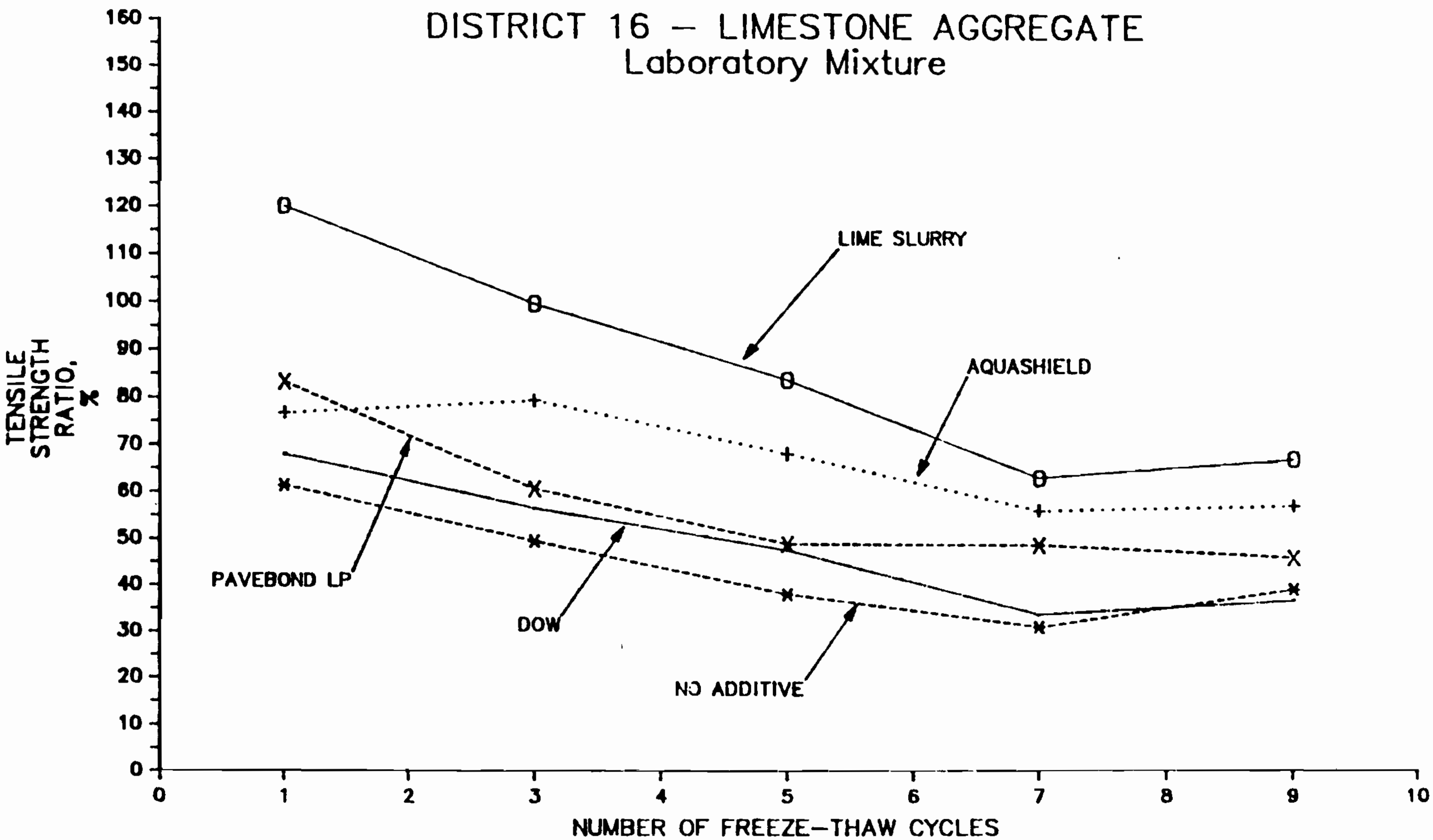


Fig B-6 Tensile Strength Ratio (TSR) Vs. Number of Freeze-Thaw Cycles for Laboratory Mixtures.

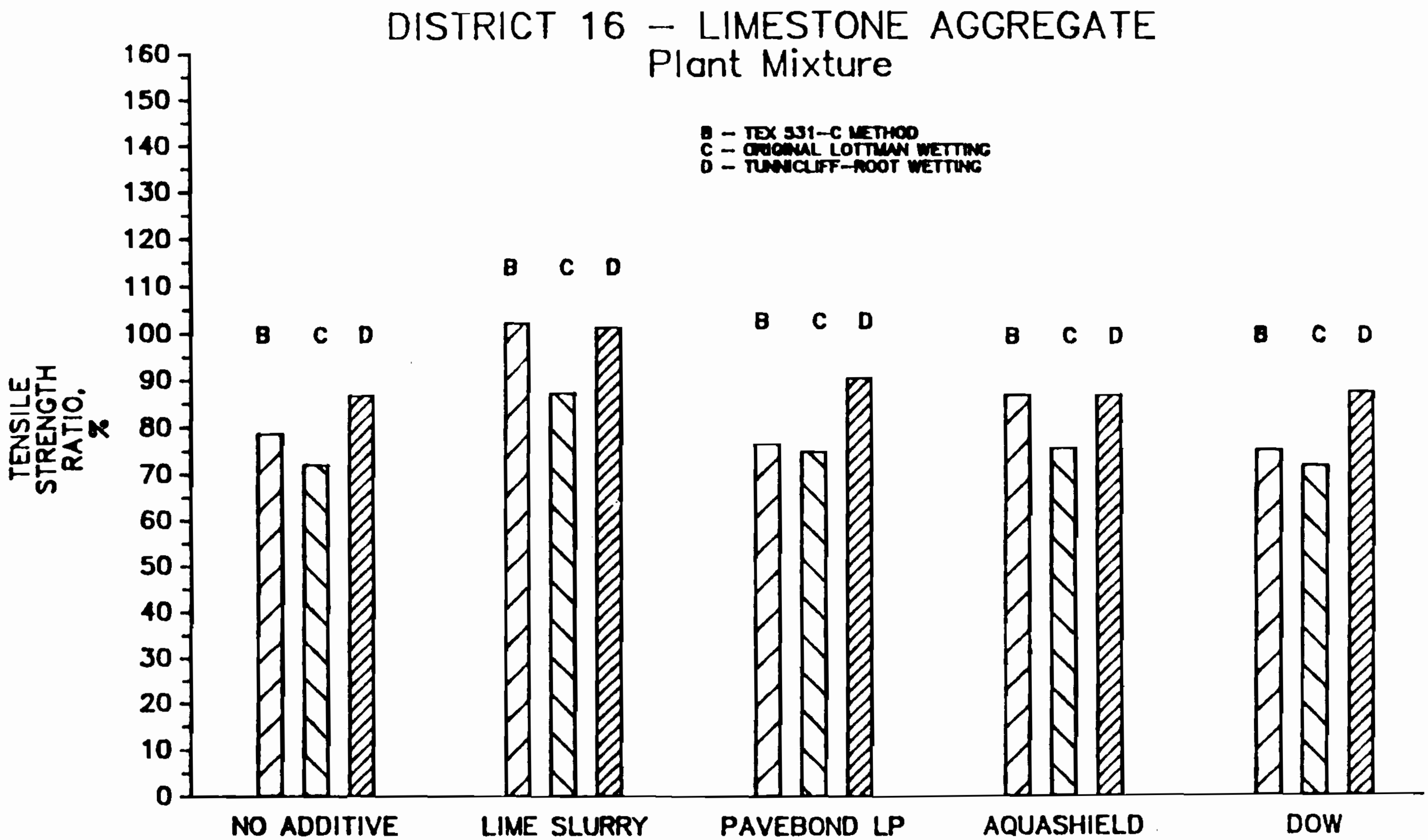


Fig B-7 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Plant Mixtures.

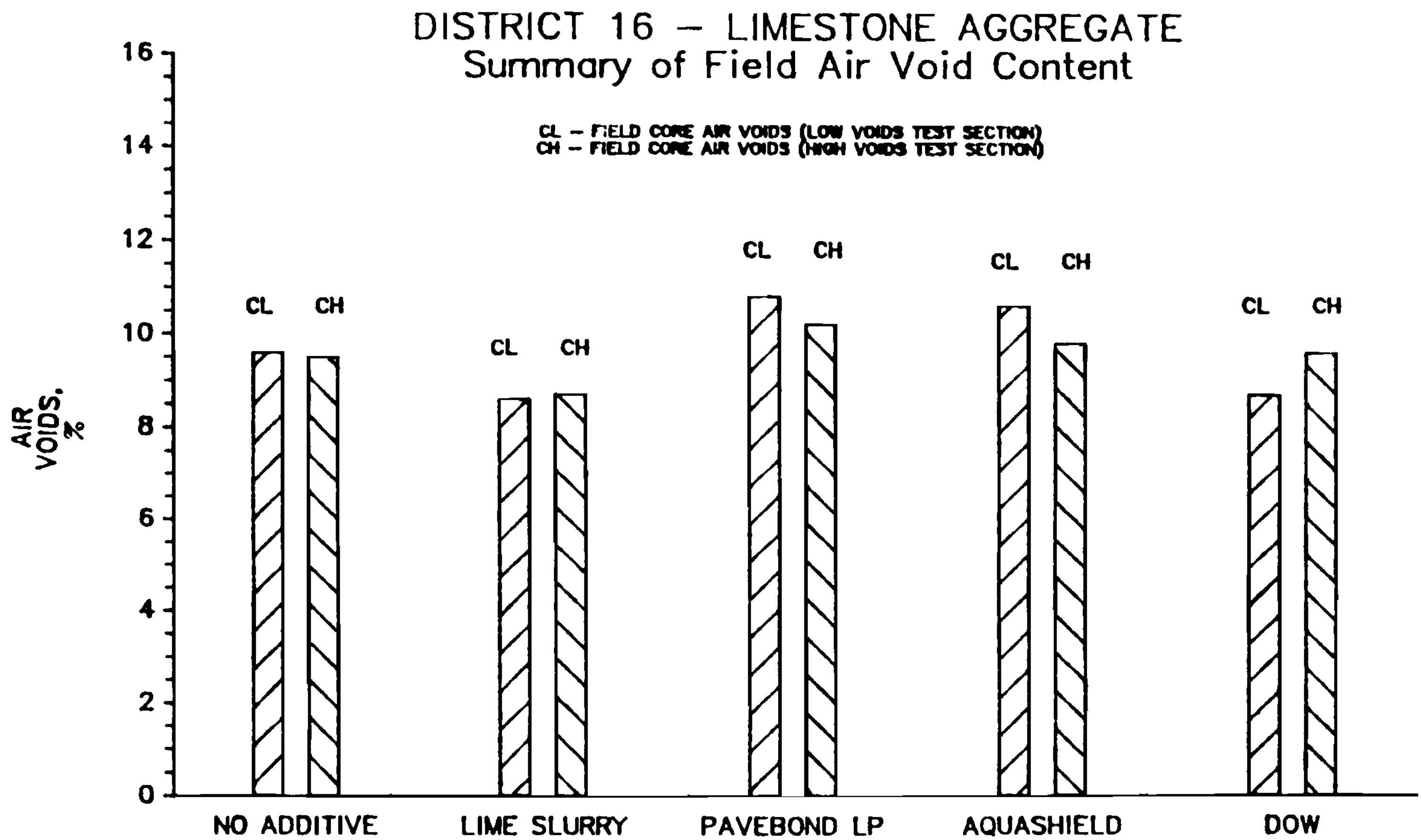


Fig B-8 Summary of Field Core Air Void Content.

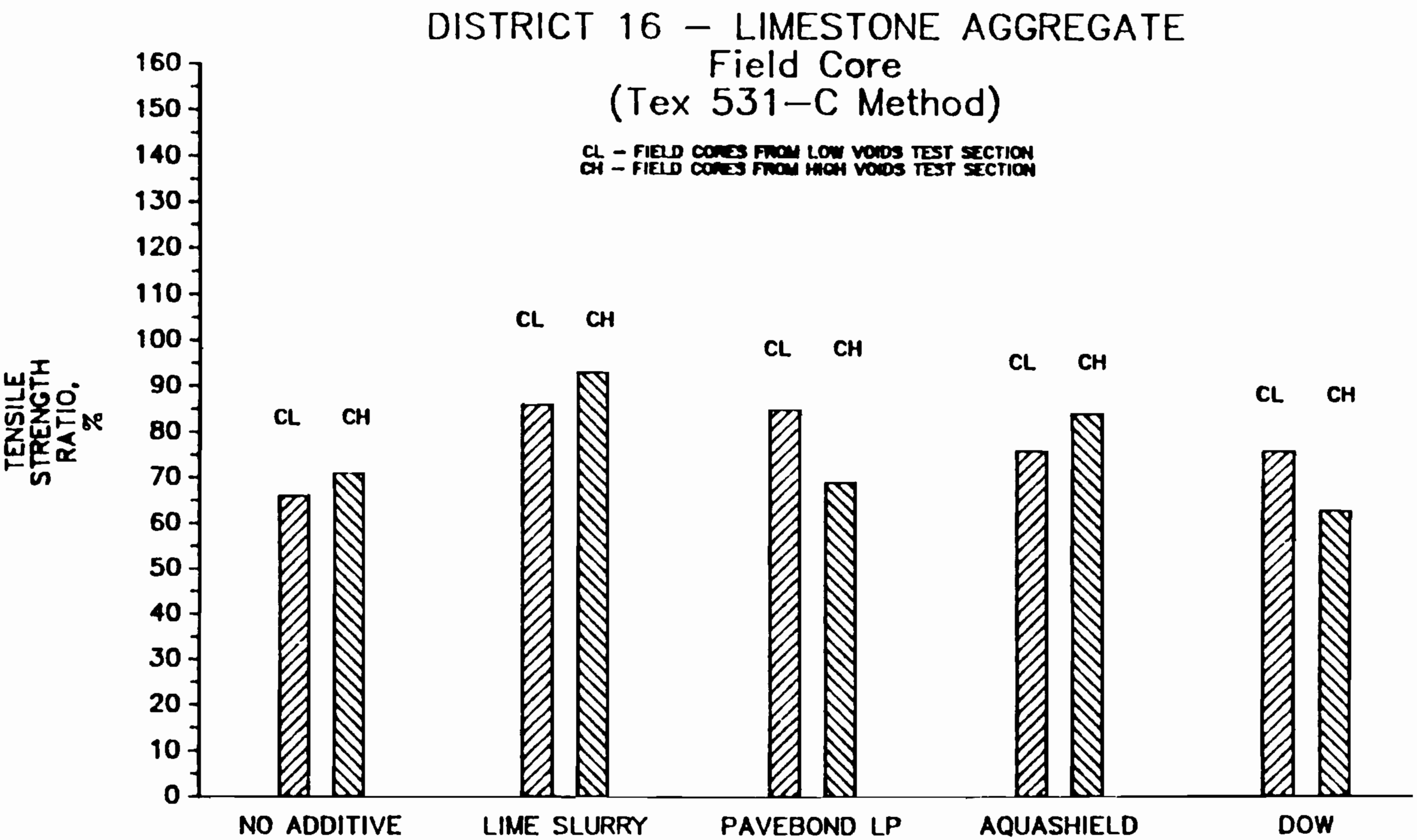


Fig B-9 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Field Cores.

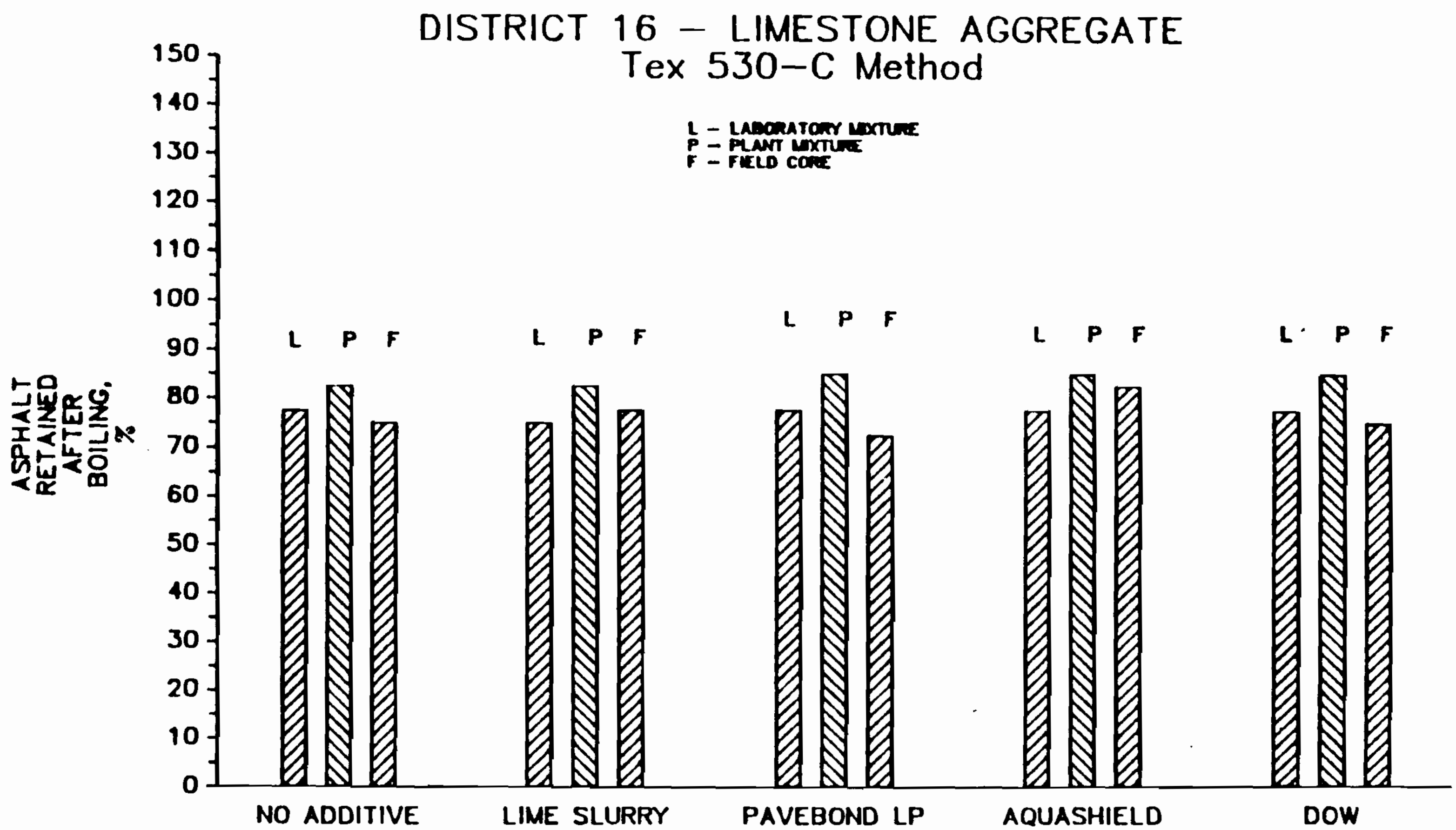


Fig B-10 Texas Boiling Test Results.

APPENDIX C

FIELD AND LABORATORY EXPERIMENTAL PROGRAM - DISTRICT 13

The objective of Appendix C is twofold: (1) to describe the site specific (District 13) field operations of the test sections along with a description of the materials, additives and construction techniques used for this field project, (2) to present the laboratory test results of the laboratory mixed and plant mixed asphalt mixtures along with the zero-aged (immediately after construction) pavement cores for the field experimental study at District 13 (Figure C-1) of the Texas State Department of Highways and Public Transportation (SDHPT).

FIELD EXPERIMENTAL PROGRAM

The test pavements were constructed on US 87 approximately 19 miles south of Victoria, Texas, in October 1986, and involved pavement overlay to one lane of the two lane highway. The test sections were installed as the surface course in the southbound lane, as shown schematically in Figure C-2. Each test section was approximately one to two inches thick, 12 feet wide, and 1000 feet long. The underlying old pavement was a portland cement concrete (PCC) pavement. A total of eight (8) test sections were constructed and two liquid antistripping additives were used in addition to the hydrated lime and the control materials. The composition of the eight test sections are as follows:

Test Section 1. Hot mix with 1.0% Perma-Tac Plus, low air voids.

Test Section 2. Hot mix with 1.0% Perma-Tac Plus, high air voids.

Test Section 3. Control Section - No additive, low air voids.

Test Section 4. Control Section - No additive, high air voids.

Test Section 5. Hot mix with 1.0% BA 2000, low air voids.

Test Section 6. Hot mix with 1.0% BA 2000, high air voids.

Test Section 7. Hot mix with 2.0% Lime Slurry, low air voids.

Test Section 8. Hot mix with 2.0% Lime Slurry, high air voids.

The field construction was conducted by District 13 of the Texas State Department of Highways and Public Transportation (SDHPT) and was assisted by the Center for Transportation Research, The University of Texas at Austin. The average daily traffic (ADT) is estimated at 4,200 vehicles for the test pavement.

MATERIALS AND PAVING MIXTURE

An AC-20 asphalt cement from Texas Fuel and Asphalt was used throughout this project. Four aggregates--a crushed gravel, a limestone coarse aggregate, a limestone screening, and a field sand, were combined to produce the project gradation. Gradations of the individual aggregates, the project gradation, percentages of each aggregate combined, and the specification are given on Table C-1. The project gradation is plotted on a 0.45 power graph in Figure C-3.

The asphalt concrete mixture used in this study met the SDHPT specifications of Item 340, Type D (Modified) fine graded surface course (Ref 45). Preliminary laboratory test results for this mixture design are given below:

Asphalt Content	-	5.0%
Average Density	-	97 percent of theoretical maximum density
Air Void Content	-	3 percent
Hveem Stability	-	46%

FIELD OPERATIONS

A weigh batch plant was used to prepare hot mixed asphalt mixtures containing lime slurry and liquid antistripping additives. Identical raw material sources (asphalt cement and aggregates) were utilized throughout the experiment. The actual asphalt content of the plant mix was 4.8%. Two commercially available liquid antistripping additives were used for the test sections, i.e., BA 2000 and Perma-Tac Plus.

The hydrated lime was mixed and added in slurry form to the aggregates on cold feed belt of weigh batch plant. The BA 2000 and Perma-Tac Plus were mixed with the asphalt cement in the storage tank.

Compaction of each test section was achieved using a vibratory roller, and a pneumatic roller. For the low air test sections, the same rolling pattern was used as established for the regular construction project. In order to achieve the high air void test sections, the vibratory roller was used in the static mode and the number of passes decreased.

The field cores were obtained soon after the construction. Three pairs of samples were cored from each test section with each pair approximately 200 feet apart. The sample size was approximately 4-inches in diameter and 1 to 2 inches in thickness. The coring process was in accordance with the general coring layout procedure described in the main text of this report (Chapter 2). The field cores were transported to the Center for Transportation Research laboratory immediately after sampling.

LABORATORY TESTING PROGRAM

The laboratory compacted specimens were made at such a compactive effort as to provide an approximately 7.0 $\pm$ 1.0% air void content. Two liquid antistripping additives were used in addition to the raw material and the hydrated lime slurry. The additives and the dosage are given below:

a. Hydrated lime slurry (2.0% by weight of aggregate).

b. BA 2000 (1.0% by weight of asphalt).

c. Perma-Tac Plus (1.0% by weight of asphalt).

The laboratory testing program was discussed in Chapter 2 of the main text and Appendix A, and was carried out through the duration of this study. Sample preparation, conditioning, test procedures and engineering properties analyzed for the test methods were also discussed in Chapter 2.

PRESENTATION OF TEST RESULTS

Laboratory Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables C-2 through C-5. The data are plotted in Figure C-4 for laboratory mixtures using Methods A through E. The cyclic freeze-thaw test results are shown in Figures C-5 and C-6.

Plant Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables C-6 through C-9. The data are also plotted in Figure C-7 for plant mixtures using Methods B through D.

Plant Mixed/Field Compacted Mixtures (Field Cores)

Summary of the test results are presented on Table C-10. The achieved field compaction to have the low and high air voids are summarized in Figure C-8 which shows the average air void content of the field cores from the low and high voids test sections in the field. The average TSR values are shown in Figure C-9 for the low and high voids test sections.

Texas Boiling Test Results

The Texas boiling test results are presented on Table C-11 and plotted in Figure C-10 for the laboratory mixture, the plant mixture, and the field core.

APPENDIX C SUMMARY OF DATA FOR DISTRICT 13

TABLE C-1 AGGREGATE GRADATION (DISTRICT 13)

SIEVE SIZE	CRUSHED GRAVEL SIEVE ANALYSIS	CRUSHED GRAVEL 50%	LIMESTONE SIEVE ANALYSIS	LIMESTONE 10%	LIMESTONE SCREENING SIEVE ANALYSIS	LIMESTONE SCREENING 20%	FIELD SAND SIEVE ANALYSIS	FIELD SAND 20%	COMBINED GRADATION	SDHPT SPECIFICATION
Plus 1/2 in.	0	0	0	0					0	0
1/2 to 3/8 in.	4.8	2.4	6.4	0.6	0	0	0	0	3.0	0-15
3/8 to No. 4	50.4	25.2	86.3	8.6	1.4	0.3	0.1	0.0	34.1	21-53
No. 4 to No. 10	36.0	18.0	4.8	0.5	31.6	6.3	0.1	0.0	24.8	11-32
Plus No. 10									61.9	54-74
No. 10 to No. 40	7.3	3.6	0.7	0.1	46.3	9.3	16.8	3.4	16.4	6-32
No. 40 to No. 80	0.3	0.2	0.1	0.0	12.2	2.4	59.7	11.9	14.5	4-27
No. 80 to No.200	0.7	0.3	0.2	0.0	3.4	0.7	18.5	3.7	4.7	3-27
Minus No. 200	0.5	0.3	1.5	0.2	5.1	1.0	4.8	1.0	2.5	1-8
TOTAL	100.0	50.0	100.0	10.0	100.0	20.0	100.0	20.0	100.0	

TABLE C-2 TEST RESULTS FOR LABORATORY MIXTURES (D-13)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.9	140.6	70	
	A2	DRY	7.2	141.7	71	
	A3	DRY	7.3	141.6	75	
		DRY AVG	7.5	141.3	72	
	A4	WET	7.2	141.7	35	
	A5	WET	7.4	141.4	31	
	A6	WET	7.5	141.3	28	
		WET AVG	7.3	141.5	31	0.43
B	B1	DRY	6.7	142.5	93	
	B2	DRY	7.2	141.7	84	
	B3	DRY	7.0	142.0	85	
		DRY AVG**	7.0	142.0	87	
	B4	WET	6.8	142.3	48	
	B5	WET	6.7	142.5	52	
	B6	WET	6.7	142.4	44	
		WET AVG	6.7	142.4	48	0.55
C	C1	WET	6.9	142.1	48	
	C2	WET	6.7	142.5	49	
	C3	WET	7.1	141.9	42	
		WET AVG	6.9	142.2	46	
		DRY AVG**	7.0	142.0	87	0.53
D	D1	WET	7.0	142.0	58	
	D2	WET	6.8	142.4	63	
	D3	WET	7.0	142.1	63	
		WET AVG	6.9	142.1	62	
		DRY AVG**	7.0	142.0	87	0.70

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE C-2 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.6	142.5	78	
	E2	1 CYCLE	6.7	142.5	64	
		WET AVG	6.7	142.5	71	
		DRY AVG**	7.0	142.0	87	0.81
	E3	3 CYCLES	7.0	142.1	46	
	E4	3 CYCLES	6.9	142.2	54	
		WET AVG	6.9	142.1	50	
		DRY AVG**	7.0	142.0	87	0.57
E	E5	5 CYCLES	6.7	142.5	39	
	E6	5 CYCLES	6.6	142.5	37	
		WET AVG	6.7	142.5	38	
		DRY AVG**	7.0	142.0	87	0.43
	E7	7 CYCLES	7.1	141.8	31	
	E8	7 CYCLES	6.9	142.1	31	
		WET AVG	7.0	141.9	31	
		DRY AVG**	7.0	142.0	87	0.36
	E9	9 CYCLES	7.0	142.0	28	
	E10	9 CYCLES	6.7	142.5	31	
		WET AVG	6.8	142.2	29	
		DRY AVG**	7.0	142.0	87	0.33

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE C-3 TEST RESULTS FOR LABORATORY MIXTURES (D-13)
ADDITIVE: LIME SLURRY (2.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	7.9	140.7	67	
	A2	DRY	7.5	141.3	78	
	A3	DRY	7.5	141.3	85	
		DRY AVG	7.6	141.1	77	
A						
	A4	WET	7.0	142.0	122	
	A5	WET	7.5	141.3	101	
	A6	WET	7.5	141.4	103	
		WET AVG	7.3	141.6	109	
						1.42
	B1	DRY	7.7	141.0	81	
	B2	DRY	8.0	140.5	78	
	B3	DRY	7.7	141.0	77	
		DRY AVG**	7.8	140.8	79	
B						
	B4	WET	7.3	141.6	105	
	B5	WET	8.0	140.5	98	
	B6	WET	8.0	140.6	97	
		WET AVG	7.8	140.9	100	
						1.27
	C1	WET	7.9	140.7	96	
	C2	WET	7.9	140.7	99	
	C3	WET	7.8	140.8	93	
		WET AVG	7.9	140.7	96	
C						
		DRY AVG**	7.8	140.8	79	
						1.22
	D1	WET	7.9	140.7	104	
	D2	WET	7.9	140.6	99	
	D3	WET	7.8	140.9	95	
		WET AVG	7.9	140.7	99	
D						
		DRY AVG**	7.8	140.8	79	
						1.26

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE C-3 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	8.0	140.6	95	
	E2	1 CYCLE	8.0	140.5	93	
		WET AVG	8.0	140.6	94	
		DRY AVG**	7.8	140.8	79	
						1.19
	E3	3 CYCLES	7.9	140.7	84	
	E4	3 CYCLES	7.8	140.9	81	
		WET AVG	7.8	140.8	82	
		DRY AVG**	7.8	140.8	79	
						1.05
E	E5	5 CYCLES	7.3	141.6	86	
	E6	5 CYCLES	7.7	141.0	81	
		WET AVG	7.5	141.3	84	
		DRY AVG**	7.8	140.8	79	
						1.06
	E7	7 CYCLES	8.0	140.5	77	
	E8	7 CYCLES	7.6	141.2	68	
		WET AVG	7.8	140.8	73	
		DRY AVG**	7.8	140.8	79	
						0.92
	E9	9 CYCLES	7.6	141.1	81	
	E10	9 CYCLES	7.4	141.5	80	
		WET AVG	7.5	141.3	81	
		DRY AVG**	7.8	140.8	79	
						1.02

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE C-4 TEST RESULTS FOR LABORATORY MIXTURES (D-13)
ADDITIVE: BA 2000 (1.0%)
ASPHALT CONTENT = 5.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	7.0	141.8	107	
	A2	DRY	6.4	142.6	111	
	A3	DRY	7.2	141.4	107	
		DRY AVG	6.9	141.9	108	
A						
	A4	WET	6.3	142.8	70	
	A5	WET	6.8	142.0	76	
	A6	WET	6.5	142.5	61	
		WET AVG	6.5	142.4	69	
						0.64
	B1	DRY	7.5	140.9	94	
	B2	DRY	6.5	142.5	105	
	B3	DRY	7.1	141.5	97	
		DRY AVG**	7.0	141.6	99	
B						
	B4	WET	7.4	141.1	63	
	B5	WET	7.5	141.0	66	
	B6	WET	7.6	140.8	67	
		WET AVG	7.5	140.9	65	
						0.66
	C1	WET	6.6	142.3	79	
	C2	WET	6.6	142.3	80	
	C3	WET	6.7	142.2	74	
		WET AVG	6.6	142.3	78	
C						
		DRY AVG**	7.0	141.6	99	
						0.79
	D1	WET	7.2	141.4	83	
	D2	WET	6.6	142.3	88	
	D3	WET	7.0	141.8	80	
		WET AVG	6.9	141.8	84	
D						
		DRY AVG**	7.0	141.6	99	
						0.85

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE C-4 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.8	142.1	115	
	E2	1 CYCLE	6.4	142.6	124	
		WET AVG	6.6	142.3	120	
		DRY AVG**	7.0	141.6	99	1.21
	E3	3 CYCLES	6.8	142.0	100	
	E4	3 CYCLES	6.9	141.9	101	
		WET AVG	6.9	141.9	101	
		DRY AVG**	7.0	141.6	99	1.02
E	E5	5 CYCLES	6.1	143.1	101	
	E6	5 CYCLES	6.5	142.5	97	
		WET AVG	6.3	142.8	99	
		DRY AVG**	7.0	141.6	99	1.00
	E7	7 CYCLES	7.0	141.7	52	
	E8	7 CYCLES	7.3	141.3	54	
		WET AVG	7.1	141.5	53	
		DRY AVG**	7.0	141.6	99	0.54
	E9	9 CYCLES	6.9	141.9	78	
	E10	9 CYCLES	6.7	142.1	79	
		WET AVG	6.8	142.0	78	
		DRY AVG**	7.0	141.6	99	0.79

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE C-5 TEST RESULTS FOR LABORATORY MIXTURES (D-13)
ADDITIVE: PERMA-TAC PLUS (1.0%)
ASPHALT CONTENT = 5.0%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	7.6	141.6	87	
	A2	DRY	7.3	142.0	87	
	A3	DRY	7.2	142.2	90	
		DRY AVG	7.4	141.9	88	
A						
	A4	WET	7.3	142.1	53	
	A5	WET	7.4	142.0	54	
	A6	WET	7.5	141.7	55	
		WET AVG	7.4	141.9	54	
						0.61
	B1	DRY	7.6	141.7	79	
	B2	DRY	8.0	140.9	77	
	B3	DRY	7.2	142.2	83	
		DRY AVG**	7.6	141.6	80	
B						
	B4	WET	7.4	141.9	56	
	B5	WET	7.3	142.1	58	
	B6	WET	7.7	141.5	52	
		WET AVG	7.5	141.8	55	
						0.69
	C1	WET	8.0	141.0	57	
	C2	WET	7.1	142.3	64	
	C3	WET	7.3	142.1	66	
		WET AVG	7.5	141.8	62	
C						
		DRY AVG**	7.6	141.6	88	
						0.78
	D1	WET	7.8	141.4	71	
	D2	WET	7.5	141.8	73	
	D3	WET	7.9	141.1	67	
		WET AVG	7.7	141.4	70	
D						
		DRY AVG**	7.6	141.6	88	
						0.88

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE C-5 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	8.0	141.0	78	
	E2	1 CYCLE	7.5	141.7	87	
		WET AVG	7.8	141.4	83	
		DRY AVG**	7.6	141.6	80	1.03
	E3	3 CYCLES	7.2	142.2	89	
	E4	3 CYCLES	7.9	141.2	79	
		WET AVG	7.5	141.7	84	
		DRY AVG**	7.6	141.6	80	1.05
E	E5	5 CYCLES	7.7	141.4	73	
	E6	5 CYCLES	7.7	141.4	70	
		WET AVG	7.7	141.4	72	
		DRY AVG**	7.6	141.6	80	0.89
	E7	7 CYCLES	7.8	141.4	53	
	E8	7 CYCLES	7.7	141.5	58	
		WET AVG	7.7	141.4	56	
		DRY AVG**	7.6	141.6	80	0.70
	E9	9 CYCLES	7.7	141.5	69	
	E10	9 CYCLES	7.2	142.2	74	
		WET AVG	7.4	141.9	72	
		DRY AVG**	7.6	141.6	80	0.90

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE C-6 TEST RESULTS FOR PLANT MIXTURES (D-13)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.1	141.3	94	
	B2	DRY	6.9	141.7	92	
	B3	DRY	6.8	141.7	91	
		DRY AVG**	6.9	141.6	92	
	B4	WET	6.8	141.7	93	
	B5	WET	6.8	141.8	99	
	B6	WET	6.8	141.9	94	
		WET AVG	6.8	141.8	95	1.03
C	C1	WET	6.7	141.9	95	
	C2	WET	6.8	141.8	101	
	C3	WET	7.4	140.9	87	
		WET AVG	7.0	141.5	94	
		DRY AVG**	6.9	141.6	92	1.02
D	D1	WET	6.8	141.8	93	
	D2	WET	7.1	141.4	95	
	D3	WET	7.1	141.3	83	
		WET AVG	7.0	141.5	90	
		DRY AVG**	6.9	141.6	92	0.98

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE C-7 TEST RESULTS FOR PLANT MIXTURES (D-13)
ADDITIVE: LIME SLURRY (2.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.0	141.1	108	
	B2	DRY	6.9	141.3	99	
		DRY AVG**	6.9	141.2	104	
	B4	WET	7.1	140.9	107	
	B5	WET	6.8	141.4	116	
	B6	WET	7.5	140.3	96	
		WET AVG	7.1	140.9	106	
						1.03
C	C1	WET	7.2	140.8	110	
	C2	WET	7.2	140.8	104	
	C3	WET	7.2	140.7	103	
		WET AVG	7.2	140.8	106	
		DRY AVG**	6.9	141.2	104	
						1.02
D	D1	WET	6.4	142.0	104	
	D2	WET	7.0	141.1	100	
	D3	WET	6.6	141.7	97	
		WET AVG	6.7	141.6	100	
		DRY AVG**	6.9	141.2	104	
						0.97
****	B3	DRY	5.1	144.0	96	

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)
****The air voids exceed the tolerance.

TABLE C-8 TEST RESULTS FOR PLANT MIXTURES (D-13)
ADDITIVE: BA 2000 (1.0%)
ASPHALT CONTENT = 5.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	6.2	142.5	128	
	B2	DRY	6.1	142.6	127	
	B3	DRY	6.3	142.4	128	
		DRY AVG**	6.2	142.5	128	
B	B4	WET	6.0	142.8	139	
	B5	WET	6.2	142.6	126	
	B6	WET	6.0	142.8	147	
		WET AVG	6.1	142.7	137	1.08
	C1	WET	6.2	142.6	122	
	C2	WET	6.0	142.8	121	
	C3	WET	6.1	142.6	126	
C		WET AVG	6.1	142.7	123	
		DRY AVG**	6.2	142.5	128	0.96
	D1	WET	6.2	142.5	131	
	D2	WET	6.0	142.8	131	
	D3	WET	6.3	142.4	118	
D		WET AVG	6.2	142.5	127	
		DRY AVG**	6.2	142.5	128	0.99

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE C-9 TEST RESULTS FOR PLANT MIXTURES (D-13)
ADDITIVE: PERMA-TAC PLUS (1.0%)
ASPHALT CONTENT = 5.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.2	142.9	103	
	B2	DRY	6.6	142.2	106	
	B3	DRY	6.1	143.0	101	
		DRY AVG**	6.3	142.7	103	
	B4	WET	6.0	143.1	104	
	B5	WET	6.0	143.1	105	
	B6	WET	6.1	143.0	101	
		WET AVG	6.0	143.1	103	1.00
C	C1	WET	6.5	142.3	106	
	C2	WET	6.0	143.1	106	
	C3	WET	6.1	143.0	93	
		WET AVG	6.2	142.8	102	
		DRY AVG**	6.3	142.7	103	0.98
D	D1	WET	6.1	143.0	104	
	D2	WET	6.3	142.7	93	
	D3	WET	6.1	142.9	101	
		WET AVG	6.2	142.9	99	
		DRY AVG**	6.3	142.7	103	0.96

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE C-10 TEST RESULTS FOR FIELD CORES
DISTRICT 13
ASPHALT CONTENT = 5.0 %

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
NO ADDITIVE (CONTROL)	LOW AIR VOIDS SECTION	1A	DRY	5.5	143.8	95	
		1B	WET	5.4	143.9	75	
							0.79
		2A	WET	6.5	142.2	76	
		2B	DRY	6.4	142.3	87	
							0.87
		3A	DRY	4.7	144.9	92	
		3B	WET	4.9	144.6	87	
							0.95
		(AVG VOIDS)		5.6		(AVG TSR)	0.87
	HIGH AIR VOIDS SECTION	4A	WET	6.1	142.9	63	
		4B	DRY	6.4	142.4	84	
							0.75
		5A	DRY	7.2	141.2	73	
		5B	WET	5.7	143.4	80	
							1.09
		6A	WET	7.7	140.4	57	
		6B	DRY	4.2	145.7	91	
							0.62
		(AVG VOIDS)		6.2		(AVG TSR)	0.82
LIME SLURRY	LOW AIR VOIDS SECTION	7A	DRY	4.4	145.1	92	
		7B	WET	9.6	137.1	53	
							0.58
		8A	WET	4.4	145.0	93	
		8B	DRY	4.4	145.1	95	
							0.99
		9A	DRY	4.2	145.3	93	
		9B	WET	6.1	142.4	85	
							0.91
		(AVG VOIDS)		5.5		(AVG TSR)	0.82
	HIGH AIR VOIDS SECTION	10A	WET	6.7	141.6	81	
		10B	DRY	6.4	141.9	80	
							1.02
		11A	DRY	3.9	145.8	88	
		11B	WET	3.7	146.1	98	
							1.12
		(AVG VOIDS)		5.2		(AVG TSR)	1.07
	LOW AIR VOIDS SECTION	12A	DRY	4.4	145.3	100	
		12B	WET	5.6	143.4	77	
							0.77
		13A	WET	4.8	144.7	94	
		13B	DRY	6.8	141.7	84	
							1.12
		14A	DRY	6.0	142.8	93	

TABLE C-10 (Continued)

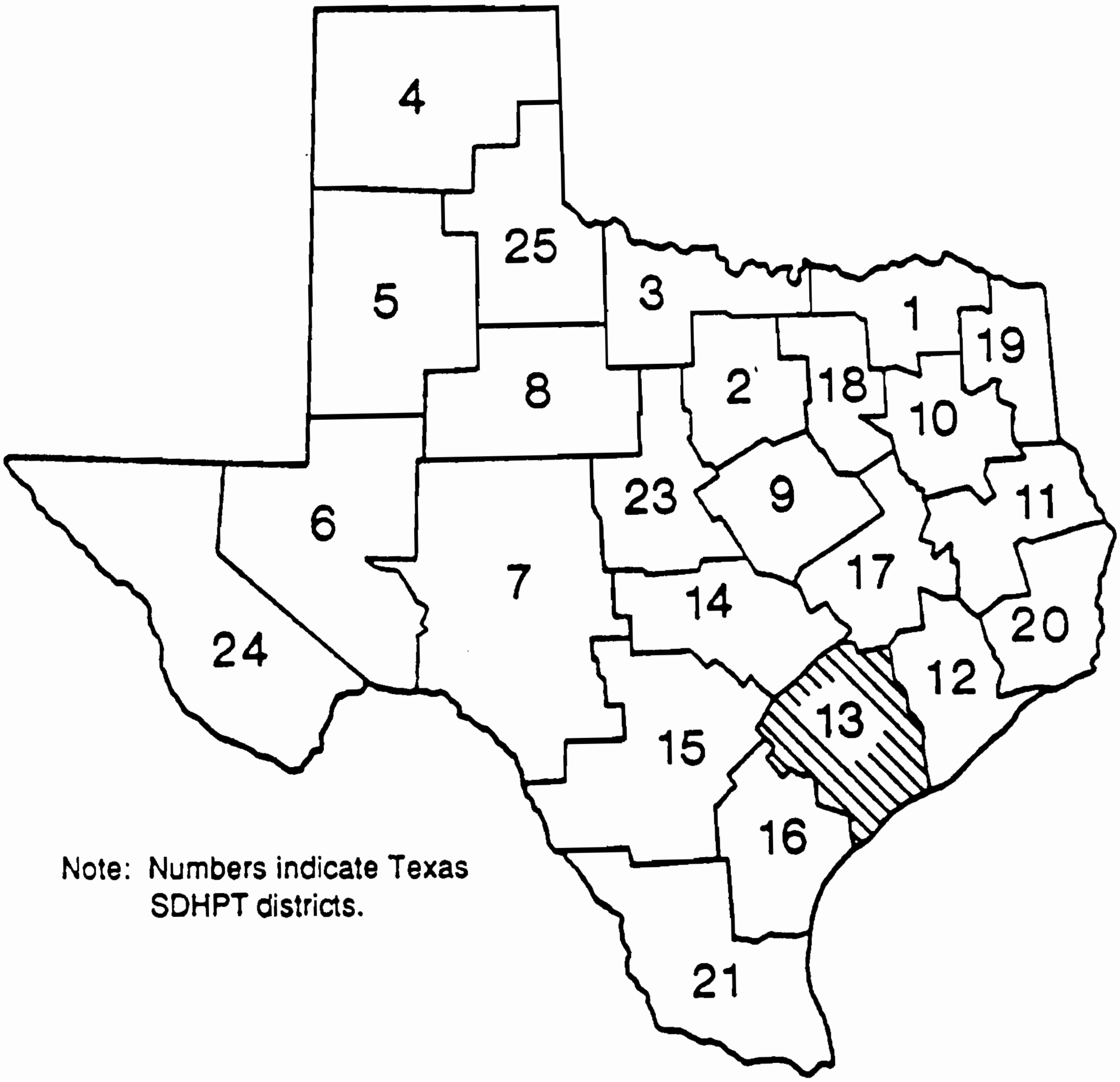
TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		14B	WET	7.3	140.9	83	
							0.89
		(AVG VOIDS)		5.8		(AVG TSR)	0.93
BA 2000							
	HIGH AIR VOIDS SECTION	15A	WET	7.5	140.6	77	
		15B	DRY	5.4	143.8	89	
							0.87
		16A	DRY	5.8	143.1	84	
		16B	WET	6.7	141.8	76	
							0.90
		17A	WET	6.2	142.5	77	
		17B	DRY	5.0	144.4	88	
							0.87
		(AVG VOIDS)		6.1		(AVG TSR)	0.88
	LOW AIR VOIDS SECTION	18A	WET	4.9	144.8	96	
		18B	DRY	3.3	147.2	102	
							0.94
		19A	DRY	4.7	145.1	102	
		19B	WET	3.4	147.1	96	
							0.94
		20A	WET	5.4	144.0	85	
		20B	DRY	3.8	146.5	104	
							0.82
		(AVG VOIDS)		4.3		(AVG TSR)	0.90
PERMA-TAC PLUS	HIGH AIR VOIDS SECTION	21A	DRY	5.8	143.4	79	
		21B	WET	5.6	143.8	87	
							1.10
		22A	WET	5.2	144.4	86	
		22B	DRY	5.6	143.8	75	
							1.16
		23A	DRY	4.4	145.6	82	
		23B	WET	4.5	145.4	94	
							1.15
		24A	WET	6.7	142.0	73	
		24B	DRY	5.9	143.3	84	
							0.88
		25A	DRY	7.1	141.4	71	
		25B	WET	4.8	145.0	84	
							1.19
		26A	WET	5.1	144.5	83	
		26B	DRY	5.8	143.4	81	
							1.02
		(AVG VOIDS)		5.5		(AVG TSR)	1.08

*TSR = Tensile Strength Ratio
= Tensile Strength (Wet)/Tensile Strength (Dry)

TABLE C-11 BOILING TEST RESULTS
DISTRICT 13

TYPE OF MIXTURE	TYPE OF ADDITIVE	ASPHALT RETAINED AFTER BOILING, %		
		RATING 1	RATING 2	AVG
	NO ADDITIVE	75	80	77.5
LABORATORY	LIME	98	95	96.5
	BA 2000	100	95	97.5
	PERMA-TAC	98	95	96.5
	NO ADDITIVE	70	85	77.5
PLANT	LIME	98	95	96.5
	BA 2000	98	95	96.5
	PERMA-TAC	95	95	95.0
	NO ADDITIVE	85	80	82.5
FIELD CORE	LIME	90	90	90.0
	BA 2000	95	90	92.5
	PERMA-TAC	95	90	92.5

APPENDIX C LIST OF FIGURES



Note: Numbers indicate Texas SDHPT districts.

Figure C-1. Location of Field Test Sections (District 13).

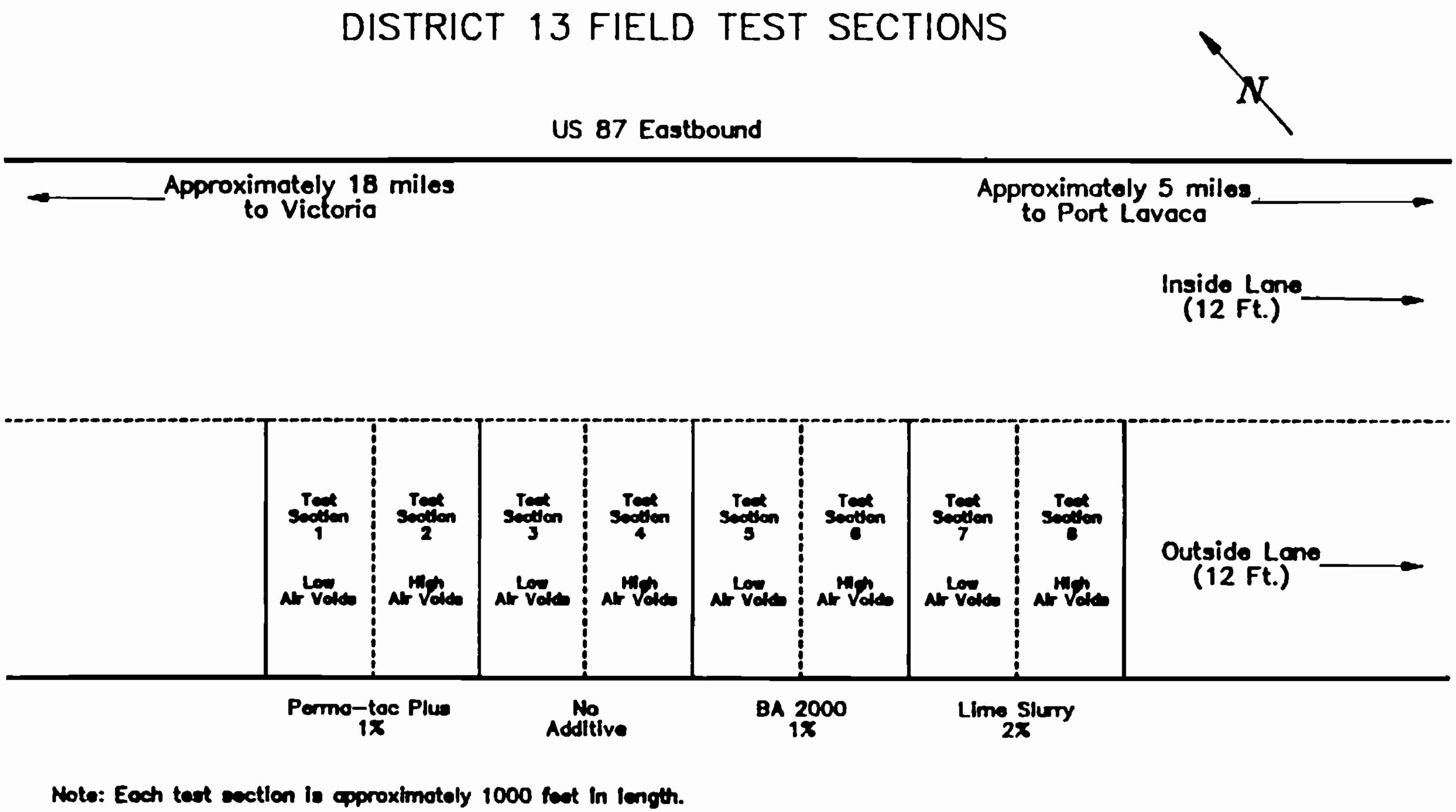


Fig C-2 Schematic Illustration of Field Test Sections.

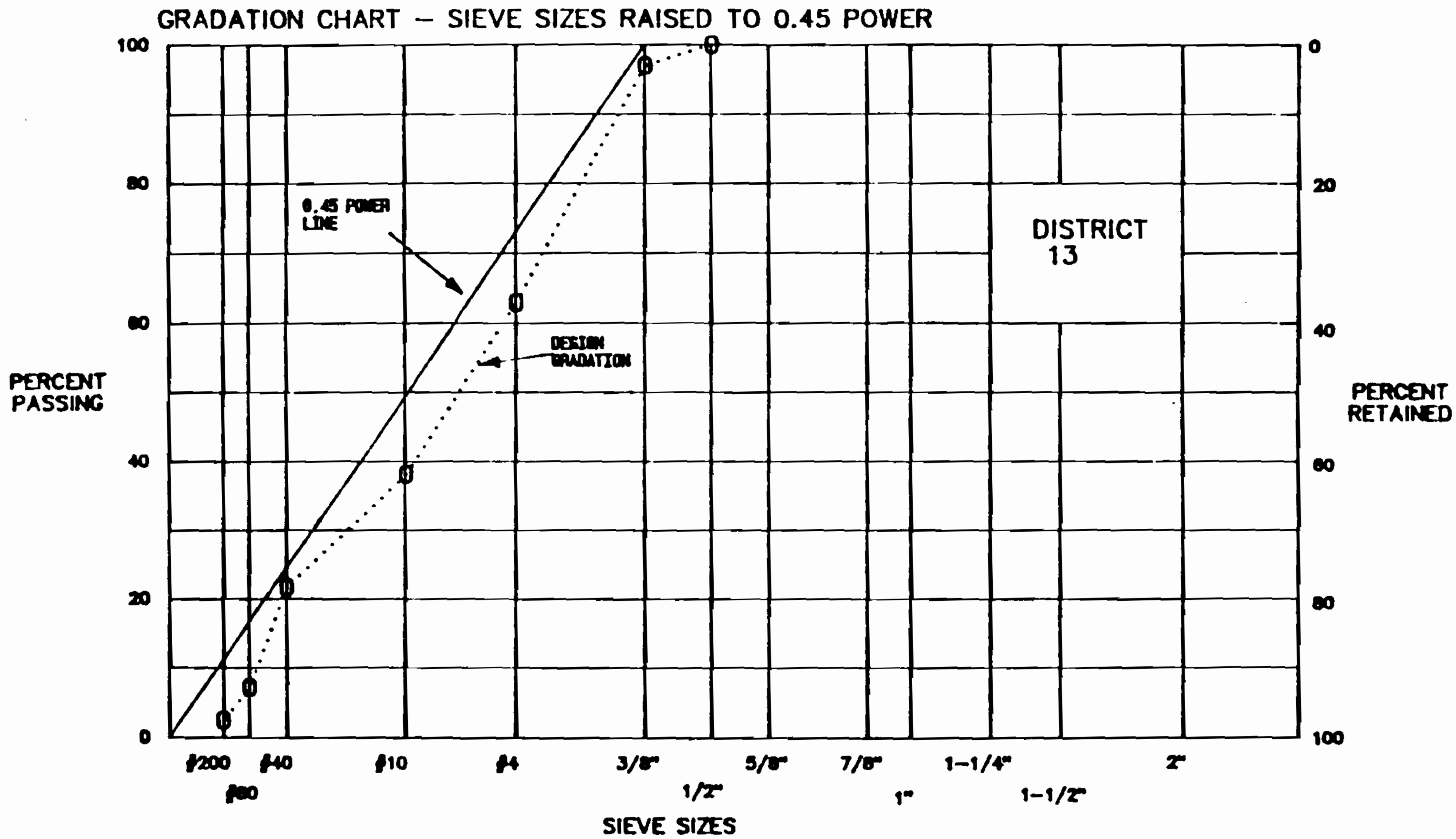


Fig C-3 Aggregate Gradation Chart.

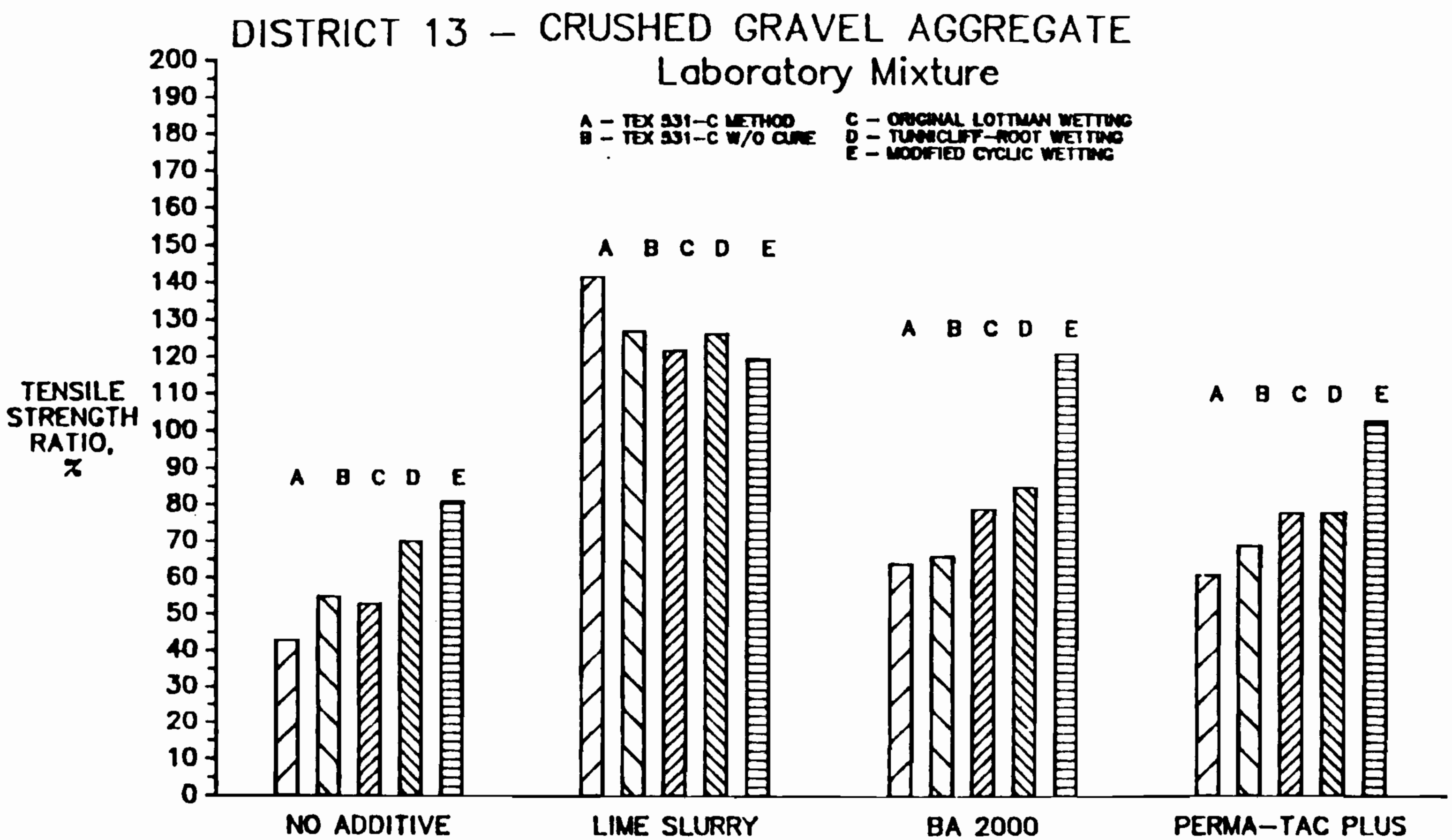


Fig C-4 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

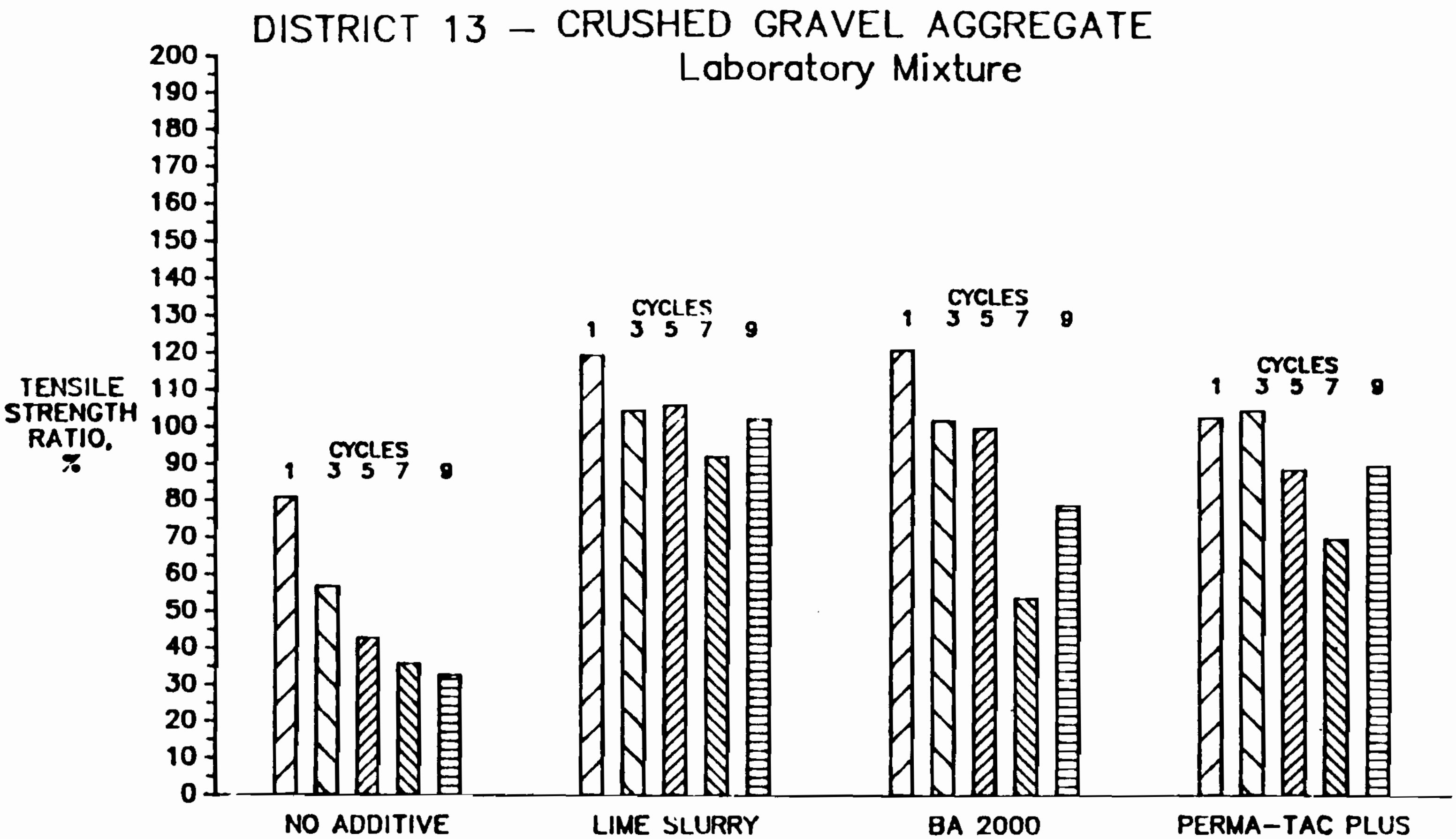


Fig C-5 Wet-Dry Indirect Tensile Cyclic Freeze-Thaw Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

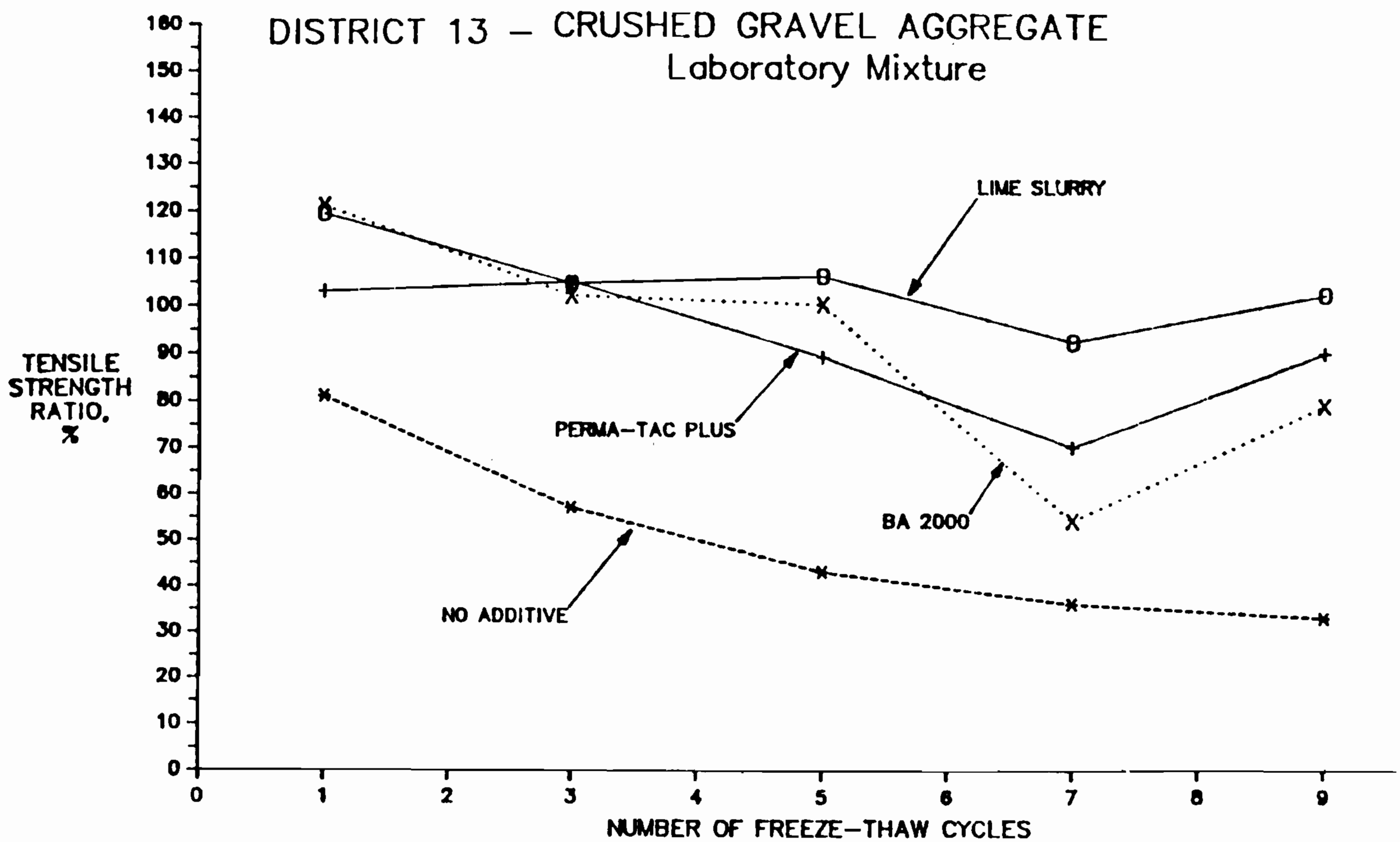


Fig C-6 Tensile Strength Ratio (TSR) Vs. Number of Freeze-Thaw Cycles for Laboratory Mixtures.

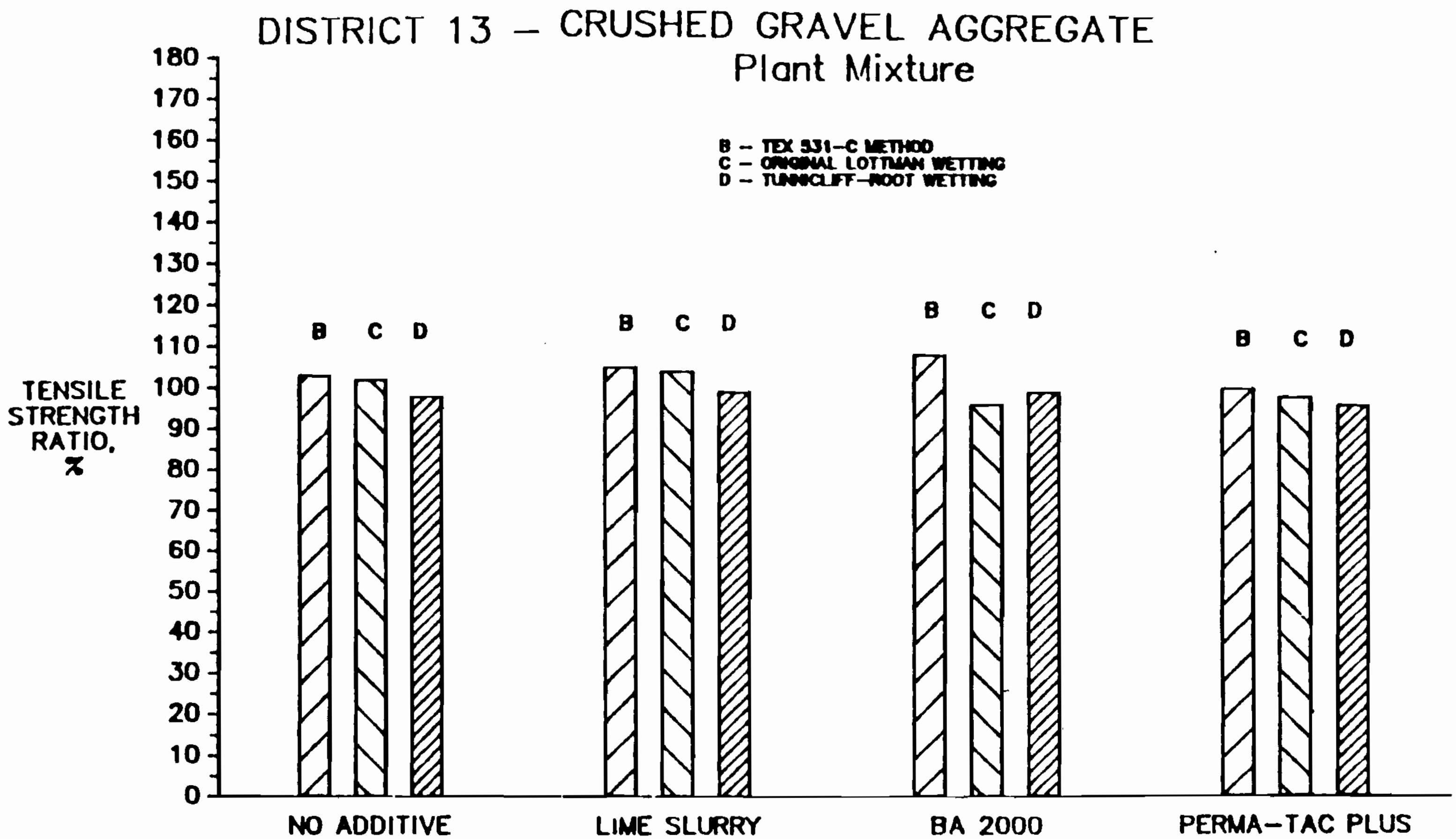


Fig C-7 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Plant Mixtures.

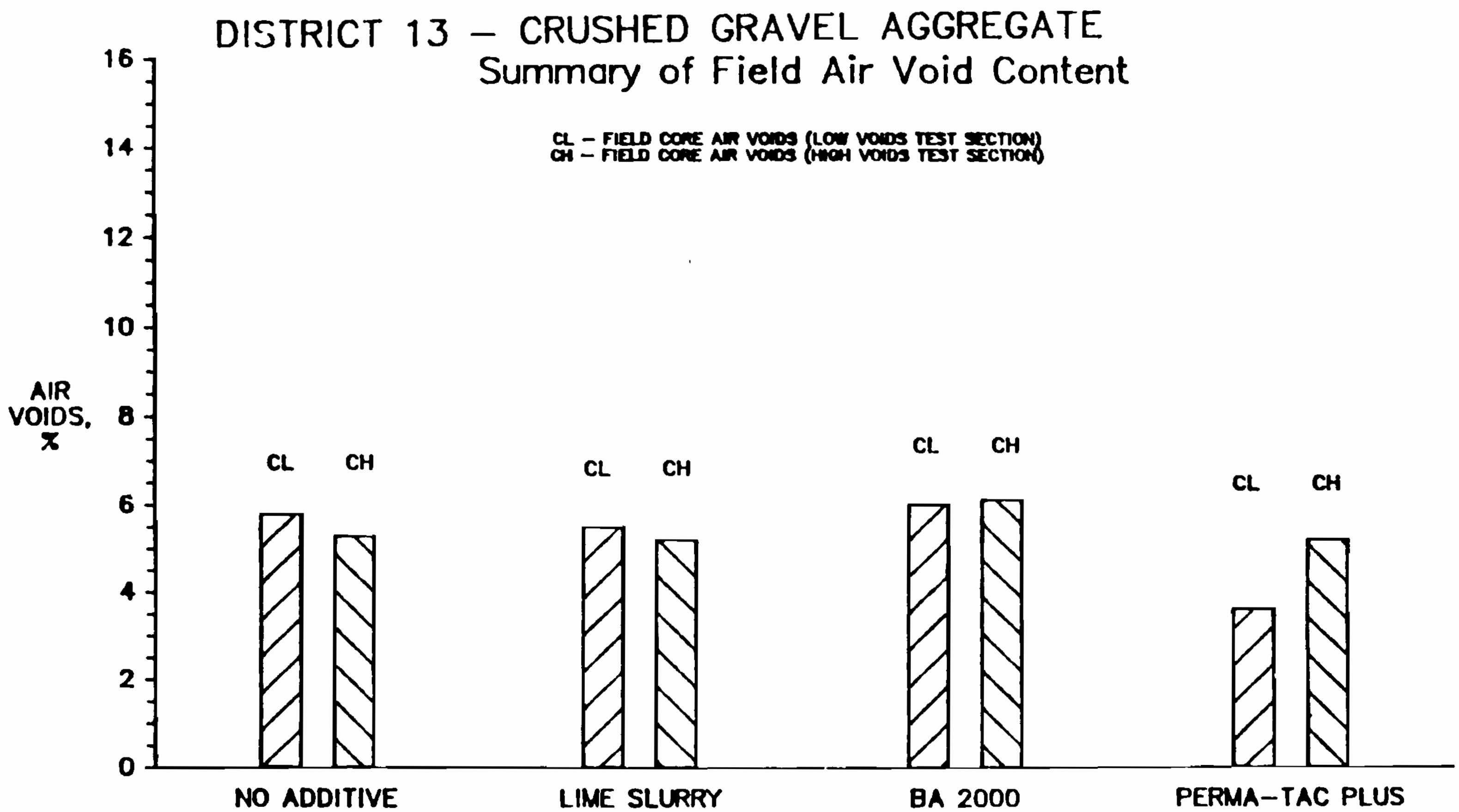


Fig C-8 Summary of Field Core Air Void Content.

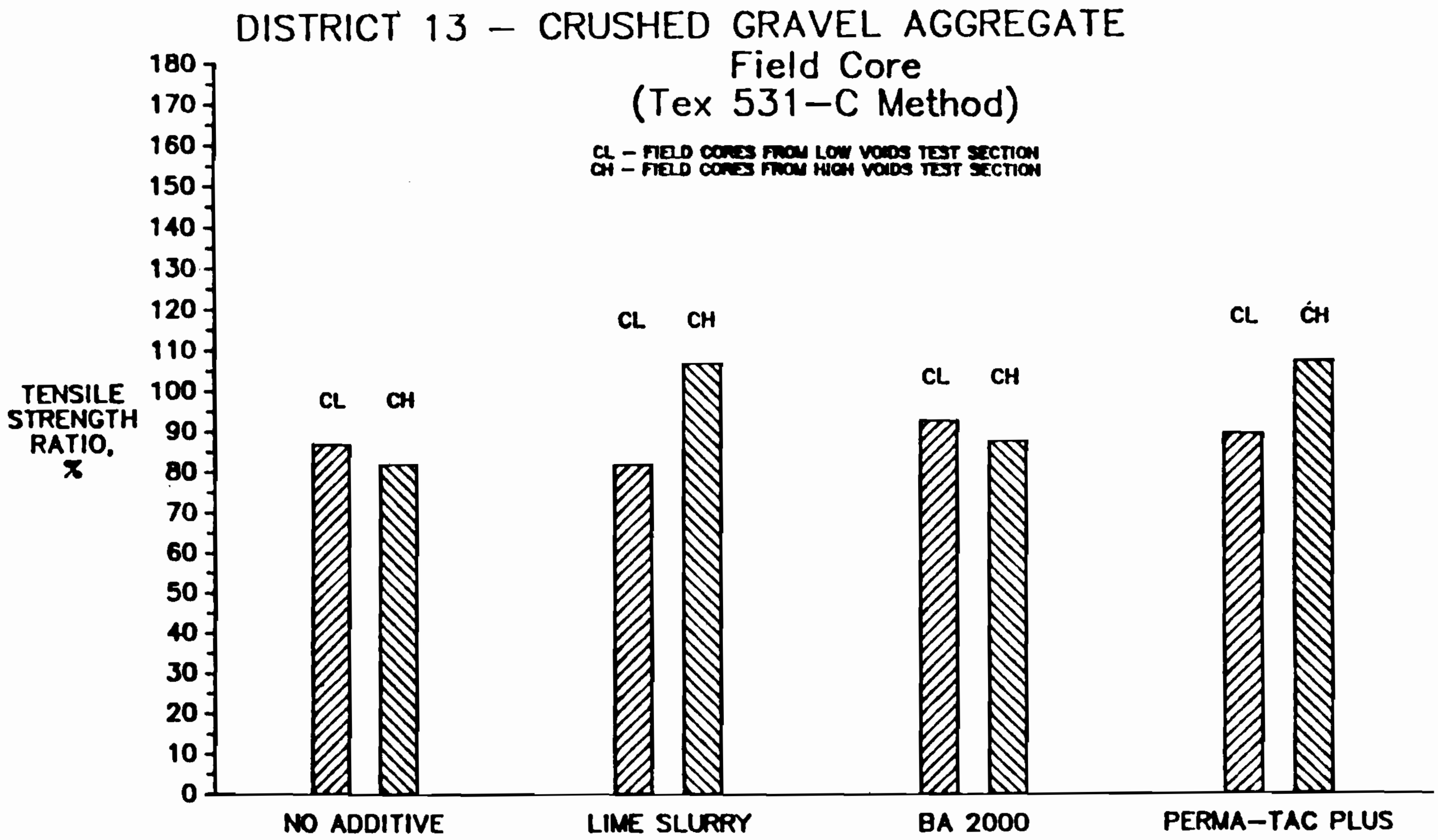


Fig C-9 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Field Cores.

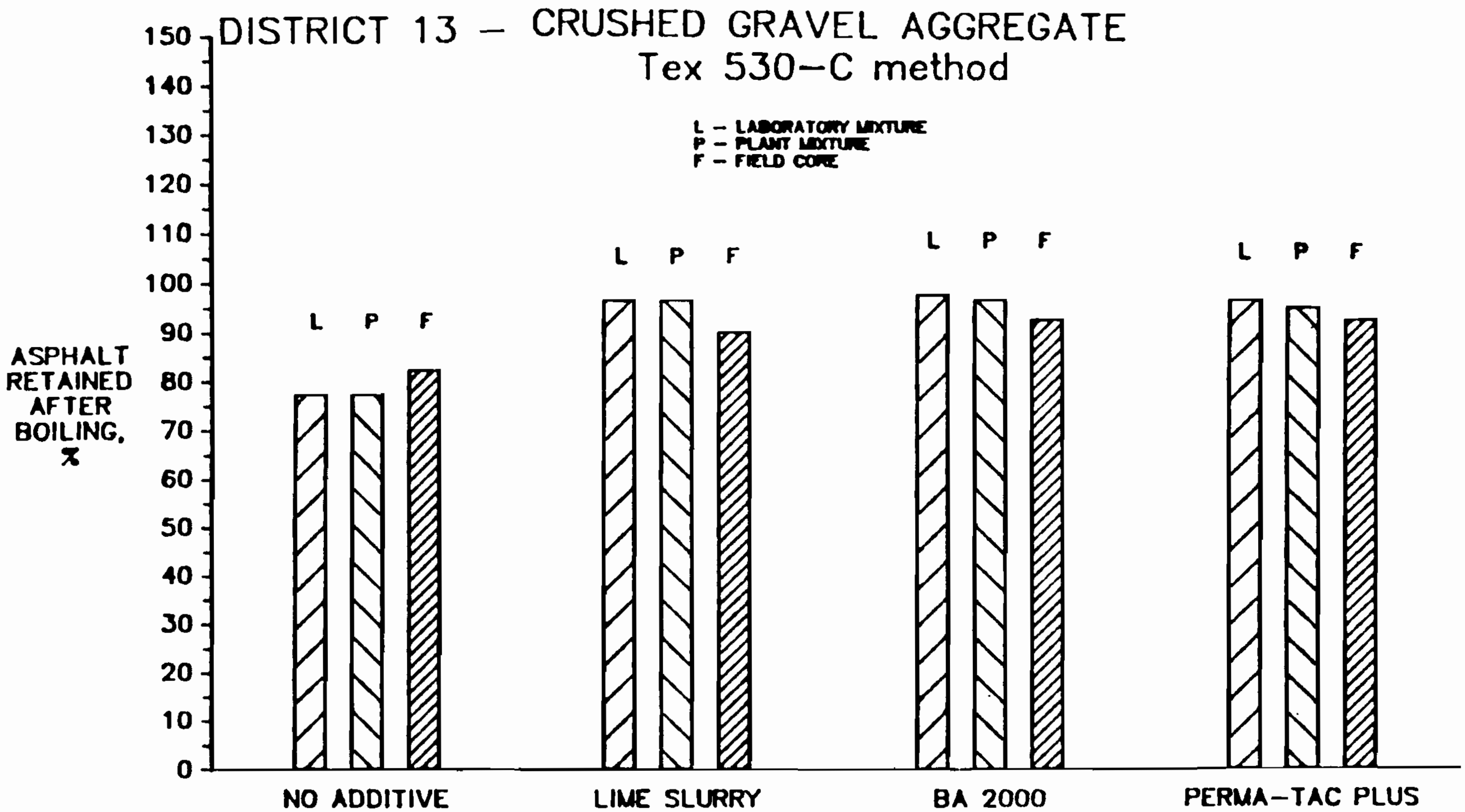


Fig C-10 Texas Boiling Test Results.

APPENDIX D

FIELD AND LABORATORY EXPERIMENTAL PROGRAM - DISTRICT 6

The objective of Appendix D is twofold: (1)to describe the site specific (District 6) field operations of the test sections along with a description of the materials, additives and construction techniques used for this field project, (2) to present the laboratory test results of the laboratory mixed and plant mixed asphalt mixtures along with the zero-aged (immediately after construction) pavement cores for the field experimental study at District 6 (Figure D-1) of the Texas State Department of Highways and Public Transportation (SDHPT).

FIELD EXPERIMENTAL PROGRAM

The test pavements were constructed on Spur 268 in Midland, Texas, in November 1986, and involved pavement overlay to two lanes of the roadway. The test sections were installed as the surface course in the two main westbound travel lanes as shown schematically in Figure D-2. Each test section was approximately two inches thick, 12 feet wide, and 1000 feet long. A total of ten (10) test sections were constructed and three liquid antistripping additives were used in addition to the hydrated lime and the control materials. The composition of the ten test sections are as follows:

Test Section 1. Hot mix with 1.0% Perma-Tac, low air voids.

Test Section 2. Hot mix with 1.0% Unichem, low air voids.

Test Section 3. Hot mix with 1.0% Pavebond LP, low air voids.

Test Section 4. Control Section - No additive, low air voids.

Test Section 5. Hot mix with 1.0% Lime Slurry, low air voids.

Test Section 6. Hot mix with 1.0% Perma-Tac, high air voids.

Test Section 7. Hot mix with 1.0% Unichem, high air voids.

Test Section 8. Hot mix with 1.0% Pavebond LP, high air voids.

Test Section 9. Control Section - No additive, high air voids.

Test Section 10. Hot mix with 1.0% lime slurry, high air voids

The field construction was conducted by District 6 of the Texas State Department of Highways and Public Transportation (SDHPT) and was assisted by the Center for Transportation Research, The University of Texas at Austin. The average daily traffic (ADT) is estimated at 13,900 vehicles for the test pavement.

MATERIALS AND PAVING MIXTURE

An AC-20 asphalt cement from the American Petrofina refinery in Big Spring, Texas was used throughout this project. Three aggregates--a Rhyolite "D" rock, a limestone screening, and a field sand, were combined to produce the project gradation. Gradations of the individual aggregates, the project gradation, percentages of each aggregate combined, and the specification are given on Table D-1. The project gradation is plotted on a 0.45 power graph in Figure D-3.

The asphalt concrete mixture used in this study met the SDHPT specifications of Item 340, Type D (Modified) fine graded surface course (Ref 45). Preliminary laboratory test results for this mixture design are given below:

Asphalt Content	-	6.2%
Average Density	-	95.5 percent of theoretical maximum density
Air Void Content	-	4.5 percent
Hveem Stability	-	49%

FIELD OPERATIONS

A drum mix plant was used to prepare hot mixed asphalt mixtures containing lime and liquid antistripping additives. Identical raw material sources (asphalt cement and aggregates) were utilized throughout the experiment. Three commercially available liquid antistripping additives were used for the test sections, i.e., Pavebond LP, Perma-Tac, and Unichem.

The dry lime was added in layers about 12 hours prior to use after the coarse aggregate stockpile was watered down. The Pavebond LP, Perma-Tac, and Unichem were metered into the asphalt cement in-line injection system.

Compaction of each test section was achieved using a 3 wheel static roller, a tandem static steel wheel roller, a 25-ton pneumatic roller and a 12-ton pneumatic roller. The field air voids were controlled using a Troxler Thin Layer Asphalt Gauge and a rolling pattern was established for all of the low air void test sections. For the high air void test sections, the rolling pattern was altered and the mat was allowed to cool to 170 F.

The field cores were obtained soon after the construction. Three pairs of samples were cored from each test section with each pair approximately 200 feet apart. The sample size was approximately 4-inches in diameter and 2 inches in thickness. The coring process was in accordance with the general coring layout procedure described in the main text of this report (Chapter 2). The field cores were transported to the Center for Transportation Research laboratory immediately after sampling.

LABORATORY TESTING PROGRAM

The laboratory compacted specimens were made at such a compactive effort as to provide an approximately 7.0 ± 1.0% air void content. Three liquid antistripping additives were used in addition to the raw material and the hydrated lime. The additives and the dosage are given below:

a. Hydrated lime (1.0% by weight of aggregate).

b. Pavebond LP (1.0% by weight of asphalt).

c. Perma-Tac (1.0% by weight of asphalt).

d. Unichem (1.0% by weight of asphalt).

The laboratory testing program was discussed in Chapter 2 of the main text and Appendix A, and it was carried out through the duration of this study. Sample preparation, conditioning, test procedures and engineering properties analyzed for the test methods were also discussed in Chapter 2.

PRESENTATION OF TEST RESULTS

Laboratory Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables D-2 through D-6. The data are plotted in Figure D-4 for laboratory mixtures using Methods A through E. The cyclic freeze-thaw test results are shown in Figures D-5 and D-6.

Plant Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables D-7 through D-11. The data are also plotted in Figure D-7 for plant mixtures using Methods B through D.

Plant Mixed/Field Compacted Mixtures (Field Cores)

Summary of the test results are presented on Table D-12. The achieved field compaction to have the low and high air voids are summarized in Figure D-8 which shows the average air void content of the field cores from the low and high voids test sections in the field. The average TSR values are shown in Figure D-9 for the low and high voids test sections.

Texas Boiling Test Results

The Texas boiling test results are presented on Table D-13 and plotted in Figure D-10 for the laboratory mixture, the plant mixture, and the field core.

APPENDIX D SUMMARY OF DATA FOR DISTRICT 6

TABLE D-1 AGGREGATE GRADATION (DISTRICT 6)

SIEVE SIZE	"D" ROCK SIEVE ANALYSIS	"D" ROCK 56.0%	SCREENINGS SIEVE ANALYSIS	SCREENINGS 37.0%	FIELD SAND SIEVE ANALYSIS	FIELD SAND 7.0%	COMBINED GRADATION	SDHPT SPECIFICATIONS
Plus 1/2 in.	0	0			0	0	0	0
1/2 to 3/8 in.	5.9	3.3	0	0	0.4	0	3.3	0-15
3/8 to No. 4	60.8	34.0	0.6	0.2	1.8	0.1	34.3	21-53
No. 4 to No. 10	29.2	16.3	23.7	8.8	0.6	0.0	25.1	11-32
Plus No. 10							62.7	54-74
No. 10 to No. 40	3.6	2.0	36.6	13.6	1.5	0.2	15.8	6-32
No. 40 to No. 80	0.3	0.2	18.6	6.9	77.0	5.4	12.5	4-27
No. 80 to No. 200	0.1	0.1	10.4	3.8	17.6	1.2	5.1	3-27
Minus No. 200	0.1	0.1	10.1	3.7	1.1	0.1	3.9	1-8
TOTAL	100.0	56.0	100.0	37.0	100.0	7.0	100.0	

TABLE D-2 TEST RESULTS FOR LABORATORY MIXTURES (D-6)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.0	136.3	147	
	A2	DRY	6.4	135.7	159	
	A3	DRY	6.3	135.8	162	
		DRY AVG	6.2	135.9	156	
	A4	WET	7.0	134.8	28	
	A5	WET	6.2	135.9	32	
	A6	WET	6.2	136.0	34	
		WET AVG	6.5	135.5	31	
						0.20
B	B1	DRY	6.1	136.2	141	
	B2	DRY	6.2	136.0	144	
		DRY AVG**	6.1	136.1	142	
	B3	WET	6.7	135.2	27	
	B4	WET	6.0	136.3	42	
	B5	WET	6.4	135.7	29	
		WET AVG	6.3	135.8	33	
						0.23
C	C1	WET	6.3	135.8	21	
	C2	WET	6.0	136.3	22	
	C3	WET	6.1	136.1	20	
		WET AVG	6.1	136.1	21	
		DRY AVG**	6.1	136.1	142	
						0.15
D	D1	WET	6.4	135.7	39	
	D2	WET	6.4	135.7	42	
	D3	WET	6.1	136.1	56	
		WET AVG	6.3	135.8	46	
		DRY AVG**	6.1	136.1	142	
						0.32

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE D-2 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	6.3	135.8	102	
	E2	1 CYCLE	6.4	135.6	86	
		WET AVG	6.4	135.7	94	
		DRY AVG**	6.1	136.1	142	0.66
	E3	3 CYCLES	6.5	135.5	35	
	E4	3 CYCLES	6.1	136.1	29	
		WET AVG	6.3	135.8	32	
		DRY AVG**	6.1	136.1	142	0.22
	E5	5 CYCLES	6.3	135.9	19	
	E6	5 CYCLES	6.3	135.8	17	
		WET AVG	6.3	135.8	18	
		DRY AVG**	6.1	136.1	142	0.13
	E7	7 CYCLES	6.1	136.2	24	
	E8	7 CYCLES	6.1	136.2	23	
		WET AVG	6.1	136.2	23	
		DRY AVG**	6.1	136.1	142	0.16
	E9	9 CYCLES	6.2	135.9	19	
	E10	9 CYCLES	6.9	135.0	17	
		WET AVG	6.6	135.5	18	
		DRY AVG**	6.1	136.1	142	0.13
	****B6	DRY	5.0	137.7	155	
	B7	DRY	5.4	137.1	150	
	B8	DRY	5.0	137.6	157	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

**** The air voids exceed the tolerance.

TABLE D-3 TEST RESULTS FOR LABORATORY MIXTURES (D-6)
ADDITIVE: LIME SLURRY (1.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.0	136.3	119	
	A2	DRY	6.5	135.6	122	
		DRY AVG	6.2	135.9	121	
	A3	WET	6.0	136.2	86	
	A4	WET	6.0	136.2	101	
	A5	WET	6.0	136.3	95	
		WET AVG	6.0	136.2	94	0.78
B	B1	DRY	6.9	135.0	105	
	B2	DRY	6.6	135.4	116	
	B3	DRY	6.1	136.2	132	
		DRY AVG**	6.5	135.5	118	
	B4	WET	6.6	135.3	73	
	B5	WET	6.1	136.1	74	
	B6	WET	6.1	136.1	73	
		WET AVG	6.3	135.9	73	0.62
C	C1	WET	6.7	135.2	69	
	C2	WET	6.9	134.9	66	
	C3	WET	7.5	134.0	68	
		WET AVG	7.1	134.7	68	
		DRY AVG**	6.5	135.5	118	0.58
D	D1	WET	7.3	134.4	78	
	D2	WET	6.1	136.2	101	
	D3	WET	6.5	135.5	95	
		WET AVG	6.6	135.3	91	
		DRY AVG**	6.5	135.5	118	0.78

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE D-3 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	6.1	136.2	126	
	E2	1 CYCLE	6.0	136.2	125	
		WET AVG	6.0	136.2	126	
		DRY AVG**	6.5	135.5	118	1.07
	E3	3 CYCLES	6.3	135.9	96	
	E4	3 CYCLES	6.2	136.0	113	
		WET AVG	6.2	135.9	105	
		DRY AVG**	6.5	135.5	118	0.89
	E5	5 CYCLES	6.6	135.4	85	
	E6	5 CYCLES	7.3	134.4	81	
		WET AVG	6.9	134.9	83	
		DRY AVG**	6.5	135.5	118	0.71
	E7	7 CYCLES	6.2	135.9	67	
	E8	7 CYCLES	7.1	134.7	61	
		WET AVG	6.7	135.3	64	
		DRY AVG**	6.5	135.5	118	0.54
	E9	9 CYCLES	6.7	135.3	61	
	E10	9 CYCLES	6.5	135.5	72	
		WET AVG	6.6	135.4	67	
		DRY AVG**	6.5	135.5	118	0.57
****	A6	DRY	5.1	137.5	147	
	A7	DRY	5.4	137.1	139	
	A8	DRY	5.3	137.3	142	
	A9	DRY	5.8	136.5	129	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE D-4 TEST RESULTS FOR LABORATORY MIXTURES (D-6)
ADDITIVE: PAVEBOND LP (1.0%)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.1	136.5	148	
	A2	DRY	6.1	136.5	142	
	A3	DRY	6.1	136.5	140	
		DRY AVG	6.1	136.5	143	
	A4	WET	7.5	134.5	46	
	A5	WET	6.2	136.4	74	
	A6	WET	6.4	136.0	52	
		WET AVG	6.7	135.6	57	0.40
B	B1	DRY	6.8	135.5	141	
	B2	DRY	6.7	135.6	135	
	B3	DRY	6.9	135.3	133	
		DRY AVG**	6.8	135.4	136	
	B4	WET	7.4	134.6	39	
	B5	WET	6.3	136.1	59	
	B6	WET	7.2	134.9	47	
		WET AVG	7.0	135.2	48	0.35
C	C1	WET	7.9	133.8	32	
	C2	WET	7.4	134.6	37	
	C3	WET	6.6	135.7	38	
		WET AVG	7.3	134.7	36	
		DRY AVG**	6.8	135.4	136	0.26
D	D1	WET	6.1	136.4	79	
	D2	WET	7.7	134.2	48	
	D3	WET	7.6	134.2	43	
		WET AVG	7.1	134.9	57	
		DRY AVG**	6.8	135.4	136	0.42

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE D-4 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.4	134.5	67	
	E2	1 CYCLE	6.8	135.5	79	
		WET AVG	7.1	135.0	73	
		DRY AVG**	6.8	135.4	136	0.53
	E3	3 CYCLES	6.2	136.3	68	
	E4	3 CYCLES	6.7	135.6	59	
		WET AVG	6.4	136.0	64	
		DRY AVG**	6.8	135.4	136	0.47
E	E5	5 CYCLES	7.4	134.6	34	
	E6	5 CYCLES	6.6	135.8	47	
		WET AVG	7.0	135.2	40	
		DRY AVG**	6.8	135.4	136	0.30
	E7	7 CYCLES	7.0	135.2	28	
	E8	7 CYCLES	7.8	134.0	23	
		WET AVG	7.4	134.6	26	
		DRY AVG**	6.8	135.4	136	0.19
	E9	9 CYCLES	7.2	134.8	31	
	E10	9 CYCLES	6.8	135.5	35	
		WET AVG	7.0	135.2	33	
		DRY AVG**	6.8	135.4	136	0.24

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE D-5 TEST RESULTS FOR LABORATORY MIXTURES (D-6)
ADDITIVE: PERMA-TAC (1.0%)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	6.8	135.4	116	
	A2	DRY	6.8	135.4	118	
	A3	DRY	6.4	136.0	120	
		DRY AVG	6.6	135.6	118	
A	A4	WET	6.2	136.3	58	
	A5	WET	6.0	136.5	64	
	A6	WET	7.1	135.0	52	
		WET AVG	6.4	135.9	58	
						0.49
	B1	DRY	7.0	135.2	135	
	B2	DRY	6.2	136.2	146	
		DRY AVG**	6.6	135.7	140	
B	B4	WET	6.9	135.3	44	
	B5	WET	6.1	136.4	58	
	B6	WET	6.5	135.8	53	
		WET AVG	6.5	135.8	52	
						0.37
	C1	WET	6.5	135.8	47	
	C2	WET	6.5	135.9	41	
	C3	WET	6.8	135.4	38	
		WET AVG	6.6	135.7	42	
C		DRY AVG**	6.6	135.7	140	
						0.30
	D1	WET	7.1	135.0	41	
	D2	WET	6.7	135.6	66	
	D3	WET	6.7	135.5	69	
		WET AVG	6.8	135.4	59	
D		DRY AVG**	6.6	135.7	140	
						0.42

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE D-5 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.3	134.7	73	
	E2	1 CYCLE	6.8	135.3	69	
		WET AVG	7.0	135.0	71	
		DRY AVG**	6.6	135.7	140	
						0.51
	E3	3 CYCLES	6.4	136.0	58	
	E4	3 CYCLES	6.1	136.4	73	
		WET AVG	6.2	136.2	65	
		DRY AVG**	6.6	135.7	140	
						0.47
E						
	E5	5 CYCLES	6.2	136.2	47	
	E6	5 CYCLES	6.1	136.5	44	
		WET AVG	6.1	136.3	46	
		DRY AVG**	6.6	135.7	140	
						0.32
	E7	7 CYCLES	7.4	134.5	39	
	E8	7 CYCLES	7.0	135.1	39	
		WET AVG	7.2	134.8	39	
		DRY AVG**	6.6	135.7	140	
						0.28
	E9	9 CYCLES	6.5	135.8	38	
	E10	9 CYCLES	6.6	135.7	36	
		WET AVG	6.6	135.7	37	
		DRY AVG**	6.6	135.7	140	
						0.26
****	A7	DRY	5.4	137.4	164	
	A8	DRY	5.1	137.9	167	
	A9	DRY	5.2	137.7	150	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE D-6 TEST RESULTS FOR LABORATORY MIXTURES (D-6)
ADDITIVE: UNICHEM (1.0%)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.0	136.0	155	
	A2	DRY	6.1	135.9	138	
	A3	DRY	6.2	135.7	150	
		DRY AVG	6.1	135.9	148	
	A4	WET	6.1	135.9	63	
	A5	WET	6.5	135.4	50	
	A6	WET	6.2	135.7	53	
		WET AVG	6.3	135.7	55	0.37
B	B1	DRY	6.3	135.6	132	
	B2	DRY	6.1	135.9	148	
		DRY AVG**	6.2	135.8	140	
	B4	WET	6.5	135.3	51	
	B5	WET	6.0	136.0	72	
	B6	WET	6.6	135.1	53	
		WET AVG	6.4	135.5	59	0.42
C	C1	WET	6.6	135.2	42	
	C2	WET	6.0	136.0	39	
	C3	WET	6.2	135.8	43	
		WET AVG	6.3	135.6	41	
		DRY AVG**	6.2	135.8	140	0.30
D	D1	WET	6.0	136.0	89	
	D2	WET	6.3	135.6	70	
	D3	WET	6.7	135.0	68	
		WET AVG	6.3	135.5	76	
		DRY AVG**	6.2	135.8	140	0.54

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE D-6 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.7	135.1	77	
	E2	1 CYCLE	6.1	135.9	94	
		WET AVG	6.4	135.5	86	
		DRY AVG**	6.2	135.8	140	
						0.61
	E3	3 CYCLES	6.0	136.0	78	
	E4	3 CYCLES	6.1	135.9	66	
		WET AVG	6.1	135.9	72	
		DRY AVG**	6.2	135.8	140	
						0.51
E						
	E5	5 CYCLES	6.1	135.9	59	
	E6	5 CYCLES	6.1	135.9	45	
		WET AVG	6.1	135.9	52	
		DRY AVG**	6.2	135.8	140	
						0.37
	E7	7 CYCLES	6.0	136.0	41	
	E8	7 CYCLES	6.0	136.1	44	
		WET AVG	6.0	136.0	42	
		DRY AVG**	6.2	135.8	140	
						0.30
	E9	9 CYCLES	6.5	135.2	36	
	E10	9 CYCLES	6.7	135.0	35	
		WET AVG	6.6	135.1	35	
		DRY AVG**	6.2	135.8	140	
						0.25
****	B3	DRY	5.3	137.1	151	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE D-7 TEST RESULTS FOR PLANT MIXTURES (D-6)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.6	136.0	127	
	B2	DRY	7.0	135.3	133	
	B3	DRY	7.0	135.3	126	
		DRY AVG**	6.9	135.6	129	
	B4	WET	6.8	135.7	63	
	B5	WET	6.9	135.6	54	
	B6	WET	7.1	135.3	66	
		WET AVG	6.9	135.5	61	0.47
C	C1	WET	6.7	135.8	54	
	C2	WET	7.1	135.3	41	
	C3	WET	6.4	136.2	52	
		WET AVG	6.7	135.8	49	
		DRY AVG**	6.9	135.6	129	0.38
D	D1	WET	6.4	136.2	72	
	D2	WET	6.8	135.7	69	
	D3	WET	6.8	135.6	67	
		WET AVG	6.7	135.8	69	
		DRY AVG**	6.9	135.6	129	0.54

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE D-8 TEST RESULTS FOR PLANT MIXTURES (D-6)
ADDITIVB: LIME SLURRY (1.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	6.9	135.7	108	
	B2	DRY	6.7	135.9	98	
	B3	DRY	6.5	136.3	100	
		DRY AVG**	6.7	136.0	102	
B	B4	WET	6.7	135.9	54	
	B5	WET	6.6	136.1	49	
	B6	WET	6.9	135.6	62	
		WET AVG	6.8	135.8	55	
						0.54
	C1	WET	7.0	135.5	51	
	C2	WET	7.2	135.1	43	
	C3	WET	7.3	135.1	37	
		WET AVG	7.2	135.3	44	
C		DRY AVG**	6.7	136.0	102	
						0.43
	D1	WET	6.8	135.8	74	
	D2	WET	7.4	134.9	67	
	D3	WET	6.7	136.0	60	
		WET AVG	7.0	135.6	67	
D		DRY AVG**	6.7	136.0	102	
						0.66

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE D-9 TEST RESULTS FOR PLANT MIXTURES (D-6)
ADDITIVE: PAVEBOND LP (1.0%)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.0	136.2	121	
	B2	DRY	6.0	136.2	119	
	B3	DRY	6.7	135.2	108	
		DRY AVG**	6.3	135.9	116	
	B4	WET	6.3	135.9	99	
	B5	WET	6.1	136.1	92	
	B6	WET	6.9	134.9	98	
		WET AVG	6.4	135.6	96	0.83
C	C1	WET	6.1	136.1	78	
	C2	WET	6.7	135.3	70	
	C3	WET	6.3	135.8	80	
		WET AVG	6.4	135.7	76	
		DRY AVG**	6.3	135.9	116	0.66
D	D1	WET	6.3	135.8	91	
	D2	WET	6.1	136.1	97	
	D3	WET	6.4	135.7	90	
		WET AVG	6.3	135.9	93	
		DRY AVG**	6.3	135.9	116	0.80

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE D-10 TEST RESULTS FOR PLANT MIXTURES (D-6)
ADDITIVE: PERMA-TAC (1.0%)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.6	134.5	106	
	B2	DRY	7.2	135.0	127	
	B3	DRY	6.2	136.4	127	
		DRY AVG**	7.0	135.3	120	
	B4	WET	6.9	135.5	89	
	B5	WET	6.5	136.0	91	
	B6	WET	6.8	135.5	99	
		WET AVG	6.7	135.7	93	
						0.78
C	C1	WET	6.6	135.9	73	
	C2	WET	7.0	135.3	81	
	C3	WET	6.9	135.4	79	
		WET AVG	6.8	135.5	78	
		DRY AVG**	7.0	135.3	120	
						0.65
D	D1	WET	6.9	135.4	104	
	D2	WET	6.3	136.2	101	
	D3	WET	6.7	135.7	101	
		WET AVG	6.7	135.8	102	
		DRY AVG**	7.0	135.3	120	
						0.85

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE D-11 TEST RESULTS FOR PLANT MIXTURES (D-6)
ADDITIVE: UNICHEM (1.0%)
ASPHALT CONTENT = 6.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	7.0	135.6	140	
	B2	DRY	6.9	135.8	128	
	B3	DRY	7.5	134.9	119	
		DRY AVG**	7.1	135.4	129	
B	B4	WET	7.1	135.4	91	
	B5	WET	6.9	135.6	78	
	B6	WET	6.9	135.8	79	
		WET AVG	7.0	135.6	83	0.64
	C1	WET	6.6	136.1	78	
	C2	WET	7.3	135.2	82	
	C3	WET	7.4	135.0	76	
C		WET AVG	7.1	135.4	79	
		DRY AVG**	7.1	135.4	129	0.61
	D1	WET	7.0	135.6	103	
	D2	WET	6.5	136.3	95	
	D3	WET	7.0	135.5	104	
D		WET AVG	6.8	135.8	101	
		DRY AVG**	7.1	135.4	129	0.78

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE D-12 TEST RESULTS FOR FIELD CORES
DISTRICT 6
ASPHALT CONTENT = 6.2 %

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		1A	DRY	7.9	134.0	85	
		1B	WET	8.5	133.1	42	
	LOW						0.50
	AIR	2A	WET	8.0	133.9	42	
	VOIDS	2B	DRY	9.1	132.3	73	
	SECTION						0.58
		3A	DRY	7.5	134.7	84	
		3B	WET	8.1	133.8	40	
							0.48
NO		(AVG VOIDS)		8.2		(AVG TSR)	0.52
ADDITIVE (CONTROL)		4A	WET	12.1	128.0	19	
		4B	DRY	11.9	128.2	49	
	HIGH						0.38
	AIR	5A	DRY	10.1	130.9	73	
	VOIDS	5B	WET	10.1	130.9	29	
	SECTION						0.40
		6A	WET	11.1	129.5	26	
		6B	DRY	11.2	129.2	49	
							0.52
		(AVG VOIDS)		11.1		(AVG TSR)	0.44
		7A	WET	8.0	134.1	40	
		7B	DRY	8.2	133.8	85	
	LOW						0.46
	AIR	8A	DRY	8.8	132.8	66	
	VOIDS	8B	WET	8.7	133.1	41	
	SECTION						0.63
		9A	WET	8.7	133.0	37	
		9B	DRY	8.4	133.5	88	
							0.42
		(AVG VOIDS)		8.5		(AVG TSR)	0.50
LIME SLURRY		10A	DRY	10.8	130.0	56	
		10B	WET	11.3	129.2	25	
	HIGH						0.45
	AIR	11A	WET	10.9	129.8	25	
	VOIDS	11B	DRY	10.9	129.8	61	
	SECTION						0.41
		12A	DRY	9.9	131.2	65	
		12B	WET	10.4	130.5	29	
							0.45
		(AVG VOIDS)		10.7		(AVG TSR)	0.44
		13A	WET	9.7	130.9	36	
		13B	DRY	9.5	131.2	55	
							0.66
		14A	DRY	9.8	130.7	45	

TABLE D-12 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
	LOW AIR VOIDS SECTION	14B	WET	9.2	131.7	32	
							0.71
		15A	WET	8.2	133.1	62	
		15B	DRY	8.5	132.6	79	
							0.77
		(AVG VOIDS)		9.2		(AVG TSR)	0.72
PAVEBOND LP	HIGH AIR VOIDS SECTION	16A	DRY	8.6	132.5	77	
		16B	WET	8.9	132.0	49	
							0.63
		17A	WET	12.3	127.1	27	
		17B	DRY	12.0	127.6	38	
							0.70
		18A	DRY	11.0	129.0	47	
		18B	WET	10.5	129.8	29	
							0.60
		(AVG VOIDS)		10.6		(AVG TSR)	0.64
	LOW AIR VOIDS SECTION	19A	WET	10.2	130.5	33	
		19B	DRY	11.0	129.5	63	
							0.53
		20A	DRY	10.0	130.9	64	
		20B	WET	10.0	130.9	34	
							0.53
		21A	WET	7.6	134.4	54	
		21B	DRY	8.5	133.1	74	
							0.74
		(AVG VOIDS)		9.5		(AVG TSR)	0.60
PERMA-TAC	HIGH AIR VOIDS SECTION	22A	DRY	8.1	133.6	78	
		22B	WET	7.9	134.0	53	
							0.69
		23A	WET	8.8	132.7	45	
		23B	DRY	8.8	132.6	58	
							0.77
		24A	DRY	7.2	134.9	93	
		24B	WET	6.9	135.5	52	
							0.56
		(AVG VOIDS)		8.0		(AVG TSR)	0.67
	LOW AIR VOIDS SECTION	25A	DRY	8.7	133.1	75	
		25B	WET	9.4	132.0	56	
							0.74
		26A	WET	11.1	129.6	29	
		26B	DRY	11.0	129.7	45	
							0.63
		27A	DRY	8.8	132.9	75	
		27B	WET	9.8	131.4	43	
							0.57

TABLE D-12 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
UNICHEM		(AVG VOIDS)		9.8		(AVG TSR)	0.65
	HIGH AIR VOIDS SECTION	28A	WET	8.2	133.9	58	
		28B	DRY	8.0	134.1	83	
							0.70
		29A	DRY	12.2	128.0	60	
		29B	WET	11.5	129.0	32	
							0.53
		30A	WET	9.0	132.7	56	
		30B	DRY	9.1	132.5	75	
							0.74
		(AVG VOIDS)		9.7		(AVG TSR)	0.65

*TSR = Tensile Strength Ratio
= Tensile Strength (Wet)/Tensile Strength (Dry)

TABLE D-13 BOILING TEST RESULTS
DISTRICT 6

TYPE OF MIXTURE	TYPE OF ADDITIVE	ASPHALT RETAINED AFTER BOILING, %		
		RATING 1	RATING 2	AVG
	NO ADDITIVE	50	50	50.0
	LIME	65	80	72.5
LABORATORY	PAVEBOND LP	60	60	60.0
	PERMA-TAC	60	70	65.0
	UNICHEM	65	70	67.5
	NO ADDITIVE	65	75	70.0
	LIME	70	75	72.5
PLANT	PAVEBOND LP	90	80	85.0
	PERMA-TAC	80	80	80.0
	UNICHEM	85	85	85.0
	NO ADDITIVE	60	60	60.0
	LIME	60	60	60.0
FIELD CORE	PAVEBOND LP	85	90	87.5
	PERMA-TAC	70	80	75.0
	UNICHEM	90	90	90.0

APPENDIX D LIST OF FIGURES

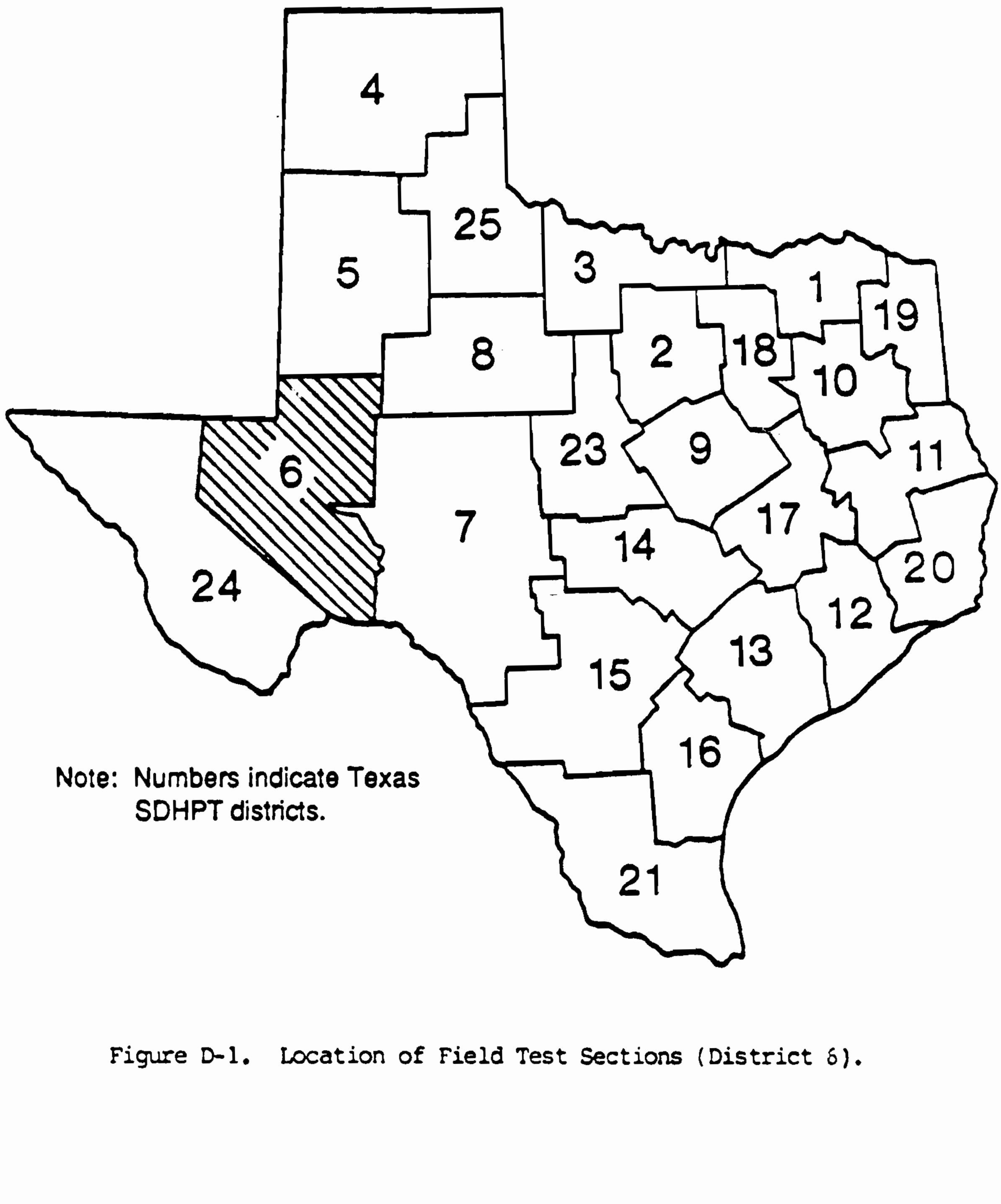


Figure D-1. Location of Field Test Sections (District 6).

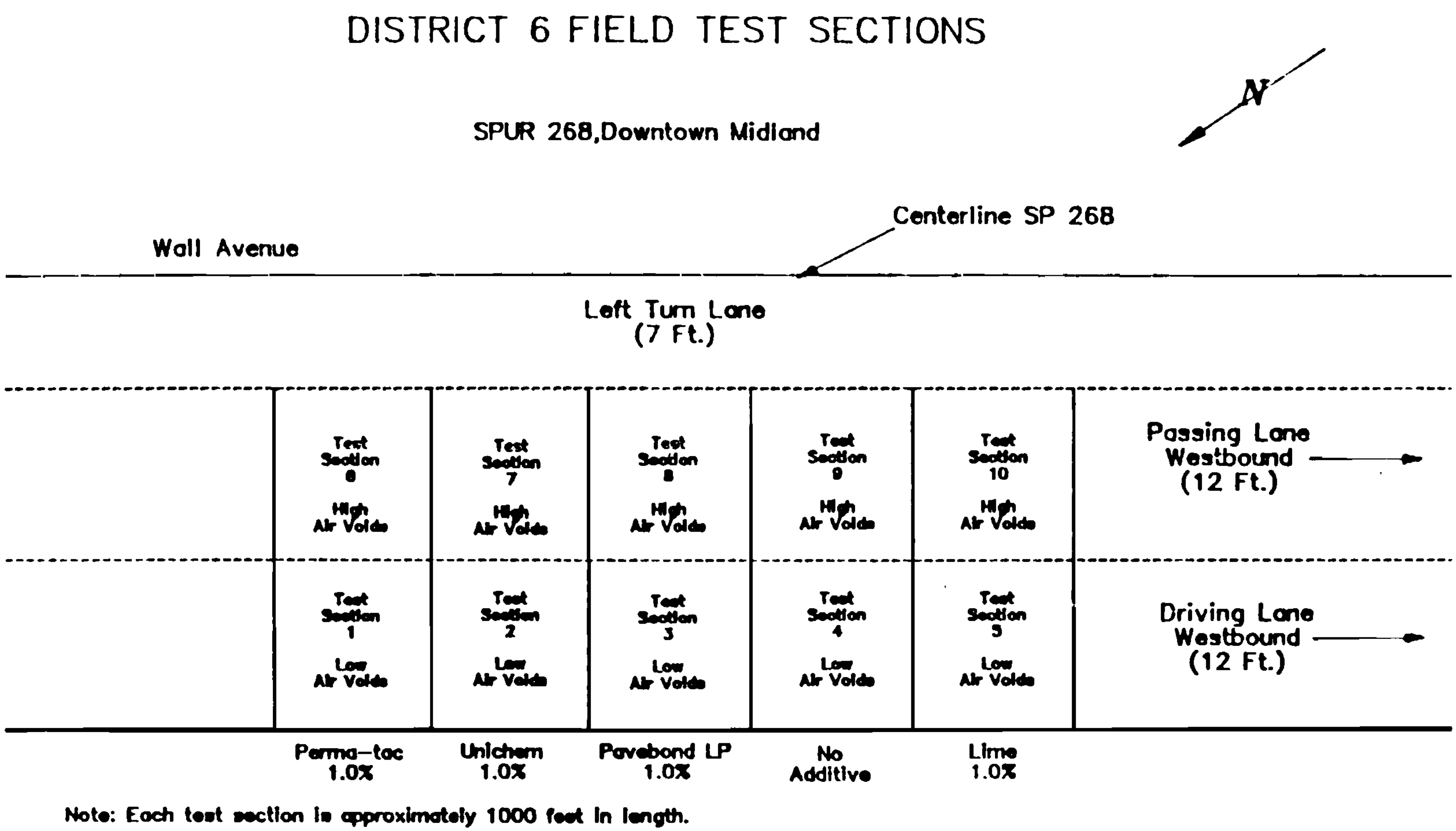


Fig D-2 Schematic Illustration of Field Test Sections

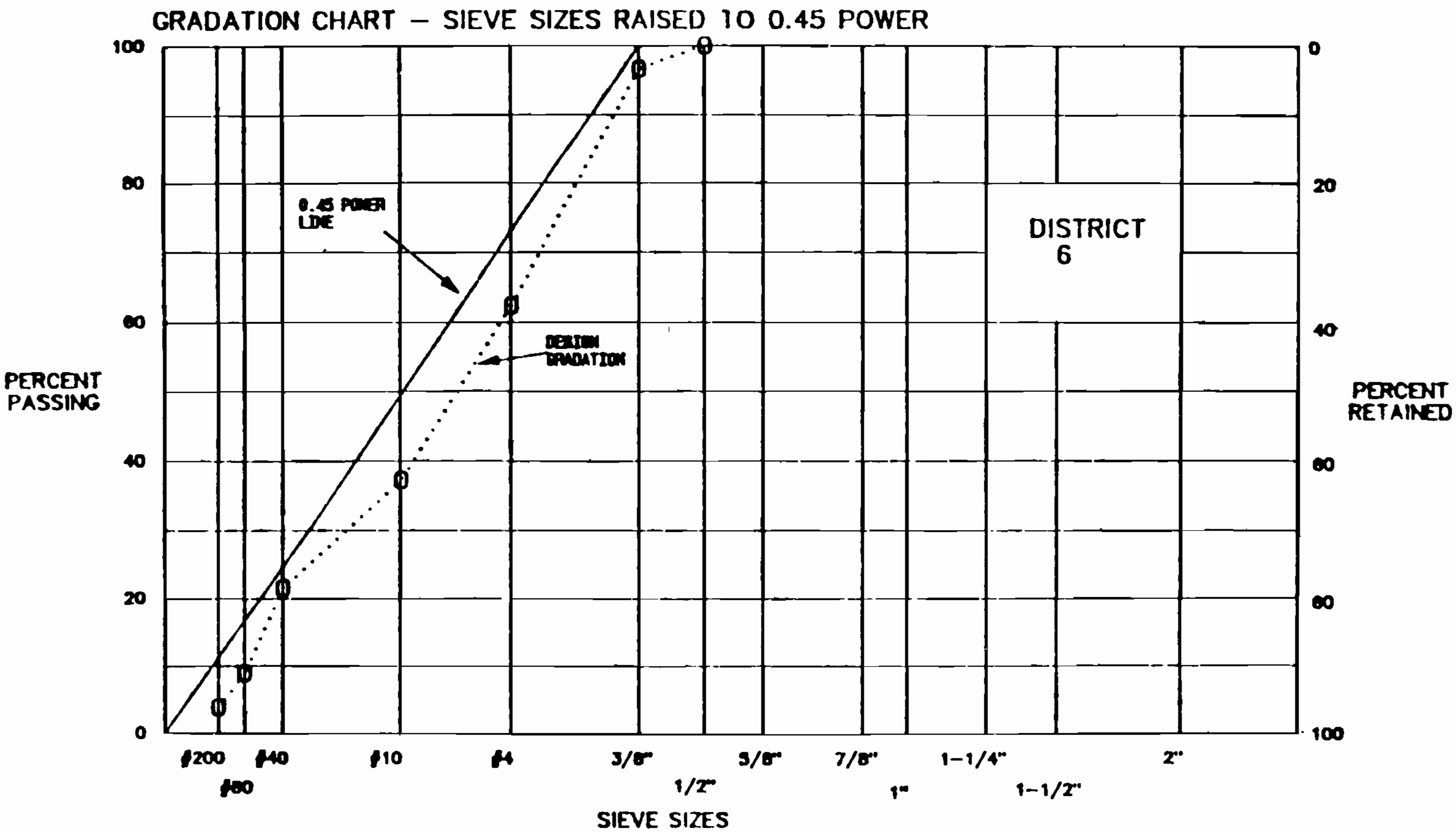


Fig D-3 Aggregate Gradation Chart.

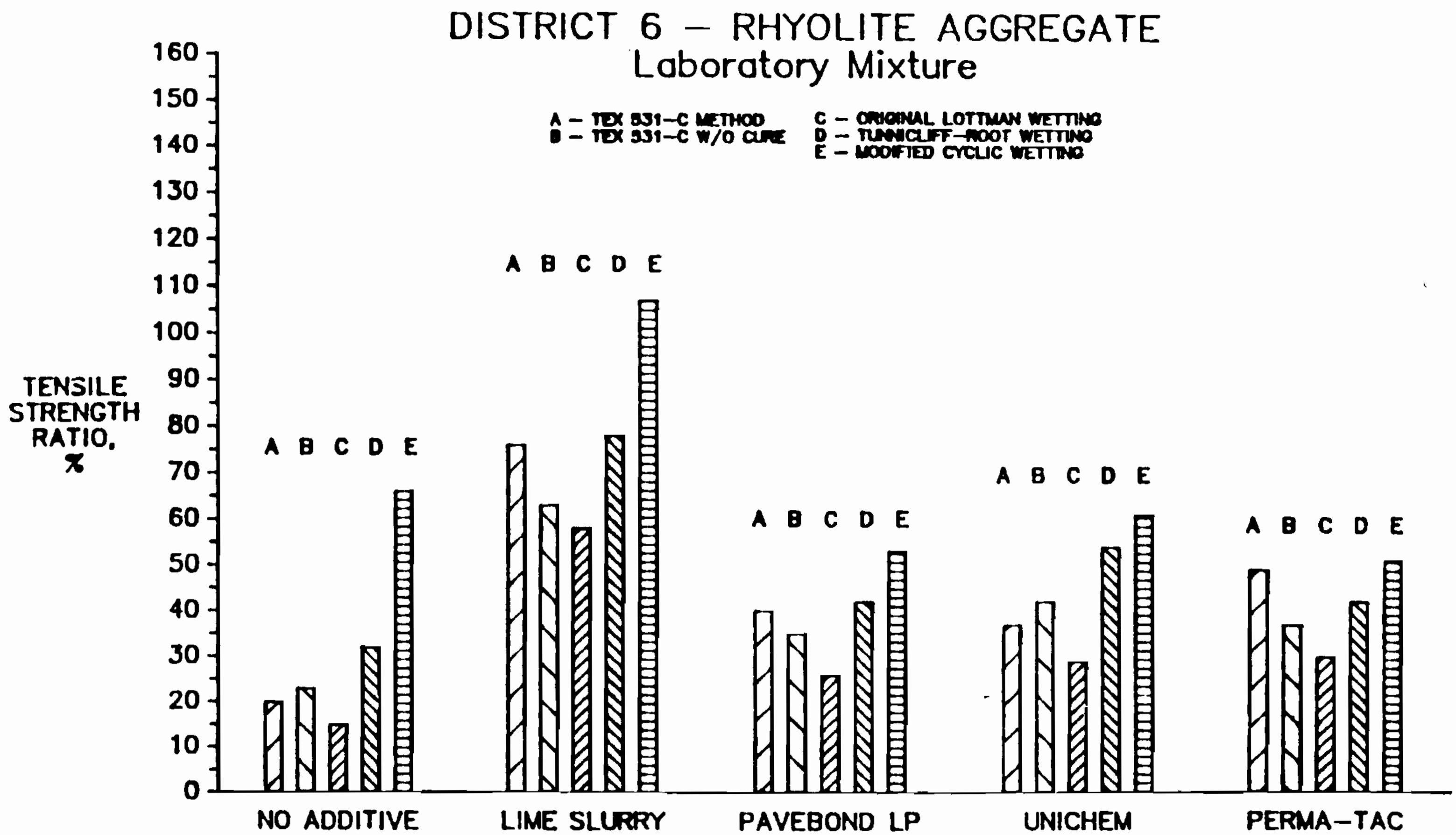


Fig D-4 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

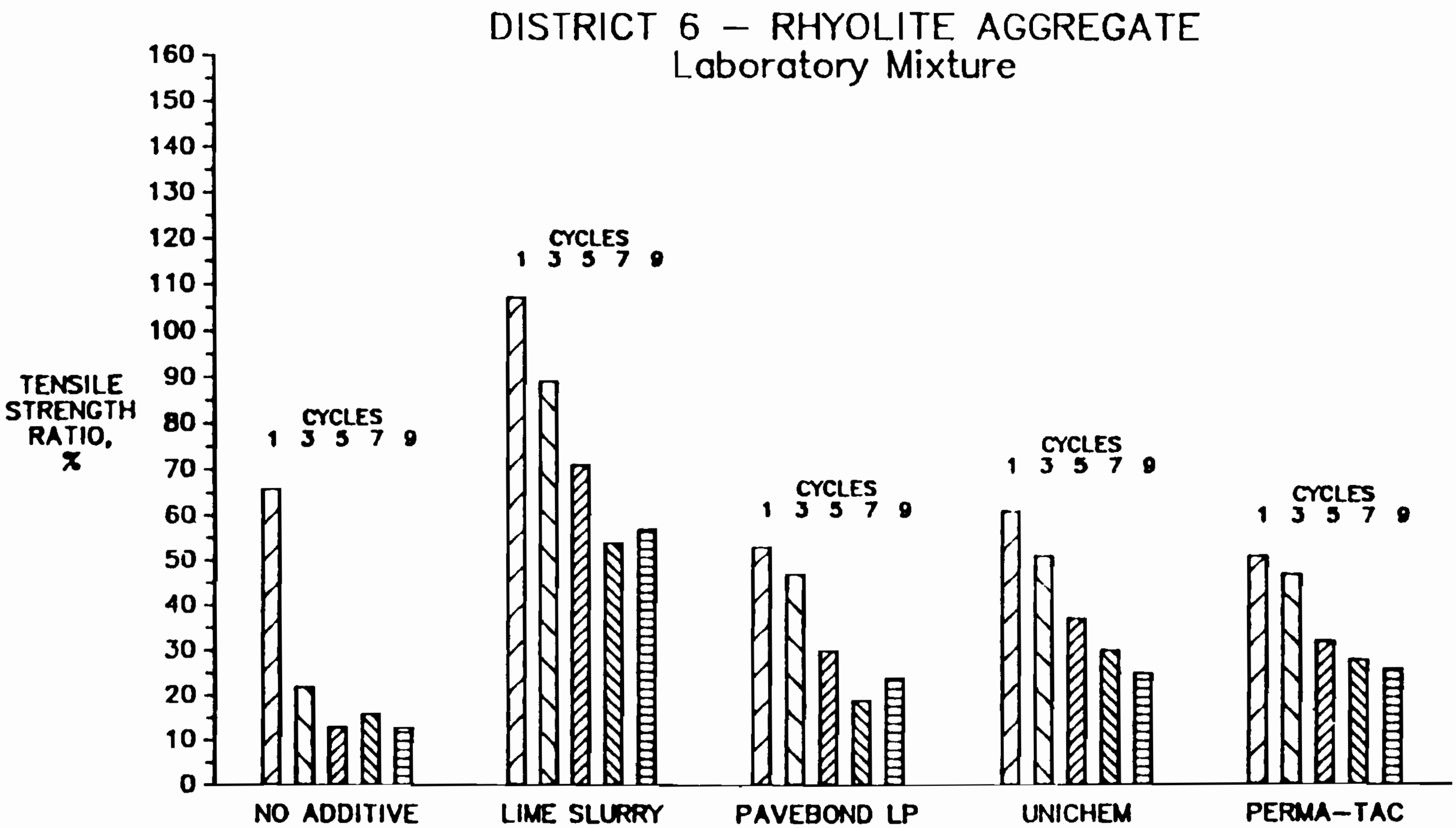


Fig D-5 Wet-Dry Indirect Tensile Cyclic Freeze-Thaw Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

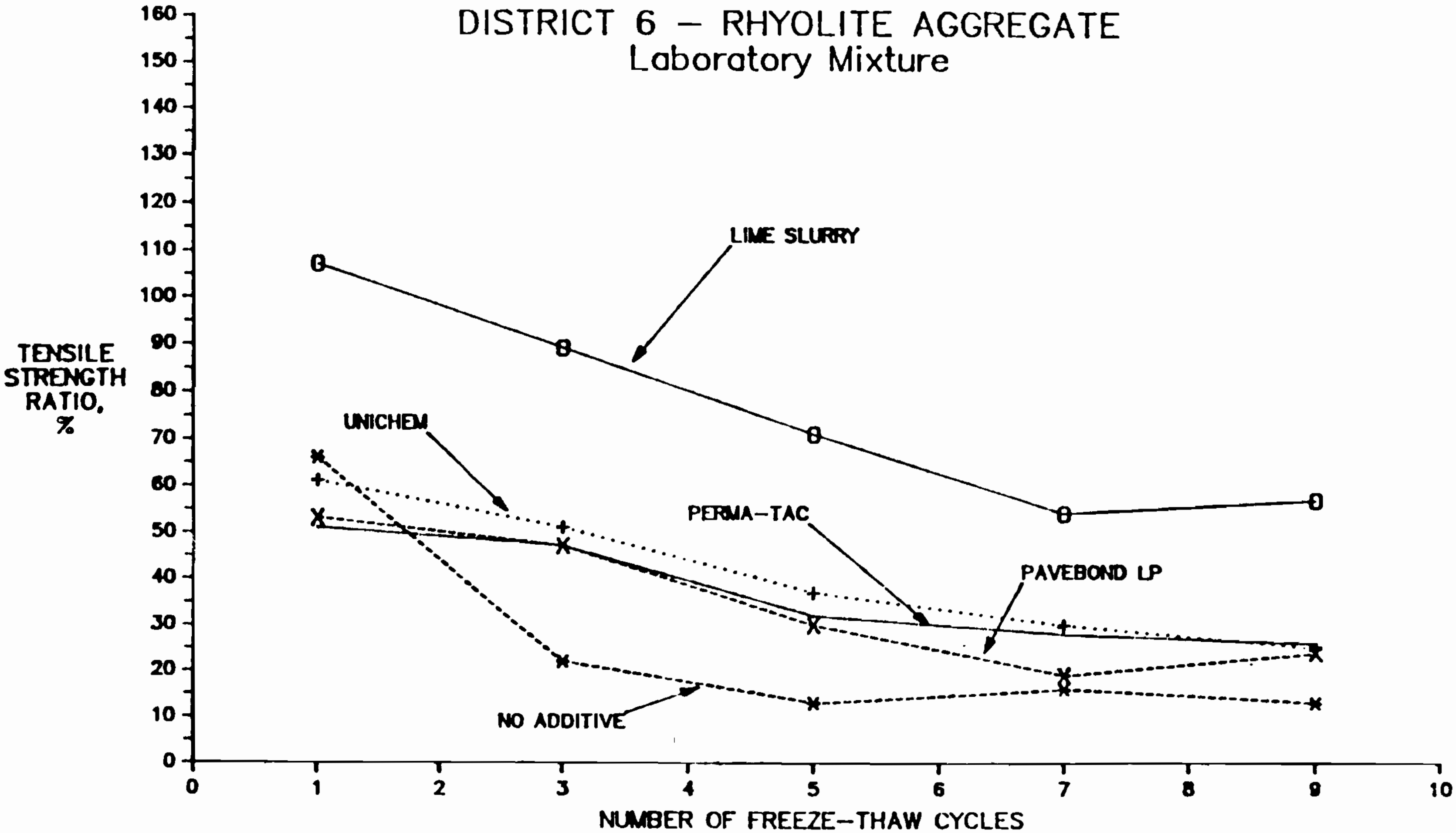


Fig D-6 Tensile Strength Ratio (TSR) Vs. Number of Freeze-Thaw Cycles for Laboratory Mixtures.

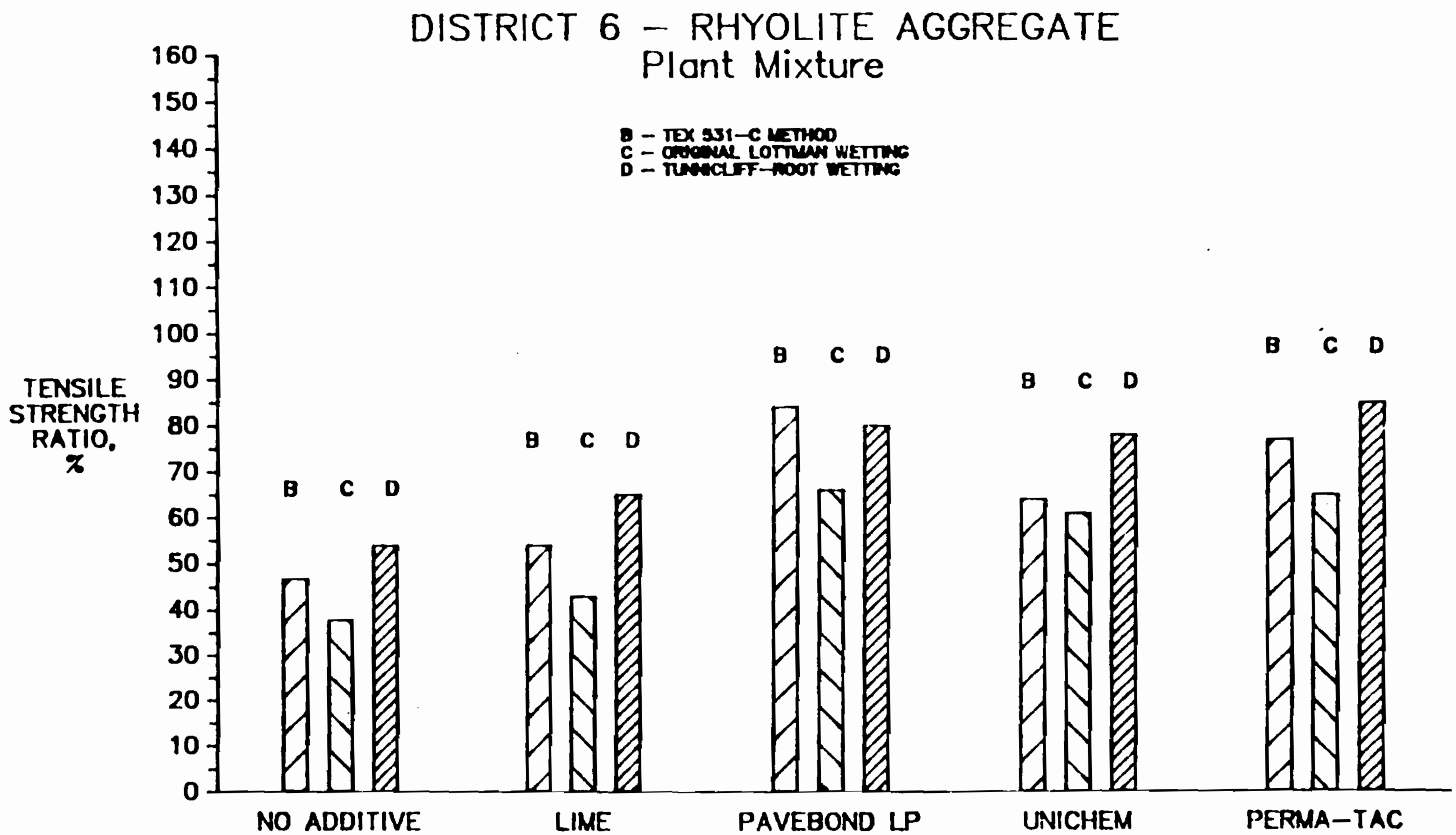


Fig D-7 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Plant Mixtures.

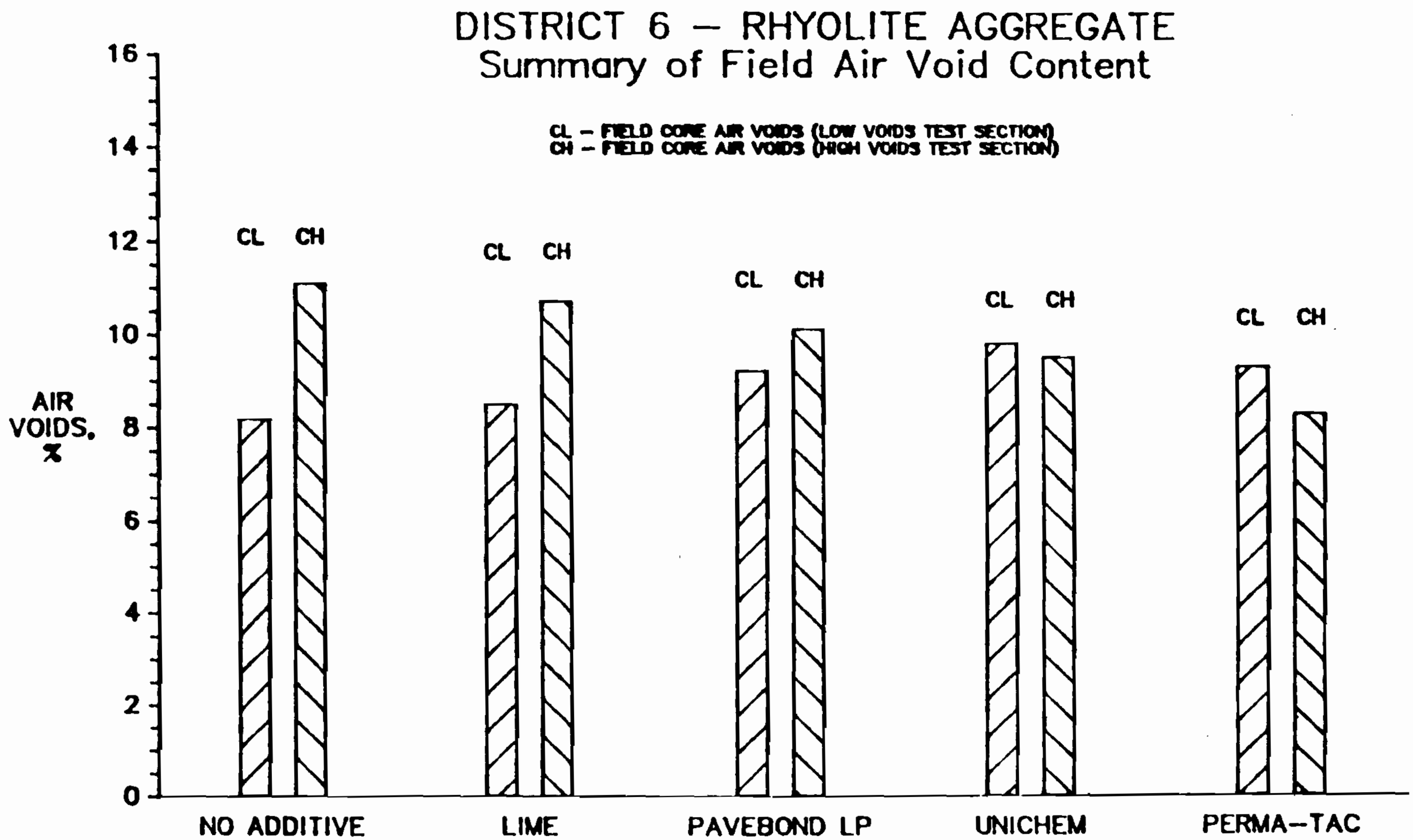


Fig D-8 Summary of Field Core Air Void Content.

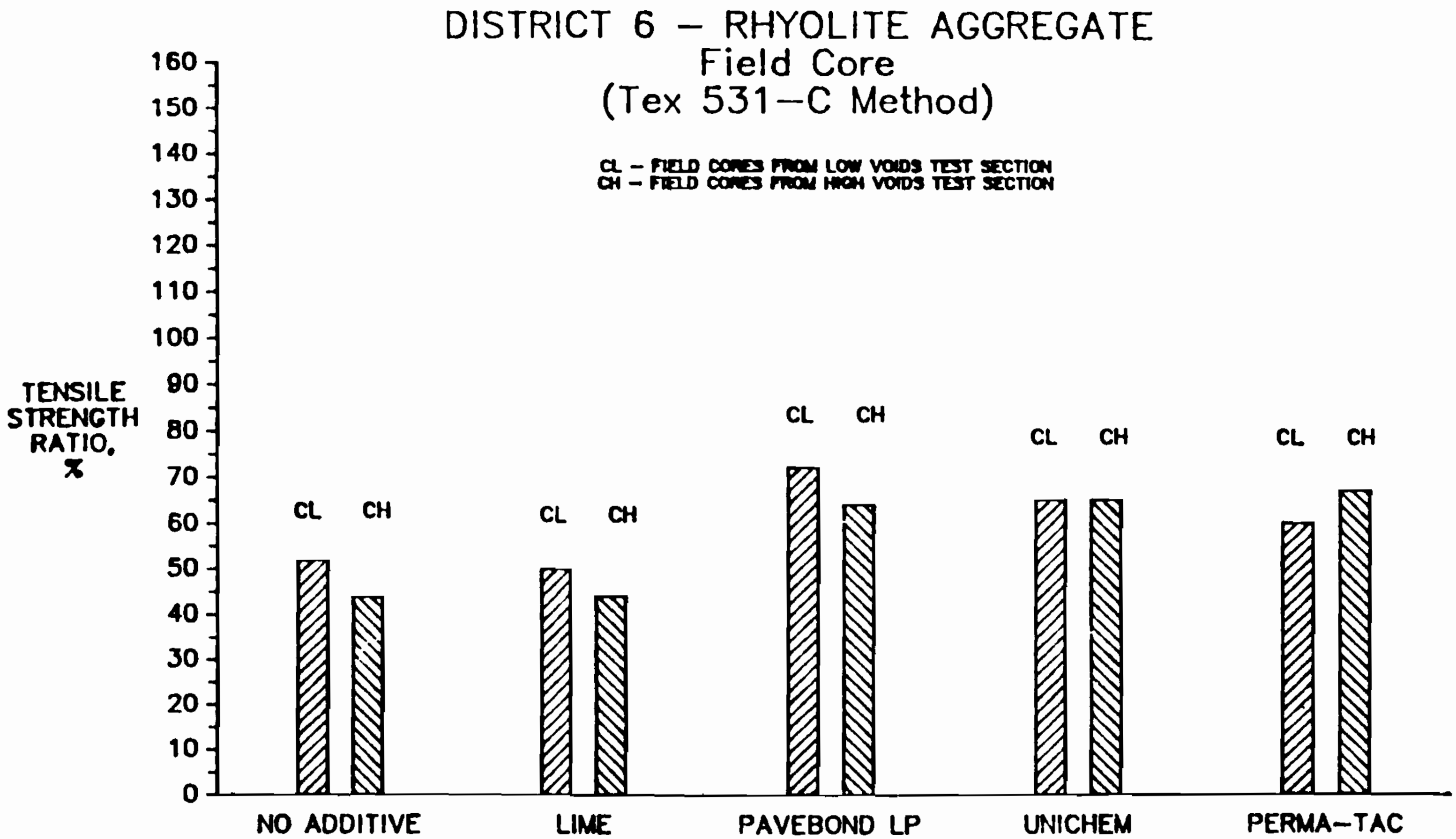


Fig D-9 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Field Cores.

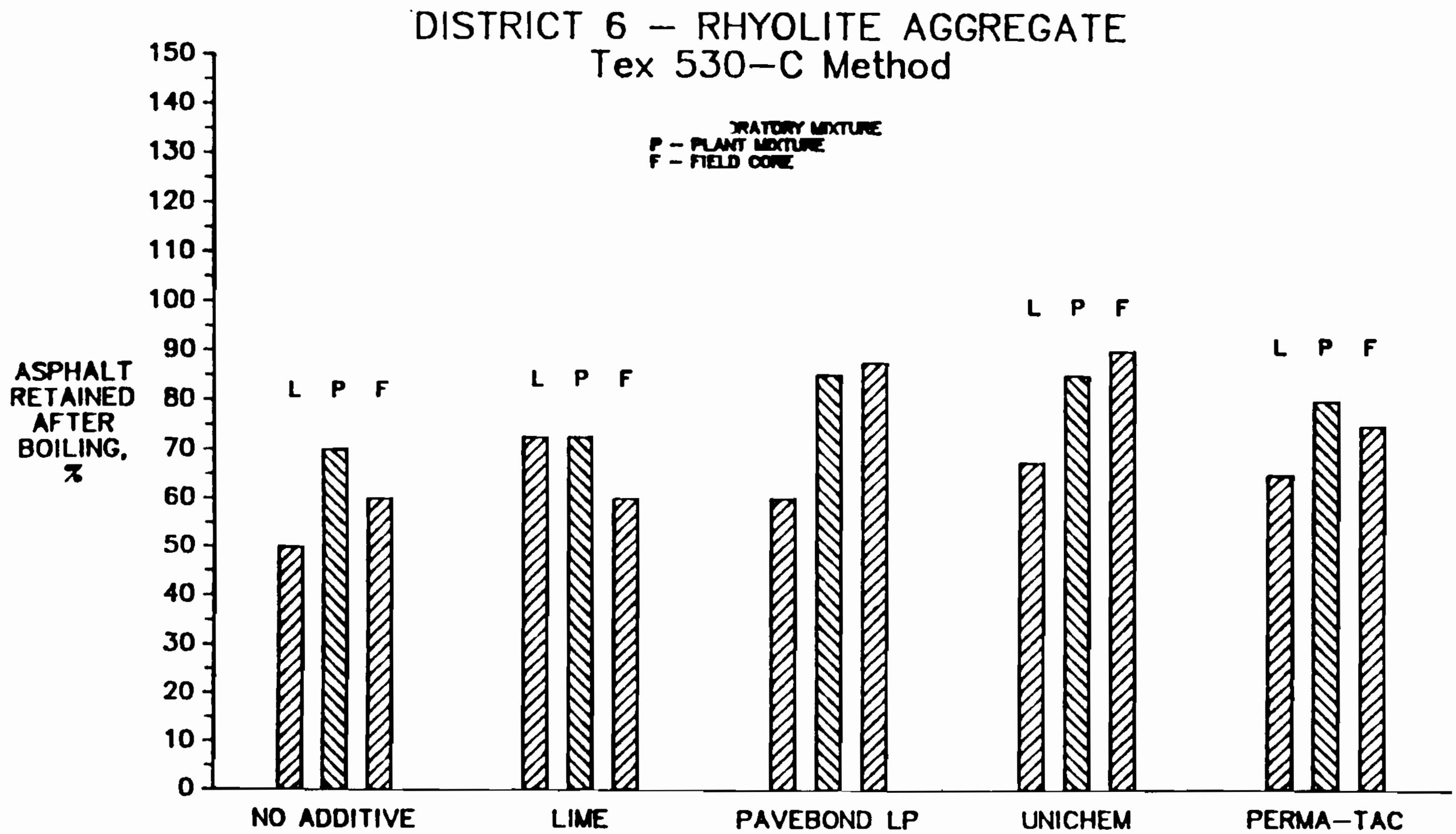


Fig D-10 Texas Boiling Test Results.

APPENDIX E

FIELD AND LABORATORY EXPERIMENTAL PROGRAM - DISTRICT 25

The objective of Appendix E is twofold: (1) to describe the site specific (District 25) field operations of the test sections along with a description of the materials, additives and construction techniques used for this field project, (2) to present the laboratory test results of the laboratory mixed and plant mixed mixtures along with the zero-aged (immediately after construction) pavement cores for the field experimental study at District 25 (Figure E-1) of the Texas State Department of Highways and Public Transportation (SDHPT).

FIELD EXPERIMENTAL PROGRAM

The test pavements were constructed on US 287 in Hall and Childress Counties, Texas, in May 1987, and involved pavement overlay to one lane of the highway. The test sections were installed as the surface course in the outside southbound main travel lane as shown schematically in Figure E-2. Each test section was approximately one to two inches thick, 12 feet wide, and 1000 feet long. A total of twelve (12) test sections were constructed and four liquid antistripping additives were used in addition to the hydrated lime and the control materials. The composition of the twelve test sections are as follows:

Test Section 1. Hot mix with 1.0% Aquashield II,low air voids.

Test Section 2. Hot mix with 1.0% Aquashield II, high air voids.

Test Section 3. Hot mix with 1.0% Fina-A, low air voids.

Test Section 4. Hot mix with 1.0% Fina-A, high air voids.

Test Section 5. Hot mix with 1.0% Unichem, low air voids.

Test Section 6. Hot mix with 1.0% Unichem, high air voids.

Test Section 7. Control Section - No additive, low air voids.

Test Section 8. Control Section - No additive, high air voids.

Test Section 9. Hot mix with 1.0% Perma-Tac, low air voids.

Test Section 10. Hot mix with 1.0% Perma-Tac, high air voids.

Test Section 11. Hot mix with 1.0% lime slurry, high air voids.

Test Section 12. Hot mix with 1.0% lime slurry, low air voids.

Perma-Tac was used as the antistripping additive throughout the entire pavement overlay where the test sections were not involved. The field construction was conducted by District 25 of the Texas State Department of Highways and Public Transportation (SDHPT) and was assisted by the Center for Transportation Research, The University of Texas at Austin. The average daily traffic (ADT) is estimated at 5,800 vehicles for the test pavement.

MATERIALS AND PAVING MIXTURE

An AC-20 asphalt cement from the Diamond Shamrock refinery was used throughout this project. Three aggregates--a coarse gravel aggregate, an intermediate gravel aggregate, and a fine gravel screening, were combined to produce the project gradation. Gradations of the individual aggregates, the project gradation, percentages of each aggregate combined, and the specification are given on Table E-1. The project gradation is plotted on a 0.45 power graph in Figure E-3.

The asphalt concrete mixture used in this study met the SDHPT specifications of Item 340, Type C coarse graded surface course (Ref 45). Preliminary laboratory test results for this mixture design are given below:

Asphalt Content	-	5.2%
Average Density	-	97 percent of theoretical maximum density
Air Void Content	-	3 percent
Hveem Stability	-	45%

FIELD OPERATIONS

A drum mix plant was used to prepare hot mixed asphalt mixtures containing lime and liquid antistripping additives. Identical raw material sources (asphalt cement and aggregates) were utilized throughout the experiment. Four commercially available liquid antistripping additives were used for the test sections, i.e., Aquashield II, Fina-A, Perma-Tac, and Unichem.

The hydrated lime was mixed and added in slurry form to the aggregates on the cold feed belt of the drum dryer. The liquid additives were metered into the asphalt in-line injection system of the plant.

Compaction of each test section was achieved using a vibratory roller, a pneumatic roller, and a steel wheel roller. The field air voids were controlled using a Troxler Thin Layer Asphalt Gauge. After one to two passes were made using a 25-ton vibratory roller, the Troxler gauge was placed on top of the pavement to measure the density of the in-place asphalt layer. A trial and error method of increasing or decreasing the number of passes by the vibratory roller was used to achieve the desired field density (i.e., the desired air voids of the test sections). Final rolling involved using the pneumatic and the steel wheel roller.

The field cores were taken soon after the construction. Three pairs of samples were cored from each test section with each pair approximately 200 feet apart. The sample size was approximately 4-inches in diameter and 1 to 2-inches in thickness. The coring process was in accordance with the general coring layout procedure described in the main text of this report (Chapter 2). The field cores were transported to the Center for Transportation Research laboratory immediately after sampling.

LABORATORY TESTING PROGRAM

The laboratory compacted specimens were made at such a compactive effort as to provide an approximately 7.0 $\pm$ 1.0% air void content. Four liquid antistripping additives were used in addition to the raw material and the hydrated lime slurry. The additives and the dosage are given below:

a. Hydrated lime slurry (1.0% by weight of aggregate).

b. Aquashield II (1.0% by weight of asphalt).

c. Fina-A (1.0% by weight of asphalt).

d. Perma-Tac (1.0% by weight of asphalt).

e. Unichem (1.0% by weight of asphalt).

The laboratory testing program was discussed in Chapter 2 of the main text and Appendix A, and it was carried out through the duration of this study. Sample preparation, conditioning, test procedures and engineering properties analyzed for the test methods were also discussed in Chapter 2.

PRESENTATION OF TEST RESULTS

Laboratory Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables E-2 through E-7. The data are plotted in Figure E-4 for laboratory mixtures using Methods A through E. The cyclic freeze-thaw test results are shown in Figures E-5 and E-6.

Plant Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables E-8 through E-13. The data are also plotted in Figure E-7 for plant mixtures using Methods B through D.

Plant Mixed/Field Compacted Mixtures (Field Cores)

Summary of the test results are presented on Table E-14. The achieved field compaction to have the low and high air voids are summarized in Figure E-8 which shows the average air void content of the field cores from the low and high voids test sections in the field. The average TSR values are shown in Figure E-9 for the low and high voids test sections.

Texas Boiling Test Results

The Texas boiling test results are presented on Table E-15 and plotted in Figure E-10 for the laboratory mixture, the plant mixture, and the field core.

APPENDIX E SUMMARY OF DATA FOR DISTRICT 25

TABLE E-1 AGGREGATE GRADATION (DISTRICT 25)

SIEVE SIZE	COARSE AGGREGATE SIEVE ANALYSIS	COARSE AGGREGATE 20.0%	INTER. AGGREGATE SIEVE ANALYSIS	INTER. AGGREGATE 34.0%	SCREENINGS SIEVE ANALYSIS	SCREENINGS 46.0%	COMBINED GRADATION	SDHPT SPECIFICATIONS
Plus 7/8 in.	0	0					0	0
Plus 5/8 in.	0.9	0.2	0	0			0.2	0-5
1/2 to 3/8 in.	89.1	17.9	1.1	0.4			18.3	16-42
3/8 to No. 4	9.6	1.9	51.6	17.6	0	0	19.5	11-37
No. 4 to No. 10	0.2	0.0	41.6	14.1	13.1	6.0	20.1	11-32
Plus No. 10							58.1	54-74
No. 10 to No. 40	0.0	0.0	4.5	1.5	52.3	24.1	25.6	6-32
No. 40 to No. 80	0.1	0.0	0.5	0.2	15.5	7.1	7.3	4-27
No. 80 to No. 200	0.0	0.0	0.3	0.1	12.0	5.5	5.6	3-27
Minus No. 200	0.1	0.0	0.4	0.1	7.1	3.3	3.4	1-8
TOTAL	100.0	20.0	100.0	34.0	100.0	46.0	100.0	

TABLE E-2 TEST RESULTS FOR LABORATORY MIXTURES (D-25)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.5	141.0	80	
	A2	DRY	6.6	142.4	85	
		DRY AVG	7.0	141.7	83	
	A4	WET	7.6	140.9	50	
	A5	WET	7.5	141.1	49	
	A6	WET	6.2	142.9	68	
		WET AVG	7.1	141.6	56	
						0.67
B	B1	DRY	6.5	142.5	86	
	B2	DRY	7.9	140.3	73	
		DRY AVG**	7.2	141.4	80	
	B3	WET	7.5	141.0	50	
	B4	WET	7.6	140.8	53	
	B5	WET	8.0	140.2	46	
		WET AVG	7.7	140.7	50	
						0.62
C	C1	WET	6.8	142.1	35	
	C2	WET	6.7	142.3	39	
	C3	WET	7.9	140.3	36	
		WET AVG	7.1	141.6	37	
		DRY AVG**	7.2	141.4	80	
						0.46
D	D1	WET	7.1	141.6	53	
	D2	WET	7.7	140.8	48	
	D3	WET	7.5	141.1	52	
		WET AVG	7.4	141.2	51	
		DRY AVG**	7.2	141.4	80	
						0.64

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE E-2 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.2	143.0	60	
	E2	1 CYCLE	6.9	141.9	54	
		WET AVG	6.5	142.5	57	
		DRY AVG**	7.2	141.4	80	0.71
	E3	3 CYCLES	7.4	141.2	37	
	E4	3 CYCLES	7.0	141.8	33	
		WET AVG	7.2	141.5	35	
		DRY AVG**	7.2	141.4	80	0.44
E	E5	5 CYCLES	7.5	141.0	22	
	E6	5 CYCLES	7.4	141.2	21	
		WET AVG	7.5	141.1	22	
		DRY AVG**	7.2	141.4	80	0.27
	E7	7 CYCLES	7.8	140.5	21	
	E8	7 CYCLES	7.8	140.5	23	
		WET AVG	7.8	140.5	22	
		DRY AVG**	7.2	141.4	80	0.28
	E9	9 CYCLES	7.4	141.1	19	
	E10	9 CYCLES	6.5	142.6	18	
		WET AVG	6.9	141.9	18	
		DRY AVG**	7.2	141.4	80	0.23
****	A3	DRY	5.3	144.4	96	
	B3	DRY	5.9	143.5	95	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

****The air voids exceed the tolerance.

TABLE E-3 TEST RESULTS FOR LABORATORY MIXTURES (D-25)
ADDITIVE: LIME SLURRY (1.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.6	142.2	82	
	A2	DRY	6.8	141.8	85	
	A3	DRY	6.1	142.9	92	
		DRY AVG	6.5	142.3	86	
	A4	WET	6.5	142.4	106	
	A5	WET	6.3	142.7	113	
	A6	WET	6.9	141.8	117	
		WET AVG	6.5	142.3	112	1.30
B	B1	DRY	7.4	140.9	78	
	B2	DRY	6.6	142.2	77	
	B3	DRY	6.1	143.0	82	
		DRY AVG**	6.7	142.1	79	
	B4	WET	7.0	141.5	100	
	B5	WET	6.0	143.1	91	
	B6	WET	6.6	142.1	101	
		WET AVG	6.6	142.3	97	1.23
C	C1	WET	6.6	142.3	80	
	C2	WET	7.5	140.8	73	
	C3	WET	8.0	140.0	67	
		WET AVG	7.4	141.0	73	
		DRY AVG**	6.7	142.1	79	0.93
D	D1	WET	7.6	140.6	83	
	D2	WET	6.4	142.6	86	
		WET AVG	7.0	141.6	85	
		DRY AVG**	6.7	142.1	79	1.07

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE E-3 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.3	141.1	91	
	E2	1 CYCLE	6.2	142.9	94	
		WET AVG	6.7	142.0	93	
		DRY AVG**	6.7	142.1	79	1.17
	E3	3 CYCLES	7.0	141.7	78	
	E4	3 CYCLES	6.2	142.9	87	
		WET AVG	6.6	142.3	82	
		DRY AVG**	6.7	142.1	79	1.04
E	E5	5 CYCLES	6.0	143.1	69	
	E6	5 CYCLES	7.5	140.9	67	
		WET AVG	6.7	142.0	68	
		DRY AVG**	6.7	142.1	79	0.86
	E7	7 CYCLES	6.7	142.0	75	
	E8	7 CYCLES	6.7	142.1	80	
		WET AVG	6.7	142.1	78	
		DRY AVG**	6.7	142.1	79	0.98
	E9	9 CYCLES	7.0	141.6	67	
	E10	9 CYCLES	6.6	142.1	74	
		WET AVG	6.8	141.8	70	
		DRY AVG**	6.7	142.1	79	0.89
****	B7	DRY	5.3	144.2	95	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE E-4 TEST RESULTS FOR LABORATORY MIXTURES (D-25)
ADDITIVE: AQUA-SHIELD II (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	8.0	139.8	72	
	A2	DRY	7.4	140.8	85	
	A3	DRY	6.5	142.1	86	
		DRY AVG	7.3	140.9	81	
	A4	WET	7.1	141.2	89	
	A5	WET	7.0	141.3	96	
	A6	WET	6.5	142.2	105	
		WET AVG	6.9	141.6	97	1.19
B	B1	DRY	7.0	141.4	79	
	B2	DRY	7.9	140.0	70	
	B3	DRY	7.7	140.2	75	
		DRY AVG**	7.5	140.5	75	
	B4	WET	7.4	140.7	87	
	B5	WET	7.1	141.3	92	
	B6	WET	7.2	141.0	96	
		WET AVG	7.2	141.0	92	1.23
C	C1	WET	6.6	142.0	69	
	C2	WET	8.0	139.8	58	
	C3	WET	8.0	139.8	56	
		WET AVG	7.5	140.5	61	
		DRY AVG**	7.5	140.5	75	0.82
D	D1	WET	7.5	140.7	79	
	D2	WET	7.3	141.0	73	
	D3	WET	7.7	140.3	75	
		WET AVG	7.5	140.6	76	
		DRY AVG**	7.5	140.5	75	1.01

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE E-4 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	7.4	140.7	75	
	E2	1 CYCLE	7.4	140.8	77	
		WET AVG	7.4	140.8	76	
		DRY AVG**	7.5	140.5	75	1.02
	E3	3 CYCLES	7.9	139.9	63	
	E4	3 CYCLES	7.5	140.6	64	
		WET AVG	7.7	140.3	64	
		DRY AVG**	7.5	140.5	75	0.85
	E5	5 CYCLES	7.2	141.1	60	
	E6	5 CYCLES	8.0	139.8	59	
		WET AVG	7.6	140.5	60	
		DRY AVG**	7.5	140.5	75	0.80
	E7	7 CYCLES	6.6	142.0	69	
	E8	7 CYCLES	7.7	140.2	65	
		WET AVG	7.2	141.1	67	
		DRY AVG**	7.5	140.5	75	0.90
	E9	9 CYCLES	7.7	140.3	53	
	E10	9 CYCLES	7.9	140.1	52	
		WET AVG	7.8	140.2	53	
		DRY AVG**	7.5	140.5	75	0.71

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE E-5 TEST RESULTS FOR LABORATORY MIXTURES (D-25)
ADDITIVE: FINA-A (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.3	142.6	89	
	A2	DRY	6.3	142.5	91	
	A3	DRY	7.2	141.1	86	
		DRY AVG	6.6	142.1	89	
	A4	WET	7.0	141.3	84	
	A5	WET	7.5	140.7	82	
	A6	WET	6.5	142.1	96	
		WET AVG	7.0	141.4	87	
						0.98
B	B1	DRY	8.0	139.8	77	
	B2	DRY	7.7	140.3	79	
		DRY AVG**	7.9	140.1	78	
	B4	WET	6.3	142.5	92	
	B5	WET	6.6	142.1	93	
	B6	WET	7.0	141.4	92	
		WET AVG	6.6	142.0	92	
						1.18
C	C1	WET	7.6	140.5	62	
	C2	WET	6.7	141.8	68	
	C3	WET	7.2	141.1	61	
		WET AVG	7.2	141.2	64	
		DRY AVG**	7.9	140.1	78	
						0.82
D	D1	WET	7.5	140.7	74	
	D2	WET	7.1	141.2	71	
	D3	WET	7.0	141.5	74	
		WET AVG	7.2	141.1	73	
		DRY AVG**	7.9	140.1	78	
						0.94

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE E-5 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	7.9	140.1	78	
	E2	1 CYCLE	6.8	141.7	80	
		WET AVG	7.4	140.9	79	
		DRY AVG**	7.9	140.1	78	1.01
	E3	3 CYCLES	7.6	140.6	62	
	E4	3 CYCLES	7.6	140.6	63	
		WET AVG	7.6	140.6	62	
		DRY AVG**	7.9	140.1	78	0.80
	E5	5 CYCLES	7.4	140.9	62	
	E6	5 CYCLES	6.4	142.4	68	
		WET AVG	6.9	141.6	65	
		DRY AVG**	7.9	140.1	78	0.83
	E7	7 CYCLES	7.4	140.8	59	
	E8	7 CYCLES	7.3	140.9	59	
		WET AVG	7.4	140.9	59	
		DRY AVG**	7.9	140.1	78	0.76
	E9	9 CYCLES	6.0	143.0	61	
	E10	9 CYCLES	6.4	142.4	61	
		WET AVG	6.2	142.7	61	
		DRY AVG**	7.9	140.1	78	0.79
****	B3	DRY	5.6	143.5	95	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

****The air voids exceed the tolerance.

TABLE E-6 TEST RESULTS FOR LABORATORY MIXTURES (D-25)
ADDITIVE: PERMA-TAC (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.0	141.5	87	
	A2	DRY	6.9	141.6	90	
	A3	DRY	7.8	140.3	84	
		DRY AVG	7.2	141.1	87	
	A4	WET	6.7	142.0	85	
	A5	WET	6.3	142.6	98	
	A6	WET	6.8	141.8	86	
		WET AVG	6.6	142.1	90	
						1.03
B	B1	DRY	6.6	142.1	87	
	B2	DRY	6.1	142.9	95	
	B3	DRY	8.0	140 0	78	
		DRY AVG**	6.9	141.6	87	
	B4	WET	7.0	141.5	82	
	B5	WET	7.3	141.1	82	
	B6	WET	6.8	141.8	87	
		WET AVG	7.0	141.5	84	
						0.97
C	C1	WET	7.1	141.3	64	
	C2	WET	7.7	140.5	55	
	C3	WET	6.6	142.2	62	
		WET AVG	7.1	141.3	60	
		DRY AVG**	6.9	141.6	87	
						0.70
D	D1	WET	6.6	142.0	75	
	D2	WET	7.8	140.3	72	
	D3	WET	6.2	142.6	77	
		WET AVG	6.9	141.7	75	
		DRY AVG**	6.9	141.6	87	
						0.86

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE E-6 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.1	141.4	76	
	E2	1 CYCLE	7.8	140.2	68	
		WET AVG	7.5	140.8	72	
		DRY AVG**	6.9	141.6	87	
						0.83
	E3	3 CYCLES	6.9	141.7	60	
	E4	3 CYCLES	6.9	141.6	59	
		WET AVG	6.9	141.6	60	
		DRY AVG**	6.9	141.6	87	
						0.69
E						
	E5	5 CYCLES	8.0	139.9	48	
	E6	5 CYCLES	6.1	142.8	59	
		WET AVG	7.1	141.4	54	
		DRY AVG**	6.9	141.6	87	
						0.62
	E7	7 CYCLES	6.8	141.7	51	
	E8	7 CYCLES	7.5	140.7	51	
		WET AVG	7.2	141.2	51	
		DRY AVG**	6.9	141.6	87	
						0.59
	E9	9 CYCLES	7.3	141.0	40	
	E10	9 CYCLES	7.4	140.9	37	
		WET AVG	7.3	141.0	38	
		DRY AVG**	6.9	141.6	87	
						0.44

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE E-7 TEST RESULTS FOR LABORATORY MIXTURES (D-25)
ADDITIVE: UNICHEM (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.5	141.0	74	
	A2	DRY	7.7	140.6	75	
	A3	DRY	7.8	140.5	78	
		DRY AVG	7.7	140.7	76	
	A4	WET	7.2	141.4	80	
	A5	WET	7.8	140.6	68	
	A6	WET	8.0	140.2	61	
		WET AVG	7.6	140.7	70	0.92
B	B1	DRY	7.2	141.4	75	
	B2	DRY	8.0	140.2	69	
	B3	DRY	7.4	141.2	80	
		DRY AVG**	7.5	140.9	75	
	B4	WET	6.8	141.9	82	
	B5	WET	7.2	141.4	76	
	B6	WET	7.9	140.4	70	
		WET AVG	7.3	141.2	76	1.02
C	C1	WET	7.9	140.4	53	
	C2	WET	8.0	140.2	52	
	C3	WET	7.2	141.5	57	
		WET AVG	7.7	140.7	54	
		DRY AVG**	7.5	140.9	75	0.72
D	D1	WET	7.6	140.8	64	
	D2	WET	8.0	140.2	63	
	D3	WET	7.2	141.4	67	
		WET AVG	7.6	140.8	65	
		DRY AVG**	7.5	140.9	75	0.87

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE E-7 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	7.0	141.7	77	
	E2	1 CYCLE	7.0	141.7	75	
		WET AVG	7.0	141.7	76	
		DRY AVG**	7.5	140.9	75	1.02
	E3	3 CYCLES	7.0	141.7	59	
	E4	3 CYCLES	7.6	140.8	52	
		WET AVG	7.3	141.3	56	
		DRY AVG**	7.5	140.9	75	0.75
	E5	5 CYCLES	7.5	141.0	48	
	E6	5 CYCLES	7.4	141.1	51	
		WET AVG	7.4	141.0	49	
		DRY AVG**	7.5	140.9	75	0.66
	E7	7 CYCLES	7.8	140.6	45	
	E8	7 CYCLES	7.2	141.5	49	
		WET AVG	7.5	141.0	47	
		DRY AVG**	7.5	140.9	75	0.62
	E9	9 CYCLES	7.5	141.0	36	
	E10	9 CYCLES	7.8	140.4	35	
		WET AVG	7.7	140.7	36	
		DRY AVG**	7.5	140.9	75	0.48

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE E-8 TEST RESULTS FOR PLANT MIXTURES (D-25)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.0	142.4	118	
	B2	DRY	7.1	142.1	106	
	B3	DRY	7.2	142.0	119	
		DRY AVG**	7.1	142.1	114	
	B4	WET	7.1	142.2	72	
	B5	WET	6.7	142.8	61	
	B6	WET	7.1	142.2	74	
		WET AVG	6.9	142.4	69	
						0.60
C	C1	WET	7.1	142.1	53	
	C2	WET	6.9	142.4	50	
	C3	WET	7.0	142.3	47	
		WET AVG	7.0	142.3	50	
		DRY AVG**	7.1	142.1	114	
						0.44
D	D1	WET	7.0	142.3	77	
	D2	WET	7.4	141.7	70	
	D3	WET	7.1	142.1	73	
		WET AVG	7.2	142.0	73	
		DRY AVG**	7.1	142.1	114	
						0.64

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE E-9 TEST RESULTS FOR PLANT MIXTURES (D-25)
ADDITIVE: LIME SLURRY (1.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.1	141.9	104	
	B2	DRY	7.0	142.0	104	
	B3	DRY	7.3	141.7	104	
		DRY AVG**	7.2	141.9	104	
	B4	WET	6.5	142.9	98	
	B5	WET	7.4	141.5	90	
	B6	WET	7.5	141.4	91	
		WET AVG	7.1	141.9	93	0.89
C	C1	WET	6.6	142.7	76	
	C2	WET	7.1	141.9	80	
	C3	WET	7.3	141.7	81	
		WET AVG	7.0	142.1	79	
		DRY AVG**	7.2	141.9	104	0.76
D	D1	WET	7.1	141.9	96	
	D2	WET	7.4	141.5	93	
	D3	WET	7.1	142.0	91	
		WET AVG	7.2	141.8	93	
		DRY AVG**	7.2	141.9	104	0.90

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE E-10 TEST RESULTS FOR PLANT MIXTURES (D-25)
ADDITIVE: AQUA-SHIELD II (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	6.4	142.2	112	
	B2	DRY	6.3	142.3	115	
	B3	DRY	6.2	142.6	106	
		DRY AVG**	6.3	142.4	111	
B	B4	WET	6.8	141.7	68	
	B5	WET	6.2	142.6	67	
	B6	WET	6.1	142.6	65	
		WET AVG	6.4	142.3	67	0.60
	C1	WET	6.1	142.6	52	
	C2	WET	6.5	142.0	54	
	C3	WET	6.6	141.9	53	
C		WET AVG	6.4	142.2	53	
		DRY AVG**	6.3	142.4	111	0.48
	D1	WET	6.5	142.1	71	
	D2	WET	6.6	141.9	70	
	D3	WET	6.4	142.2	69	
D		WET AVG	6.5	142.1	70	
		DRY AVG**	6.3	142.4	111	0.63

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE E-11 TEST RESULTS FOR PLANT MIXTURES (D-25)
ADDITIVE: FINA-A (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.0	141.5	104	
	B2	DRY	7.4	140.9	112	
	B3	DRY	6.7	141.9	104	
		DRY AVG**	7.0	141.4	107	
	B4	WET	7.6	140.5	97	
	B5	WET	7.1	141.3	84	
	B6	WET	7.1	141.3	91	
		WET AVG	7.3	141.1	91	0.85
C	C1	WET	6.8	141.8	87	
	C2	WET	7.2	141.3	85	
	C3	WET	7.0	141.5	82	
		WET AVG	7.0	141.5	85	
		DRY AVG**	7.0	141.4	107	0.79
D	D1	WET	6.8	141.7	106	
	D2	WET	7.1	141.4	99	
	D3	WET	7.1	141.3	101	
		WET AVG	7.0	141.5	102	
		DRY AVG**	7.0	141.4	107	0.96

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE E-12 TEST RESULTS FOR PLANT MIXTURES (D-25)
ADDITIVE: PERMA-TAC (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.9	142.0	90	
	B2	DRY	7.1	141.6	101	
	B3	DRY	7.0	141.7	101	
		DRY AVG**	7.0	141.8	97	
	B4	WET	7.0	141.8	71	
	B5	WET	7.3	141.3	71	
	B6	WET	7.4	141.2	80	
		WET AVG	7.2	141.4	74	
						0.76
C	C1	WET	6.9	141.9	61	
	C2	WET	7.1	141.6	63	
	C3	WET	7.1	141.7	59	
		WET AVG	7.0	141.7	61	
		DRY AVG**	7.0	141.8	97	
						0.63
D	D1	WET	7.1	141.6	76	
	D2	WET	7.4	141.1	74	
	D3	WET	7.5	141.1	71	
		WET AVG	7.3	141.2	74	
		DRY AVG**	7.0	141.8	97	
						0.76

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE E-13 TEST RESULTS FOR PLANT MIXTURES (D-25)
ADDITIVE: UNICHEM (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.9	141.6	96	
	B2	DRY	6.7	141.9	94	
	B3	DRY	7.3	140.9	94	
		DRY AVG**	6.9	141.5	95	
	B4	WET	7.1	141.3	70	
	B5	WET	7.1	141.2	68	
	B6	WET	7.1	141.2	75	
		WET AVG	7.1	141.3	71	0.75
C	C1	WET	6.8	141.7	60	
	C2	WET	6.9	141.5	64	
	C3	WET	6.9	141.6	65	
		WET AVG	6.9	141.6	63	
		DRY AVG**	6.9	141.5	95	0.67
D	D1	WET	7.1	141.2	77	
	D2	WET	6.8	141.8	77	
	D3	WET	6.7	141.8	67	
		WET AVG	6.9	141.6	74	
		DRY AVG**	6.9	141.5	95	0.78

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE E-14 TEST RESULTS FOR FIELD CORES
DISTRICT 25
ASPHALT CONTENT = 5.2 %

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
NO ADDITIVE (CONTROL)	LOW AIR VOIDS SECTION	1A	WET	10.2	137.4	33	
		1B	DRY	9.7	138.2	59	
							0.56
		2A	DRY	10.4	137.1	62	
		2B	WET	10.3	137.3	33	
							0.54
		3A	WET	9.2	138.9	37	
		3B	DRY	9.4	138.6	74	
							0.50
		(AVG VOIDS)		9.9		(AVG TSR)	0.53
	HIGH AIR VOIDS SECTION	4A	DRY	10.9	136.3	55	
		4B	WET	11.3	135.8	37	
							0.68
		5A	WET	11.5	135.4	31	
		5B	DRY	11.6	135.2	53	
							0.59
		6A	DRY	11.2	135.9	51	
		6B	WET	11.0	136.2	33	
							0.65
		(AVG VOIDS)		11.2		(AVG TSR)	0.64
LIME SLURRY	LOW AIR VOIDS SECTION	7A	WET	8.7	139.5	91	
		7B	DRY	8.3	140.1	88	
							1.03
		8A	DRY	7.8	140.9	87	
		8B	WET	7.7	141.1	87	
							1.01
		9A	WET	8.8	139.3	75	
		9B	DRY	8.2	140.3	78	
							0.97
		(AVG VOIDS)		8.3		(AVG TSR)	1.00
	HIGH AIR VOIDS SECTION	10A	DRY	8.2	140.3	89	
		10B	WET	8.8	139.4	85	
							0.96
		11A	WET	8.8	139.4	87	
		11B	DRY	7.4	141.6	93	
							0.93
		12A	DRY	6.8	142.4	87	
		12B	WET	7.2	141.9	92	
							1.07
		(AVG VOIDS)		7.9		(AVG TSR)	0.98
		13A	WET	8.1	139.6	39	
		13B	DRY	9.1	138.1	64	
							0.60
		14A	DRY	7.7	140.3	71	

TABLE E-14 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
	LOW AIR VOIDS SECTION	14B	WET	7.4	140.7	43	
							0.61
		15A	WET	10.9	135.3	38	
		15B	DRY	11.8	134.1	56	
							0.68
				--------			-------
AQUA-SHIELD II		(AVG VOIDS)		9.2		(AVG TSR)	0.63
	HIGH AIR VOIDS SECTION	16A	DRY	8.8	138.6	65	
		16B	WET	14.4	130.1	46	
							0.72
		17A	WET	9.4	137.6	59	
		17B	DRY	9.5	137.6	53	
							1.12
		18A	DRY	9.2	137.9	60	
		18B	WET	9.2	137.9	62	
							1.03
				--------			-------
		(AVG VOIDS)		10.1		(AVG TSR)	0.96
	LOW AIR VOIDS SECTION	19A	WET	6.9	141.6	79	
		19B	DRY	7.3	141.1	70	
							1.14
		20A	DRY	10.5	136.2	48	
		20B	WET	9.8	137.2	58	
							1.21
		21A	WET	7.9	140.1	70	
		21B	DRY	8.0	139.9	71	
							0.98
				--------			-------
		(AVG VOIDS)		8.4		(AVG TSR)	1.11
FINA-A	HIGH AIR VOIDS SECTION	22A	DRY	10.6	136.0	63	
		22B	WET	10.3	136.4	60	
							0.96
		23A	WET	10.3	136.4	66	
		23B	DRY	7.9	140.1	59	
							1.12
		24A	DRY	11.7	134.3	60	
		24B	WET	11.0	135.4	59	
							0.99
				--------			-------
		(AVG VOIDS)		10.3		(AVG TSR)	1.02
	LOW AIR VOIDS SECTION	25A	WET	10.1	137.0	43	
		25B	DRY	9.6	137.8	57	
							0.76
		26A	DRY	7.1	141.7	71	
		26B	WET	7.9	140.3	51	
							0.72
		27A	WET	6.8	142.1	70	
		27B	DRY	6.4	142.7	75	
							0.93
				--------			-------

TABLE E-14 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		(AVG VOIDS)		8.0		(AVG TSR)	0.80
PERMA-TAC							
	HIGH AIR VOIDS SECTION	28A	DRY	8.6	139.4	67	
		28B	WET	7.9	140.3	62	
							0.93
		29A	WET	6.9	141.9	67	
		29B	DRY	7.8	140.5	69	
							0.97
		30A	DRY	10.7	136.1	54	
		30B	WET	10.4	136.6	50	
							0.93
		(AVG VOIDS)		8.7		(AVG TSR)	0.94
	LOW AIR VOIDS SECTION	31A	WET	9.1	138.2	50	
		31B	DRY	8.9	138.5	65	
							0.76
		32A	DRY	7.7	140.4	70	
		32B	WET	9.0	138.4	50	
							0.72
		33A	WET	8.1	139.7	62	
		33B	DRY	9.3	137.9	60	
							1.04
		(AVG VOIDS)		8.7		(AVG TSR)	0.84
UNICHEM							
	HIGH AIR VOIDS SECTION	34A	DRY	10.0	136.8	61	
		34B	WET	9.8	137.2	38	
							0.61
		35A	WET	9.6	137.5	37	
		35B	DRY	10.1	136.7	60	
							0.62
		36A	DRY	8.1	139.8	68	
		36B	WET	8.6	139.0	38	
							0.56
		(AVG VOIDS)		9.4		(AVG TSR)	0.60

*TSR = Tensile Strength Ratio
= Tensile Strength (Wet)/Tensile Strength (Dry)

TABLE E-15 BOILING TEST RESULTS
DISTRICT 25

TYPE OF MIXTURE	TYPE OF ADDITIVE	ASPHALT RETAINED AFTER BOILING, % RATING 1	RATING 2	AVG
	NO ADDITIVE	50	50	50.0
	LIME	80	90	85.0
LABORATORY	AQUASHIELD II	98	95	96.5
	FINA-A	98	90	94.0
	PERMA-TAC	90	90	90.0
	UNICHEM	98	90	94.0
	NO ADDITIVE	75	80	77.5
	LIME	80	95	87.5
PLANT	AQUASHIELD II	75	80	77.5
	FINA-A	90	98	94.0
	PERMA-TAC	90	95	92.5
	UNICHEM	80	95	87.5
	NO ADDITIVE	75	70	72.5
	LIME	90	80	85.0
FIELD CORE	AQUASHIELD II	75	70	72.5
	FINA-A	95	90	92.5
	PERMA-TAC	90	85	87.5
	UNICHEM	80	75	77.5

APPENDIX E LIST OF FIGURES

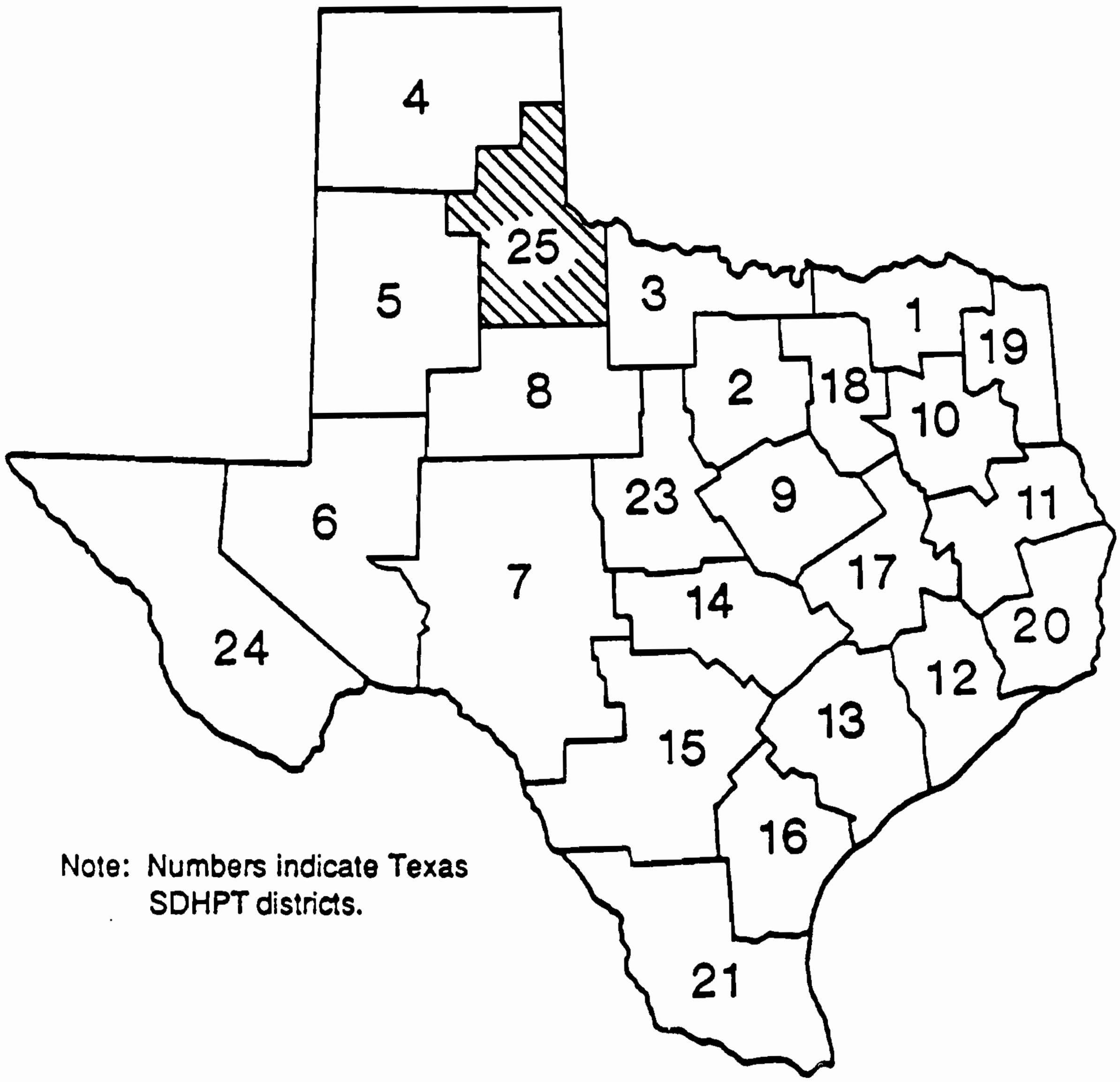
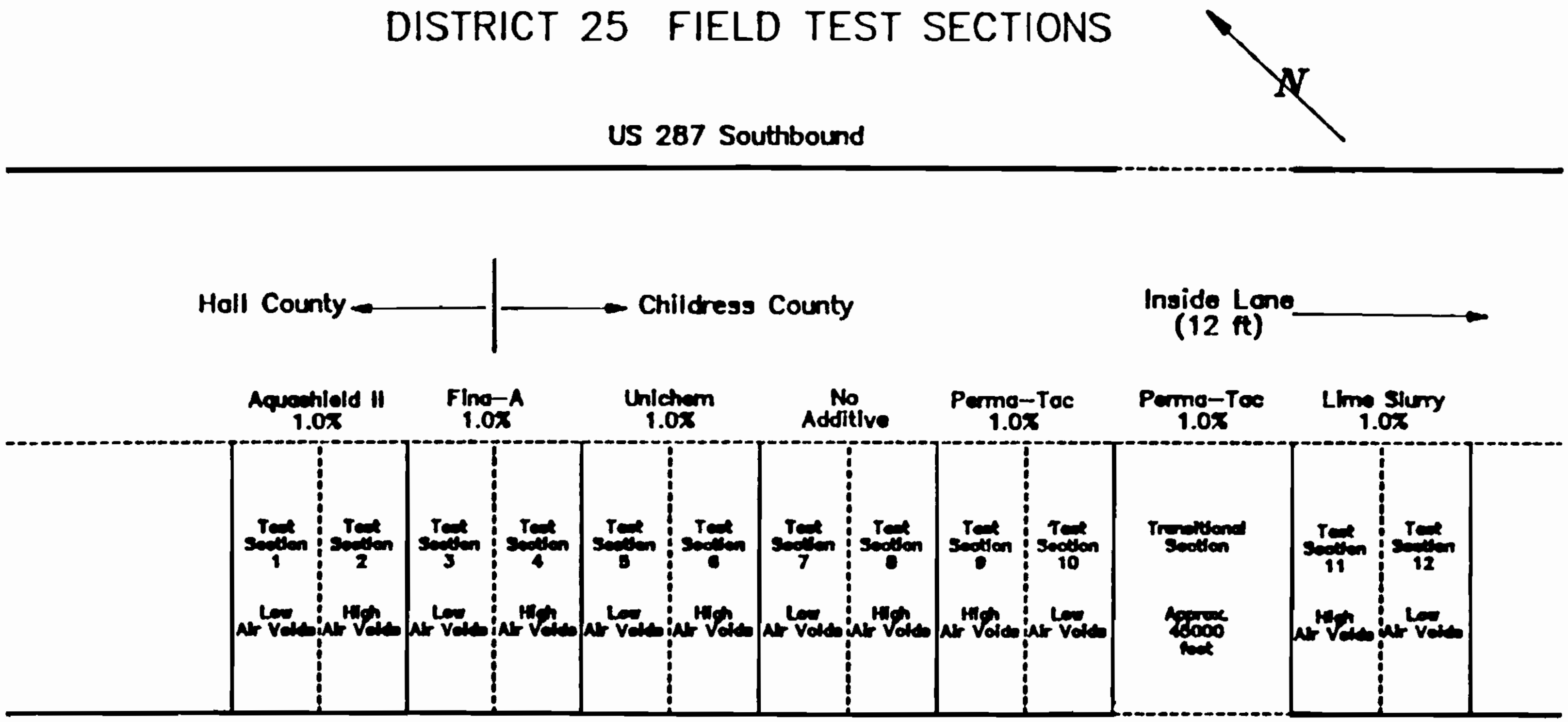


Figure E-1. Location of Field Test Sections (District 25)



Note: Each test section is approximately 1000 feet in length.

Fig E-2 Schematic Illustration of Field Test Sections.

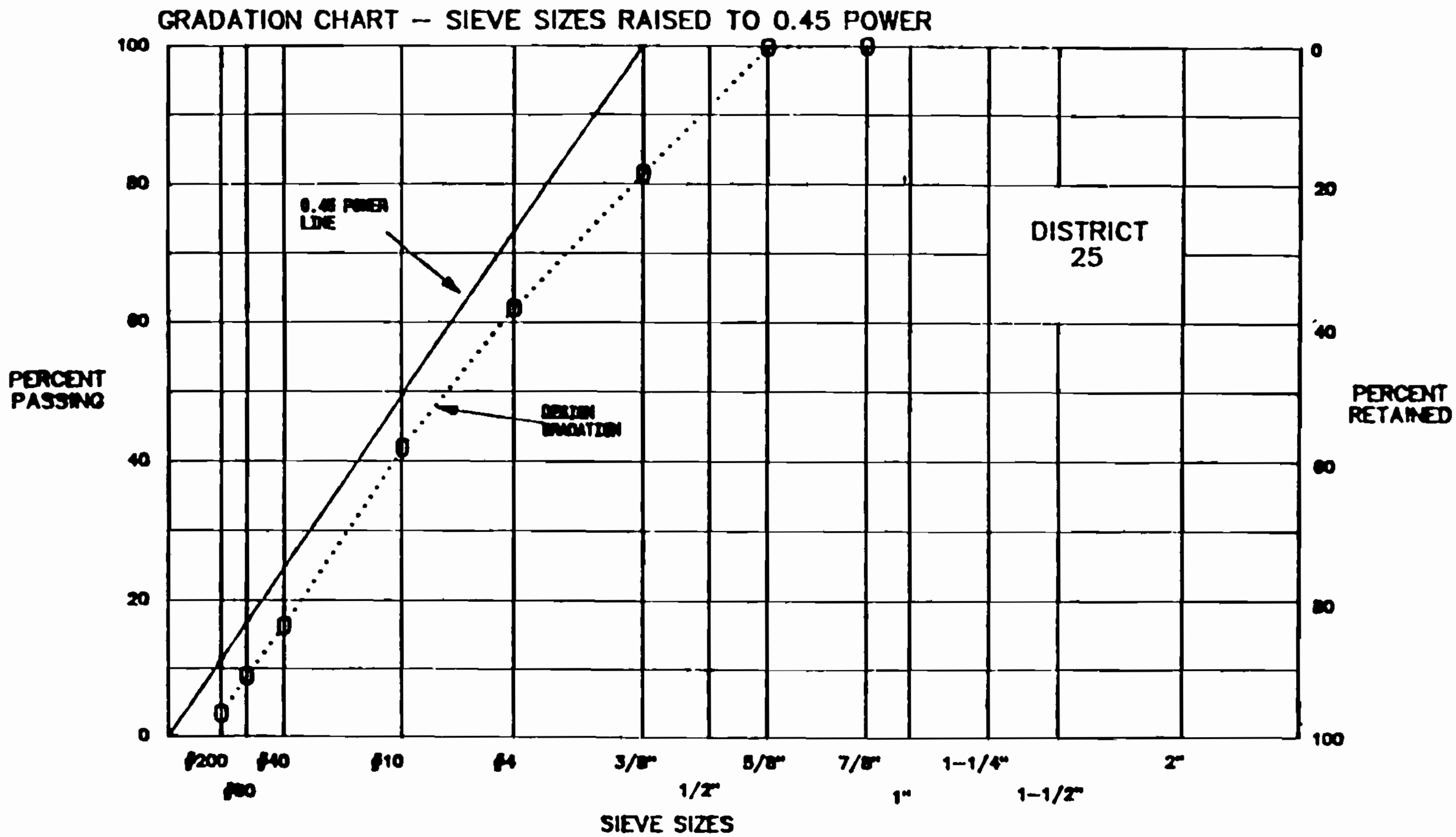


Fig E-3 Aggregate Gradation Chart.

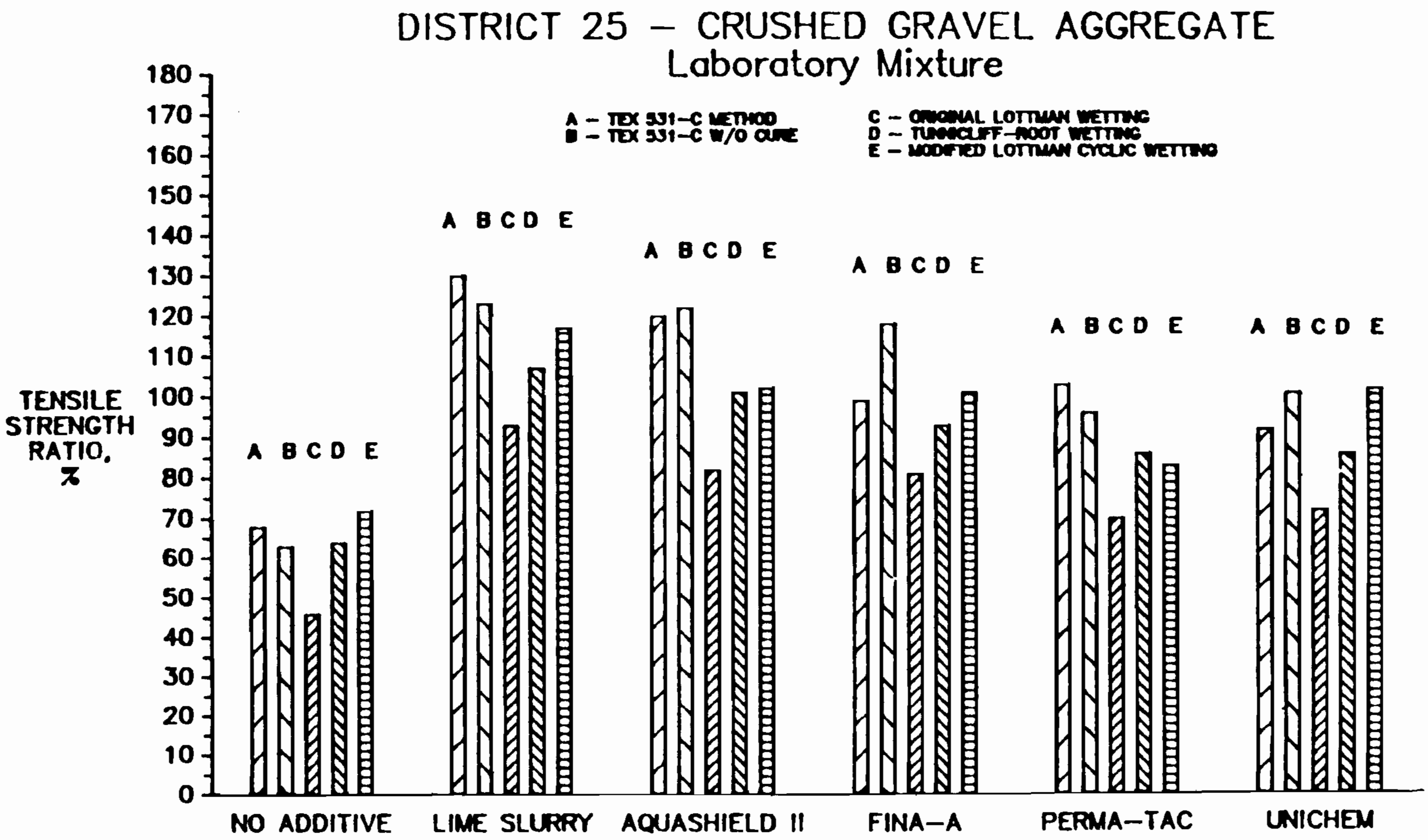


Fig E-4 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

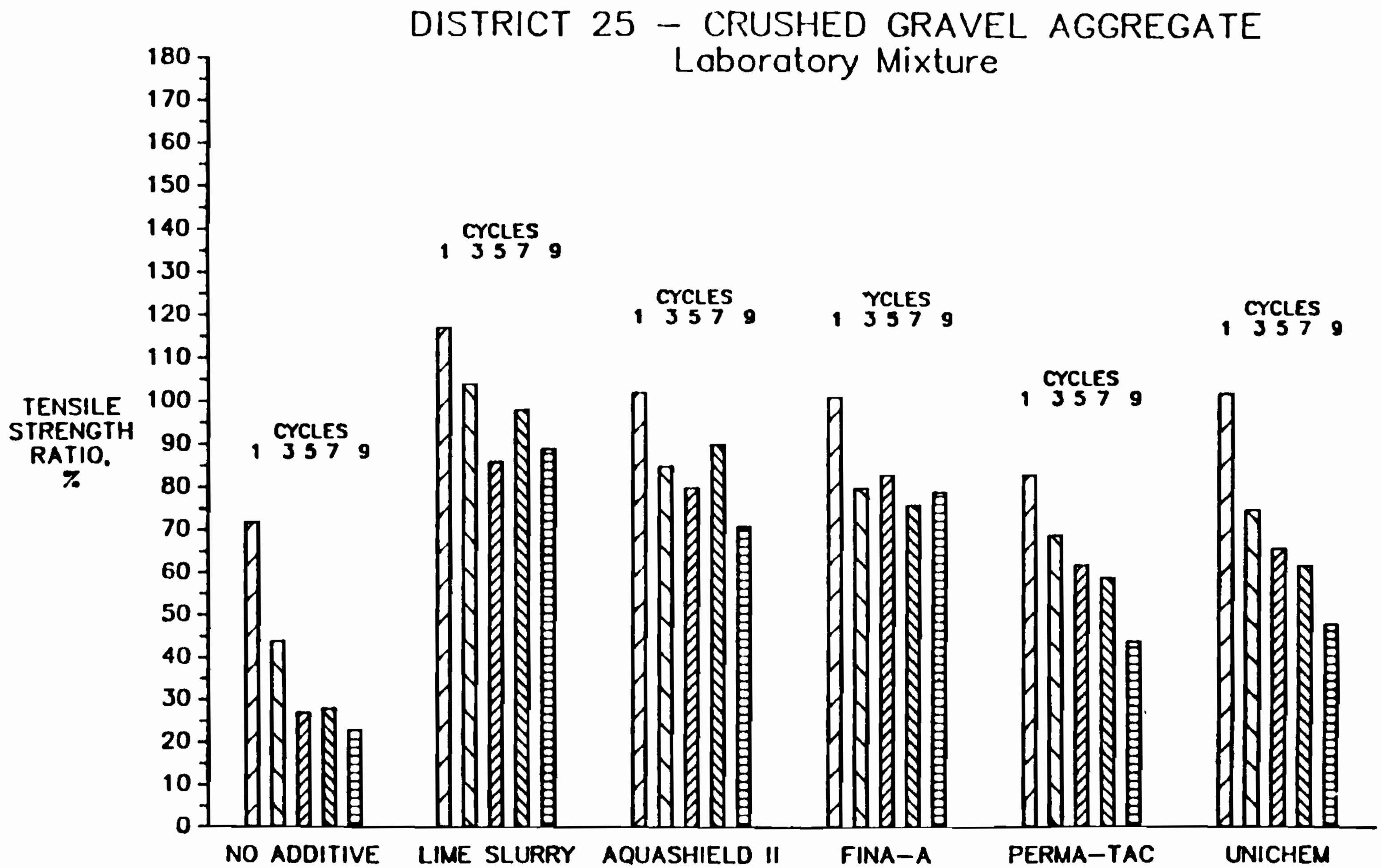


Fig E-5 Wet-Dry Indirect Tensile Cyclic Freeze-Thaw Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

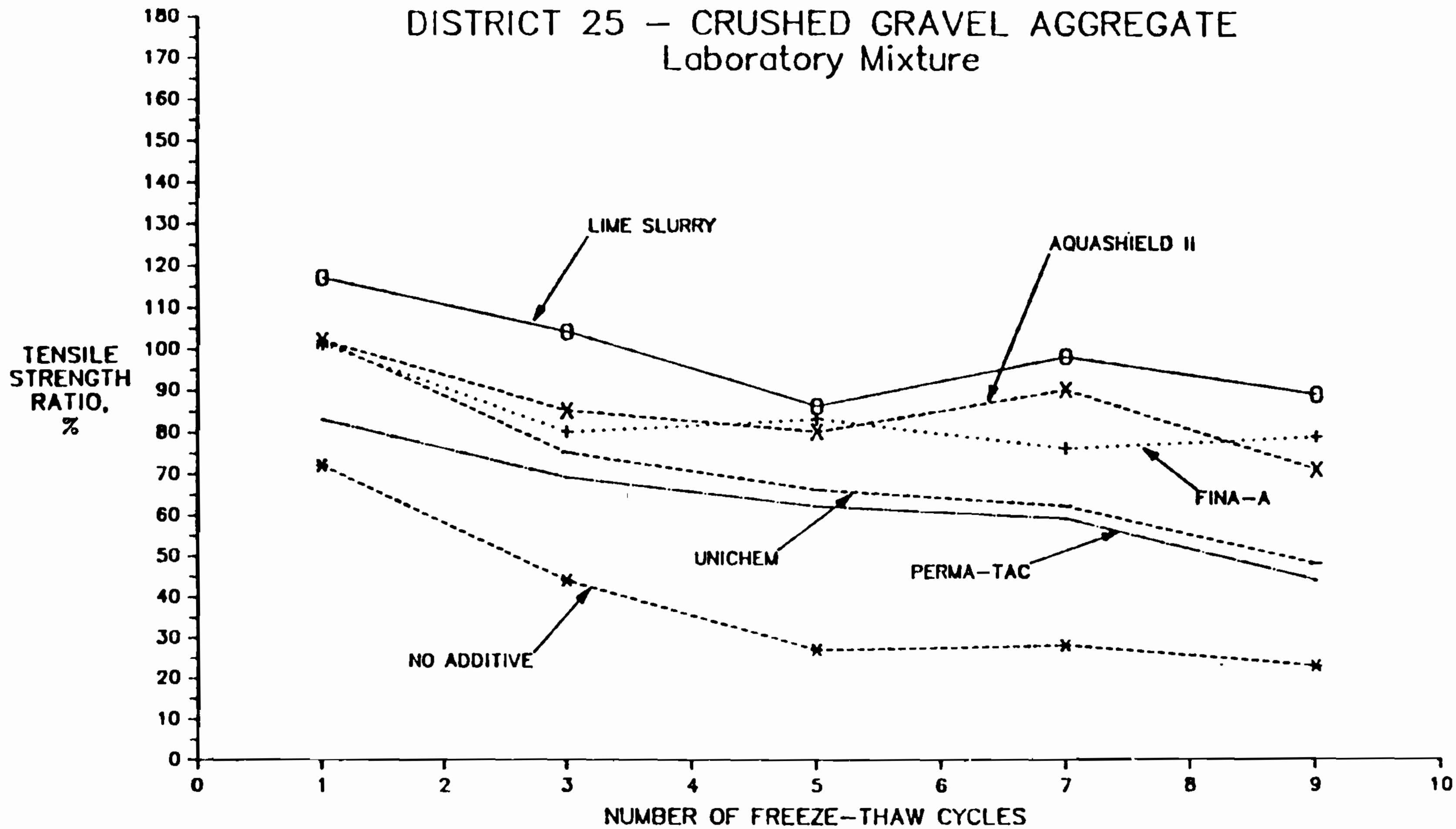


Fig E-6 Tensile Strength Ratio (TSR) Vs. Number of Freeze-Thaw Cycles for Laboratory Mixtures.

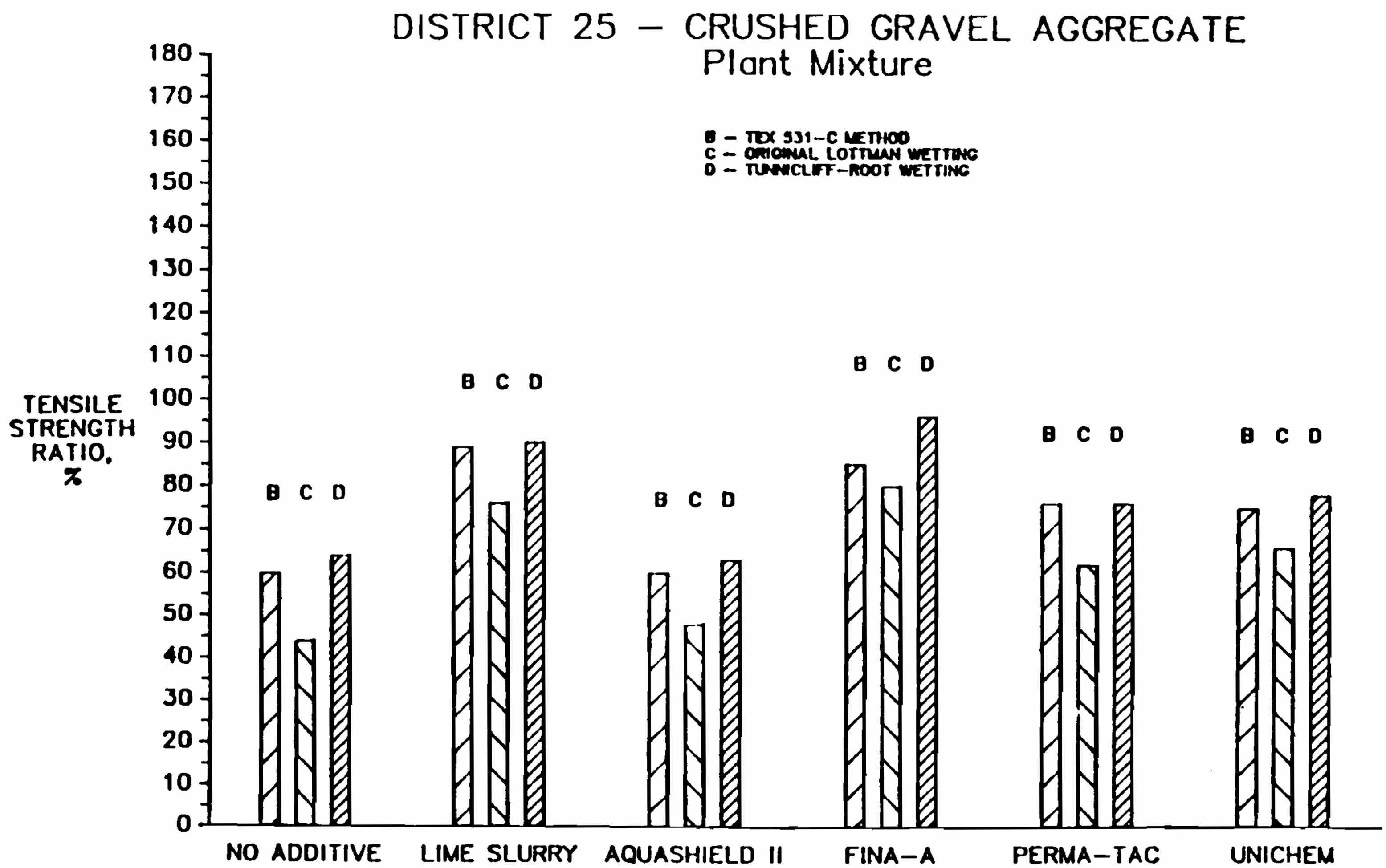


Fig E-7 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Plant Mixtures.

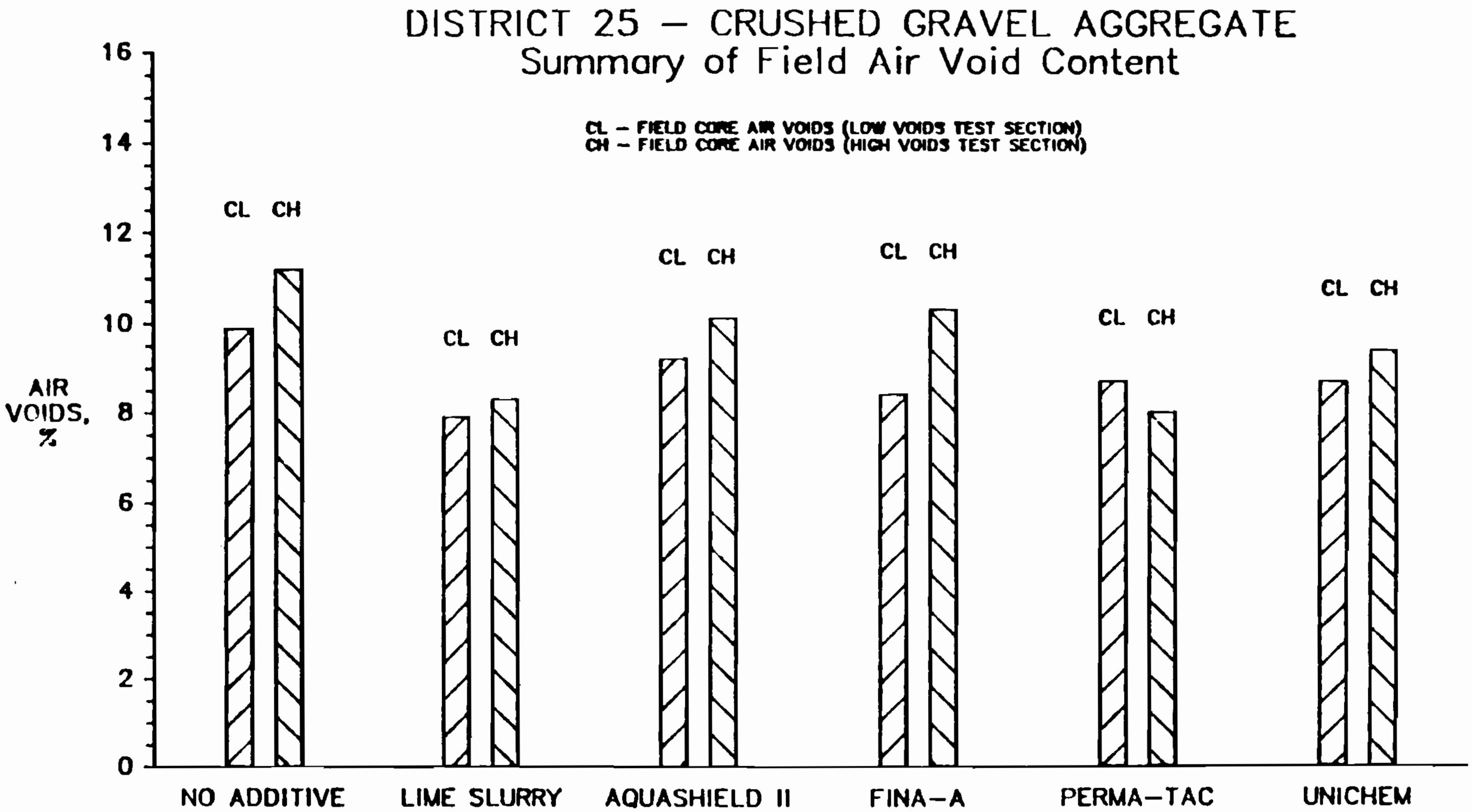


Fig E-8 Summary of Field Core Air Void Content.

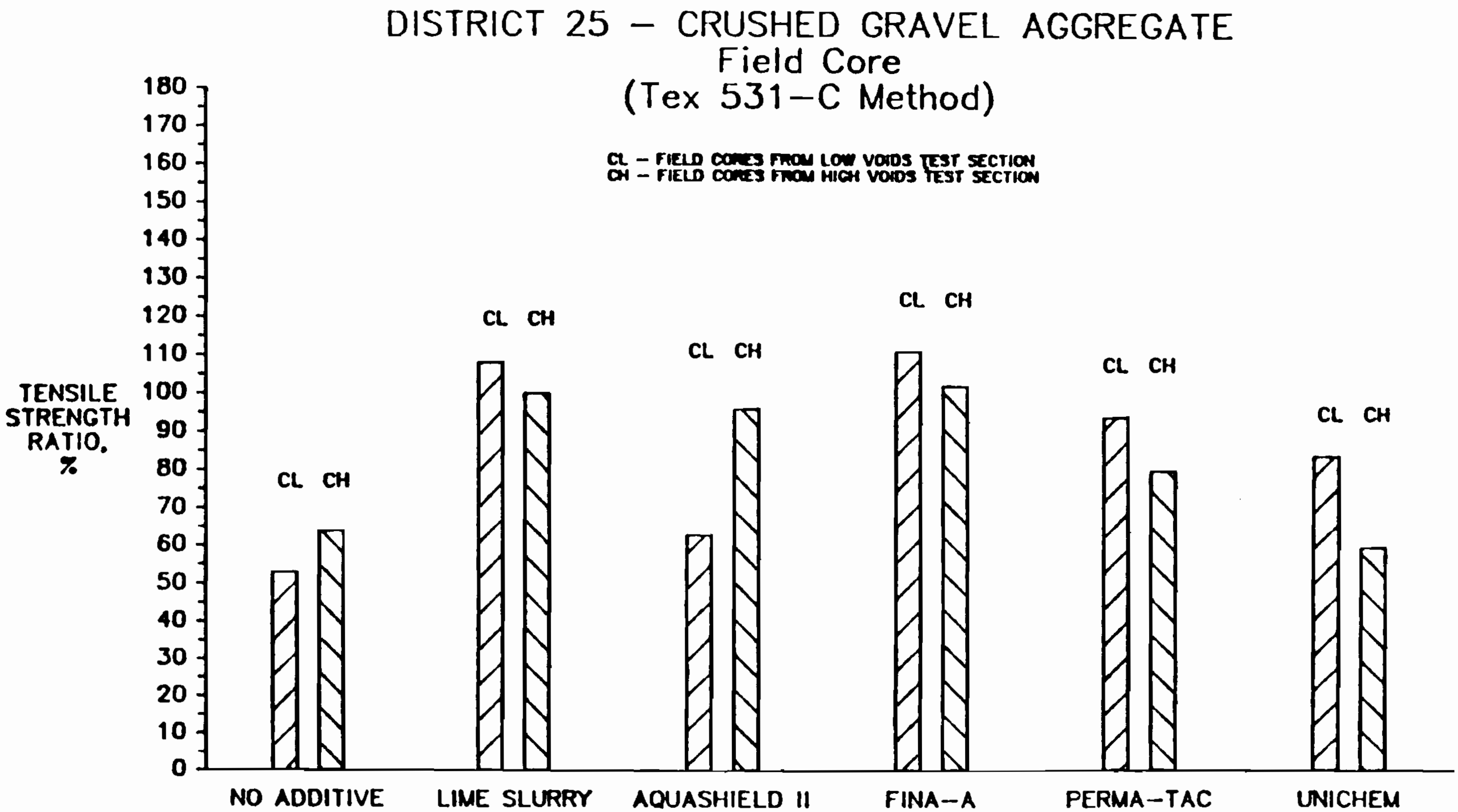


Fig E-9 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Field Cores.

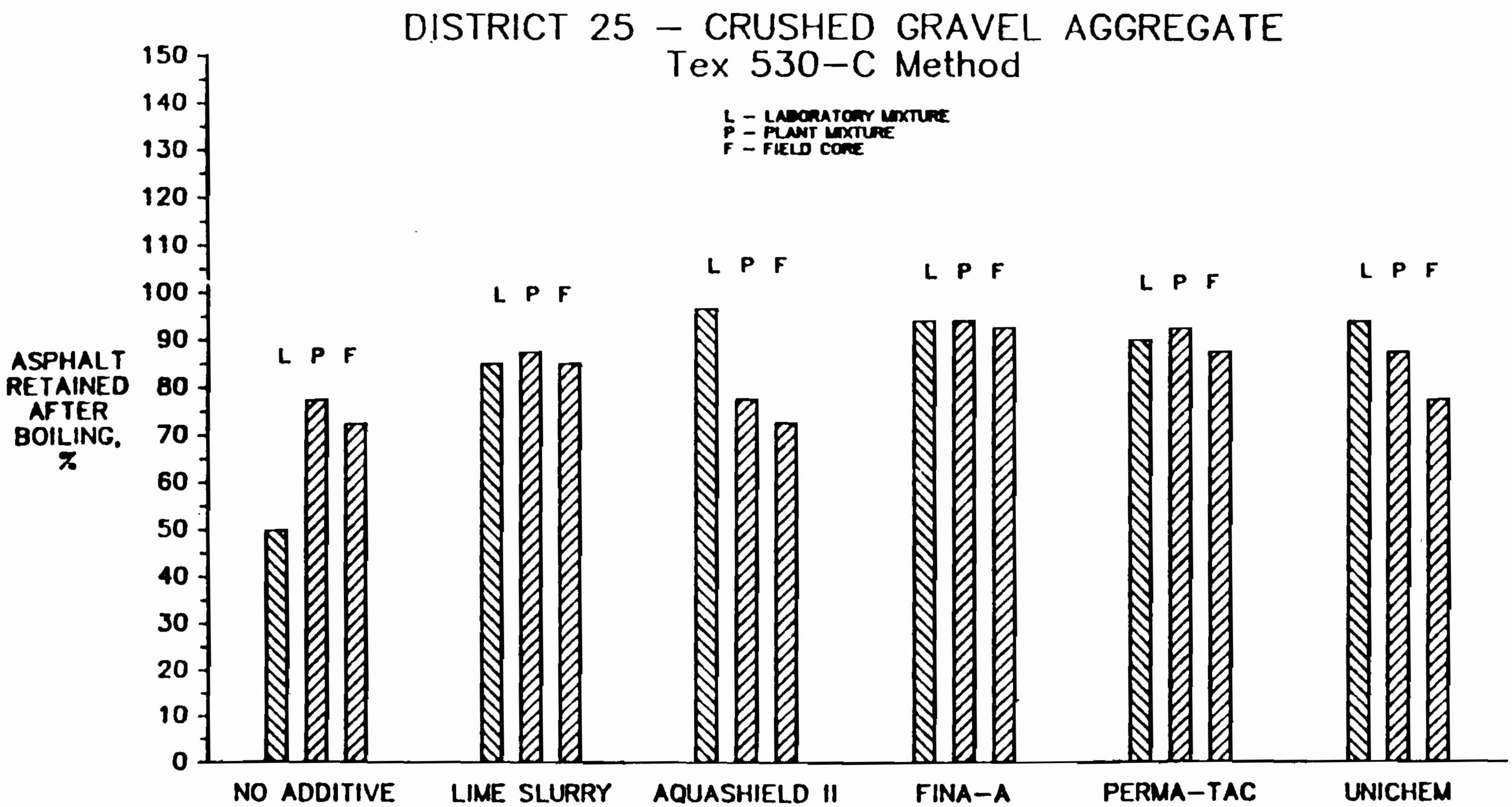


Fig E-10 Texas Boiling Test Results.

APPENDIX F

FIELD AND LABORATORY EXPERIMENTAL PROGRAM - DISTRICT 1

The objective of Appendix F is twofold: (1) to describe the site specific (District 1) field operations of the test sections along with a description of the materials, additives and construction techniques used for this field project, (2) to present the laboratory test results of the laboratory mixed and plant mixed mixtures along with the zero-aged (immediately after construction) pavement cores for the field experimental study at District 1 (Fig F-1) of the Texas State Department of Highways and Public Transportation (SDHPT).

FIELD EXPERIMENTAL PROGRAM

The test pavements were constructed on US 82 approximately 6 miles west of Bonham, Texas, in September 1987, and involved pavement overlay to one lane of the two lane highway. All of the test sections were installed as the surface course in the westbound lane as shown schematically in Figure F-2. Each test section was approximately two to two and one half inches (2.5) thick, 12 feet wide, and 500 feet long. A total of sixteen (16) test sections were constructed and six liquid antistripping additives were used in addition to the hydrated lime and the control materials. The composition of the sixteen test sections are as follows:

Test Section 1A. Control Section - No additive, low air voids.

Test Section 1B. Control Section - No additive, high air voids.

Test Section 2A. Hot mix with 1.0% Perma-Tac Plus, low air voids.

Test Section 2B. Hot mix with 1.0% Perma-Tac Plus, high air voids.

Test Section 3A. Hot mix with 1.0% Pavebond Special, low air voids.

Test Section 3B. Hot mix with 1.0% Pavebond Special, high air voids.

Test Section 4A. Hot mix with 0.45% Dow Polyethylene, low air voids.

Test Section 4B Hot mix with 0.18% Dow Polyethylene, high air voids.

Test Section 5A. Hot mix with 1.0% Fina-A, low air voids.

Test Section 5B. Hot mix with 1.0% Fina-A, high air voids.

Test Section 6A. Hot mix with 1.0% Indulin AS-1, low air voids.

Test Section 6B. Hot mix with 1.0% Indulin AS-1, high air voids.

Test Section 7A. Hot mix with 0.75% ARR-MAZ, low air voids.

Test Section 7B. Hot mix with 0.75% ARR-MAZ, high air voids.

Test Section 8A. Hot mix with 1.5% lime slurry, low air voids.

Test Section 8B. Hot mix with 1.5% lime slurry, high air voids.

The field construction was conducted by District 1 of the Texas State Department of Highways and Public Transportation (SDHPT) and was assisted by the Center for Transportation Research, The University of Texas at Austin. The average daily traffic (ADT) is estimated at 5,000 vehicles for the test pavement.

MATERIALS AND PAVING MIXTURE

An AC-20 asphalt cement from the Total Petroleum refinery in Ardmore, Oklahoma was used throughout this project. Three aggregates--a coarse stone aggregate, unwashed screenings, and a field sand, were combined to produce the project gradation. Gradations of the individual aggregates, the project gradation, percentages of each aggregate combined, and the specification are given on Table F-1. The project gradation is plotted on a 0.45 power graph in Figure F-3.

The asphalt concrete mixture used in this study met the SDHPT specifications of Item 340, Type D (Modified) fine graded surface course (Ref 45). Preliminary laboratory test results for this mixture design are given below:

Asphalt Content	-	6.0%
Average Density	-	97 percent of theoretical maximum density
Air Void Content	-	3 percent
Hveem Stability	-	46%

FIELD OPERATIONS

A drum mix plant was used to prepare hot mixed asphalt mixtures containing lime slurry and liquid antistripping additives. Identical raw material sources (asphalt cement and agregates) were utilized throughout the experiment. The actual asphalt content used in field was about 5.5%. Six commercially available liquid antistripping additives were used for the test sections, i.e., ARR-MAZ, Dow, Fina-A, Indulin AS-1, Pavebond Special, and Perma-Tac Plus.

The hydrated lime was added in slurry form to the aggregate stockpile and was used the same day. The liquid additives were metered into the asphalt cement in-line injection system. The Dow Polyethylene was in pellet form which required time to be blended with the asphalt cement. The blending was done in a distributor truck approximately 1 hour prior to use. The dosage was difficult to determine because the pellets were not thoroughly blended with the asphalt cement. The percentage of the dosage was determined by analyzing a sample of the blended asphalt cement form the distributor truck.

Compaction of each test section was achieved using a steel wheel roller; a vibratory roller, and a pneumatic roller. For the low air void test sections, the same rolling pattern was used as established on the regular construction project. In order to achieve the high air void test sections, the number of passes by the vibratory roller was reduced.

The field cores were obtained soon after the construction. Three pairs of samples were cored from each test section with each pair approximately 100 feet apart. The sample size was approximately 4-inches in diameter and 2 to 2.5-inches in thickness. The coring process was in accordance with the general coring layout procedure described in the main text of this report (Chapter 2). The field cores were transported to the Center for Transportation Research laboratory immediately after sampling.

LABORATORY TESTING PROGRAM

The laboratory compacted specimens were made at such a compactive effort as to provide an approximately 7.0 $\pm$ 1.0% air void content. Six liquid antistripping additives were used in addition to the raw material and the hydrated lime slurry. The additives and the dosage are given below:

a. Hydrated lime slurry (1.5% by weight of aggregate).

b. ARR-MAZ (0.75% by weight of asphalt).

c. Dow Polyethylene (0.45% by weight of asphalt).

d. Fina-A (1.0% by weight of asphalt).

e. Indulin AS-1 (1.0% by weight of asphalt).

f. Pavebond Special (1.0% by weight of asphalt).

g. Perma-Tac Plus (1.0% by weight of asphalt).

The laboratory testing program was discussed in Chapter 2 of the main text and Appendix A, and it was carried out through the duration of this study. Sample preparation, conditioning, test procedures and engineering properties analyzed for the test methods were also discussed in Chapter 2.

PRESENTATION OF TEST RESULTS

Laboratory Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables F-2 through F-9. The data are plotted in Figure F-4 for laboratory mixtures using Methods A through E. The cyclic freeze-thaw test results are shown in Figures F-5 and F-6.

Plant Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables F-10 through F-17. The data are also plotted in Figure F-7 for plant mixtures using Methods B through D.

Plant Mixed/Field Compacted Mixtures (Field Cores)

Summary of the test results are presented on Table F-18. The achieved field compaction to have the low and high air voids are summarized in Figure F-8 which shows the average air void content of the field cores from the low and high voids test sections in the field. The average TSR values are shown in Figure F-9 for the low and high voids test sections.

Texas Boiling Test Results

The Texas boiling test results are presented on Table F-19 and plotted in Figure F-10 for the laboratory mixture, the plant mixture, and the field core.

APPENDIX F SUMMARY OF DATA FOR DISTRICT 1

TABLE F-1 AGGREGATE GRADATIONS (DISTRICT 1)

SIEVE SIZE	COARSE SANDSTONE		UNWASHED SCREENINGS		FIELD SAND		COMBINED GRADATION	SDHPT SPECIFICATIONS
	SIEVE ANALYSIS	55.5%	SIEVE ANALYSIS	30.0%	SIEVE ANALYSIS	15.0%		
Plus 1/2 in.	0	0					0	0
1/2 to 3/8 in.	11.7	6.4	0				6.4	0-15
3/8 to No. 4	71.9	39.6	0.1	0	0	0	39.6	21-53
No. 4 to No. 10	13.1	7.2	19.0	5.7	0.7	0.1	13.0	11-32
Plus No. 10							59.0	54-74
No. 10 to No. 40	0.4	0.2	35.0	10.5	6.1	0.9	11.6	6-32
No. 40 to No. 80	0.4	0.2	14.6	4.4	61.6	9.3	13.9	4-27
No. 80 to No. 200	1.0	0.6	19.7	5.9	30.1	4.5	11.0	3-27
Minus No. 200	1.5	0.8	11.6	3.5	1.5	0.2	4.5	1-8
TOTAL	100.0	55.0	100.0	30.0	100.0	15.0	100.0	

TABLE F-2 TEST RESULTS FOR LABORATORY MIXTURES (D-1)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 6.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	7.7	136.2	89	
	A2	DRY	7.0	137.2	93	
	A3	DRY	7.0	137.1	87	
		DRY AVG	7.2	136.9	90	
A						
	A4	WET	6.7	137.6	62	
	A5	WET	7.4	136.5	75	
	A6	WET	7.6	136.3	61	
		WET AVG	7.3	136.8	66	
						0.74
	B1	DRY	6.7	137.6	82	
	B2	DRY	6.9	137.3	82	
		DRY AVG**	6.8	137.5	82	
B						
	B4	WET	6.9	137.4	70	
	B5	WET	5.9	138.8	89	
	B6	WET	6.3	138.2	78	
		WET AVG	6.4	138.1	79	
						0.96
	C1	WET	7.0	137.2	68	
	C2	WET	7.5	136.5	63	
	C3	WET	7.7	136.2	66	
		WET AVG	7.4	136.6	66	
C						
		DRY AVG**	6.8	137.5	82	
						0.80
	D1	WET	7.1	137.0	72	
	D2	WET	6.3	138.3	81	
	D3	WET	7.3	136.7	95	
		WET AVG	6.9	137.3	83	
D						
		DRY AVG**	6.8	137.5	82	
						1.01

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE F-2 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	6.7	137.6	76	
	E2	1 CYCLE	7.1	137.0	74	
		WET AVG	6.9	137.3	75	
		DRY AVG**	6.8	137.5	82	0.91
	E3	3 CYCLES	7.3	136.8	53	
	E4	3 CYCLES	6.7	137.7	58	
		WET AVG	7.0	137.2	56	
		DRY AVG**	6.8	137.5	82	0.68
	E5	5 CYCLES	7.6	136.3	42	
	E6	5 CYCLES	7.0	137.1	43	
		WET AVG	7.3	136.7	42	
		DRY AVG**	6.8	137.5	82	0.52
	E7	7 CYCLES	7.3	136.7	41	
	E8	7 CYCLES	7.5	136.5	36	
		WET AVG	7.4	136.6	38	
		DRY AVG**	6.8	137.5	82	0.47
	E9	9 CYCLES	7.3	136.8	27	
	E10	9 CYCLES	7.2	136.8	24	
		WET AVG	7.3	136.8	25	
		DRY AVG**	6.8	137.5	82	0.31
****	B3	DRY	10.2	132.5	59	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerange.

TABLE F-3 TEST RESULTS FOR LABORATORY MIXTURES (D-1)
ADDITIVE: LIME SLURRY (1.5% BY WT OF AGGREGATE)
ASPHALT CONTENT = 6.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	6.5	138.4	95	
	A2	DRY	8.0	136.2	82	
	A3	DRY	7.2	137.4	89	
		DRY AVG	7.2	137.3	89	
A						
	A4	WET	8.0	136.2	81	
	A5	WET	6.3	138.6	106	
	A6	WET	6.2	138.8	94	
		WET AVG	6.8	137.9	94	
						1.06
	B1	DRY	6.5	138.4	90	
	B2	DRY	6.5	138.3	90	
	B3	DRY	7.7	136.7	75	
		DRY AVG**	6.9	137.8	85	
B						
	B4	WET	6.6	138.3	108	
	B5	WET	6.9	137.9	107	
	B6	WET	6.9	137.8	96	
		WET AVG	6.8	138.0	104	
						1.22
	C1	WET	7.7	136.6	91	
	C2	WET	6.4	138.5	98	
	C3	WET	7.3	137.2	101	
		WET AVG	7.2	137.4	97	
C						
		DRY AVG**	6.9	137.8	85	
						1.14
	D1	WET	8.0	136.2	101	
	D2	WET	7.0	137.7	118	
	D3	WET	7.0	137.6	98	
		WET AVG	7.3	137.2	106	
D						
		DRY AVG**	6.9	137.8	85	
						1.24

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE F-3 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.0	137.7	103	
	E2	1 CYCLE	6.6	138.3	111	
		WET AVG	6.8	138.0	107	
		DRY AVG**	6.9	137.8	85	1.26
	E3	3 CYCLES	7.0	137.6	96	
	E4	3 CYCLES	7.7	136.6	74	
		WET AVG	7.4	137.1	85	
		DRY AVG**	6.9	137.8	85	1.01
E	E5	5 CYCLES	7.0	137.7	83	
	E6	5 CYCLES	6.2	138.9	87	
		WET AVG	6.6	138.3	85	
		DRY AVG**	6.9	137.8	85	1.00
	E7	7 CYCLES	6.5	138.4	83	
	E8	7 CYCLES	6.9	137.9	71	
		WET AVG	6.7	138.2	77	
		DRY AVG**	6.9	137.8	85	0.91
	E9	9 CYCLES	7.3	137.2	71	
	E10	9 CYCLES	6.6	138.2	80	
		WET AVG	7.0	137.7	75	
		DRY AVG**	6.9	137.8	85	0.89

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE F-4 TEST RESULTS FOR LABORATORY MIXTURES (D-1)
ADDITIVE: ARR-MAZ (0.75%)
ASPHALT CONTENT = 6.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.0	137.7	89	
	A2	DRY	7.4	137.0	83	
	A3	DRY	6.8	138.0	95	
		DRY AVG	7.0	137.6	89	
	A4	WET	7.0	137.7	101	
	A5	WET	7.9	136.3	89	
	A6	WET	6.2	138.8	114	
		WET AVG	7.0	137.6	101	
						1.14
B	B1	DRY	6.4	138.5	86	
	B2	DRY	6.8	137.9	91	
	B3	DRY	7.1	137.4	80	
		DRY AVG**	6.8	137.9	86	
	B4	WET	6.5	138.5	111	
	B5	WET	7.0	137.7	105	
		WET AVG	6.7	138.1	108	
						1.26
C	C1	WET	6.8	137.9	101	
	C2	WET	6.9	137.8	101	
	C3	WET	7.0	137.7	92	
		WET AVG	6.9	137.8	98	
		DRY AVG**	6.8	137.9	86	
						1.14
D	D1	WET	6.6	138.2	121	
	D2	WET	7.1	137.6	93	
	D3	WET	7.0	137.6	118	
		WET AVG	6.9	137.8	111	
		DRY AVG**	6.8	137.9	86	
						1.29

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE F-4 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.0	137.6	111	
	E2	1 CYCLE	6.8	137.9	102	
		WET AVG	6.9	137.8	106	
		DRY AVG**	6.8	137.9	86	1.24
	E3	3 CYCLES	7.3	137.3	86	
	E4	3 CYCLES	6.9	137.9	97	
		WET AVG	7.1	137.6	91	
		DRY AVG**	6.8	137.9	86	1.07
E	E5	5 CYCLES	6.4	138.5	97	
	E6	5 CYCLES	6.2	138.8	83	
		WET AVG	6.3	138.7	90	
		DRY AVG**	6.8	137.9	86	1.06
	E7	7 CYCLES	6.4	138.5	82	
	E8	7 CYCLES	6.4	138.6	74	
		WET AVG	6.4	138.5	78	
		DRY AVG**	6.8	137.9	86	0.91
	E9	9 CYCLES	6.5	138.4	77	
	E10	9 CYCLES	6.1	139.1	76	
		WET AVG	6.3	138.7	76	
		DRY AVG**	6.8	137.9	86	0.89
****	B6	DRY	5.6	139.7	86	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE F-5 TEST RESULTS FOR LABORATORY MIXTURES (D-1)
ADDITIVE: DOW POLY BEADS (0.18%)
ASPHALT CONTENT = 6.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.8	137.2	73	
	A2	DRY	6.8	137.1	91	
	A3	DRY	7.8	135.7	83	
		DRY AVG	7.1	136.7	82	
	A4	WET	6.8	137.2	57	
	A5	WET	6.8	137.1	58	
	A6	WET	7.7	135.8	59	
		WET AVG	7.1	136.7	58	
						0.70
B	B1	DRY	7.0	136.9	79	
	B2	DRY	7.4	136.2	80	
		DRY AVG**	7.2	136.5	80	
	B4	WET	6.8	137.2	66	
	B5	WET	8.0	135.4	74	
	B6	WET	6.8	137.1	63	
		WET AVG	7.2	136.6	68	
						0.85
C	C1	WET	6.0	138.3	65	
	C2	WET	7.0	136.8	70	
	C3	WET	7.4	136.3	60	
		WET AVG	6.8	137.1	65	
		DRY AVG**	7.2	136.5	80	
						0.82
D	D1	WET	6.6	137.4	71	
	D2	WET	6.9	137.0	81	
	D3	WET	6.6	137.5	75	
		WET AVG	6.7	137.3	76	
		DRY AVG**	7.2	136.5	80	
						0.95

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE F-5 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.5	137.6	74	
	E2	1 CYCLE	7.1	136.8	70	
		WET AVG	6.8	137.2	72	
		DRY AVG**	7.2	136.5	80	0.90
	E3	3 CYCLES	7.1	136.7	61	
	E4	3 CYCLES	6.5	137.6	50	
		WET AVG	6.8	137.2	56	
		DRY AVG**	7.2	136.5	80	0.70
E	E5	5 CYCLES	6.6	137.4	48	
	E6	5 CYCLES	7.1	136.7	46	
		WET AVG	6.9	137.0	47	
		DRY AVG**	7.2	136.5	80	0.59
	E7	7 CYCLES	6.6	137.5	31	
	E8	7 CYCLES	7.5	136.1	38	
		WET AVG	7.0	136.8	34	
		DRY AVG**	7.2	136.5	80	0.43
	E9	9 CYCLES	6.8	137.1	26	
	E10	9 CYCLES	7.0	136.8	24	
		WET AVG	6.9	137.0	25	
		DRY AVG**	7.2	136.5	80	0.32
****	B3	DRY	5.9	138.4	89	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE F-6 TEST RESULTS FOR LABORATORY MIXTURES (D-1)
ADDITIVE: FINA-A (1.0%)
ASPHALT CONTENT = 6.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	7.2	136.8	86	
	A2	DRY	7.4	136.6	86	
	A3	DRY	6.2	138.4	91	
		DRY AVG	6.9	137.3	88	
A						
	A4	WET	6.6	137.8	92	
	A5	WET	7.2	136.9	97	
	A6	WET	7.4	136.6	100	
		WET AVG	7.1	137.1	96	
						1.10
	B1	DRY	6.1	138.6	99	
	B2	DRY	6.5	137.9	96	
	B3	DRY	6.1	138.5	94	
		DRY AVG**	6.2	138.3	96	
B						
	B4	WET	6.3	138.2	97	
	B5	WET	6.6	137.8	108	
	B6	WET	6.7	137.6	114	
		WET AVG	6.5	137.9	106	
						1.10
	C1	WET	6.5	138.0	105	
	C2	WET	6.9	137.4	102	
	C3	WET	6.1	138.6	112	
		WET AVG	6.5	138.0	106	
C						
		DRY AVG**	6.2	138.3	96	
						1.10
	D1	WET	6.9	137.3	121	
	D2	WET	7.4	136.7	114	
	D3	WET	7.2	136.8	112	
		WET AVG	7.2	136.9	116	
D						
		DRY AVG**	6.2	138.3	96	
						1.20

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE F-6 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.0	138.7	117	
	E2	1 CYCLE	6.0	138.7	109	
		WET AVG	6.0	138.7	113	
		DRY AVG**	6.2	138.3	96	
						1.18
	E3	3 CYCLES	6.3	138.2	101	
	E4	3 CYCLES	6.5	138.0	89	
		WET AVG	6.4	138.1	95	
		DRY AVG**	6.2	138.3	96	
						0.99
E						
	E5	5 CYCLES	6.8	137.5	91	
	E6	5 CYCLES	6.8	137.5	92	
		WET AVG	6.8	137.5	92	
		DRY AVG**	6.2	138.3	96	
						0.95
	E7	7 CYCLES	6.4	138.1	83	
	E8	7 CYCLES	6.4	138.1	79	
		WET AVG	6.4	138.1	81	
		DRY AVG**	6.2	138.3	96	
						0.84
	E9	9 CYCLES	6.7	137.7	83	
	E10	9 CYCLES	6.4	138.0	80	
		WET AVG	6.5	137.9	82	
		DRY AVG**	6.2	138.3	96	
						0.85

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE F-7 TEST RESULTS FOR LABORATORY MIXTURES (D-1)
ADDITIVE: INDULIN AS-1 (1.0%)
ASPHALT CONTENT = 6.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.1	136.7	91	
	A2	DRY	7.6	136.0	83	
	A3	DRY	6.8	137.1	89	
		DRY AVG	7.2	136.6	88	
	A4	WET	6.7	137.3	99	
	A5	WET	6.6	137.4	95	
	A6	WET	7.3	136.4	87	
		WET AVG	6.9	137.0	94	
						1.07
B	B1	DRY	6.0	138.3	91	
	B2	DRY	8.0	135.4	77	
	B3	DRY	6.0	138.4	92	
		DRY AVG**	6.6	137.4	87	
	B4	WET	6.9	136.9	104	
	B5	WET	6.9	137.1	94	
		WET AVG	6.9	137.0	99	
						1.14
C	C1	WET	7.7	135.8	96	
	C2	WET	6.2	138.0	107	
		WET AVG	7.0	136.9	102	
		DRY AVG**	6.6	137.4	87	
						1.17
D	D1	WET	6.4	137.8	113	
	D2	WET	7.9	135.5	99	
		WET AVG	7.1	136.6	106	
		DRY AVG**	6.6	137.4	87	
						1.22

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE F-7 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.2	136.5	97	
	E2	1 CYCLE	6.7	137.3	92	
		WET AVG	7.0	136.9	95	
		DRY AVG**	6.6	137.4	87	
						1.09
	E3	3 CYCLES	7.2	136.6	89	
	E4	3 CYCLES	7.6	136.0	84	
		WET AVG	7.4	136.3	87	
		DRY AVG**	6.6	137.4	87	
						1.00
E						
	E5	5 CYCLES	7.9	135.6	80	
	E6	5 CYCLES	7.3	136.4	77	
		WET AVG	7.6	136.0	79	
		DRY AVG**	6.6	137.4	87	
						0.91
	E7	7 CYCLES	7.8	135.6	75	
	E8	7 CYCLES	7.1	136.7	74	
		WET AVG	7.4	136.2	75	
		DRY AVG**	6.6	137.4	87	
						0.86
	E9	9 CYCLES	6.8	137.1	69	
	E10	9 CYCLES	7.1	136.7	69	
		WET AVG	6.9	136.9	69	
		DRY AVG**	6.6	137.4	87	
						0.80
****	B6	DRY	4.1	141.0	97	
	B7	DRY	5.6	138.8	94	
	B8	DRY	8.5	134.7	79	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerange.

TABLE F-8 TEST RESULTS FOR LABORATORY MIXTURES (D-1)
ADDITIVE: PAVEBOND SPECIAL (1.0%)
ASPHALT CONTENT = 6.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	6.8	137.7	90	
	A2	DRY	6.6	138.1	82	
		DRY AVG	6.7	137.9	86	
A						
	A4	WET	6.2	138.7	100	
	A5	WET	6.7	138.0	108	
		WET AVG	6.4	138.3	104	
						1.21
	B1	DRY	7.2	137.2	73	
	B2	DRY	7.0	137.5	75	
	B3	DRY	6.8	137.8	82	
		DRY AVG**	7.0	137.5	77	
B						
	B4	WET	6.2	138.6	105	
	B5	WET	6.0	138.9	105	
	B6	WET	6.0	138.9	105	
		WET AVG	6.1	138.8	105	
						1.37
	C1	WET	6.4	138.4	113	
	C2	WET	6.0	138.9	119	
	C3	WET	6.4	138.4	114	
		WET AVG	6.3	138.6	115	
C						
		DRY AVG**	7.0	137.5	77	
						1.50
	D1	WET	6.3	138.5	116	
	D2	WET	6.8	137.8	102	
	D3	WET	6.6	138.1	108	
		WET AVG	6.6	138.1	109	
D						
		DRY AVG**	7.0	137.5	77	
						1.42

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE F-8 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.7	136.4	91	
	E2	1 CYCLE	6.3	138.6	97	
		WET AVG	7.0	137.5	94	
		DRY AVG**	7.0	137.5	77	1.23
	E3	3 CYCLES	6.3	138.5	101	
	E4	3 CYCLES	6.6	138.1	94	
		WET AVG	6.4	138.3	98	
		DRY AVG**	7.0	137.5	77	1.28
E	E5	5 CYCLES	6.4	138.4	86	
	E6	5 CYCLES	7.0	137.5	91	
		WET AVG	6.7	137.9	89	
		DRY AVG**	7.0	137.5	77	1.16
	E7	7 CYCLES	7.0	137.4	78	
	E8	7 CYCLES	6.5	138.2	82	
		WET AVG	6.8	137.8	80	
		DRY AVG**	7.0	137.5	77	1.04
	E9	9 CYCLES	7.6	136.5	69	
	E10	9 CYCLES	6.4	138.3	76	
		WET AVG	7.0	137.4	72	
		DRY AVG**	7.0	137.5	77	0.95
****	A3	WET	9.2	134.3	83	
	A6	DRY	8.1	135.9	76	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerange.

TABLE F-9 TEST RESULTS FOR LABORATORY MIXTURES (D-1)
ADDITIVE: PERMA-TAC PLUS (1.0%)
ASPHALT CONTENT = 6.0 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.4	137.6	78	
	A2	DRY	7.0	136.8	73	
	A3	DRY	6.5	137.5	82	
		DRY AVG	6.6	137.3	78	
	A4	WET	6.3	137.8	100	
	A5	WET	7.3	136.3	82	
	A6	WET	6.8	137.0	87	
		WET AVG	6.8	137.0	90	
						1.15
B	B1	DRY	8.0	135.2	70	
	B2	DRY	6.5	137.5	92	
	B3	DRY	6.3	137.8	85	
		DRY AVG**	7.0	136.8	82	
	B4	WET	6.7	137.2	79	
	B5	WET	6.0	138.2	100	
	B6	WET	6.9	136.9	104	
		WET AVG	6.6	137.4	94	
						1.15
C	C1	WET	6.8	137.0	77	
	C2	WET	6.9	137.0	78	
		WET AVG	6.9	137.0	78	
		DRY AVG**	7.0	136.8	82	
						0.94
D	D1	WET	6.7	137.3	89	
	D2	WET	6.8	137.0	94	
	D3	WET	6.8	137.1	96	
		WET AVG	6.7	137.2	93	
		DRY AVG**	7.0	136.8	82	
						1.13

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE F-9 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.5	137.5	84	
	E2	1 CYCLE	6.3	137.7	83	
		WET AVG	6.4	137.6	83	
		DRY AVG**	7.0	136.8	82	1.01
	E3	3 CYCLES	6.2	138.0	92	
	E4	3 CYCLES	7.4	136.3	73	
		WET AVG	6.8	137.1	83	
		DRY AVG**	7.0	136.8	82	1.00
E	E5	5 CYCLES	6.1	138.1	80	
	E6	5 CYCLES	6.4	137.6	68	
		WET AVG	6.3	137.9	74	
		DRY AVG**	7.0	136.8	82	0.90
	E7	7 CYCLES	6.1	138.1	65	
	E8	7 CYCLES	6.2	138.0	63	
		WET AVG	6.1	138.0	64	
		DRY AVG**	7.0	136.8	82	0.78
	E9	9 CYCLES	7.6	135.9	43	
	E10	9 CYCLES	6.2	138.0	50	
		WET AVG	6.9	137.0	46	
		DRY AVG**	7.0	136.8	82	0.56
****	C3	WET	5.7	138.7	82	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerange.

TABLE F-10 TEST RESULTS FOR PLANT MIXTURES (D-1)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.5%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.4	137.1	85	
	B2	DRY	6.8	138.1	99	
	B3	DRY	6.7	138.1	90	
		DRY AVG**	7.0	137.8	91	
	B4	WET	7.3	137.4	107	
	B5	WET	6.7	138.2	92	
	B6	WET	6.8	138.0	91	
		WET AVG	6.9	137.9	97	1.06
C	C1	WET	7.1	137.6	93	
	C2	WET	6.6	138.4	80	
	C3	WET	6.8	138.1	92	
		WET AVG	6.8	138.0	88	
		DRY AVG**	7.0	137.8	91	0.97
D	D1	WET	7.2	137.4	99	
	D2	WET	6.7	138.3	103	
	D3	WET	6.9	137.9	92	
		WET AVG	6.9	137.9	98	
		DRY AVG**	7.0	137.8	91	1.07

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE F-11 TEST RESULTS FOR PLANT MIXTURES (D-1)
ADDITIVE: LIME SLURRY (1.5%)
ASPHALT CONTENT = 5.5%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	PLANT DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	6.8	137.5	86	
	B2	DRY	6.5	138.0	89	
	B3	DRY	6.5	138.0	90	
		DRY AVG**	6.6	137.8	88	
B	B4	WET	6.4	138.2	102	
	B5	WET	6.5	137.9	99	
	B6	WET	6.4	138.1	97	
		WET AVG	6.4	138.1	99	1.12
	C1	WET	6.6	137.8	113	
	C2	WET	6.9	137.4	115	
	C3	WET	6.5	138.0	108	
C		WET AVG	6.7	137.7	112	
		DRY AVG**	6.6	137.8	88	1.27
	D1	WET	7.0	137.3	100	
	D2	WET	6.1	138.5	96	
	D3	WET	6.4	138.1	100	
D		WET AVG	6.5	138.0	99	
		DRY AVG**	6.6	137.8	88	1.12

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE F-12 TEST RESULTS FOR PLANT MIXTURES (D-1)
ADDITIVE: ARR-MAZ (0.75%)
ASPHALT CONTENT = 5.5%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.6	138.7	86	
	B2	DRY	6.2	139.3	90	
	B3	DRY	6.7	138.6	93	
		DRY AVG**	6.5	138.9	90	
	B4	WET	6.6	138.7	100	
	B5	WET	7.2	137.8	99	
	B6	WET	7.0	138.0	98	
		WET AVG	6.9	138.2	99	1.10
C	C1	WET	6.6	138.7	116	
	C2	WET	6.7	138.5	111	
	C3	WET	6.9	138.3	103	
		WET AVG	6.7	138.5	110	
		DRY AVG**	6.5	138.9	90	1.23
D	D1	WET	7.3	137.7	108	
	D2	WET	7.3	137.7	105	
	D3	WET	6.7	138.6	98	
		WET AVG	7.1	138.0	104	
		DRY AVG**	6.5	138.9	90	1.16

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE F-13 TEST RESULTS FOR PLANT MIXTURES (D-1)
ADDITIVE: DOW POLY BEADS (0.18%)
ASPHALT CONTENT = 5.5%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.0	137.9	89	
	B2	DRY	7.1	137.7	79	
	B3	DRY	7.0	137.9	91	
		DRY AVG**	7.0	137.9	86	
	B4	WET	6.9	138.0	85	
	B5	WET	6.9	138.0	82	
	B6	WET	6.8	138.1	83	
		WET AVG	6.9	138.0	83	
						0.97
C	C1	WET	6.9	138.1	86	
	C2	WET	7.0	137.9	78	
	C3	WET	7.0	137.9	81	
		WET AVG	6.9	138.0	82	
		DRY AVG**	7.0	137.9	86	
						0.95
D	D1	WET	7.1	137.8	84	
	D2	WET	6.8	138.1	82	
	D3	WET	7.0	137.9	82	
		WET AVG	7.0	137.9	83	
		DRY AVG**	7.0	137.9	86	
						0.96

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE F-14 TEST RESULTS FOR PLANT MIXTURES (D-1)
ADDITIVE: FINA-A (1.0%)
ASPHALT CONTENT = 5.5%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.5	137.6	90	
	B2	DRY	6.6	137.5	91	
	B3	DRY	6.6	137.5	95	
		DRY AVG**	6.6	137.6	92	
	B4	WET	6.7	137.5	104	
	B5	WET	6.4	137.8	102	
	B6	WET	6.6	137.5	102	
		WET AVG	6.6	137.6	103	1.12
C	C1	WET	7.0	136.9	110	
	C2	WET	6.6	137.6	109	
	C3	WET	6.6	137.5	111	
		WET AVG	6.7	137.3	110	
		DRY AVG**	6.6	137.6	92	1.20
D	D1	WET	7.0	137.0	101	
	D2	WET	6.7	137.4	105	
	D3	WET	6.8	137.2	112	
		WET AVG	6.8	137.2	106	
		DRY AVG**	6.6	137.6	92	1.15

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE F-15 TEST RESULTS FOR PLANT MIXTURES (D-1)
ADDITIVE: INDULIN AS-1 (1.0%)
ASPHALT CONTENT = 5.5%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	7.5	136.6	85	
	B2	DRY	7.4	136.8	90	
	B3	DRY	7.2	137.2	84	
		DRY AVG**	7.4	136.9	86	
B	B4	WET	7.1	137.2	102	
	B5	WET	7.0	137.5	90	
	B6	WET	7.4	136.8	93	
		WET AVG	7.2	137.2	95	1.10
	C1	WET	7.1	137.2	106	
	C2	WET	6.8	137.8	104	
	C3	WET	7.2	137.2	107	
		WET AVG	7.0	137.4	106	
C		DRY AVG**	7.4	136.9	86	1.22
	D1	WET	7.3	136.9	107	
	D2	WET	7.6	136.5	100	
	D3	WET	7.1	137.3	101	
		WET AVG	7.4	136.9	103	
D		DRY AVG**	7.4	136.9	86	1.19

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE F-16 TEST RESULTS FOR PLANT MIXTURES (D-1)
ADDITIVE: PAVEBOND SPECIAL (1.0%)
ASPHALT CONTENT = 5.5%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.8	137.4	78	
	B2	DRY	7.3	136.6	83	
	B3	DRY	7.1	136.9	83	
		DRY AVG**	7.1	136.9	81	
	B4	WET	7.7	136.1	92	
	B5	WET	7.1	136.9	96	
	B6	WET	6.9	137.2	93	
		WET AVG	7.2	136.7	94	
						1.15
C	C1	WET	7.0	137.1	102	
	C2	WET	6.9	137.2	100	
	C3	WET	7.5	136.4	101	
		WET AVG	7.1	136.9	101	
		DRY AVG**	7.1	136.9	81	
						1.24
D	D1	WET	6.9	137.2	94	
	D2	WET	7.4	136.4	98	
	D3	WET	6.7	137.6	99	
		WET AVG	7.0	137.1	97	
		DRY AVG**	7.1	136.9	81	
						1.19

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE F-17 TEST RESULTS FOR PLANT MIXTURES (D-1)
ADDITIVE: PERMA-TAC PLUS (1.0%)
ASPHALT CONTENT = 5.5%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.1	138.0	94	
	B2	DRY	7.5	137.4	89	
	B3	DRY	7.2	137.8	100	
		DRY AVG**	7.3	137.8	94	
	B4	WET	7.8	137.0	107	
	B5	WET	7.3	137.8	92	
	B6	WET	7.2	137.9	90	
		WET AVG	7.4	137.6	96	1.02
C	C1	WET	7.4	137.6	105	
	C2	WET	7.2	137.9	96	
	C3	WET	7.3	137.8	102	
		WET AVG	7.3	137.8	101	
		DRY AVG**	7.3	137.8	94	1.07
D	D1	WET	7.3	137.8	109	
	D2	WET	7.4	137.6	110	
	D3	WET	7.5	137.4	99	
		WET AVG	7.4	137.6	106	
		DRY AVG**	7.3	137.8	94	1.12

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE F-18 TEST RESULTS FOR FIELD CORES
DISTRICT 1
ASPHALT CONTENT = 5.5 %

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
NO ADDITIVE (CONTROL)	LOW AIR VOIDS SECTION	1A	DRY	6.1	139.1	63	
		1B	WET	5.8	139.5	66	
							1.05
		2A	WET	4.7	141.2	78	
		2B	DRY	5.0	140.7	95	
							0.82
		3A	DRY	5.5	139.9	90	
		3B	WET	6.4	138.6	78	
							0.87
		(AVG VOIDS)		5.6		(AVG TSR)	0.91
	HIGH AIR VOIDS SECTION	4A	WET	9.2	134.5	52	
		4B	DRY	9.4	134.2	48	
							1.08
		5A	DRY	9.2	134.5	50	
		5B	WET	10.0	133.3	36	
							0.71
		6A	WET	9.7	133.8	44	
		6B	DRY	9.8	133.7	51	
							0.86
		(AVG VOIDS)		9.5		(AVG TSR)	0.88
LIME SLURRY	LOW AIR VOIDS SECTION	7A	DRY	7.7	136.3	63	
		7B	WET	7.7	136.2	78	
							1.24
		8A	WET	6.4	138.1	81	
		8B	DRY	8.7	134.8	57	
							1.41
		9A	DRY	4.6	140.7	86	
		9B	WET	4.6	140.9	111	
							1.30
		(AVG VOIDS)		6.6		(AVG TSR)	1.31
	HIGH AIR VOIDS SECTION	10A	WET	8.2	135.5	79	
		10B	DRY	7.6	136.3	64	
							1.23
		11A	DRY	7.2	137.0	71	
		11B	WET	6.6	137.9	90	
							1.27
		12A	WET	4.9	140.4	104	
		12B	DRY	4.9	140.3	95	
							1.10
		(AVG VOIDS)		6.6		(AVG TSR)	1.20
		13A	DRY	6.3	139.1	84	
		13B	WET	6.6	138.7	87	
							1.03
		14A	WET	7.1	137.9	85	

TABLE F-18 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
ARR-MAZ	LOW AIR VOIDS SECTION	14B	DRY	6.7	138.6	70	
							1.23
		15A	DRY	6.8	138.5	75	
		15B	WET	6.5	138.9	95	
							1.28
		(AVG VOIDS)		6.7		(AVG TSR)	1.18
	HIGH AIR VOIDS SECTION	16A	WET	8.8	135.4	69	
		16B	DRY	9.2	134.8	54	
							1.26
		17A	DRY	8.4	136.1	52	
		17B	WET	8.4	136.0	75	
							1.43
		18A	WET	8.3	136.2	77	
		18B	DRY	9.3	134.6	55	
							1.40
		(AVG VOIDS)		8.8		(AVG TSR)	1.36
DOW ANTI-STRIP	LOW AIR VOIDS SECTION	19A	DRY	8.7	135.3	56	
		19B	WET	8.2	136.2	53	
							0.95
		20A	WET	8.9	135.0	52	
		20B	DRY	9.6	134.0	45	
							1.16
		21A	DRY	8.4	135.8	61	
		21B	WET	8.8	135.2	68	
							1.11
		(AVG VOIDS)		8.8		(AVG TSR)	1.07
	HIGH AIR VOIDS SECTION	22A	WET	8.6	135.5	57	
		22B	DRY	8.3	136.0	56	
							1.02
		23A	DRY	8.3	135.9	55	
		23B	WET	8.0	136.4	42	
							0.77
		24A	WET	8.4	135.8	77	
		24B	DRY	8.7	135.4	62	
							1.24
		(AVG VOIDS)		8.4		(AVG TSR)	1.01
	LOW AIR VOIDS SECTION	25A	DRY	7.1	136.8	80	
		25B	WET	6.9	137.0	72	
							0.90
		26A	WET	5.5	139.1	80	
		26B	DRY	5.9	138.6	75	
							1.06
		27A	DRY	5.2	139.6	84	
		27B	WET	5.2	139.7	86	
							1.02

TABLE F-18 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		(AVG VOIDS)		6.0		(AVG TSR)	0.99
FINA-A	HIGH AIR VOIDS SECTION	28A	WET	7.1	136.8	79	
		28B	DRY	7.0	136.9	67	
							1.18
		29A	DRY	5.8	138.7	77	
		29B	WET	5.7	138.9	84	
							1.09
		30A	WET	4.8	140.2	87	
		30B	DRY	4.4	140.7	82	
							1.06
		(AVG VOIDS)		5.8		(AVG TSR)	1.11
	LOW AIR VOIDS SECTION	31A	DRY	6.5	138.2	79	
		31B	WET	6.4	138.3	90	
							1.14
		32A	WET	5.5	139.6	95	
		32B	DRY	5.6	139.6	77	
							1.23
		33A	DRY	4.7	140.9	94	
		33B	WET	4.5	141.1	94	
							1.00
		(AVG VOIDS)		5.5		(AVG TSR)	1.12
INDULIN AS-1	HIGH AIR VOIDS SECTION	34A	WET	8.1	135.8	70	
		34B	DRY	8.3	135.5	61	
							1.15
		35A	DRY	7.8	136.3	59	
		35B	WET	8.3	135.5	71	
							1.20
		36A	WET	8.2	135.7	70	
		36B	DRY	7.9	136.0	57	
							1.22
		(AVG VOIDS)		8.1		(AVG TSR)	1.19
	LOW AIR VOIDS SECTION	37A	DRY	7.1	136.9	69	
		37B	WET	6.6	137.6	69	
							1.00
		38A	WET	5.7	138.9	88	
		38B	DRY	5.5	139.2	83	
							1.07
		39A	DRY	6.2	138.3	66	
		39B	WET	6.1	138.4	67	
							1.01
		(AVG VOIDS)		6.2		(AVG TSR)	1.03
PAVEBOND SPECIAL		40A	WET	9.1	133.9	48	
		40B	DRY	9.9	132.8	41	
							1.19

TABLE F-18 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
	HIGH AIR VOIDS SECTION	41A	DRY	9.0	134.1	58	
		41B	WET	8.9	134.3	54	
							0.92
		42A	WET	9.6	133.2	49	
		42B	DRY	9.3	133.6	52	
							0.94
		(AVG VOIDS)		9.3		(AVG TSR)	1.02
	LOW AIR VOIDS SECTION	43A	DRY	7.3	137.7	67	
		43B	WET	7.3	137.8	77	
							1.15
		44A	WET	7.2	137.8	80	
		44B	DRY	6.6	138.7	64	
							1.26
		45A	DRY	6.0	139.7	81	
		45B	WET	5.5	140.4	79	
							0.97
		(AVG VOIDS)		6.6		(AVG TSR)	1.13
PERMA-TAC PLUS	HIGH AIR VOIDS SECTION	46A	WET	9.3	134.8	67	
		46B	DRY	9.5	134.5	60	
							1.13
		47A	DRY	9.8	134.1	59	
		47B	WET	9.4	134.6	60	
							1.02
		48A	WET	8.9	135.3	64	
		48B	DRY	9.5	134.5	51	
							1.25
		(AVG VOIDS)		9.4		(AVG TSR)	1.13

*TSR = Tensile Strength Ratio
= Tensile Strength (wet)/Tensile Strength (dry)

TABLE F-19 BOILING TEST RESULTS
DISTRICT 1

TYPE OF MIXTURE	TYPE OF ADDITIVE	ASPHALT RETAINED AFTER BOILING, % RATING 1	RATING 2	AVG
	NO ADDITIVE	85	80	82.5
	LIME	100	85	92.5
	ARR-MAZ	95	85	90.0
LABORATORY	DOW	85	80	82.5
	FINA-A	100	85	92.5
	INDULIN AS-1	100	85	92.5
	PVBD SPECIAL	100	85	92.5
	PERMA-TAC PLUS	100	85	92.5
	NO ADDITIVE	95	85	90.0
	LIME	100	85	92.5
	ARR-MAZ	100	95	97.5
PLANT	DOW	98	85	91.5
	FINA-A	100	90	95.0
	INDULIN AS-1	98	95	96.5
	PVBD SPECIAL	100	90	95.0
	PERMA-TAC PLUS	100	90	95.0
	NO ADDITIVE	98	85	91.5
	LIME	100	90	95.0
	ARR-MAZ	100	90	95.0
FIELD CORE	DOW	100	85	92.5
	FINA-A	100	95	97.5
	INDULIN AS-1	100	90	95.0
	PVBD SPECIAL	100	95	97.5
	PERMA-TAC PLUS	100	90	95.0

APPENDIX F LIST OF FIGURES

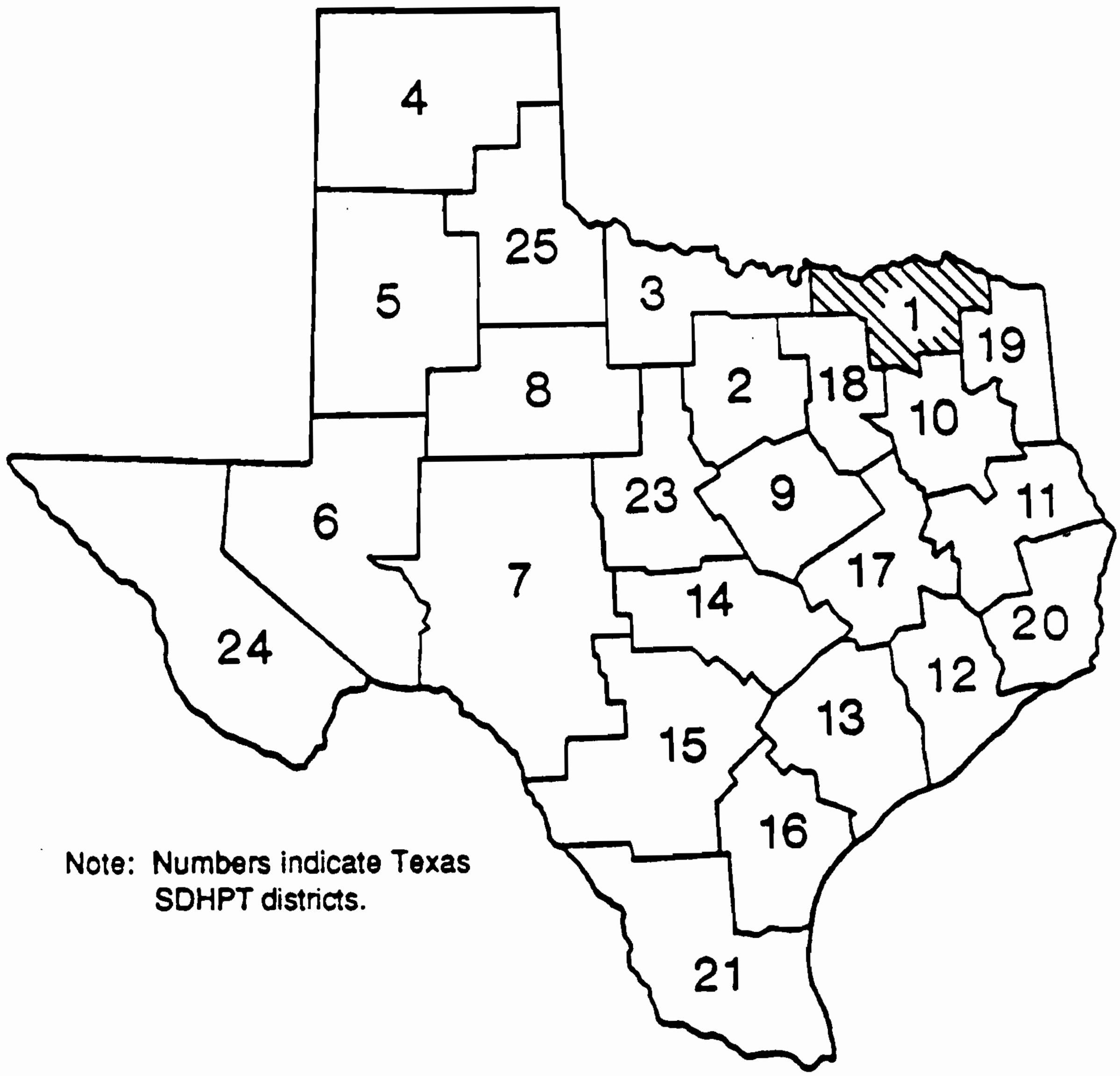
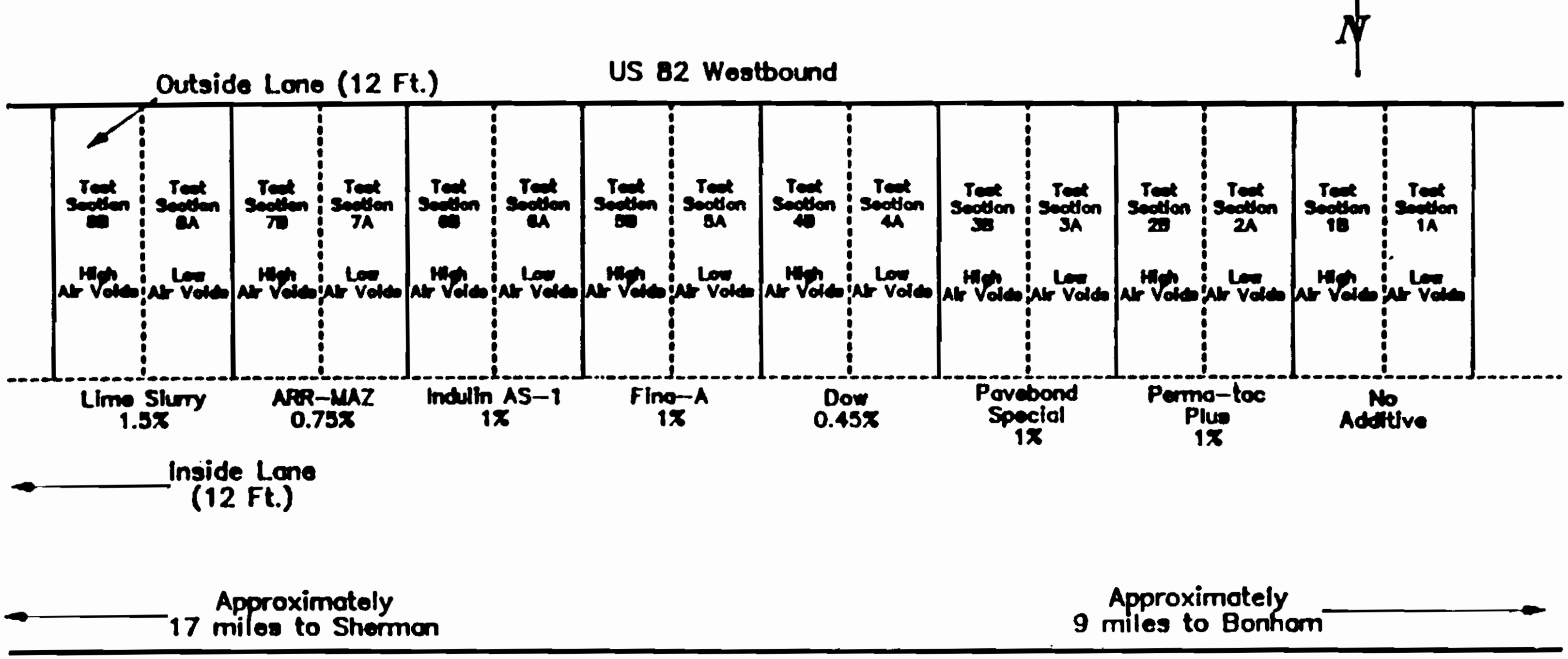


Figure F-1. Location of Field Test Sections (District 1).

DISTRICT 1 FIELD TEST SECTIONS



Note: Each test section is approximately 500 feet in length.

Fig F-2 Schematic Illustration of Field Test Sections.

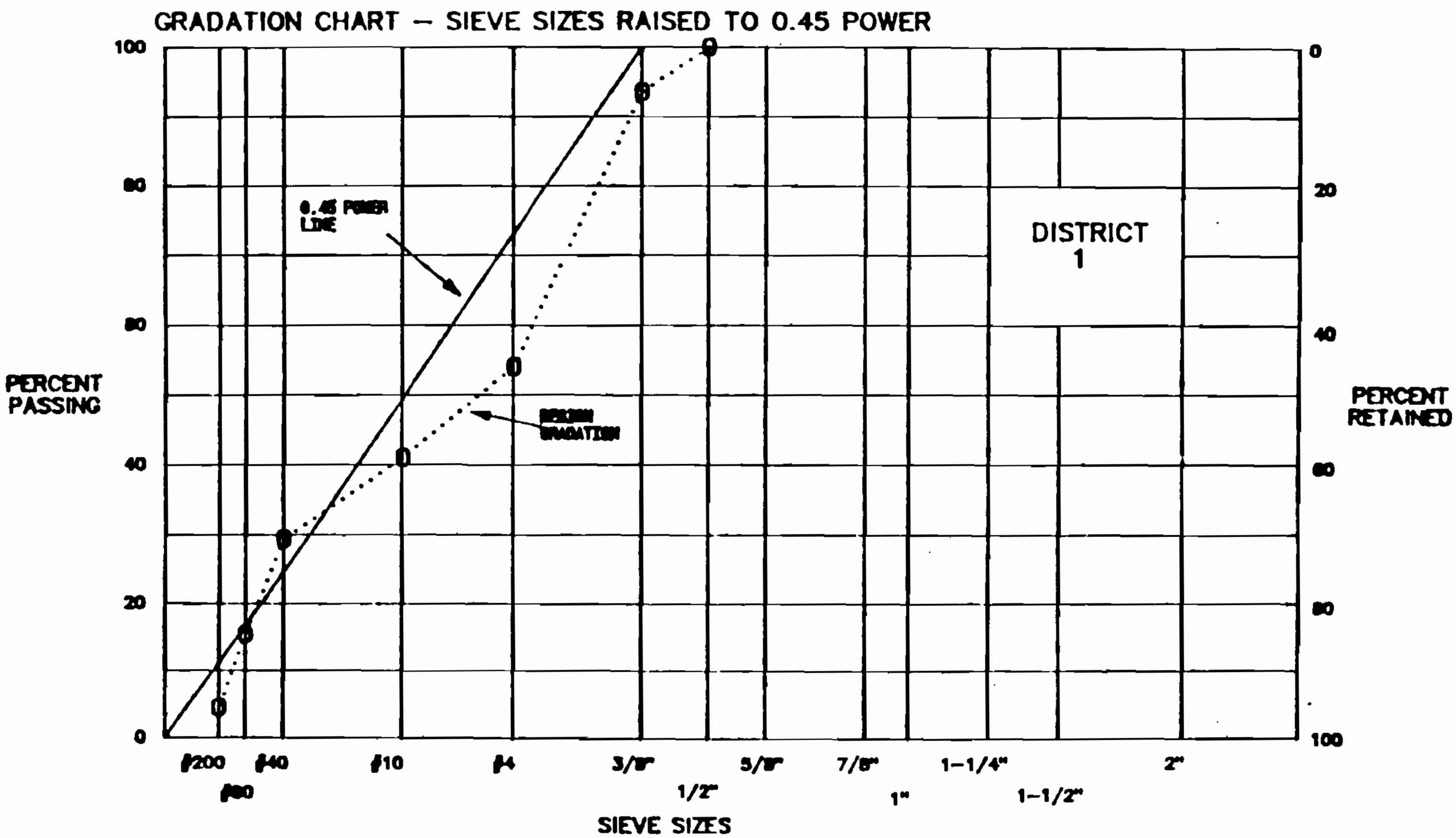


Fig F-3 Aggregate Gradation Chart.

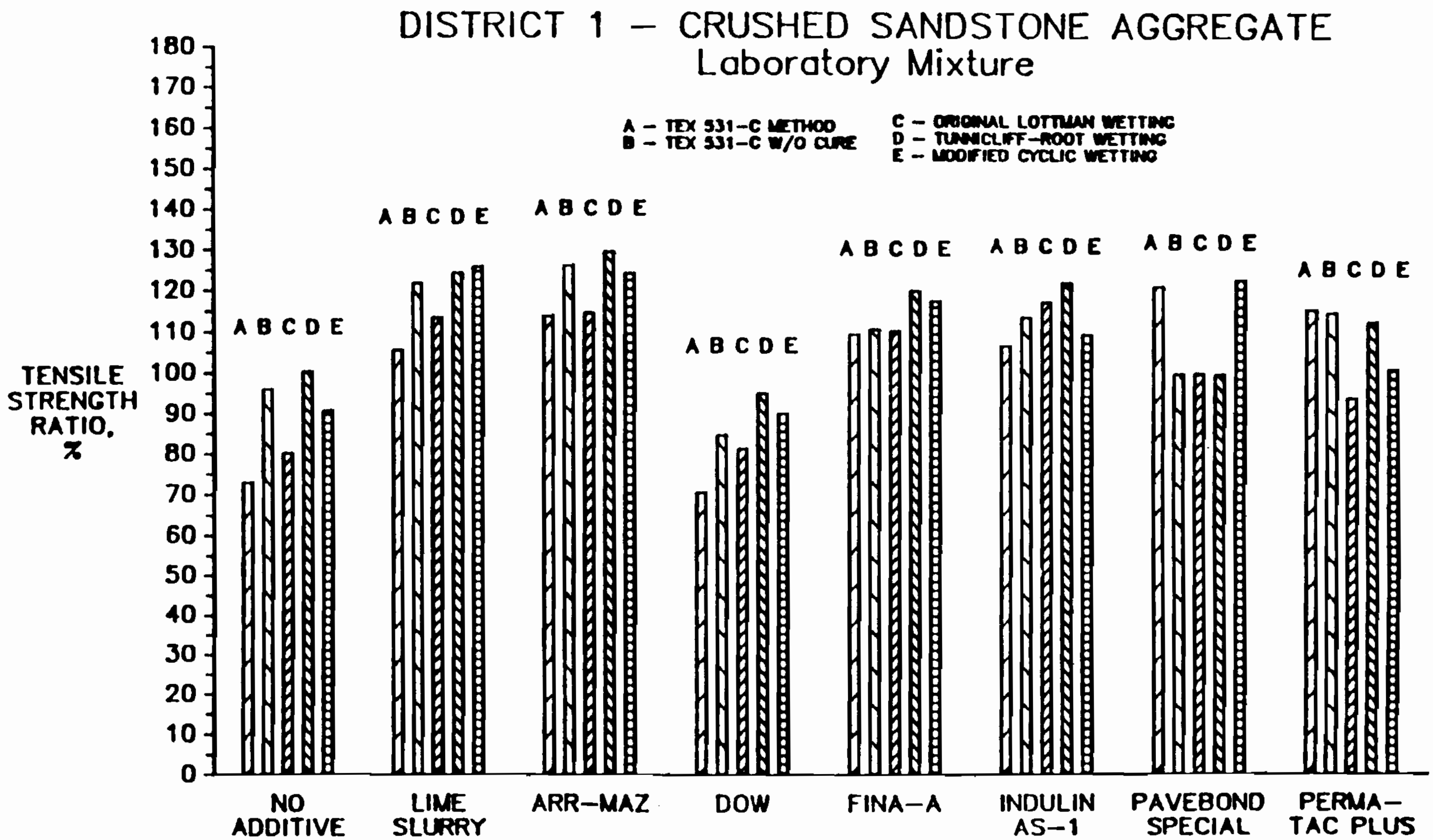


Fig F-4 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

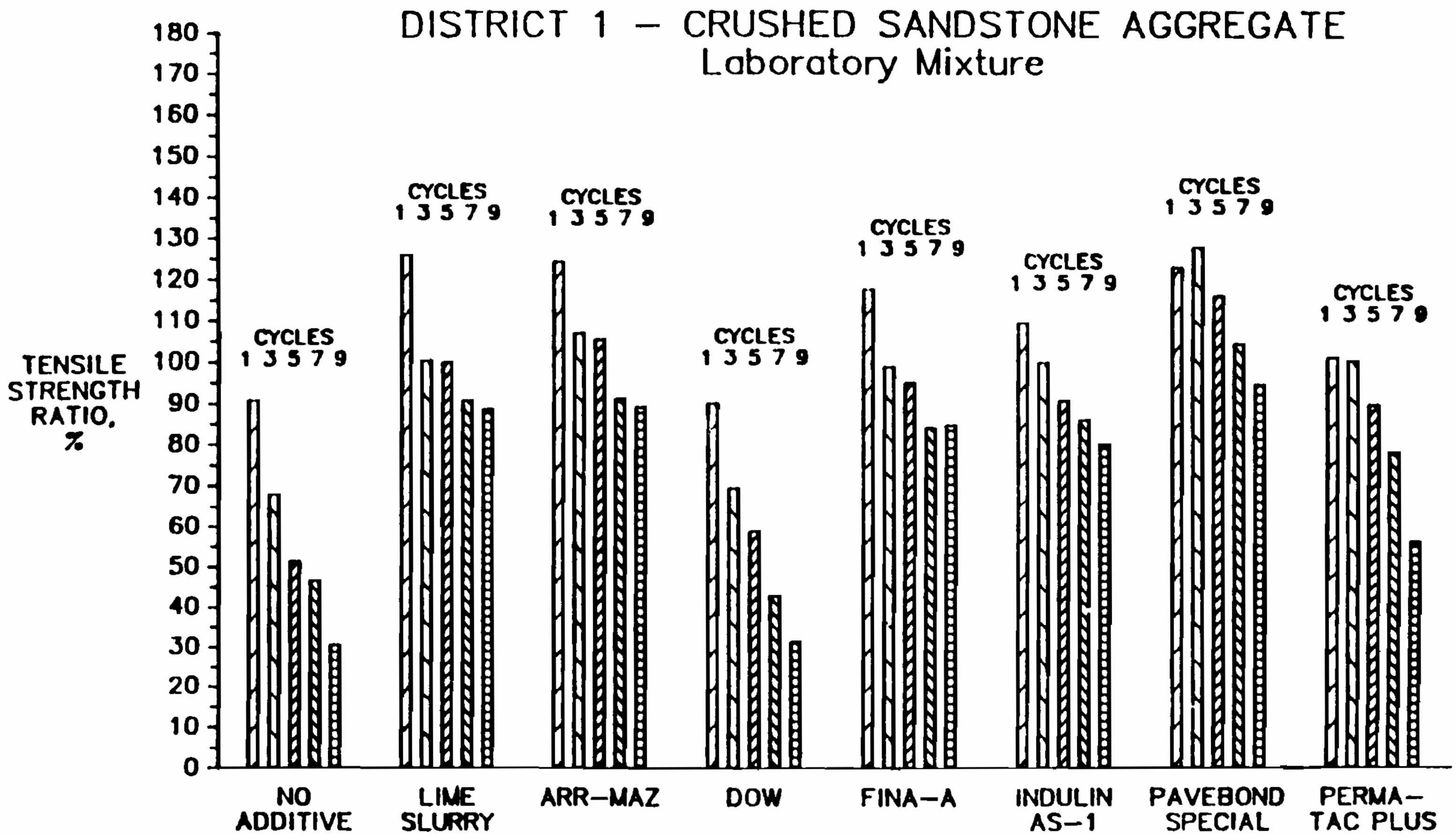


Fig F-5 Wet-Dry Indirect Tensile Cyclic Freeze-Thaw Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

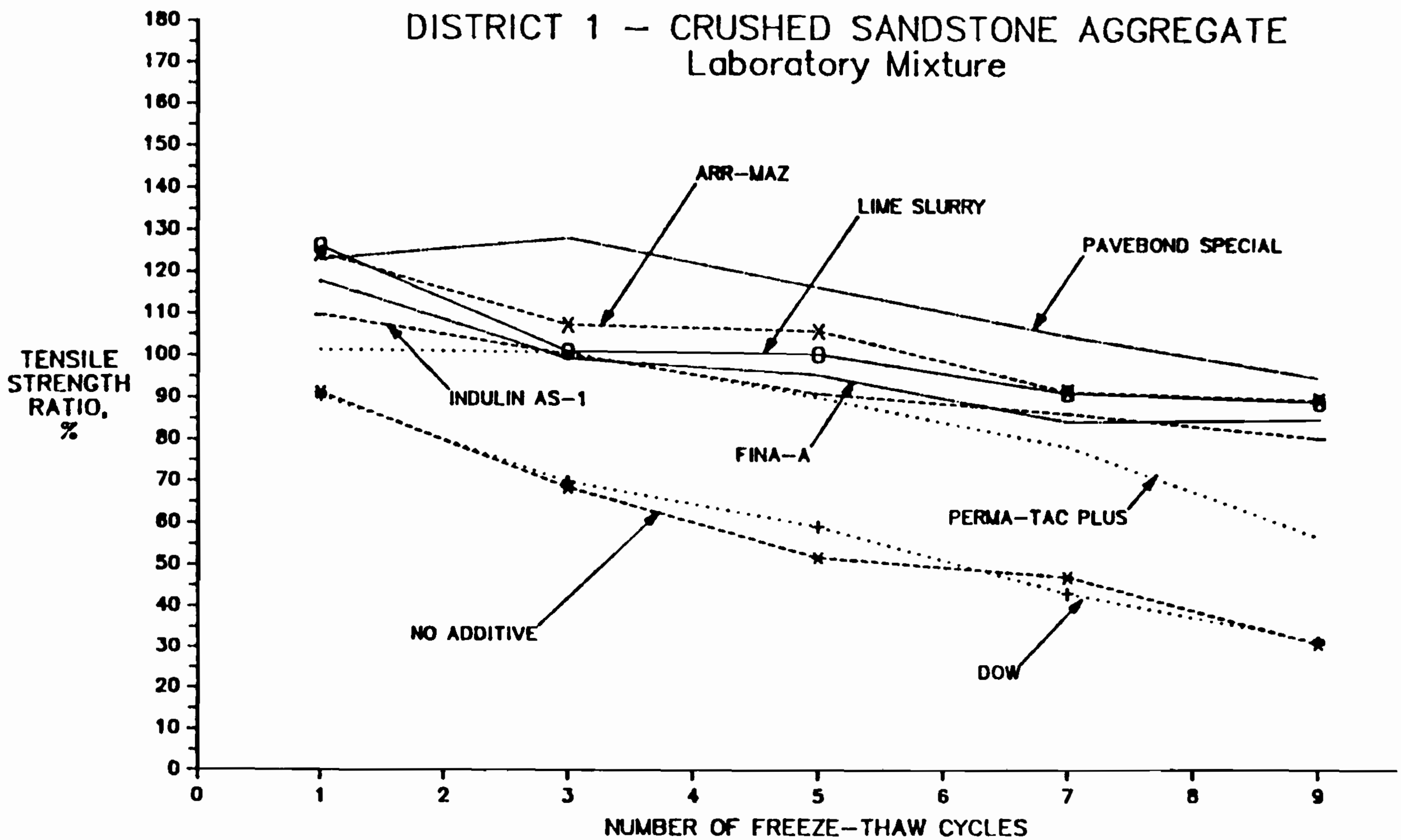


Fig F-6 Tensile Strength Ratio (TSR) Vs. Number of Freeze-Thaw Cycles for Laboratory Mixtures.

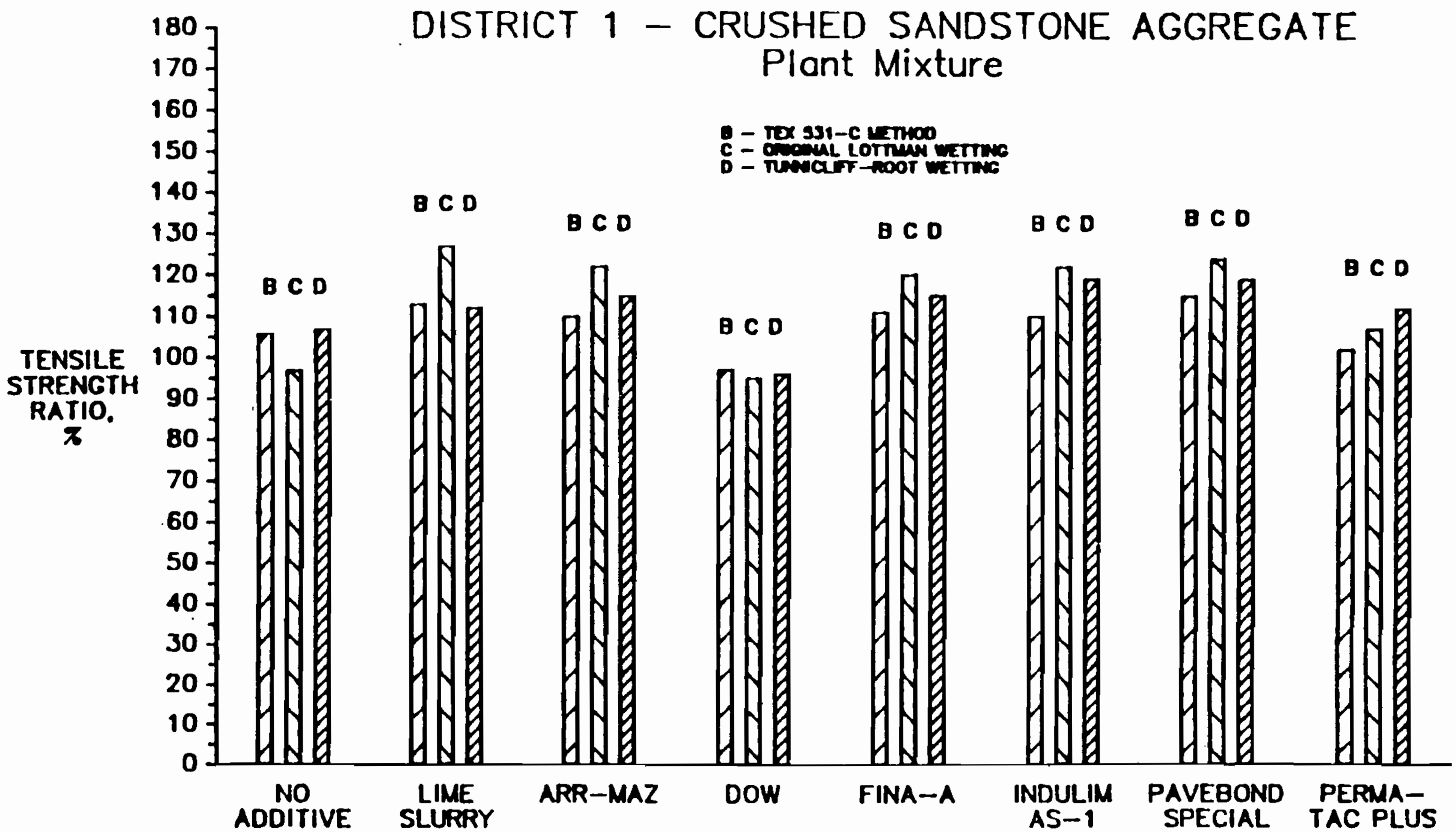


Fig F-7 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Plant Mixtures.

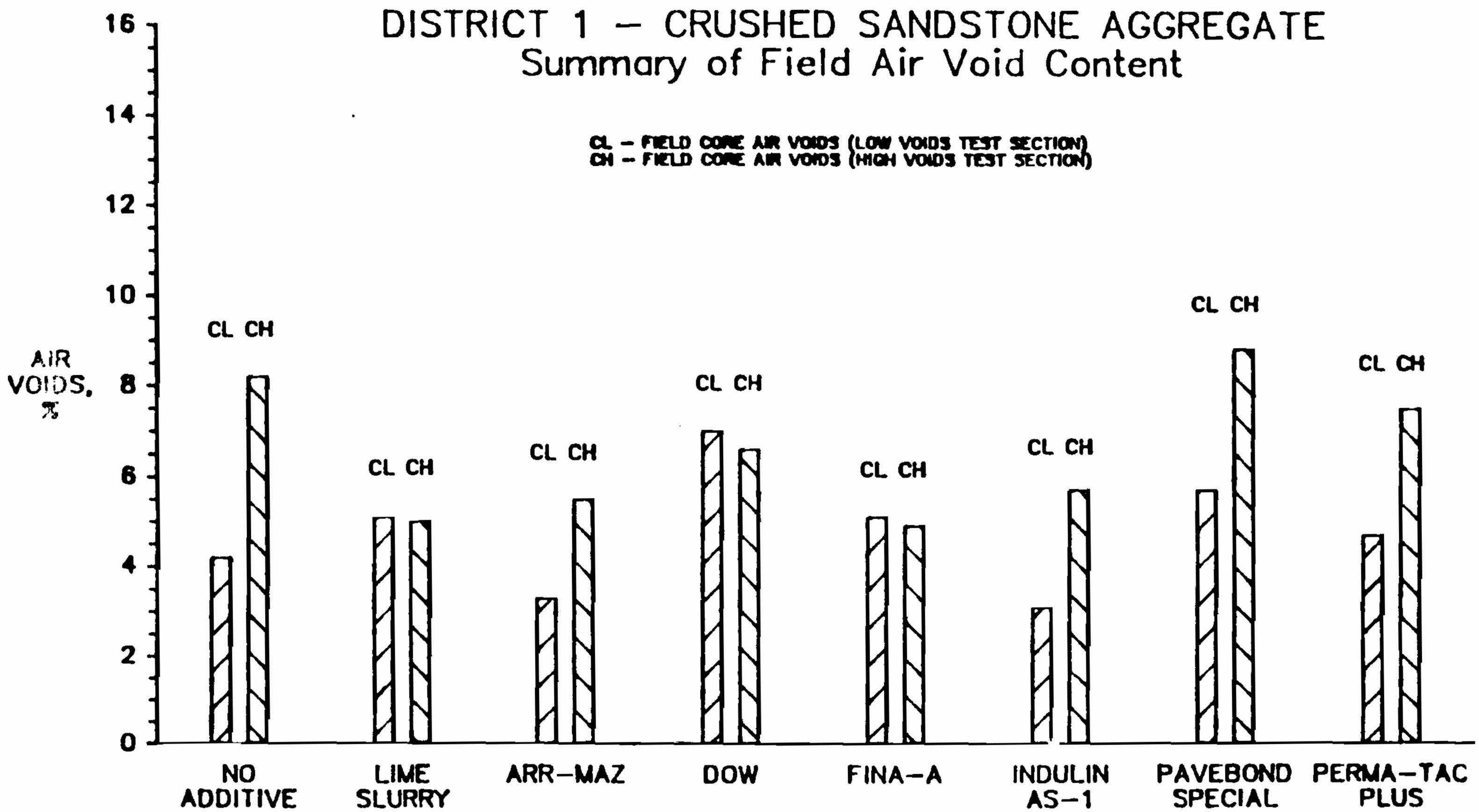


Fig F-8 Summary of Field Core Air Void Content.

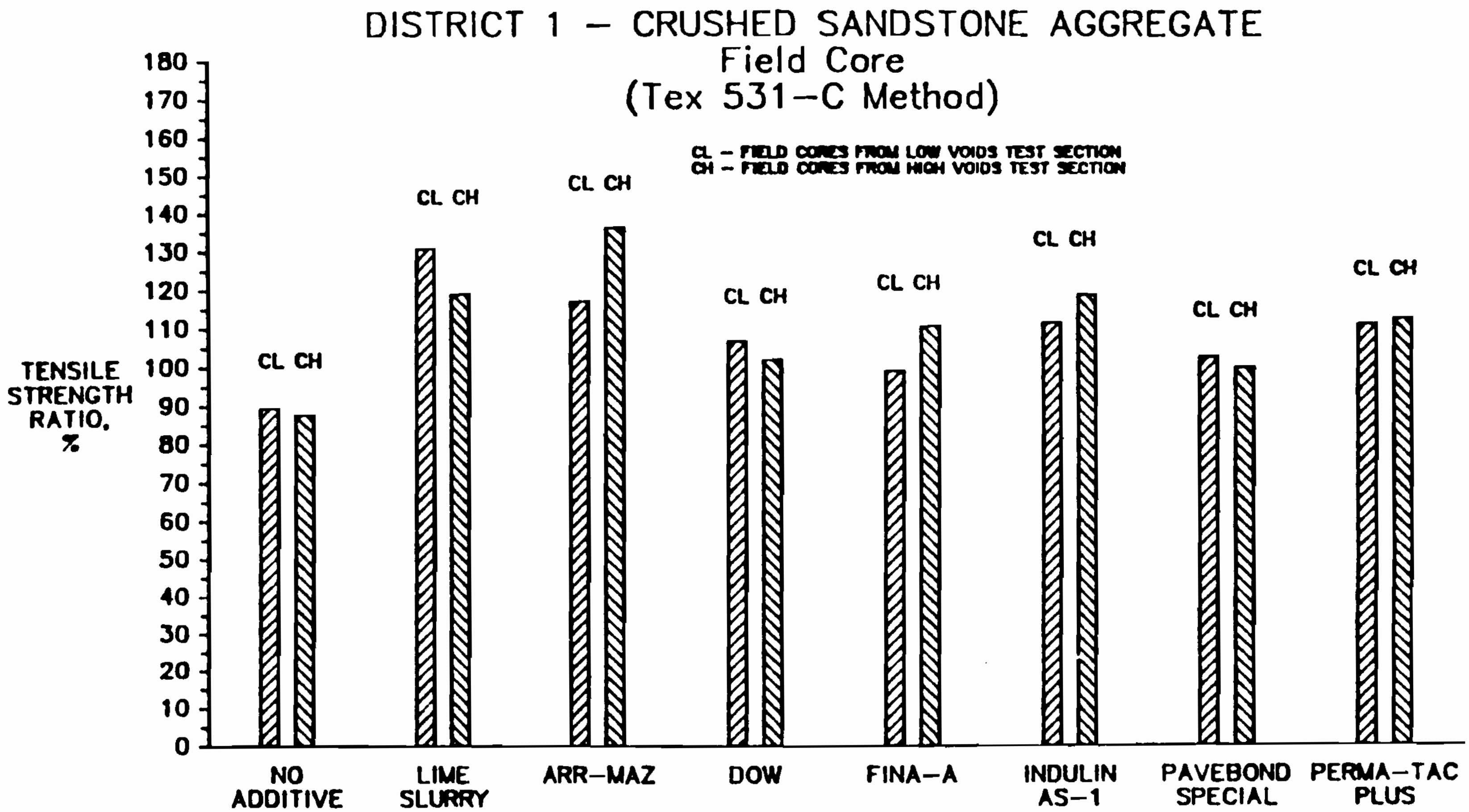


Fig F-9 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Field Cores.

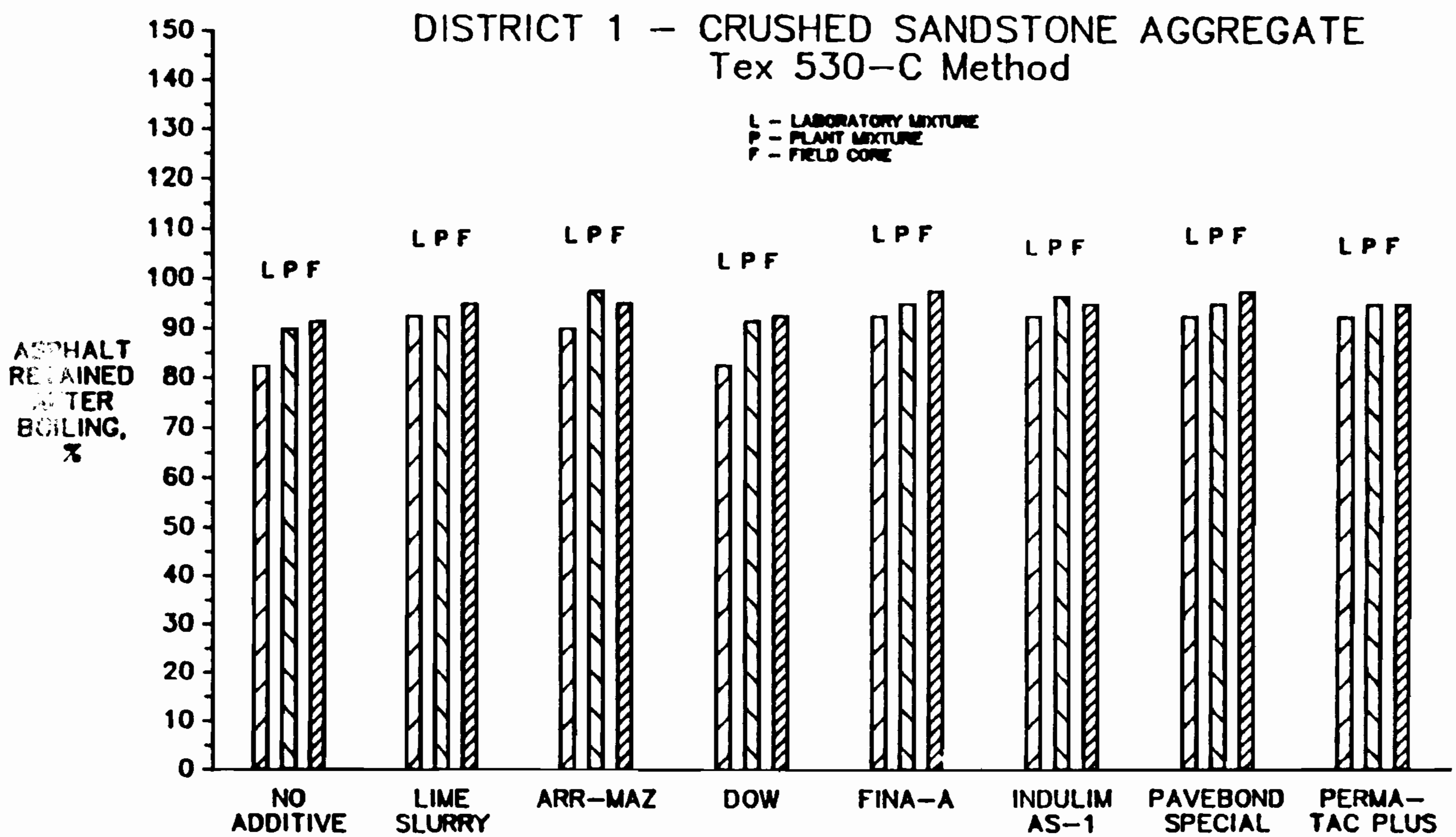


Fig F-10 Texas Boiling Test Results.

APPENDIX G

FIELD AND LABORATORY EXPERIMENTAL PROGRAM - DISTRICT 19

The objective of Appendix G is twofold: (1) to describe the site specific (District 19) field operations of the test sections along with a description of the materials, additives and construction techniques used for this field project, (2) to present the laboratory test results of the laboratory mixed and plant mixed mixtures along with the zero-aged (immediately after construction) pavement cores for the field experimental study at District 19 (Figure G-1) of the Texas State Department of Highways and Public Transportation(SDHPT).

FIELD EXPERIMENTAL PROGRAM

The test pavements were constructed on US 79 near De Berry, Texas, in October 1987, and involved pavement overlay to one lane of the 4-lane highway. The test sections were installed in the westbound outside main travel lane as shown schematically in Figure G-2. The test sections were placed beneath a Type "D" riding surface and were in the final course of three-course overlay. Each test section was approximately two to two and one-half inches thick, 12 feet wide, and 1000 feet long. A total of twelve (12) test sections were constructed and four liquid antistripping additives were used in addition to the hydrated lime and the control materials. The composition of the twelve test sections are as follows:

Test Section 1. Hot mix with 1.0% ARR-MAZ, low air voids.

Test Section 2. Hot mix with 1.0% ARR-MAZ, high air voids.

Test Section 3. Hot mix with 0.5% BA 2000, low air voids.

Test Section 4. Hot mix with 0.5% BA 2000, high air voids.

Test Section 5. Hot mix with 0.8% Aquashield II, low air voids.

Test Section 6. Hot mix with 0.8% Aquashield II, high air voids.

Test Section 7. Hot mix with 1.0% Perma-Tac, low air voids.

Test Section 8. Hot mix with 1.0% Perma-Tac, high air voids.

Test Section 9. Control Section - No additive, high air voids.

Test Section 10. Control Section - No additive, high air voids.

Test Section 11. Hot mix with 1.0% lime, high air voids.

Test Section 12. Hot mix with 1.0% lime, low air voids.

The field construction was conducted by District 19 of the Texas State Department of Highways and Public Transportation (SDHPT) and was assisted by the Center for Transportation Research, The University of Texas at Austin. The average daily traffic (ADT) is estimated at 6,700 vehicles for the test pavement.

MATERIALS AND PAVING MIXTURE

An AC-20 asphalt cement from the Lion Oil Company refinery in El Dorado, Arkansas was used throughout this project. Four aggregates--a Type "C" river gravel coarse aggregate, a Type "D" river gravel coarse aggregate, river gravel screenings, and a field sand, were combined to produce the project gradation. Gradations of the individual aggregates, the project gradation, percentages of each aggregate combined, and the specification are given on Table G-1. The project gradation is plotted on a 0.45 power graph in Figure G-3.

The asphalt concrete mixture used in this study met the SDHPT specifications of Item 340, Type C fine graded surface course (Ref 45). Preliminary laboratory test results for this mixture design are given below:

Asphalt Content	-	5.3%
Average Density	-	97 percent of theoretical maximum density
Air Void Content	-	3 percent
Hveem Stability	-	42%

FIELD OPERATIONS

A drum mix plant was used to prepare hot mixed asphalt mixtures containing lime and liquid antistripping additives. Identical raw material sources (asphalt cement and aggregates) were utilized throughout the experiment. Four commercially available liquid antistripping additives were used for the test sections, i.e., ARR-MAZ, Aquashield II, BA 2000, and Perma-Tac.

The hydrated lime was added dry to the aggregate stockpiles and then moistured by a water truck 12 hours prior to use. The liquid additives were metered into the asphalt cement in-line injection system of the drum dryer plant.

Compaction of each test section was achieved using a vibratory roller, and a pneumatic roller. For the low air void test sections the same rolling pattern was used as established for the regular constructionn project. In order to achieve the high air void test sections the number of passes by the vibratory roller was reduced.

The field cores were obtained soon after the construction. Three pairs of samples were cored from each test section with each pair approximately 200 feet apart. The sample size was approximately 4-inches in diameter and 2 to 2.5-inches in thickness. The coring process was in accordance with the general coring layout procedure described in the main text of this report (Chapter 2). The field cores were transported to the Center for Transportation Research laboratory immediately after sampling.

LABORATORY TESTING PROGRAM

The laboratory compacted specimens were made at such a compactive effort as to provide an approximately 7.0 ± 1.0% air void content. Four liquid antistripping additives were used in addition to the raw material and the hydrated lime slurry. The additives and the dosage are given below:

a. Hydrated lime slurry (1.0% by weight of aggregate).

b. ARR-MAZ (1.0% by weight of asphalt).

c. Aquashield II (0.8% by weight of asphalt).

d. BA 2000 (0.5% by weight of asphalt).

e. Perma-Tac (1.0% by weight of asphalt).

The laboratory testing program was discussed in Chapter 2 of the main text and Appendix A,and it has been carried out through the duration of this study. Sample preparation, conditioning, test procedures and engineering properties analyzed for the test methods were also discussed in Chapter 2.

PRESENTATION OF TEST RESULTS

Laboratory Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables G-2 through G-7. The data are plotted in Figure G-4 for laboratory mixtures using Methods A through E. The cyclic freeze-thaw test results are shown in Figures G-5 and G-6.

Plant Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables G-8 through G-13. The data are also plotted in Figure G-7 for plant mixtures using Methods B through D.

Plant Mixed/Field Compacted Mixtures (Field Cores)

Summary of the test results are presented on Table G-14. The achieved field compaction to have the low and high air voids are summarized in Figure G-8 which shows the average air void content of the field cores from the low and high voids test sections in the field. The average TSR values are shown in Figure G-9 for the low and high voids test sections.

Texas Boiling Test Results

The Texas boiling test results are presented on Table G-15 and plotted in Figure G-10 for the laboratory mixture, the plant mixture, and the field core.

APPENDIX G SUMMARY OF DATA FOR DISTRICT 19

TABLE G-1 AGGREGATE GRADATION (DISTRICT 19)

SIEVE SIZE	COARSE AGGREGATE "C" SIEVE ANALYSIS	COARSE AGGREGATE "C" 20%	COARSE AGGREGATE "D" SIEVE ANALYSIS	COARSE AGGREGATE "D" 40%	SCREENINGS SIEVE ANALYSIS	SCREENINGS 20%	FIELD SAND SIEVE ANALYSIS	FIELD SAND 20%	COMBINED GRADATION	SDHPT SPECIFICATIONS
Plus 7/8 in.	0	0							0	0
Plus 5/8 in.	20.9	4.2	0	0					4.2	0-5
1/2 to 3/8 in.	77.9	15.6	11.9	4.7					20.3	16-42
3/8 to No. 4	1.0	0.2	52.7	21.1	0	0			21.3	11-37
No. 4 to No. 10	0.2	0.0	25.6	10.2	21.1	4.2			14.4	11-32
Plus No. 10									60.2	54-74
No. 10 to No. 40	0.0	0.0	8.2	3.3	48.0	9.7	0	0	13.0	6-32
No. 40 to No. 80	0.0	0.0	0.8	0.3	16.6	3.3	41.0	8.2	11.8	4-27
No. 80 to No.200	0.0	0.0	0.4	0.2	10.1	2.0	51.5	10.3	12.5	3-27
Minus No. 200	0.0	0.0	0.4	0.2	4.2	0.8	7.5	1.5	2.5	1-8
TOTAL	100.0	20.0	100.0	40.0	100.0	20.0	100.0	20.0	100.0	

TABLE G-2 TEST RESULTS FOR LABORATORY MIXTURES (D-19)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.3%

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.3	140.2	88	
	A2	DRY	7.0	139.3	92	
	A3	DRY	6.8	139.5	80	
		DRY AVG	6.7	139.7	87	
	A4	WET	6.9	139.3	106	
	A5	WET	7.2	139.0	86	
	A6	WET	6.2	140.4	98	
		WET AVG	6.8	139.6	97	1.12
B	B1	DRY	6.2	140.4	85	
	B2	DRY	6.6	139.8	85	
		DRY AVG**	6.4	140.1	85	
	B4	WET	6.3	140.3	94	
	B5	WET	6.7	139.7	96	
	B6	WET	5.9	140.9	83	
		WET AVG	6.3	140.3	91	1.07
C	C1	WET	6.8	139.6	76	
	C2	WET	6.5	139.9	76	
	C3	WET	6.5	140.0	85	
		WET AVG	6.6	139.8	79	
		DRY AVG**	6.4	140.1	85	0.93
D	D1	WET	6.8	139.5	85	
	D2	WET	6.2	140.4	77	
	D3	WET	6.2	140.5	88	
		WET AVG	6.4	140.1	83	
		DRY AVG**	6.4	140.1	85	0.98

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D

TABLE G-2 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	6.0	140.7	108	
	E2	1 CYCLE	6.7	139.7	94	
		WET AVG	6.3	140.2	101	
		DRY AVG**	6.4	140.1	85	1.19
	E3	3 CYCLES	6.9	139.3	58	
	E4	3 CYCLES	6.7	139.7	54	
		WET AVG	6.8	139.5	56	
		DRY AVG**	6.4	140.1	85	0.66
	E5	5 CYCLES	6.9	139.4	43	
	E6	5 CYCLES	6.4	140.1	66	
		WET AVG	6.6	139.7	55	
		DRY AVG**	6.4	140.1	85	0.64
	E7	7 CYCLES	7.0	139.2	35	
	E8	7 CYCLES	6.3	140.3	41	
		WET AVG	6.6	139.8	38	
		DRY AVG**	6.4	140.1	85	0.45
	E9	9 CYCLES	6.8	139.6	50	
	E10	9 CYCLES	7.0	139.2	31	
		WET AVG	6.9	139.4	41	
		DRY AVG**	6.4	140.1	85	0.48
****	B3	DRY	5.7	141.1	94	

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)
****The air voids exceed the tolerance.

TABLE G-3 TEST RESULTS FOR LABORATORY MIXTURES (D-19)
ADDITIVE: LIME SLURRY (1.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.9	137.7	64	
	A2	DRY	7.2	138.9	60	
	A3	DRY	7.3	138.6	66	
		DRY AVG	7.5	138.4	63	
	A4	WET	7.4	138.4	56	
	A5	WET	7.6	138.2	78	
	A6	WET	7.0	139.2	69	
		WET AVG	7.3	138.6	68	
						1.07
B	B1	DRY	7.6	138.2	61	
	B2	DRY	7.5	138.4	58	
		DRY AVG**	7.5	138.3	60	
	B4	WET	7.1	139.0	99	
	B5	WET	8.0	137.7	84	
	B6	WET	6.9	139.3	90	
		WET AVG	7.3	138.6	91	
						1.53
C	C1	WET	7.4	138.5	82	
	C2	WET	7.8	137.9	79	
	C3	WET	6.6	139.7	97	
		WET AVG	7.3	138.7	86	
		DRY AVG**	7.5	138.3	60	
						1.45
D	D1	WET	7.3	138.6	102	
	D2	WET	6.6	139.7	101	
	D3	WET	6.8	139.4	90	
		WET AVG	6.9	139.2	98	
		DRY AVG**	7.5	138.3	60	
						1.64

*Letter indicates Test Method.
**B Dry same as the Dry Condition for Method B through D.

TABLE G-3 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.6	138.2	100	
	E2	1 CYCLE	7.5	138.3	90	
		WET AVG	7.6	138.3	95	
		DRY AVG**	7.5	138.3	60	1.59
	E3	3 CYCLES	6.7	139.5	97	
	E4	3 CYCLES	6.8	139.4	94	
		WET AVG	6.8	139.5	96	
		DRY AVG**	7.5	138.3	60	1.61
E	E5	5 CYCLES	7.2	138.8	61	
	E6	5 CYCLES	7.9	137.7	58	
		WET AVG	7.6	138.2	59	
		DRY AVG**	7.5	138.3	60	1.00
	E7	7 CYCLES	7.5	138.4	62	
	E8	7 CYCLES	8.0	137.6	64	
		WET AVG	7.7	138.0	63	
		DRY AVG**	7.5	138.3	60	1.06
	E9	9 CYCLES	7.1	139.0	68	
	E10	9 CYCLES	7.2	138.9	53	
		WET AVG	7.1	138.9	60	
		DRY AVG**	7.5	138.3	60	1.01

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE G-4 TEST RESULTS FOR LABORATORY MIXTURES (D-19)
ADDITIVE: ARR-MAZ (1.0%)
ASPHALT CONTENT = 5.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.4	139.7	78	
	A2	DRY	6.1	140.2	83	
	A3	DRY	6.9	138.9	70	
		DRY AVG	6.5	139.6	77	
	A4	WET	6.1	140.3	95	
	A5	WET	6.4	139.7	82	
	A6	WET	6.0	140.3	99	
		WET AVG	6.2	140.1	92	1.19
B	B1	DRY	6.0	140.4	80	
	B2	DRY	6.0	140.3	78	
	B3	DRY	6.7	139.4	83	
		DRY AVG**	6.2	140.0	80	
	B4	WET	6.2	140.0	93	
	B5	WET	6.3	140.0	82	
	B6	WET	6.1	140.2	88	
		WET AVG	6.2	140.0	88	1.09
C	C1	WET	6.7	139.3	78	
	C2	WET	6.0	140.3	84	
	C3	WET	7.3	138.5	77	
		WET AVG	6.7	139.4	80	
		DRY AVG**	6.2	140.0	80	0.99
D	D1	WET	6.5	139.6	97	
	D2	WET	6.0	140.3	106	
	D3	WET	6.6	139.5	85	
		WET AVG	6.4	139.8	96	
		DRY AVG**	6.2	140.0	80	1.20

*Letter Indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE G-4 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.3	139.9	104	
	E2	1 CYCLE	7.4	138.2	89	
		WET AVG	6.9	139.1	96	
		DRY AVG**	6.2	140.0	80	1.20
	E3	3 CYCLES	6.2	140.1	78	
	E4	3 CYCLES	6.5	139.6	90	
		WET AVG	6.3	139.8	84	
		DRY AVG**	6.2	140.0	80	1.05
E	E5	5 CYCLES	6.7	139.4	62	
	E6	5 CYCLES	6.7	139.3	57	
		WET AVG	6.7	139.3	60	
		DRY AVG**	6.2	140.0	80	0.75
	E7	7 CYCLES	6.6	139.5	58	
	E8	7 CYCLES	6.6	139.5	54	
		WET AVG	6.6	139.5	56	
		DRY AVG**	6.2	140.0	80	0.70
	E9	9 CYCLES	6.7	139.3	67	
	E10	9 CYCLES	6.0	140.4	52	
		WET AVG	6.4	139.8	59	
		DRY AVG**	6.2	140.0	80	0.74

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE G-5 TEST RESULTS FOR LABORATORY MIXTURES (D-19)
ADDITIVE: AQUA-SHIELD II (0.8%)
ASPHALT CONTENT = 5.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.9	139.8	88	
	A2	DRY	7.0	139.7	83	
	A3	DRY	7.3	139.2	78	
		DRY AVG	7.0	139.6	83	
	A4	WET	7.3	139.2	107	
	A5	WET	6.8	140.0	102	
	A6	WET	6.7	140.0	102	
		WET AVG	6.9	139.7	104	1.25
B	B1	DRY	6.8	140.0	87	
	B2	DRY	6.9	139.8	86	
	B3	DRY	7.0	139.7	79	
		DRY AVG**	6.9	139.8	84	
	B4	WET	7.0	139.6	90	
	B5	WET	6.6	140.2	115	
	B6	WET	6.4	140.5	108	
		WET AVG	6.7	140.1	104	1.24
C	C1	WET	7.2	139.3	87	
	C2	WET	6.5	140.4	98	
	C3	WET	6.8	139.9	94	
		WET AVG	6.8	139.9	93	
		DRY AVG**	6.9	139.8	84	1.11
D	D1	WET	6.8	140.0	129	
	D2	WET	7.0	139.6	108	
	D3	WET	7.3	139.1	106	
		WET AVG	7.0	139.6	114	
		DRY AVG**	6.9	139.8	84	1.36

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE G-5 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	6.8	140.0	114	
	E2	1 CYCLE	6.7	140.1	105	
		WET AVG	6.7	140.1	109	
		DRY AVG**	6.9	139.8	84	1.31
	E3	3 CYCLES	7.3	139.2	94	
	E4	3 CYCLES	6.8	140.0	102	
		WET AVG	7.0	139.6	98	
		DRY AVG**	6.9	139.8	84	1.16
	E5	5 CYCLES	7.0	139.7	75	
	E6	5 CYCLES	6.4	140.5	90	
		WET AVG	6.7	140.1	83	
		DRY AVG**	6.9	139.8	84	0.99
	E7	7 CYCLES	6.4	140.5	86	
	E8	7 CYCLES	6.7	140.1	92	
		WET AVG	6.5	140.3	89	
		DRY AVG**	6.9	139.8	84	1.06
	E9	9 CYCLES	6.5	140.3	92	
	E10	9 CYCLES	6.4	140.6	91	
		WET AVG	6.4	140.5	91	
		DRY AVG**	6.9	139.8	84	1.09

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE G-6 TEST RESULTS FOR LABORATORY MIXTURES (D-19)
ADDITIVE: BA 2000 (0.5%)
ASPHALT CONTENT = 5.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.4	138.7	84	
	A2	DRY	7.3	138.9	86	
	A3	DRY	7.1	139.2	97	
		DRY AVG	7.3	138.9	89	
	A4	WET	7.5	138.6	106	
	A5	WET	7.3	138.8	93	
	A6	WET	6.9	139.4	110	
		WET AVG	7.2	138.9	103	
						1.16
B	B1	DRY	6.5	140.0	96	
	B2	DRY	6.6	139.9	99	
	B3	DRY	6.2	140.5	102	
		DRY AVG**	6.4	140.1	99	
	B4	WET	7.2	139.0	103	
	B5	WET	7.2	139.0	103	
	B6	WET	7.3	138.9	113	
		WET AVG	7.2	139.0	106	
						1.07
C	C1	WET	6.4	140.1	124	
	C2	WET	6.6	139.9	118	
	C3	WET	7.0	139.3	119	
		WET AVG	6.7	139.8	120	
		DRY AVG**	6.4	140.1	99	
						1.22
D	D1	WET	6.5	140.0	129	
	D2	WET	6.6	139.9	129	
	D3	WET	6.7	139.7	128	
		WET AVG	6.6	139.8	129	
		DRY AVG**	6.4	140.1	99	
						1.30

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE G-6 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.5	140.1	132	
	E2	1 CYCLE	6.9	139.4	122	
		WET AVG	6.7	139.7	127	
		DRY AVG**	6.4	140.1	99	
						1.29
	E3	3 CYCLES	6.8	139.6	114	
	E4	3 CYCLES	6.6	139.9	113	
		WET AVG	6.7	139.8	114	
		DRY AVG**	6.4	140.1	99	
						1.15
E	E5	5 CYCLES	6.7	139.7	96	
	E6	5 CYCLES	6.8	139.5	90	
		WET AVG	6.8	139.6	93	
		DRY AVG**	6.4	140.1	99	
						0.94
	E7	7 CYCLES	7.3	138.8	92	
	E8	7 CYCLES	6.9	139.5	90	
		WET AVG	7.1	139.2	91	
		DRY AVG**	6.4	140.1	99	
						0.92
	E9	9 CYCLES	6.9	139.5	86	
	E10	9 CYCLES	7.0	139.3	78	
		WET AVG	6.9	139.4	82	
		DRY AVG**	6.4	140.1	99	
						0.83

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE G-7 TEST RESULTS FOR LABORATORY MIXTURES (D-19)
ADDITIVE: PERMA-TAC (1.0%)
ASPHALT CONTENT = 5.3 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.9	139.3	79	
	A2	DRY	7.2	138.9	75	
	A3	DRY	6.9	139.3	72	
		DRY AVG	7.0	139.1	75	
	A4	WET	7.2	138.8	70	
	A5	WET	7.4	138.6	68	
	A6	WET	6.7	139.6	72	
		WET AVG	7.1	139.0	70	0.93
B	B1	DRY	6.7	139.7	77	
	B2	DRY	7.2	138.8	70	
	B3	DRY	7.3	138.8	74	
		DRY AVG**	7.1	139.1	74	
	B4	WET	6.5	139.9	96	
	B5	WET	6.7	139.6	84	
	B6	WET	6.7	139.7	78	
		WET AVG	6.6	139.7	86	1.17
C	C1	WET	7.6	138.3	76	
	C2	WET	7.3	138.7	75	
	C3	WET	7.1	139.0	77	
		WET AVG	7.3	138.7	76	
		DRY AVG**	7.1	139.1	74	1.03
D	D1	WET	7.4	138.6	79	
	D2	WET	6.7	139.6	85	
	D3	WET	7.0	139.1	63	
		WET AVG	7.0	139.1	76	
		DRY AVG**	7.1	139.1	74	1.03

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE G-7 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
E	E1	1 CYCLE	6.9	139.3	85	
	E2	1 CYCLE	7.3	138.8	79	
		WET AVG	7.1	139.0	82	
		DRY AVG**	7.1	139.1	74	1.12
	E3	3 CYCLES	7.1	139.1	60	
	E4	3 CYCLES	7.2	138.8	64	
		WET AVG	7.2	138.9	62	
		DRY AVG**	7.1	139.1	74	0.85
	E5	5 CYCLES	7.3	138.7	51	
	E6	5 CYCLES	6.6	139.8	59	
		WET AVG	7.0	139.2	55	
		DRY AVG**	7.1	139.1	74	0.75
	E7	7 CYCLES	7.3	138.6	50	
	E8	7 CYCLES	7.6	138.2	39	
		WET AVG	7.5	138.4	45	
		DRY AVG**	7.1	139.1	74	0.61
	E9	9 CYCLES	7.4	138.6	48	
	E10	9 CYCLES	7.0	139.1	41	
		WET AVG	7.2	138.8	45	
		DRY AVG**	7.1	139.1	74	0.61

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE G-8 TEST RESULTS FOR PLANT MIXTURES (D-19)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.6 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.4	137.8	76	
	B2	DRY	7.6	137.5	69	
	B3	DRY	8.0	137.0	70	
		DRY AVG**	7.6	137.4	72	
	B4	WET	7.5	137.7	48	
	B5	WET	7.9	137.0	58	
	B6	WET	8.1	136.7	51	
		WET AVG	7.8	137.2	52	0.73
C	C1	WET	7.2	138.1	50	
	C2	WET	7.8	137.3	59	
	C3	WET	7.5	137.6	52	
		WET AVG	7.5	137.7	54	
		DRY AVG**	7.6	137.4	72	0.75
D	D1	WET	7.6	137.5	53	
	D2	WET	7.8	137.2	60	
	D3	WET	7.7	137.4	60	
		WET AVG	7.7	137.4	58	
		DRY AVG**	7.6	137.4	72	0.80

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE G-9 TEST RESULTS FOR PLANT MIXTURES (D-19)
ADDITIVE: LIME SLURRY (1.0% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.6 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.7	137.8	90	
	B2	DRY	7.5	138.1	92	
	B3	DRY	7.7	137.8	78	
		DRY AVG**	7.6	137.9	87	
	B4	WET	7.3	138.4	100	
	B5	WET	7.5	138.1	93	
		WET AVG	7.4	138.3	97	
						1.11
C	C1	WET	7.8	137.7	110	
	C2	WET	7.3	138.4	96	
	C3	WET	7.8	137.7	95	
		WET AVG	7.6	137.9	100	
		DRY AVG**	7.6	137.9	87	
						1.16
D	D1	WET	7.4	138.2	117	
	D2	WET	7.9	137.5	94	
	D3	WET	7.0	138.8	103	
		WET AVG	7.4	138.2	105	
		DRY AVG**	7.6	137.9	87	
						1.21

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE G-10 TEST RESULTS FOR PLANT MIXTURES (D-19)
ADDITIVE: ARR-MAZ (1.0%)
ASPHALT CONTENT = 5.6 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.6	139.1	86	
	B2	DRY	6.8	138.7	88	
	B3	DRY	6.6	139.0	92	
		DRY AVG**	6.7	138.9	89	
	B4	WET	6.4	139.3	100	
	B5	WET	6.8	138.7	99	
		WET AVG	6.2	139.0	100	1.12
C	C1	WET	6.9	138.7	92	
	C2	WET	6.3	139.5	89	
	C3	WET	6.4	139.4	106	
		WET AVG	6.5	139.2	96	
		DRY AVG**	6.7	138.9	89	1.08
D	D1	WET	6.9	138.6	104	
	D2	WET	6.7	138.9	99	
	D3	WET	6.6	139.0	85	
		WET AVG	6.7	138.8	96	
		DRY AVG**	6.7	138.9	89	1.08

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE G-11 TEST RESULTS FOR PLANT MIXTURES (D-19)
ADDITIVE: AQUA-SHIELD II (0.8%)
ASPHALT CONTENT = 5.6 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	7.0	140.4	117	
	B2	DRY	7.1	140.3	102	
	B3	DRY	7.3	139.9	101	
		DRY AVG**	7.1	140.2	107	
B	B4	WET	7.2	140.1	118	
	B5	WET	6.7	140.9	126	
	B6	WET	6.9	140.5	128	
		WET AVG	6.9	140.5	124	
						1.16
	C1	WET	6.8	140.6	146	
	C2	WET	7.7	139.3	122	
	C3	WET	7.4	139.8	128	
		WET AVG	7.3	139.9	132	
C		DRY AVG**	7.1	140.2	107	
						1.24
	D1	WET	7.8	139.2	118	
	D2	WET	7.0	140.3	145	
	D3	WET	7.5	139.6	110	
		WET AVG	7.4	139.7	124	
D		DRY AVG**	7.1	140.2	107	
						1.17

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE G-12 TEST RESULTS FOR PLANT MIXTURES (D-19)
ADDITIVE: BA 2000 (0.5%)
ASPHALT CONTENT = 5.6 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.4	139.1	83	
	B2	DRY	6.5	138.8	91	
	B3	DRY	6.1	139.5	68	
		DRY AVG**	6.3	139.1	81	
	B4	WET	5.6	140.2	96	
	B5	WET	7.3	137.6	102	
	B6	WET	6.3	139.2	96	
		WET AVG	6.4	139.0	98	1.21
C	C1	WET	5.8	139.9	100	
	C2	WET	5.9	139.7	98	
	C3	WET	6.0	139.7	108	
		WET AVG	5.9	139.7	102	
		DRY AVG**	6.3	139.1	81	1.26
D	D1	WET	5.9	139.8	109	
	D2	WET	5.9	139.7	103	
	D3	WET	5.8	139.9	95	
		WET AVG	5.9	139.8	102	
		DRY AVG**	6.3	139.1	81	1.27

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE G-13 TEST RESULTS FOR PLANT MIXTURES (D-19)
ADDITIVE: PERMA-TAC (1.0%)
ASPHALT CONTENT = 5.6 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.3	139.7	117	
	B2	DRY	6.9	138.9	118	
	B3	DRY	6.7	139.2	124	
		DRY AVG**	6.6	139.3	120	
	B4	WET	6.9	138.8	132	
	B5	WET	6.8	139.0	118	
	B6	WET	6.5	139.4	111	
		WET AVG	6.8	139.1	120	1.01
C	C1	WET	6.8	139.0	140	
	C2	WET	6.2	139.8	129	
	C3	WET	6.4	139.6	139	
		WET AVG	6.5	139.5	136	
		DRY AVG**	6.6	139.3	120	1.14
D	D1	WET	7.0	138.7	145	
	D2	WET	6.4	139.6	142	
	D3	WET	6.7	139.1	126	
		WET AVG	6.7	139.1	138	
		DRY AVG**	6.6	139.3	120	1.15

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength(Dry Avg)

TABLE G-14 TEST RESULTS FOR FIELD CORES
DISTRICT 19
ASPHALT CONTENT = 5.6 %

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		1A	WET	11.3	132.1	28	
		1B	DRY	11.3	132.1	38	
	LOW						0.74
	AIR	2A	DRY	9.9	134.1	58	
	VOIDS	2B	WET	9.9	134.1	44	
	SECTION						0.76
		3A	WET	8.6	136.0	55	
		3B	DRY	8.4	136.3	64	
							0.86
				--------			-------
NO		(AVG VOIDS)		9.9		(AVG TSR)	0.79
ADDITIVE							
(CONTROL)		4A	DRT	9.0	135.5	55	
		4B	WET	8.5	136.2	54	
	HIGH						0.99
	AIR	5A	WET	7.7	137.3	59	
	VOIDS	5B	DRY	7.6	137.6	66	
	SECTION						0.89
		6A	DRY	7.9	137.1	70	
		6B	WET	8.0	136.9	52	
							0.74
				--------			-------
		(AVG VOIDS)		8.1		(AVG TSR)	0.87
		7A	WET	6.6	139.3	89	
		7B	DRY	6.7	139.2	79	
	LOW						1.12
	AIR	8A	DRY	6.4	139.7	70	
	VOIDS	8B	WET	6.6	139.4	70	
	SECTION						1.00
		9A	WET	5.4	141.3	103	
		9B	DRY	5.3	141.4	87	
							1.18
				--------			-------
		(AVG VOIDS)		6.2		(AVG TSR)	1.10
LIME							
SLURRY		10A	DRY	7.6	138.0	66	
		10B	WET	7.4	138.2	94	
	HIGH						1.43
	AIR	11A	WET	8.8	136.1	72	
	VOIDS	11B	DRY	9.4	135.2	65	
	SECTION						1.10
		12A	DRY	6.8	139.1	73	
		12B	WET	7.0	138.8	84	
							1.15
				--------			-------
		(AVG VOIDS)		7.8		(AVG TSR)	1.23
		13A	DRY	8.9	135.6	65	
		13B	WET	8.4	136.4	78	
							1.19
		14A	WET	8.0	137.0	66	

TABLE G-14 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
	LOW	14B	DRY	8.3	136.5	63	
	AIR						1.05
	VOIDS	15A	DRY	8.4	136.4	63	
	SECTION	15B	WET	8.5	136.2	70	
							1.11
		(AVG VOIDS)		8.4		(AVG TSR)	1.12
ARR-MAZ							
		16A	WET	6.4	139.4	103	
		16B	DRY	6.2	139.7	83	
	HIGH						1.23
	AIR	17A	DRY	7.6	137.6	62	
	VOIDS	17B	WET	7.4	137.8	84	
	SECTION						1.36
		18A	WET	8.6	136.1	77	
		18B	DRY	9.8	134.3	67	
							1.14
		(AVG VOIDS)		7.7		(AVG TSR)	1.24
		19A	WET	10.7	134.8	74	
		19B	DRY	10.7	134.8	64	
	LOW						1.16
	AIR	20A	DRY	8.4	138.2	70	
	VOIDS	20B	WET	8.0	138.9	108	
	SECTION						1.54
		21A	WET	7.6	139.4	85	
		21B	DRY	7.6	139.4	62	
							1.37
		(AVG VOIDS)		8.8		(AVG TSR)	1.36
AQUA-SHIELD II		22A	DRY	8.6	138.0	71	
		22B	WET	8.8	137.6	108	
	HIGH						1.53
	AIR	23A	WET	7.4	139.8	123	
	VOIDS	23B	DRY	7.1	140.3	77	
	SECTION						1.59
		24A	DRY	9.0	137.3	51	
		24B	WET	9.4	136.7	101	
							1.98
		(AVG VOIDS)		8.4		(AVG TSR)	1.70
		25A	WET	8.2	136.3	92	
		25B	DRY	7.3	137.6	82	
	LOW						1.12
	AIR	26A	DRY	6.5	138.9	77	
	VOIDS	26B	WET	6.1	139.4	84	
	SECTION						1.09
		27A	WET	7.8	136.9	104	
		27B	DRY	7.1	137.9	99	
							1.05

TABLE G-14 (Continued)

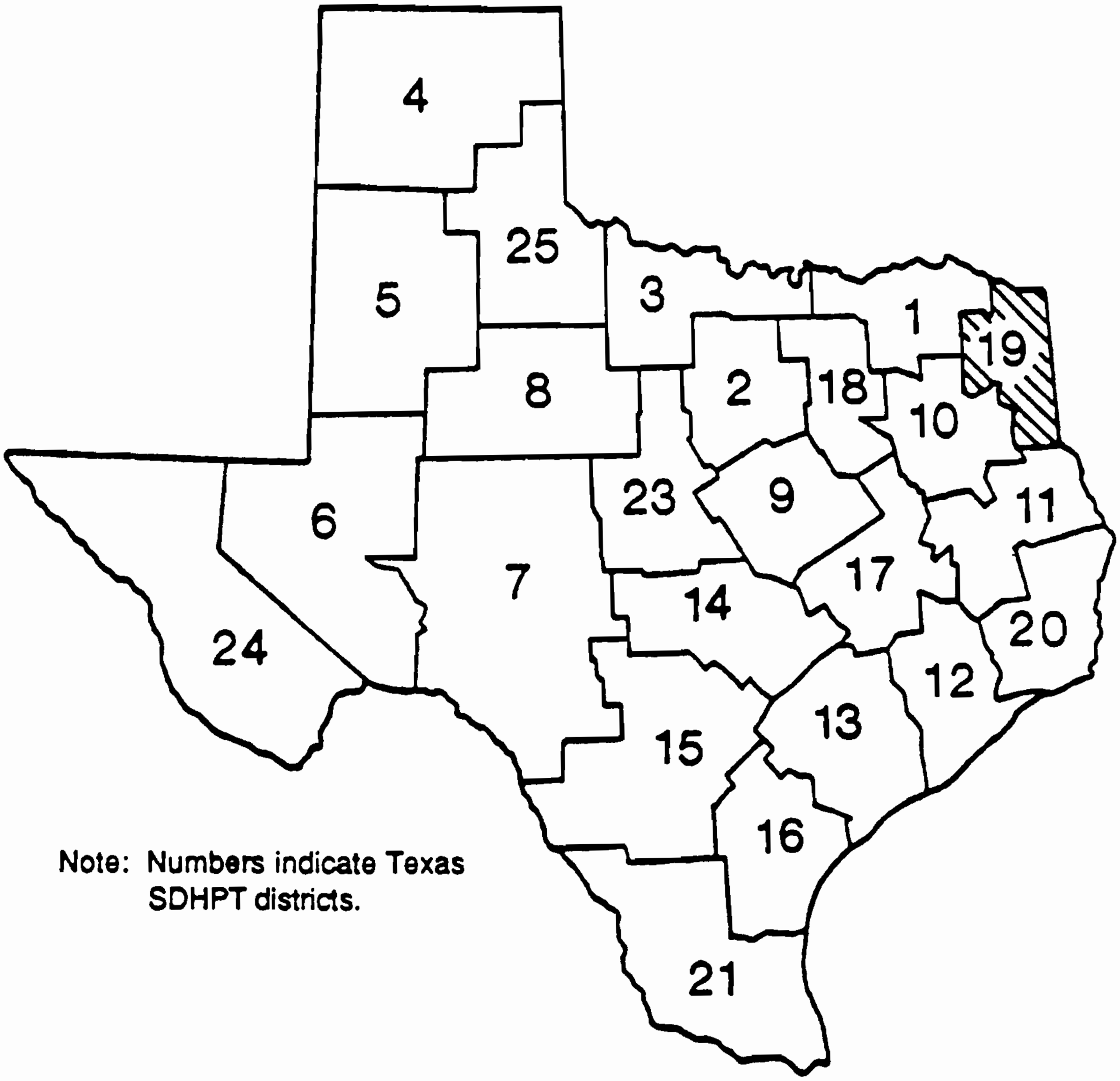
TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		(AVG VOIDS)		7.2		(AVG TSR)	1.09
BA 2000							
	HIGH AIR VOIDS SECTION	28A	DRY	6.6	138.6	91	
		28B	WET	7.1	138.0	98	
							1.07
		29A	WET	7.8	136.9	90	
		29B	DRY	7.6	137.2	82	
							1.10
		30A	DRT	8.2	136.4	81	
		30B	WET	9.2	134.9	95	
							1.18
		(AVG VOIDS)		7.8		(AVG TSR)	1.12
	LOW AIR VOIDS SECTION	31A	WET	8.1	137.0	78	
		31B	DRY	7.9	137.4	71	
							1.10
		32A	DRY	8.5	136.4	67	
		32B	WET	8.6	136.3	75	
							1.12
		33A	WET	7.2	138.4	61	
		33B	DRY	7.5	137.9	65	
							0.94
		(AVG VOIDS)		8.0		(AVG TSR)	1.05
PERMA-TAC							
	HIGH AIR VOIDS SECTION	34A	DRY	8.5	136.4	70	
		34B	WET	9.2	135.5	75	
							1.06
		35A	WET	7.8	137.5	76	
		35B	DRY	8.0	137.2	72	
							1.05
		36A	DRY	8.1	137.0	62	
		36B	WET	8.4	136.6	61	
							0.99
		(AVG VOIDS)		8.3		(AVG TSR)	1.04

*TSR = Tensile Strength Ratio
= Tensile Strength (Wet)/Tensile Strength (Dry)

TABLE G-15 BOILING TEST RESULTS
DISTRICT 19

TYPE OF MIXTURE	TYPE OF ADDITIVE	ASPHALT RETAINED AFTER BOILING, % RATING 1	RATING 2	AVG
LABORATORY	NO ADDITIVE	90	80	85.0
	LIME	98	90	94.0
	ARR-MAZ	100	85	92.5
	AQUASHIELD II	100	85	92.5
	BA 2000	100	85	92.5
	PERMA-TAC	100	85	92.5
PLANT	NO ADDITIVE	90	80	85.0
	LIME	95	85	90.0
	ARR-MAZ	90	90	90.0
	AQUASHIELD II	98	90	94.0
	BA 2000	98	95	96.5
	PERMA-TAC	95	85	90.0
FIELD CORE	NO ADDITIVE	95	80	87.5
	LIME	90	80	85.0
	ARR-MAZ	95	85	90.0
	AQUASHIELD II	95	85	90.0
	BA 2000	95	85	90.0
	PERMA-TAC	95	85	90.0

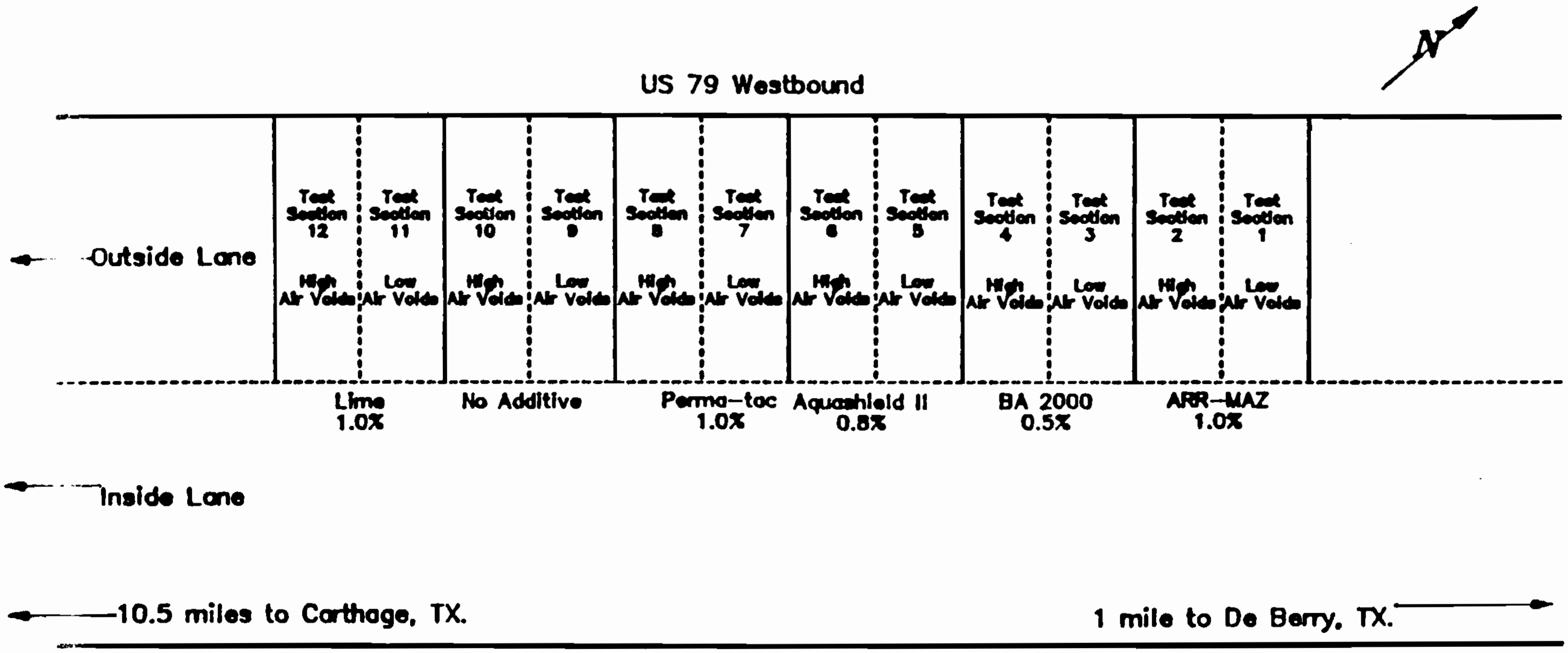
APPENDIX G LIST OF FIGURES



Note: Numbers indicate Texas SDHPT districts.

Figure G-1. Location of Field Test Sections (District 19).

DISTRICT 19 FIELD TEST SECTIONS



Note: Each test section is approximately 1000 feet in length.

Fig G-2 Schematic Illustration of Field Test Sections.

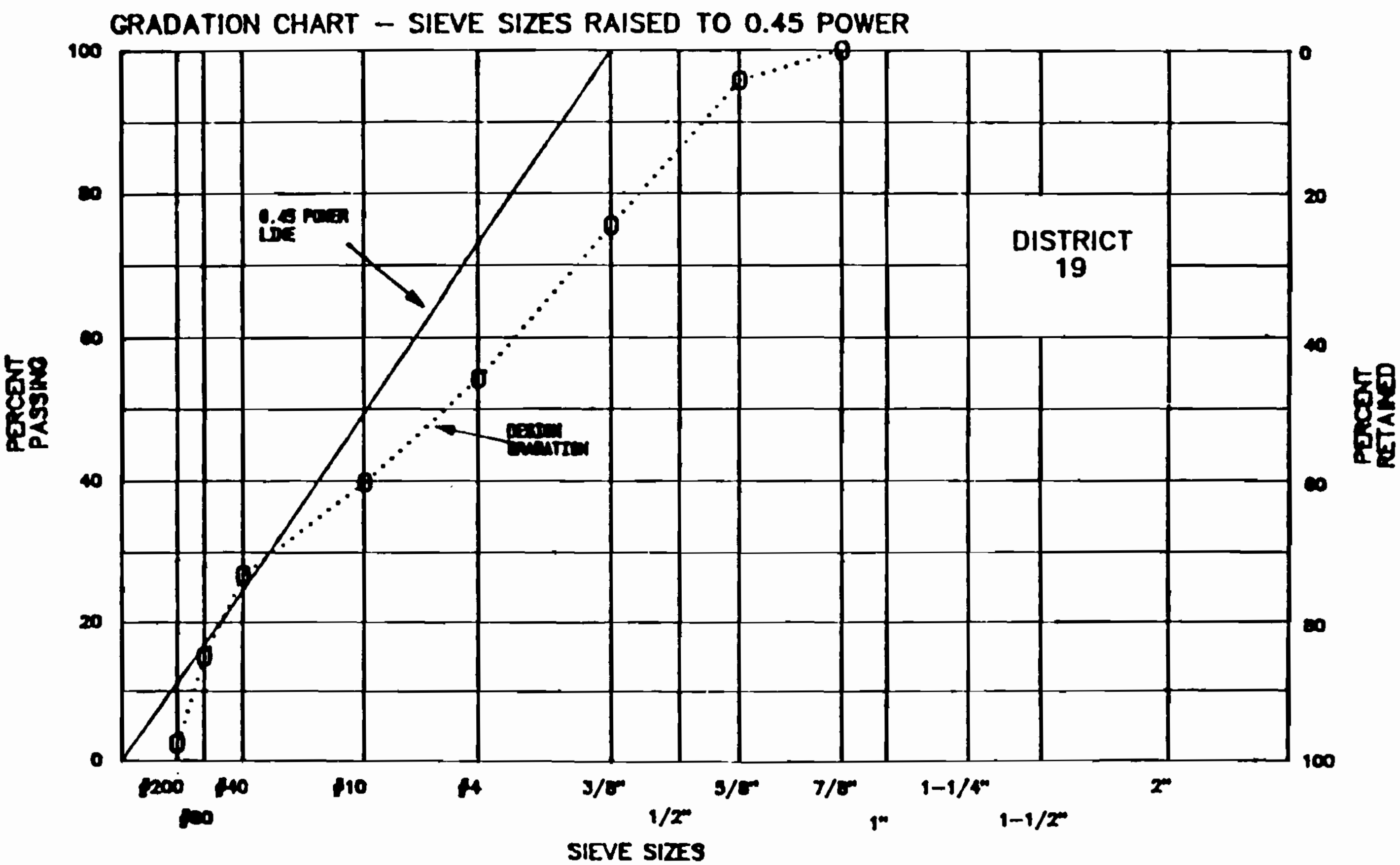


Fig G-3 Aggregate Gradation Chart.

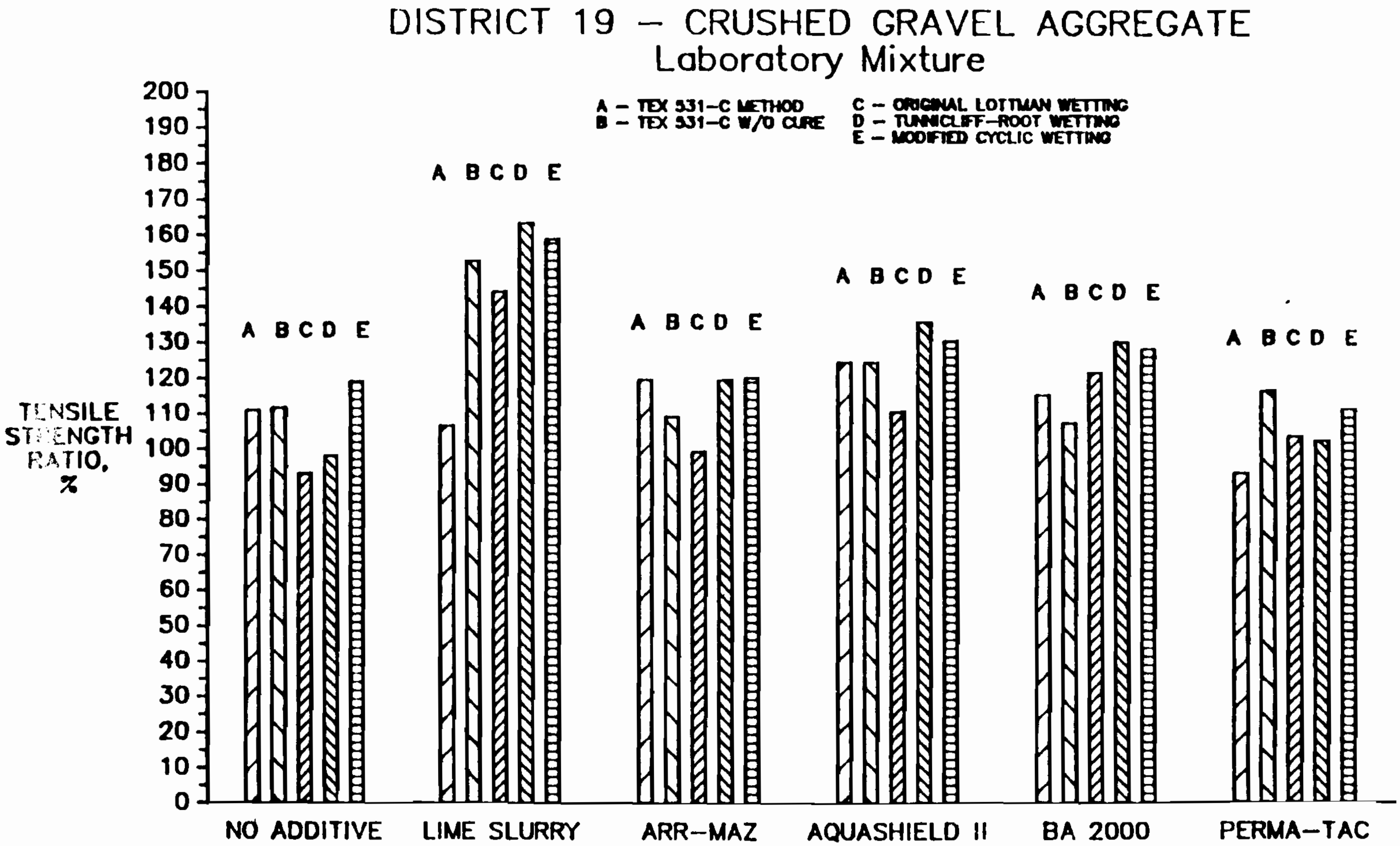


Fig G-4 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

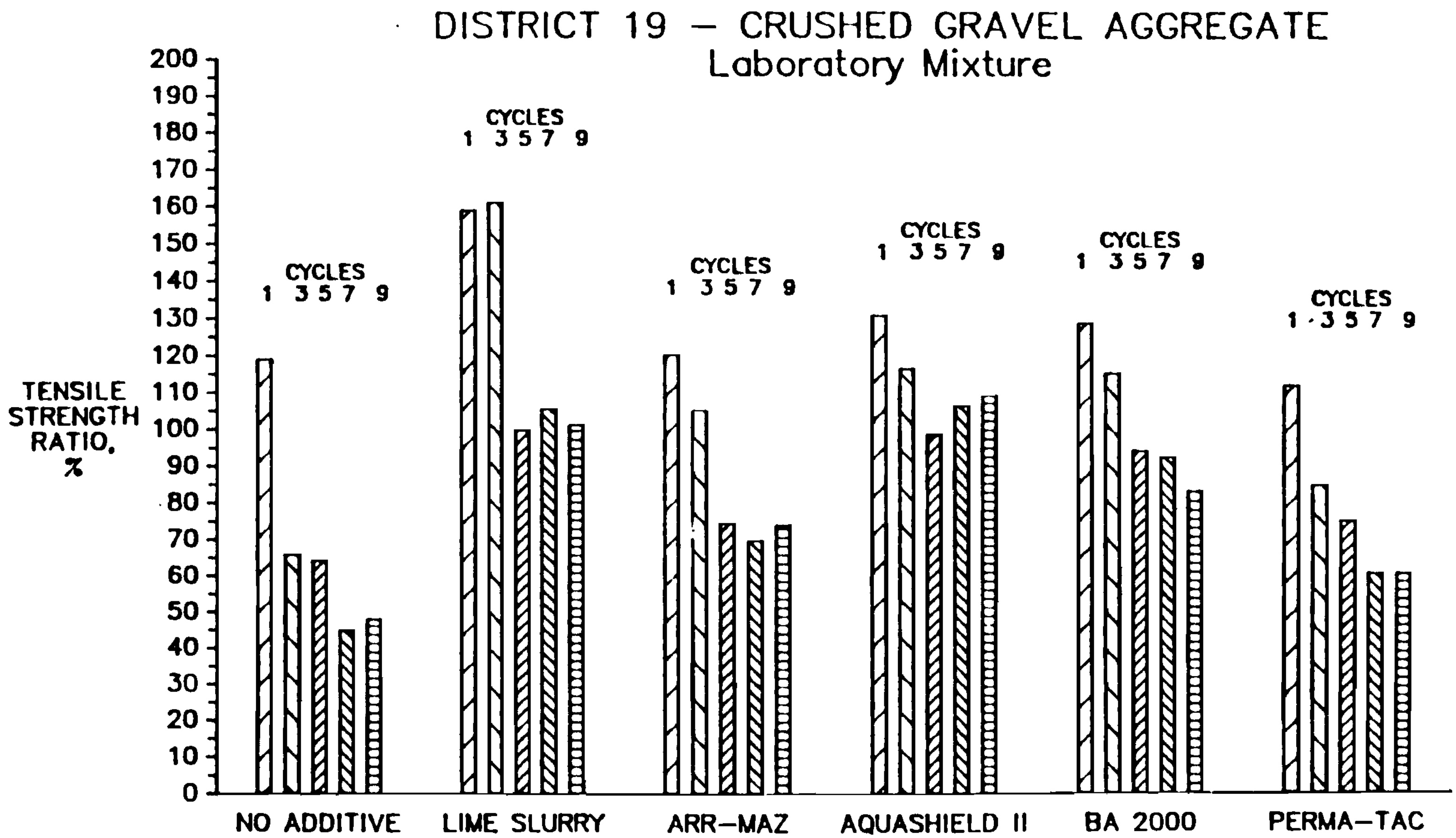


Fig G-5 Wet-Dry Indirect Tensile Cyclic Freeze-Thaw Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

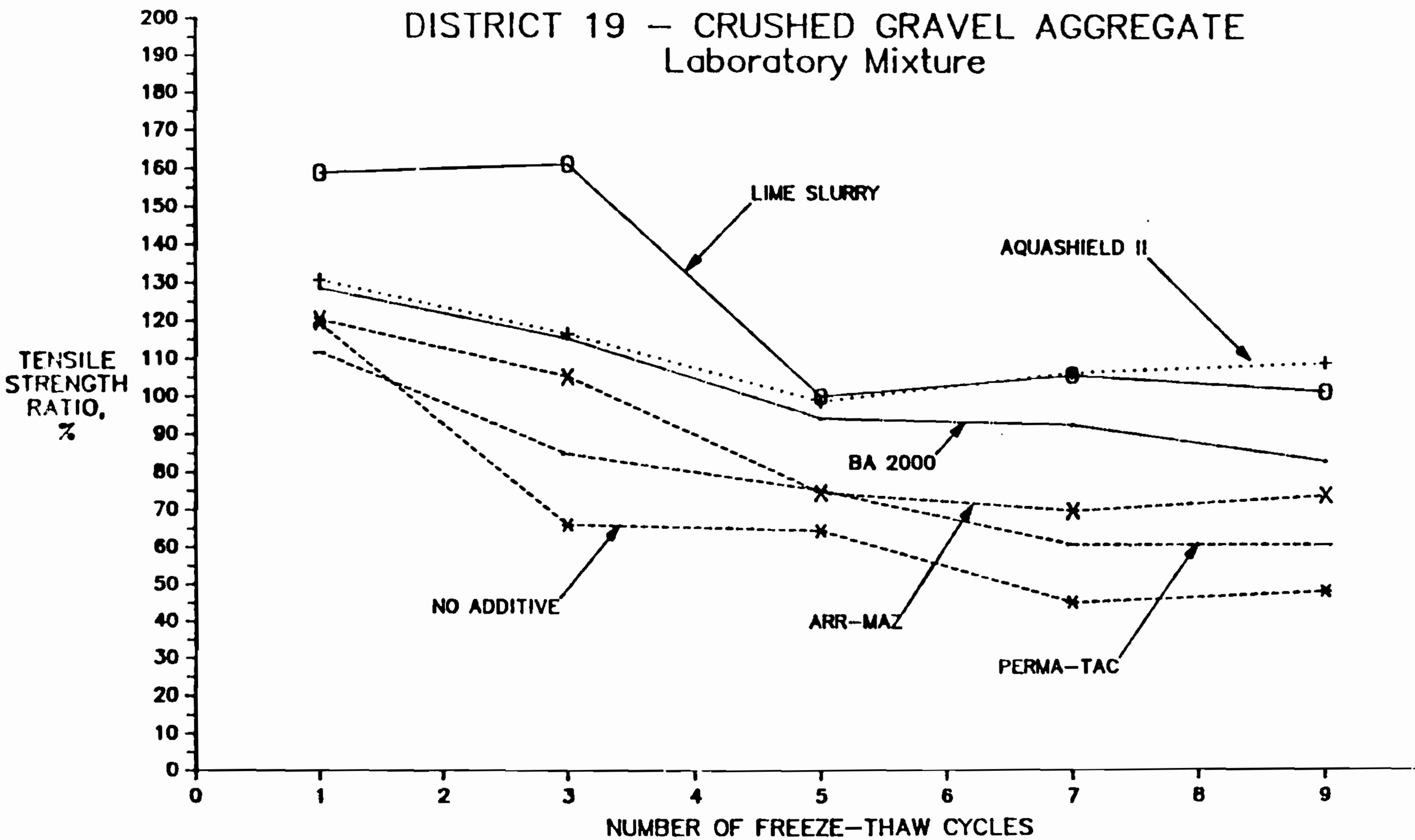


Fig G-6 Tensile Strength Ratio (TSR) Vs. Number of Freeze-Thaw Cycles for Laboratory Mixtures.

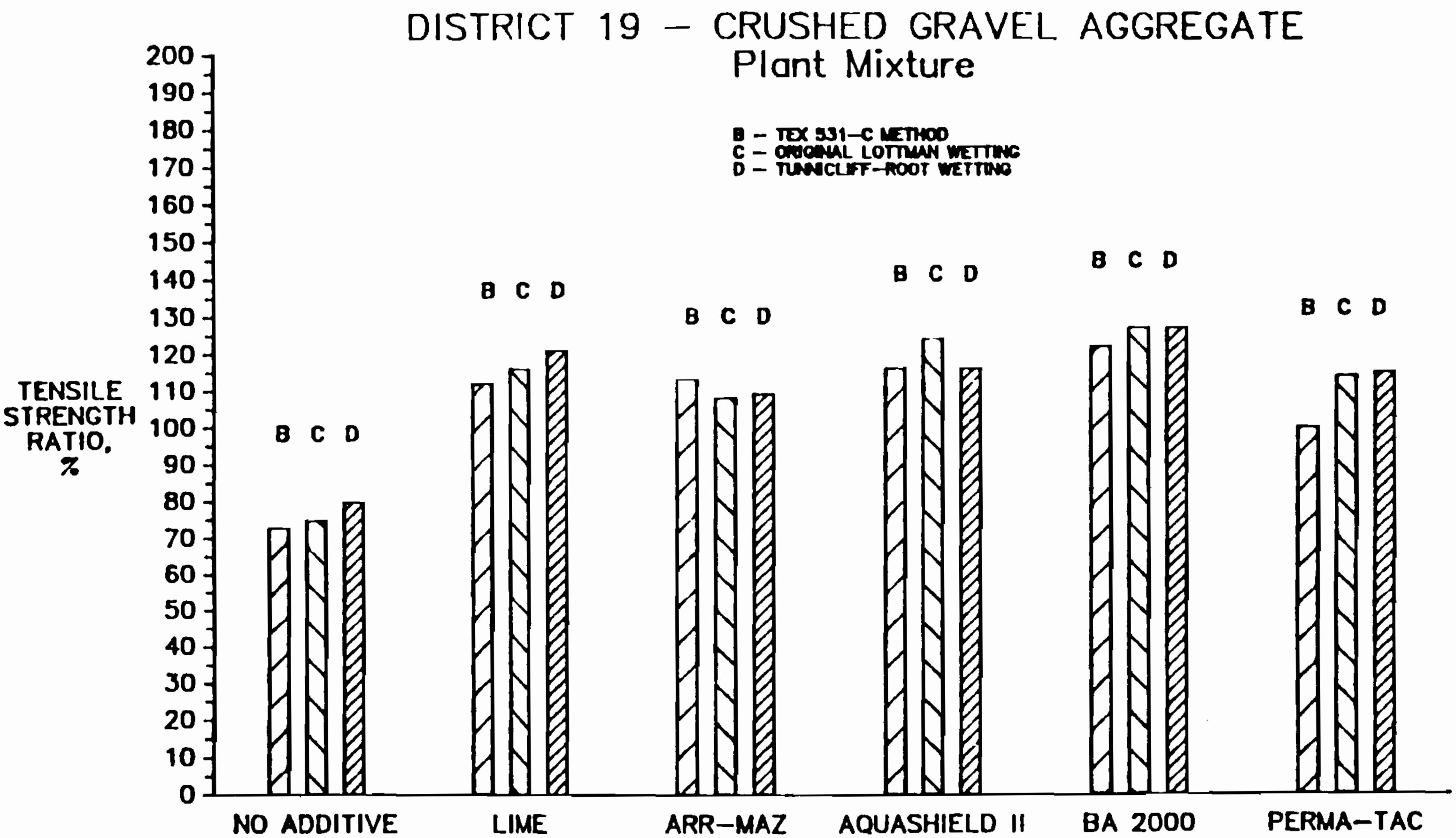


Fig G-7 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Plant Mixtures.

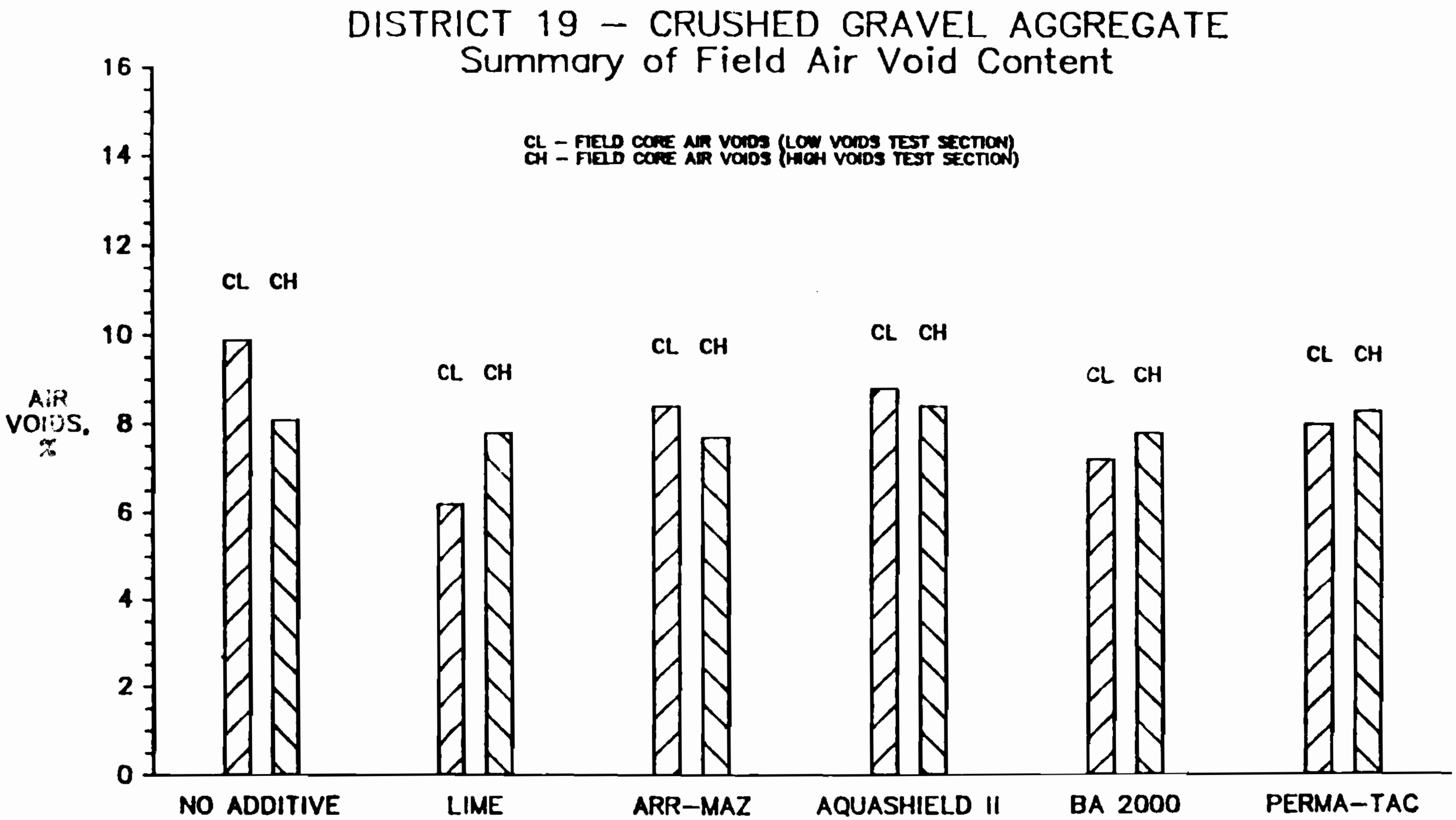


Fig G-8 Summary of Field Core Air Void Content.

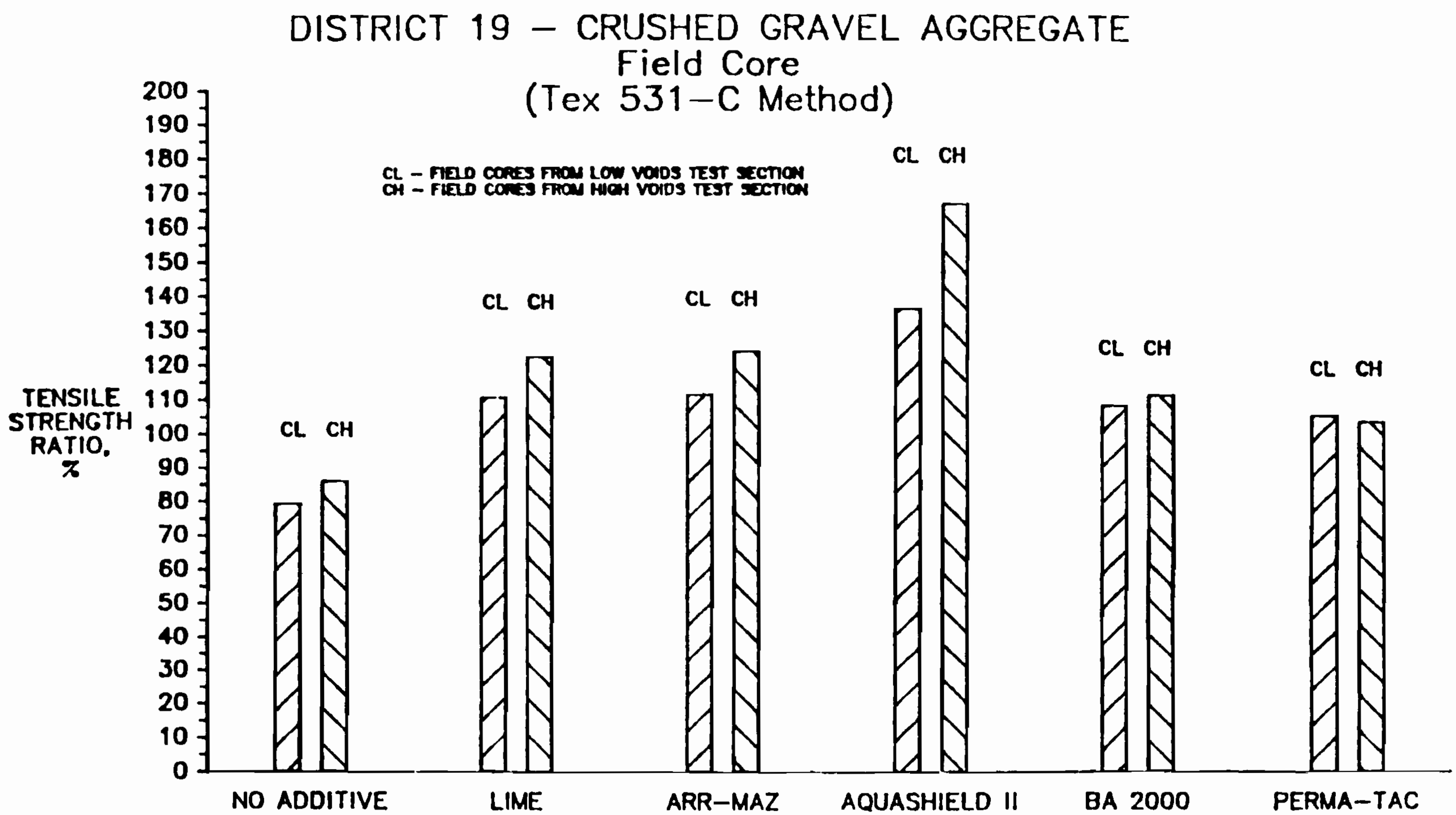


Fig G-9 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Field Cores.

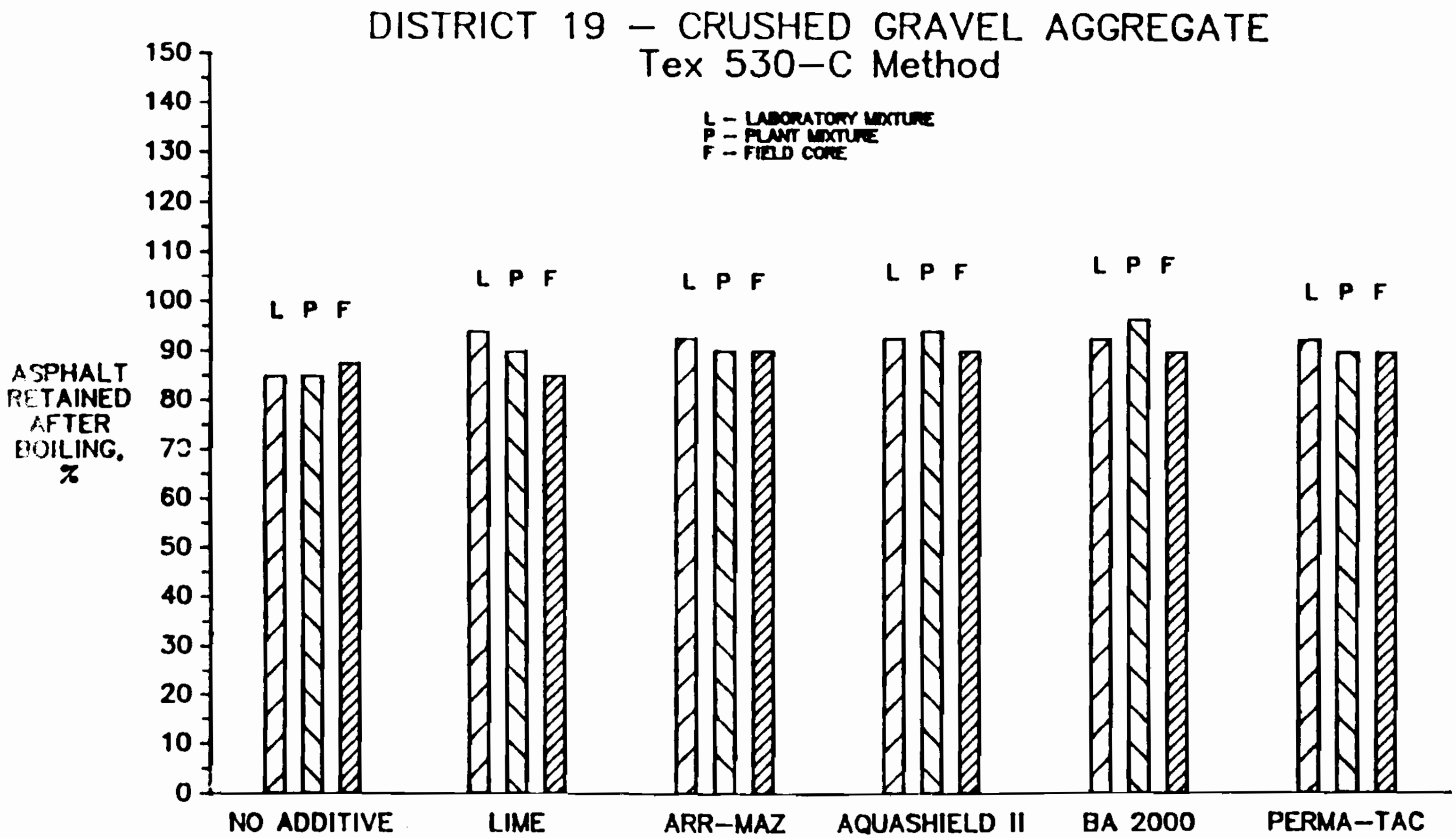


Fig G-10 Texas Boiling Test Results.

APPENDIX H

FIELD AND LABORATORY EXPERIMENTAL PROGRAM - DISTRICT 21

The objective of Appendix H is twofold: (1) to describe the site specific (District 21) field operations of the test sections along with a description of the materials, additives and construction techniques used for this field project, (2) to present the laboratory test results of the laboratory mixed and plant mixed mixtures along with the zero-aged (immediately after construction) pavement cores for the field experimental study at District 21 (Figure H-1) of the Texas State Department of Highways and Public Transportation (SDHPT).

FIELD EXPERIMENTAL PROGRAM

The test pavements were constructed on US 83 near Donna, Texas, in October 1987, and involved pavement overlay to one lane of the 4 lane divided highway. The test sections were installed as the surface course in the eastbound outside main travel lane as shown schematically in Figure H-2. Each test section was approximately 1.5 to 2.0 inches thick, 12 feet wide, and 1000 feet long. A total of sixteen (16) test sections were constructed and six liquid antistripping additives were used in addition to the hydrated lime and the control materials. The composition of the sixteen test sections are as follows:

Test Section 1. Hot mix with 1.0% lime slurry, low air voids.

Test Section 2. Hot mix with 1.0% lime slurry, high air voids.

Test Section 3. Hot mix with 1.0% Perma-Tac, low air voids.

Test Section 4. Hot mix with 1.0 Perma-Tac, high air voids.

Test Section 5. Hot mix with 1.0% Pavebond LP, low air voids.

Test Section 6. Hot mix with 1.0% Pavebond LP, high air voids

Test Section 7. Hot mix with 1.0% ARR-MAZ, low air voids.

Test Section 8. Hot mix with 1.0% ARR-MAZ, high air voids.

Test Section 9. Hot mix with 0.41% Fina-B, low air voids.

Test Section 10. Hot mix with 0.41% Fina-B, high air voids.

Test Section 11. Hot mix with 0.41% Aquashield II, low air voids.

Test Section 12. Hot mix with 0.41% Aquashield II, high air voids.

Test Section 13. Hot mix with 0.5% Dow Polyethylene, low air voids.

Test Section 14. Hot mix with 0.5% Dow Polyehylene, high air voids.

Test Section 15. Control Section - No additive, low air voids.

Test Section 16. Control Section - No additive, high air voids.

The field construction was conducted by District 21 of the Texas State Department of Highways and Public Transportation (SDHPT) and was assisted by the Center for Transportation Research, The University of Texas at Austin. The average daily traffic (ADT) is estimated at 10,600 vehicles for the test pavement.

MATERIALS AND PAVING MIXTURE

An AC-10 asphalt cement from Texas Fuel & Asphalt was used throughout this project. Four aggregates--a Type "D" 7/16" coarse aggregate, an uncrushed intermediate aggregate, screenings, and a field sand, were combined to produce the project gradation. Gradations of the individual aggregates, the project gradation, percentages of each aggregate combined, and the specification are given on Table H-1. The project gradation is plotted on a 0.45 power graph in Figure H-3.

The asphalt concrete mixture used in this study met the SDHPT specifications of Item 340, Type D (Modified) fine graded surface course (Ref 45). Preliminary laboratory test results for this mixture design are given below:

Asphalt Content	-	5.2%
Average Density	-	97 percent of theoretical maximum density
Air Void Content	-	3 percent
Hveem Stability	-	38%

FIELD OPERATIONS

A drum mix plant was used to prepare hot mixed asphalt mixtures containing lime slurry and liquid antistripping additives. Identical raw material sources (asphalt cement and aggregates) were utilized throughout the experiment. Six commercially available antistripping additives were used for the test sections, i.e., ARR-MAZ, Aquashield II, Dow Polyethylene, Fina-B, Pavebond LP, and Perma-Tac.

The hydrated lime was mixed and added in slurry form to the aggregates on cold feed belt of drum dryer plant. The liquid additives were metered into the asphalt cement in-line injection system. The Dow Polyethylene was in pellet form which required time to be blended with the asphalt cement that was done at the refinery and delivered to the project site preblended.

Compaction of each test section was achieved using a 3-wheel steel roller, a vibratory roller, and a pneumatic roller. For the low air void test sections the same rolling pattern was used as established for the regular construction project. In order to achieve the high air void test sections, the vibratory roller was used in the static made and the number of passes reduced. Final rolling involved using the pneumatic roller.

The field cores were obtained soon after the construction. Three pairs of samples were cored from each test section with each pair approximately 200 feet apart. The sample size was approximately 4-inches in diameter and 1.5 to 2.0 inches in thickness. The coring process was in accordance with the general coring layout procedure described in the main text of this report (Chapter 2). The field cores were transported to the Center for Transportation Research laboratory immediately after sampling.

LABORATORY TESTING PROGRAM

The laboratory compacted specimens were made at such a compactive effort as to provide an approximately 7.0 ± 1.0% air void content. Six liquid antistripping additives were used in addition to the raw material and the hydrated lime slurry. The additives and the dosage are given below:

a. Hydrated lime slurry (1.0% by weight of aggregate).

b. [illegible] (1.0% by weight of asphalt).

c. Aquashield II (0.41% by weight of asphalt).

d. Dow Polyethylene (0.5% by weight of asphalt).

e. Fina-B (0.41% by weight of asphalt).

f Pavebond LP (1.0% by weight of asphalt).

g. Perma-Tac (1.0% by weight of asphalt).

The laboratory testing program was discussed in Chapter 2 of the main text and Appendix A, and was carried out through the duration of this study. Sample preparation, conditioning, test procedures and engineering properties analyzed for the test methods were also discussed in Chapter 2.

PRESENTATION OF TEST RESULTS

Laboratory Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables H-2 through H-9. The data are plotted in Figure H-4 for laboratory mixtures using Methods A through E. The cyclic freeze-thaw test results are shown in Figures H-5 and H-6.

Plant Mixed/Laboratory Compacted Mixtures

Summary of the test results are presented on Tables H-10 through H-17. The data are also plotted in Figure H-7 for plant mixtures using Methods B through D.

Plant Mixed/Field Compacted Mixtures (Field Cores)

Summary of the test results are presented on Table H-18. The achieved field compaction to have the low and high air voids are summarized in Figure H-8 which shows the average air void content of the field cores from the low and high voids test sections in the field. The average TSR values are shown in Figure H-9 for the low and high voids test sections.

Texas Boiling Test Results

The Texas boiling test results are presented on Table H-19 and plotted in Figure H-10 for the laboratory mixture, the plant mixture, and the field core.

APPENDIX H SUMMARY OF DATA FOR DISTRICT 21

TABLE H-1 AGGREGATE GRADATION (DISTRICT 21)

SIEVE SIZE	COARSE AGGREGATE SIEVE ANALYSIS	35%	UNCRUSHED AGGREGATE SIEVE ANALYSIS	20%	SCREENINGS SIEVE ANALYSIS	25%	FIELD SAND SIEVE ANALYSIS	20%	COMBINED GRADATION	SDHPT SPECIFICATIONS
Plus 1/2 in.	0	0							0	0
1/2 to 3/8 in.	14.5	5.0	0	0	0	0			5.0	0-15
3/8 to No. 4	66.6	23.3	37.0	7.4	3.0	0.8			31.5	21-53
No. 4 to No. 10	15.7	5.5	61.2	12.3	32.2	8.0			25.7	11-32
Plus No. 10									62.2	54-74
No. 10 to No. 40	1.6	0.6	1.2	0.2	41.6	10.4	0	0	11.3	6-32
No. 40 to No. 80	0.0	0.0	0.0	0.0	15.0	3.8	74.0	14.8	18.5	4-27
No. 80 to No.200	0.0	0.0	0.0	0.0	6.4	1.6	24.9	5.0	6.6	3-27
Minus No. 200	1.6	0.6	0.6	0.1	1.8	0.5	1.1	0.2	1.4	1-8
TOTAL	100.0	35.0	100.0	20.0	100.0	25.0	100.0	20.0	100.0	

TABLE H-2 TEST RESULTS FOR LABORATORY MIXTURES (D-21)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.4	139.1	86	
	A2	DRY	7.0	139.7	89	
	A3	DRY	7.9	138.3	73	
		DRY AVG	7.4	139.0	83	
	A4	WET	7.3	139.2	17	
	A5	WET	7.0	139.7	23	
	A6	WET	7.8	138.4	20	
		WET AVG	7.4	139.1	20	0.24
B	B1	DRY	7.1	139.4	98	
	B2	DRY	7.4	139.1	89	
	B3	DRY	7.5	138.9	91	
		DRY AVG**	7.3	139.1	93	
	B4	WET	7.4	139.0	26	
	B5	WET	7.8	138.5	31	
	B6	WET	7.1	139.4	22	
		WET AVG	7.4	139.0	26	0.28
C	C1	WET	7.7	138.6	21	
	C2	WET	6.7	140.0	23	
	C3	WET	7.4	139.0	17	
		WET AVG	7.3	139.2	20	
		DRY AVG**	7.3	139.1	93	0.22
D	D1	WET	6.8	139.9	33	
	D2	WET	7.8	138.4	19	
	D3	WET	7.3	139.2	22	
		WET AVG	7.3	139.1	25	
		DRY AVG**	7.3	139.1	93	0.27

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE H-2 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.5	138.8	34	
	E2	1 CYCLE	7.9	138.2	31	
		WET AVG	7.7	138.5	33	
		DRY AVG**	7.3	139.1	93	0.35
	E3	3 CYCLES	7.8	138.4	15	
	E4	3 CYCLES	7.0	139.6	17	
		WET AVG	7.4	139.0	16	
		DRY AVG**	7.3	139.1	93	0.17
E	E5	5 CYCLES	7.7	138.5	21	
	E6	5 CYCLES	7.7	138.6	19	
		WET AVG	7.7	138.6	20	
		DRY AVG**	7.3	139.1	93	0.22
	E7	7 CYCLES	7.1	139.5	17	
	E8	7 CYCLES	7.8	138.4	17	
		WET AVG	7.5	138.9	17	
		DRY AVG**	7.3	139.1	93	0.18
	E9	9 CYCLES	7.7	138.6	10	
	E10	9 CYCLES	7.7	138.5	14	
		WET AVG	7.7	138.6	12	
		DRY AVG**	7.3	139.1	93	0.13

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-3 TEST RESULTS FOR LABORATORY MIXTURES (D-21)
ADDITIVE: LIME SLURRY (1.5% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.7	139.5	78	
	A2	DRY	6.9	139.2	72	
	A3	DRY	6.7	139.5	79	
		DRY AVG	6.7	139.4	76	
	A4	WET	6.8	139.3	89	
	A5	WET	7.7	138.0	74	
	A6	WET	7.3	138.5	75	
		WET AVG	7.3	138.6	79	1.04
B	B1	DRY	7.5	138.2	77	
	B2	DRY	7.8	137.8	71	
	B3	DRY	7.5	138.2	70	
		DRY AVG**	7.6	138.1	73	
	B4	WET	7.4	138.4	82	
	B5	WET	7.9	137.6	76	
	B6	WET	7.7	138.0	74	
		WET AVG	7.7	138.0	77	1.06
C	C1	WET	7.7	137.9	74	
	C2	WET	7.1	138.8	81	
	C3	WET	8.0	137.5	72	
		WET AVG	7.6	138.1	76	
		DRY AVG**	7.6	138.1	73	1.04
D	D1	WET	7.4	138.4	86	
	D2	WET	8.0	137.4	72	
	D3	WET	7.8	137.9	75	
		WET AVG	7.7	137.9	78	
		DRY AVG**	7.6	138.1	73	1.07

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE H-3 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.8	137.8	86	
	E2	1 CYCLE	7.5	138.2	87	
		WET AVG	7.7	138.0	87	
		DRY AVG**	7.6	138.1	73	1.19
	E3	3 CYCLES	7.9	137.6	74	
	E4	3 CYCLES	8.0	137.5	76	
		WET AVG	8.0	137.6	75	
		DRY AVG**	7.6	138.1	73	1.03
E	E5	5 CYCLES	7.6	138.0	70	
	E6	5 CYCLES	7.2	138.7	76	
		WET AVG	7.4	138.4	73	
		DRY AVG**	7.6	138.1	73	1.00
	E7	7 CYCLES	7.8	137.8	56	
	E8	7 CYCLES	7.5	138.2	58	
		WET AVG	7.6	138.0	57	
		DRY AVG**	7.6	138.1	73	0.79
	E9	9 CYCLES	7.9	137.7	51	
	E10	9 CYCLES	7.1	138.9	62	
		WET AVG	7.5	138.3	57	
		DRY AVG**	7.6	138.1	73	0.78

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-4 TEST RESULTS FOR LABORATORY MIXTURES (D-21)
ADDITIVE: ARR-MAZ (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.0	139.8	78	
	A2	DRY	7.0	139.8	79	
	A3	DRY	7.0	139.8	83	
		DRY AVG	7.0	139.8	80	
	A4	WET	7.3	139.3	34	
	A5	WET	6.3	140.8	50	
	A6	WET	6.9	139.9	41	
		WET AVG	6.9	140.0	42	
						0.52
B	B1	DRY	7.1	139.6	79	
	B2	DRY	6.7	140.2	78	
	B3	DRY	6.6	140.4	83	
		DRY AVG**	6.8	140.0	80	
	B4	WET	7.0	139.8	36	
	B5	WET	7.3	139.4	39	
	B6	WET	7.2	139.5	40	
		WET AVG	7.2	139.6	38	
						0.48
C	C1	WET	7.2	139.5	34	
	C2	WET	7.4	139.2	30	
	C3	WET	7.5	139.0	30	
		WET AVG	7.4	139.2	31	
		DRY AVG**	6.8	140.0	80	
						0.39
D	D1	WET	7.1	139.6	43	
	D2	WET	7.1	139.6	42	
	D3	WET	7.0	139.8	47	
		WET AVG	7.1	139.7	44	
		DRY AVG**	6.8	140.0	80	
						0.55

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE H-4 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.4	139.2	48	
	E2	1 CYCLE	6.6	140.4	53	
		WET AVG	7.0	139.8	50	
		DRY AVG**	6.8	140.0	80	
						0.63
	E3	3 CYCLES	6.5	140.6	42	
	E4	3 CYCLES	6.7	140.3	38	
		WET AVG	6.6	140.4	40	
		DRY AVG**	6.8	140.0	80	
						0.50
E	E5	5 CYCLES	7.1	139.7	37	
	E6	5 CYCLES	6.9	139.9	43	
		WET AVG	7.0	139.8	40	
		DRY AVG**	6.8	140.0	80	
						0.50
	E7	7 CYCLES	7.2	139.5	33	
	E8	7 CYCLES	6.8	140.1	35	
		WET AVG	7.0	139.8	34	
		DRY AVG**	6.8	140.0	80	
						0.42
	E9	9 CYCLES	6.7	140.2	39	
	E10	9 CYCLES	7.0	139.8	26	
		WET AVG	6.9	140.0	33	
		DRY AVG**	6.8	140.0	80	
						0.41

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-5 TEST RESULTS FOR LABORATORY MIXTURES (D-21)
ADDITIVE: AQUA-SHIELD II (0.41%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.8	138.8	80	
	A2	DRY	6.7	139.0	83	
	A3	DRY	7.3	138.1	77	
		DRY AVG	6.9	138.7	80	
	A4	WET	6.2	139.7	62	
	A5	WET	7.0	138.6	60	
	A6	WET	7.3	138.0	52	
		WET AVG	6.8	138.8	58	0.73
B	B1	DRY	7.3	138.1	76	
	B2	DRY	7.9	137.2	82	
	B3	DRY	7.6	137.6	74	
		DRY AVG**	7.6	137.7	77	
	B4	WET	6.8	138.8	60	
	B5	WET	7.1	138.3	59	
	B6	WET	7.3	138.0	58	
		WET AVG	7.1	138.4	59	0.76
C	C1	WET	7.4	137.9	42	
	C2	WET	7.5	137.7	38	
	C3	WET	7.2	138.2	45	
		WET AVG	7.4	137.9	42	
		DRY AVG**	7.6	137.7	77	0.54
D	D1	WET	7.4	137.9	54	
	D2	WET	7.1	138.4	54	
	D3	WET	6.7	139.0	64	
		WET AVG	7.1	138.4	57	
		DRY AVG**	7.6	137.7	77	0.74

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE H-5 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.4	138.0	60	
	E2	1 CYCLE	7.4	138.0	52	
		WET AVG	7.4	138.0	56	
		DRY AVG**	7.6	137.7	77	0.73
	E3	3 CYCLES	7.6	137.6	42	
	E4	3 CYCLES	7.3	138.1	52	
		WET AVG	7.5	137.8	47	
		DRY AVG**	7.6	137.7	77	0.61
E	E5	5 CYCLES	7.4	138.0	48	
	E6	5 CYCLES	7.4	137.9	44	
		WET AVG	7.4	138.0	46	
		DRY AVG**	7.6	137.7	77	0.60
	E7	7 CYCLES	7.4	137.9	42	
	E8	7 CYCLES	7.1	138.4	42	
		WET AVG	7.3	138.1	42	
		DRY AVG**	7.6	137.7	77	0.54
	E9	9 CYCLES	7.3	138.0	40	
	E10	9 CYCLES	7.5	137.8	35	
		WET AVG	7.4	137.9	38	
		DRY AVG**	7.6	137.7	77	0.49

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-6 TEST RESULTS FOR LABORATORY MIXTURES (D-21)
ADDITIVE: DOW CHEMICAL (0.5%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.7	139.8	92	
	A2	DRY	7.5	138.6	91	
	A3	DRY	7.1	139.2	82	
		DRY AVG	7.1	139.2	88	
	A4	WET	6.7	139.8	33	
	A5	WET	6.9	139.6	30	
	A6	WET	6.9	139.6	31	
		WET AVG	6.8	139.7	31	0.35
B	B1	DRY	6.8	139.7	99	
	B2	DRY	6.9	139.5	97	
	B3	DRY	7.1	139.2	84	
		DRY AVG**	7.0	139.5	94	
	B4	WET	6.8	139.7	42	
	B5	WET	7.1	139.2	33	
	B6	WET	7.3	139.0	29	
		WET AVG	7.1	139.3	35	0.37
C	C1	WET	7.3	138.9	28	
	C2	WET	6.5	140.2	29	
	C3	WET	6.9	139.5	28	
		WET AVG	6.9	139.5	28	
		DRY AVG**	7.0	139.5	94	0.30
D	D1	WET	7.3	139.0	39	
	D2	WET	7.2	139.1	37	
	D3	WET	7.3	138.9	29	
		WET AVG	7.3	139.0	35	
		DRY AVG**	7.0	139.5	94	0.37

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE H-6 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.0	139.4	47	
	E2	1 CYCLE	7.1	139.3	45	
		WET AVG	7.0	139.4	46	
		DRY AVG**	7.0	139.5	94	
						0.49
	E3	3 CYCLES	7.1	139.2	23	
	E4	3 CYCLES	7.3	139.0	25	
		WET AVG	7.2	139.1	24	
		DRY AVG**	7.0	139.5	94	
						0.26
E						
	E5	5 CYCLES	7.4	138.8	26	
	E6	5 CYCLES	7.1	139.2	25	
		WET AVG	7.2	139.0	25	
		DRY AVG**	7.0	139.5	94	
						0.27
	E7	7 CYCLES	7.3	138.9	21	
	E8	7 CYCLES	7.3	138.9	22	
		WET AVG	7.3	138.9	21	
		DRY AVG**	7.0	139.5	94	
						0.23
	E9	9 CYCLES	7.1	139.3	18	
	E10	9 CYCLES	7.0	139.4	19	
		WET AVG	7.0	139.3	18	
		DRY AVG**	7.0	139.5	94	
						0.19

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-7 TEST RESULTS FOR LABORATORY MIXTURES (D-21)
ADDITIVE: FINA-B (0.41%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	7.4	139.3	91	
	A2	DRY	7.0	140.0	91	
	A3	DRY	7.0	139.9	92	
		DRY AVG	7.1	139.7	91	
	A4	WET	7.2	139.6	38	
	A5	WET	6.8	140.3	42	
	A6	WET	6.5	140.7	42	
		WET AVG	6.8	140.2	41	0.45
B	B1	DRY	7.1	139.7	82	
	B2	DRY	6.9	140.1	84	
	B3	DRY	6.4	140.8	90	
		DRY AVG**	6.8	140.2	85	
	B4	WET	6.8	140.3	77	
	B5	WET	7.4	139.3	69	
	B6	WET	6.7	140.3	80	
		WET AVG	7.0	140.0	75	0.88
C	C1	WET	7.5	139.2	47	
	C2	WET	7.1	139.7	50	
	C3	WET	7.1	139.7	53	
		WET AVG	7.2	139.6	50	
		DRY AVG**	6.8	140.2	85	0.59
D	D1	WET	7.0	140.0	70	
	D2	WET	7.0	140.0	64	
	D3	WET	6.9	140.0	65	
		WET AVG	7.0	140.0	66	
		DRY AVG**	6.8	140.2	85	0.78

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE H-7 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.1	139.7	69	
	E2	1 CYCLE	6.9	140.1	69	
		WET AVG	7.0	139.9	69	
		DRY AVG**	6.8	140.2	85	0.81
	E3	3 CYCLES	6.9	140.0	57	
	E4	3 CYCLES	6.6	140.6	69	
		WET AVG	6.7	140.3	63	
		DRY AVG**	6.8	140.2	85	0.74
E	E5	5 CYCLES	7.2	139.6	55	
	E6	5 CYCLES	7.2	139.7	59	
		WET AVG	7.2	139.7	57	
		DRY AVG**	6.8	140.2	85	0.67
	E7	7 CYCLES	6.9	140.1	55	
	E8	7 CYCLES	6.9	140.0	51	
		WET AVG	6.9	140.1	53	
		DRY AVG**	6.8	140.2	85	0.62
	E9	9 CYCLES	7.3	139.5	47	
	E10	9 CYCLES	7.2	139.6	50	
		WET AVG	7.3	139.5	48	
		DRY AVG**	6.8	140.2	85	0.56

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-8 TEST RESULTS FOR LABORATORY MIXTURES (D-21)
ADDITIVE: PAVEBOND LP (1%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
A	A1	DRY	6.8	139.2	82	
	A2	DRY	7.0	138.7	81	
	A3	DRY	7.1	138.6	82	
		DRY AVG	7.0	138.9	82	
	A4	WET	7.3	138.4	45	
	A5	WET	7.2	138.6	42	
	A6	WET	7.6	137.9	39	
		WET AVG	7.4	138.3	42	0.51
B	B1	DRY	7.0	138.8	88	
	B2	DRY	7.0	138.8	84	
	B3	DRY	7.3	138.4	83	
		DRY AVG**	7.1	138.7	85	
	B4	WET	7.6	137.9	52	
	B5	WET	6.9	138.9	46	
	B6	WET	7.4	138.2	41	
		WET AVG	7.3	138.3	46	0.55
C	C1	WET	7.3	138.4	49	
	C2	WET	6.7	139.2	48	
	C3	WET	7.2	138.6	37	
		WET AVG	7.1	138.7	45	
		DRY AVG**	7.1	138.7	85	0.53
D	D1	WET	7.4	138.3	54	
	D2	WET	7.2	138.6	49	
	D3	WET	7.2	138.6	45	
		WET AVG	7.2	138.5	49	
		DRY AVG**	7.1	138.7	85	0.58

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE H-8 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	7.0	138.8	50	
	E2	1 CYCLE	7.1	138.7	56	
		WET AVG	7.1	138.7	53	
		DRY AVG**	7.1	138.7	85	0.63
	E3	3 CYCLES	7.2	138.5	40	
	E4	3 CYCLES	6.8	139.2	40	
		WET AVG	7.0	138.8	40	
		DRY AVG**	7.1	138.7	85	0.47
E	E5	5 CYCLES	7.0	138.8	48	
	E6	5 CYCLES	6.7	139.3	42	
		WET AVG	6.8	139.1	45	
		DRY AVG**	7.1	138.7	85	0.53
	E7	7 CYCLES	7.1	138.6	38	
	E8	7 CYCLES	6.9	139.0	38	
		WET AVG	7.0	138.8	38	
		DRY AVG**	7.1	138.7	85	0.45
	E9	9 CYCLES	6.7	139.2	41	
	E10	9 CYCLES	6.8	139.1	37	
		WET AVG	6.8	139.1	39	
		DRY AVG**	7.1	138.7	85	0.46

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-9 TEST RESULTS FOR LABORATORY MIXTURES (D-21)
ADDITIVE: PERMA-TAC (1%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	A1	DRY	6.6	140.1	84	
	A2	DRY	6.7	140.0	81	
	A3	DRY	7.0	139.6	89	
		DRY AVG	6.7	139.9	85	
A	A4	WET	6.7	139.9	35	
	A5	WET	6.7	140.0	40	
	A6	WET	6.6	140.2	45	
		WET AVG	6.7	140.0	40	
						0.47
	B1	DRY	6.8	139.9	86	
	B2	DRY	6.8	139.8	91	
	B3	DRY	7.3	139.0	84	
		DRY AVG**	7.0	139.5	87	
B	B4	WET	7.4	139.0	41	
	B5	WET	7.3	139.1	42	
	B6	WET	6.3	140.6	54	
		WET AVG	7.0	139.6	46	
						0.52
	C1	WET	7.4	138.9	29	
	C2	WET	6.9	139.6	38	
	C3	WET	7.0	139.5	34	
		WET AVG	7.1	139.3	34	
C		DRY AVG**	7.0	139.5	87	
						0.39
	D1	WET	6.9	139.7	42	
	D2	WET	6.7	139.9	38	
	D3	WET	6.7	139.9	49	
		WET AVG	6.8	139.8	43	
D		DRY AVG**	7.0	139.5	87	
						0.49

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through E.

TABLE H-9 (continued)

TEST METHOD	SAMPLE NO.*	NO. OF CYCLES	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	E1	1 CYCLE	6.6	140.1	54	
	E2	1 CYCLE	6.8	139.9	57	
		WET AVG	6.7	140.0	56	
		DRY AVG**	7.0	139.5	87	
						0.64
	E3	3 CYCLES	6.1	140.9	38	
	E4	3 CYCLES	6.9	139.7	37	
		WET AVG	6.5	140.3	37	
		DRY AVG**	7.0	139.5	87	
						0.43
E						
	E5	5 CYCLES	6.7	139.9	36	
	E6	5 CYCLES	6.8	139.7	34	
		WET AVG	6.8	139.8	35	
		DRY AVG**	7.0	139.5	87	
						0.40
	E7	7 CYCLES	7.1	139.4	31	
	E8	7 CYCLES	6.8	139.8	29	
		WET AVG	7.0	139.6	30	
		DRY AVG**	7.0	139.5	87	
						0.35
	E9	9 CYCLES	6.9	139.7	30	
	E10	9 CYCLES	6.7	140.0	32	
		WET AVG	6.8	139.8	31	
		DRY AVG**	7.0	139.5	87	
						0.36

***TSR = Tensile Strength Ratio
= Tensile Strength(Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-10 TEST RESULTS FOR PLANT MIXTURES (D-21)
ADDITIVE: CONTROL (NO ADDITIVE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	7.1	137.6	97	
	B2	DRY	7.0	137.8	96	
	B3	DRY	7.0	137.8	102	
		DRY AVG**	7.0	137.8	98	
B						
	B4	WET	6.6	138.4	24	
	B5	WET	7.1	137.5	23	
	B6	WET	6.7	138.1	22	
		WET AVG	6.8	138.0	23	
						0.23
	C1	WET	7.0	137.7	33	
	C2	WET	6.6	138.3	23	
	C3	WET	7.2	137.4	26	
		WET AVG	7.0	137.8	27	
C						
		DRY AVG**	7.0	137.8	98	
						0.28
	D1	WET	6.8	138.0	28	
	D2	WET	6.9	137.8	23	
	D3	WET	6.7	138.2	26	
		WET AVG	6.8	138.0	26	
D						
		DRY AVG**	7.0	137.8	98	
						0.26

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-11 TEST RESULTS FOR PLANT MIXTURES (D-21)
ADDITIVE: LIME SLURRY (1.5% BY WT OF AGGREGATE)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.9	137.9	105	
	B2	DRY	7.8	138.1	112	
	B3	DRY	8.0	137.8	105	
		DRY AVG**	7.9	138.0	107	
	B4	WET	7.9	138.0	18	
	B5	WET	7.9	137.9	18	
	B6	WET	7.8	138.0	18	
		WET AVG	7.9	138.0	18	0.17
C	C1	WET	7.7	138.2	23	
	C2	WET	8.0	137.8	18	
	C3	WET	7.8	138.0	20	
		WET AVG	7.9	138.0	20	
		DRY AVG**	7.9	138.0	107	0.19
D	D1	WET	7.5	138.5	19	
	D2	WET	7.8	138.0	22	
	D3	WET	7.7	138.2	20	
		WET AVG	7.7	138.2	20	
		DRY AVG**	7.9	138.0	107	0.19

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-12 TEST RESULTS FOR PLANT MIXTURES (D-21)
ADDITIVE: ARR-MAZ (1.0%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.6	137.9	95	
	B2	DRY	7.4	138.2	92	
	B3	DRY	7.7	137.9	96	
		DRY AVG**	7.6	138.0	94	
	B4	WET	7.5	138.1	37	
	B5	WET	7.4	138.3	39	
	B6	WET	7.6	138.0	35	
		WET AVG	7.5	138.1	37	0.39
C	C1	WET	7.3	138.5	39	
	C2	WET	7.2	138.6	40	
	C3	WET	7.3	138.4	38	
		WET AVG	7.3	138.5	39	
		DRY AVG**	7.6	138.0	94	0.41
D	D1	WET	7.4	138.2	38	
	D2	WET	7.4	138.2	41	
	D3	WET	7.1	138.7	33	
		WET AVG	7.3	138.4	37	
		DRY AVG**	7.6	138.0	94	0.40

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-13 TEST RESULTS FOR PLANT MIXTURES (D-21)
ADDITIVE: AQUASHIELD II (0.41%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.7	137.3	89	
	B2	DRY	7.5	137.6	85	
	B3	DRY	7.6	137.4	90	
		DRY AVG**	7.6	137.4	88	
	B4	WET	7.6	137.4	42	
	B5	WET	7.7	137.2	41	
	B6	WET	7.6	137.4	42	
		WET AVG	7.6	137.3	42	0.47
C	C1	WET	7.8	137.2	47	
	C2	WET	7.7	137.2	46	
	C3	WET	7.5	137.5	46	
		WET AVG	7.7	137.3	46	
		DRY AVG**	7.6	137.4	88	0.53
D	D1	WET	7.2	137.9	47	
	D2	WET	7.6	137.5	43	
	D3	WET	7.7	137.3	43	
		WET AVG	7.5	137.6	44	
		DRY AVG**	7.6	137.4	88	0.50

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-14 TEST RESULTS FOR PLANT MIXTURES (D-21)
ADDITIVE: DOW CHEMICAL (0.5%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.3	140.3	120	
	B2	DRY	7.1	140.5	124	
	B3	DRY	7.1	140.5	126	
		DRY AVG**	7.2	140.4	123	
	B4	WET	7.2	140.4	40	
	B5	WET	7.2	140.5	34	
	B6	WET	7.2	140.4	36	
		WET AVG	7.2	140.4	37	0.30
C	C1	WET	6.9	140.8	40	
	C2	WET	7.1	140.6	33	
	C3	WET	7.0	140.7	37	
		WET AVG	7.0	140.7	37	
		DRY AVG**	7.2	140.4	123	0.30
D	D1	WET	7.5	140.0	38	
	D2	WET	7.3	140.2	38	
	D3	WET	7.2	140.4	33	
		WET AVG	7.3	140.2	36	
		DRY AVG**	7.2	140.4	123	0.29

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-15 TEST RESULTS FOR PLANT MIXTURES (D-21)
ADDITIVE: FINA-B (0.41%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	6.9	138.0	88	
	B2	DRY	7.1	137.7	91	
	B3	DRY	7.1	137.7	89	
		DRY AVG**	7.0	137.8	89	
	B4	WET	6.9	137.9	53	
	B5	WET	7.1	137.6	51	
	B6	WET	7.2	137.6	45	
		WET AVG	7.1	137.7	50	
						0.56
C	C1	WET	7.2	137.6	59	
	C2	WET	7.2	137.5	59	
	C3	WET	7.1	137.7	57	
		WET AVG	7.2	137.6	58	
		DRY AVG**	7.0	137.8	89	
						0.65
D	D1	WET	6.9	137.9	54	
	D2	WET	7.3	137.4	50	
	D3	WET	6.9	137.9	46	
		WET AVG	7.1	137.7	50	
		DRY AVG**	7.0	137.8	89	
						0.56

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-16 TEST RESULTS FOR PLANT MIXTURES (D-21)
ADDITIVE: PAVEBOND LP (1%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
	B1	DRY	7.1	139.2	110	
	B2	DRY	6.8	139.8	105	
	B3	DRY	7.2	139.2	115	
		DRY AVG**	7.0	139.4	110	
B	B4	WET	7.4	138.9	59	
	B5	WET	7.3	139.0	54	
	B6	WET	7.3	139.1	55	
		WET AVG	7.3	139.0	56	0.51
	C1	WET	7.5	138.7	69	
	C2	WET	7.0	139.4	63	
	C3	WET	7.2	139.2	62	
		WET AVG	7.2	139.1	65	
C		DRY AVG**	7.0	139.4	110	0.59
	D1	WET	7.1	139.2	57	
	D2	WET	7.1	139.4	55	
	D3	WET	7.2	139.2	55	
		WET AVG	7.1	139.3	56	
D		DRY AVG**	7.0	139.4	110	0.51

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-17 TEST RESULTS FOR PLANT MIXTURES (D-21)
ADDITIVE: PERMA-TAC (1%)
ASPHALT CONTENT = 5.2 %

TEST METHOD	SAMPLE NO. *	TEST CONDITION, WET/DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR***
B	B1	DRY	7.3	138.9	106	
	B2	DRY	7.3	138.8	106	
	B3	DRY	7.1	139.2	122	
		DRY AVG**	7.2	139.0	111	
	B4	WET	6.9	139.5	47	
	B5	WET	7.3	138.9	45	
	B6	WET	7.3	138.9	48	
		WET AVG	7.2	139.1	47	0.42
C	C1	WET	7.2	139.0	51	
	C2	WET	7.5	138.6	47	
	C3	WET	7.2	139.0	66	
		WET AVG	7.3	138.9	55	
		DRY AVG**	7.2	139.0	111	0.49
D	D1	WET	7.1	139.2	48	
	D2	WET	7.1	139.1	49	
	D3	WET	7.0	139.4	50	
		WET AVG	7.1	139.3	49	
		DRY AVG**	7.2	139.0	111	0.44

*Letter indicates Test Method.
**B Dry serves as the Dry Condition for Method B through D.
***TSR = Tensile Strength Ratio
= Tensile Strength (Wet Avg)/Tensile Strength (Dry Avg)

TABLE H-18 TEST RESULTS FOR FIELD CORES
DISTRICT 21
ASPHALT CONTENT = 5.2 %

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
NO ADDITIVE (CONTROL)	LOW AIR VOIDS SECTION	1A	DRY	7.8	136.5	64	
		1B	WET	7.8	136.6	34	
							0.53
		2A	WET	8.0	136.3	31	
		2B	DRY	7.9	136.4	63	
							0.50
		3A	DRY	9.5	134.0	48	
		3B	WET	8.8	135.1	31	
							0.65
		(AVG VOIDS)		8.3		(AVG TSR)	0.56
	HIGH AIR VOIDS SECTION	4A	WET	9.5	134.0	23	
		4B	DRY	9.8	133.6	49	
							0.47
		5A	DRY	10.4	132.7	42	
		5B	WET	9.6	133.9	26	
							0.64
		6A	WET	9.5	134.0	19	
		6B	DRY	9.5	134.1	40	
							0.48
		(AVG VOIDS)		9.7		(AVG TSR)	0.53
LIME SLURRY	LOW AIR VOIDS SECTION	7A	DRY	11.0	133.2	35	
		7B	WET	11.2	133.1	22	
							0.62
		8A	WET	10.2	134.4	40	
		8B	DRY	10.7	133.8	39	
							1.02
		9A	DRY	11.3	132.9	43	
		9B	WET	10.9	133.4	28	
							0.66
		(AVG VOIDS)		10.9		(AVG TSR)	0.77
	HIGH AIR VOIDS SECTION	10A	WET	14.0	128.8	38	
		10B	DRY	13.0	130.3	26	
							1.47
		12A	DRY	11.3	132.9	37	
		12B	WET	11.5	132.5	37	
							0.99
		13A	WET	10.6	133.8	50	
		13B	DRY	10.8	133.6	43	
							1.16
		(AVG VOIDS)		11.9		(AVG TSR)	1.21
		14A	DRY	7.7	137.8	51	
		14B	WET	7.3	138.4	40	
							0.79
		15A	WET	8.7	136.4	39	

TABLE H-18 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
	LOW AIR VOIDS SECTION	15B	DRY	8.3	136.9	56	
							0.70
		16A	DRY	8.7	136.3	49	
		16B	WET	8.3	137.0	44	
							0.91
		(AVG VOIDS)		8.2		(AVG TSR)	0.80
ARR-MAZ	HIGH AIR VOIDS SECTION	17A	WET	12.0	131.4	24	
		17B	DRY	12.2	131.1	32	
							0.75
		18A	DRY	11.2	132.6	40	
		18B	WET	10.5	133.6	32	
							0.79
		19A	WET	7.6	138.0	36	
		19B	DRY	7.5	138.2	45	
							0.80
		20A	DRY	9.2	135.5	48	
		20B	WET	9.3	135.4	31	
							0.64
		21A	WET	12.0	131.4	26	
		21B	DRY	12.9	130.1	38	
							0.69
		(AVG VOIDS)		10.4		(AVG TSR)	0.73
	LOW AIR VOIDS SECTION	22A	DRY	6.4	139.2	64	
		22B	WET	6.4	139.2	59	
							0.92
		23A	WET	6.7	138.7	35	
		23B	DRY	6.4	139.2	71	
							0.49
		24A	DRY	7.2	138.0	64	
		24B	WET	7.1	138.1	50	
							0.78
		(AVG VOIDS)		6.7		(AVG TSR)	0.73
AQUA-SHIELD II	HIGH AIR VOIDS SECTION	25A	WET	8.3	136.3	58	
		25B	DRY	8.3	136.3	53	
							1.09
		26A	DRY	7.9	136.9	55	
		26B	WET	7.8	137.0	49	
							0.88
		27A	WET	7.6	137.4	51	
		27B	DRY	7.5	137.6	58	
							0.87
		(AVG VOIDS)		7.9		(AVG TSR)	0.95
		28A	DRY	9.3	137.3	58	
		28B	WET	9.0	137.7	45	
							0.78
		29A	WET	7.8	139.5	40	

TABLE H-18 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
	LOW AIR VOIDS SECTION	29B	DRY	7.9	139.4	67	
							0.59
		30A	DRY	9.4	137.1	52	
		30B	WET	9.3	137.3	25	
							0.48
		(AVG VOIDS)		8.8		(AVG TSR)	0.62
DOW ANTI-STRIP	HIGH AIR VOIDS SECTION	31A	WET	10.5	135.5	28	
		31B	DRY	10.7	135.1	53	
							0.54
		32A	DRY	12.1	133.0	44	
		32B	WET	11.8	133.5	29	
							0.66
		33A	WET	13.8	130.4	15	
		33B	DRY	13.1	131.5	40	
							0.39
		(AVG VOIDS)		12.0		(AVG TSR)	0.53
	LOW AIR VOIDS SECTION	34A	DRY	6.7	138.2	63	
		34B	WET	6.9	138.0	50	
							0.80
		35A	WET	7.7	136.8	36	
		35B	DRY	7.5	137.1	53	
							0.69
		36A	DRY	6.9	137.9	57	
		36B	WET	6.9	137.9	45	
							0.78
		(AVG VOIDS)		7.1		(AVG TSR)	0.76
FINA-B	HIGH AIR VOIDS SECTION	37A	WET	7.2	137.6	48	
		37B	DRY	7.5	137.1	57	
							0.84
		38A	DRY	10.1	133.3	44	
		38B	WET	9.7	133.9	33	
							0.74
		39A	WET	7.5	137.0	48	
		39B	DRY	5.3	140.4	72	
							0.67
		(AVG VOIDS)		7.9		(AVG TSR)	0.75
	LOW AIR VOIDS SECTION	40A	DRY	9.2	136.2	53	
		40B	WET	9.0	136.4	53	
							1.00
		41A	WET	9.7	135.3	27	
		41B	DRY	9.6	135.6	45	
							0.61
		42A	DRY	8.4	137.3	53	
		42B	WET	8.6	137.1	41	
							0.78

TABLE H-18 (Continued)

TYPE OF ADDITIVE	TEST SECTION	SAMPLE NO.	WET OR DRY	AIR VOIDS, %	SAMPLE DENSITY, PCF	TENSILE STRENGTH, PSI	TSR*
		(AVG VOIDS)		9.1		(AVG TSR)	0.80
PAVEBOND LP		43A	WET	12.9	130.5	22	
		43B	DRY	13.6	129.6	46	
	HIGH						0.48
	AIR	44A	DRY	12.3	131.4	34	
	VOIDS	44B	WET	13.1	130.4	25	
	SECTION						0.74
		45A	WET	9.8	135.3	38	
		45B	DRY	9.9	135.1	40	
							0.97
		(AVG VOIDS)		11.9		(AVG TSR)	0.73
		46A	DRY	8.9	136.4	53	
		46B	WET	9.0	136.4	51	
	LOW						0.97
	AIR	47A	WET	9.6	135.5	47	
	VOIDS	47B	DRY	9.5	135.6	47	
	SECTION						1.00
		48A	DRY	8.3	137.4	47	
		48B	WET	7.9	138.0	47	
							1.01
		(AVG VOIDS)		8.9		(AVG TSR)	0.99
PERMA-TAC		49A	WET	11.7	132.3	25	
		49B	DRY	12.3	131.4	32	
	HIGH						0.78
	AIR	50A	DRY	13.3	129.9	39	
	VOIDS	50B	WET	12.8	130.6	21	
	SECTION						0.54
		51A	WET	12.2	131.5	26	
		51B	DRY	12.7	130.8	36	
							0.72
		(AVG VOIDS)		12.5		(AVG TSR)	0.68

*TSR = Tensile Strength Ratio
= Tensile Strength (Wet)/Tensile Strength (Dry)

TABLE H-19 BOILING TEST RESULTS
DISTRICT 21

TYPE OF MIXTURE	TYPE OF ADDITIVE	ASPHALT RETAINED AFTER BOILING, % RATING 1	RATING 2	AVG
LABORATORY	NO ADDITIVE	30	45	37.5
	LIME	77	85	81.0
	ARR-MAZ	60	50	55.0
	AQUASHIELD II	80	75	77.5
	DOW	60	55	57.5
	FINA-B	85	75	80.0
	PAVEBOND LP	60	70	65.0
	PERMA-TAC	50	60	55.0
PLANT	NO ADDITIVE	20	30	25.0
	LIME	35	40	37.5
	ARR-MAZ	55	60	57.5
	AQUASHIELD II	65	70	67.5
	DOW	55	50	52.5
	FINA-B	70	80	75.0
	PAVEBOND LP	65	70	67.5
	PERMA-TAC	62	60	61.0
FIELD CORE	NO ADDITIVE	20	30	25.0
	LIME	50	40	45.0
	ARR-MAZ	50	50	50.0
	AQUASHIELD II	65	70	67.5
	DOW	50	45	47.5
	FINA-B	60	70	65.0
	PAVEBOND LP	65	60	62.5
	PERMA-TAC	60	60	60.0

APPENDIX H LIST OF FIGURES

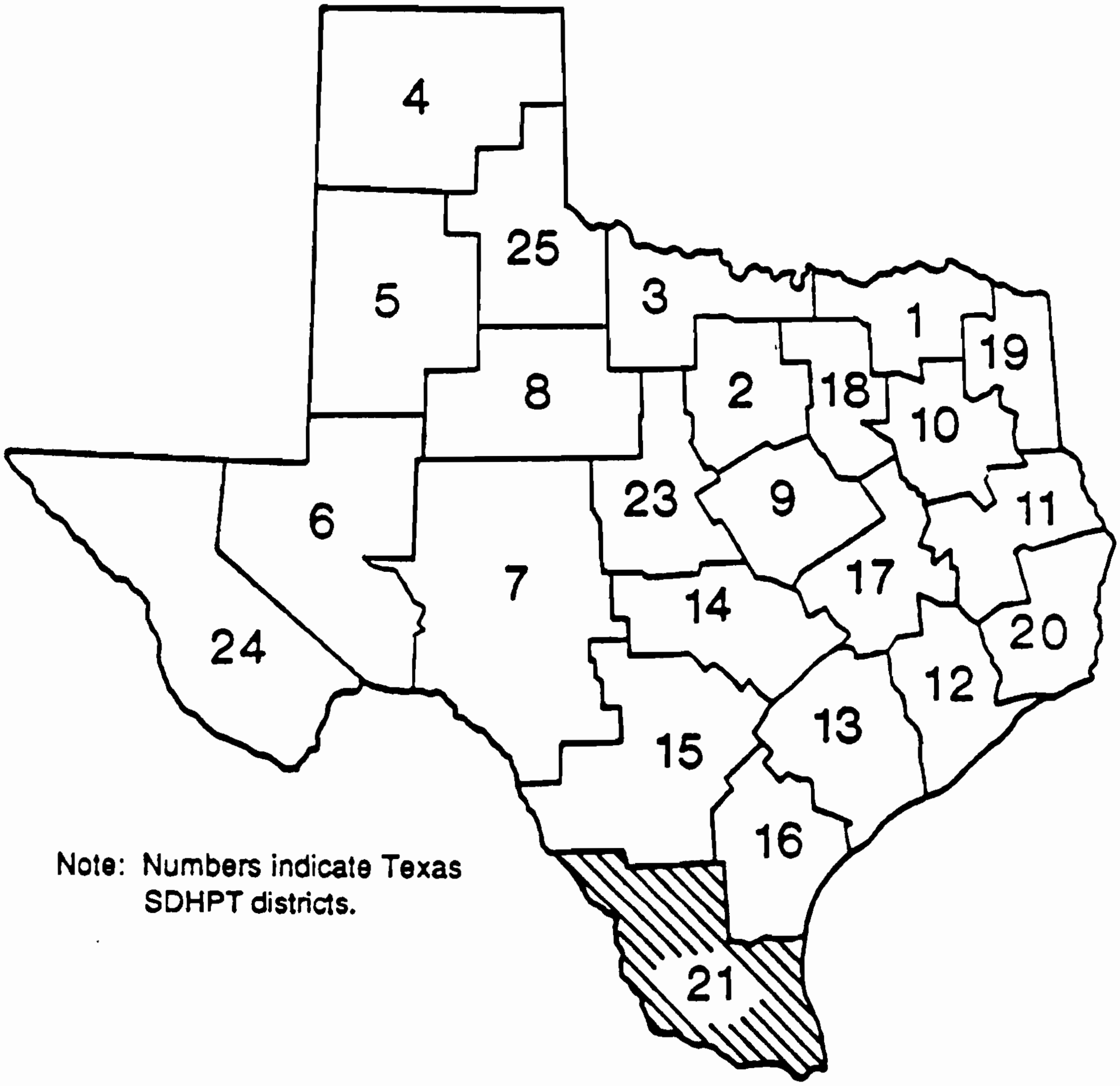
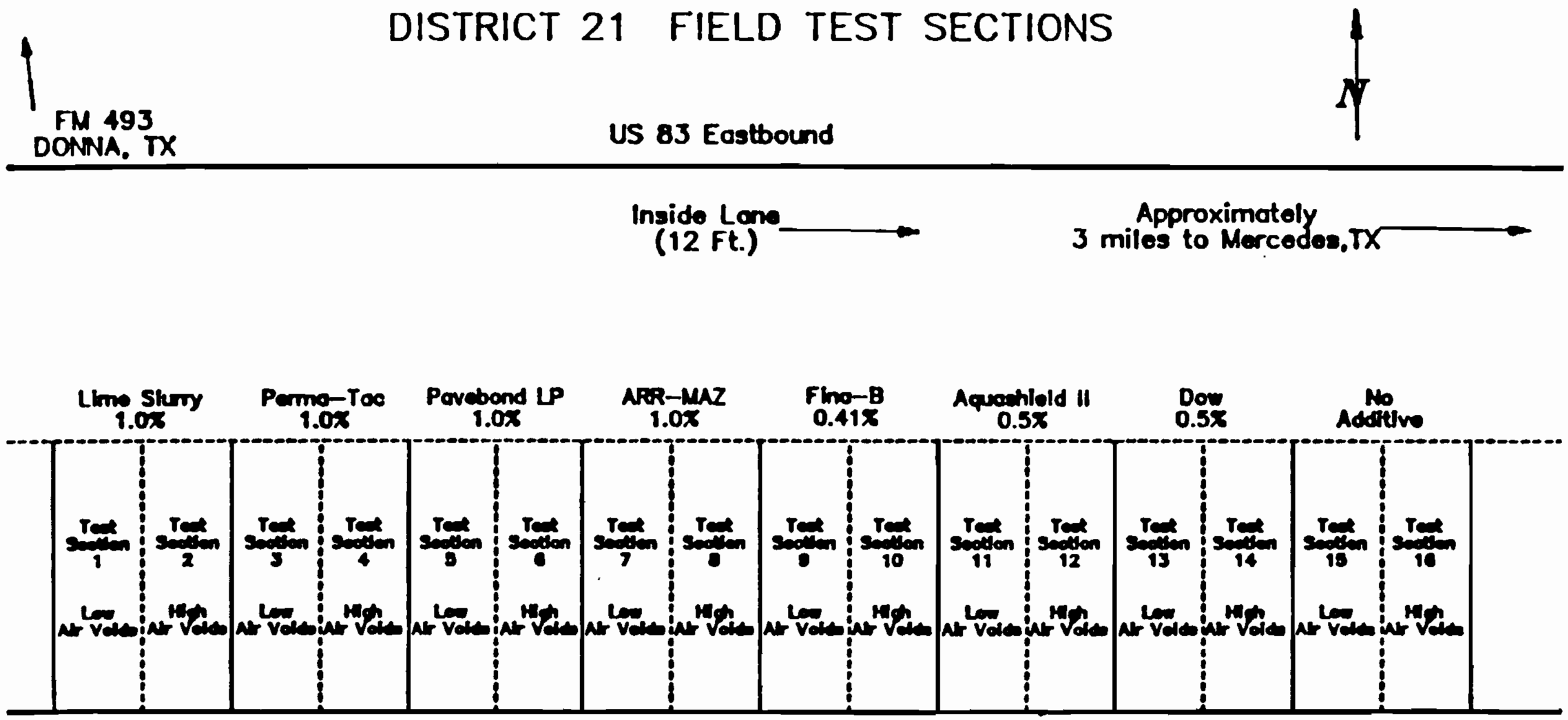


Figure H-1. Location of Field Test Sections (District 21).



Note: Each test section is approximately 1000 feet in length.

Fig H-2 Schematic Illustration of Field Test Sections.

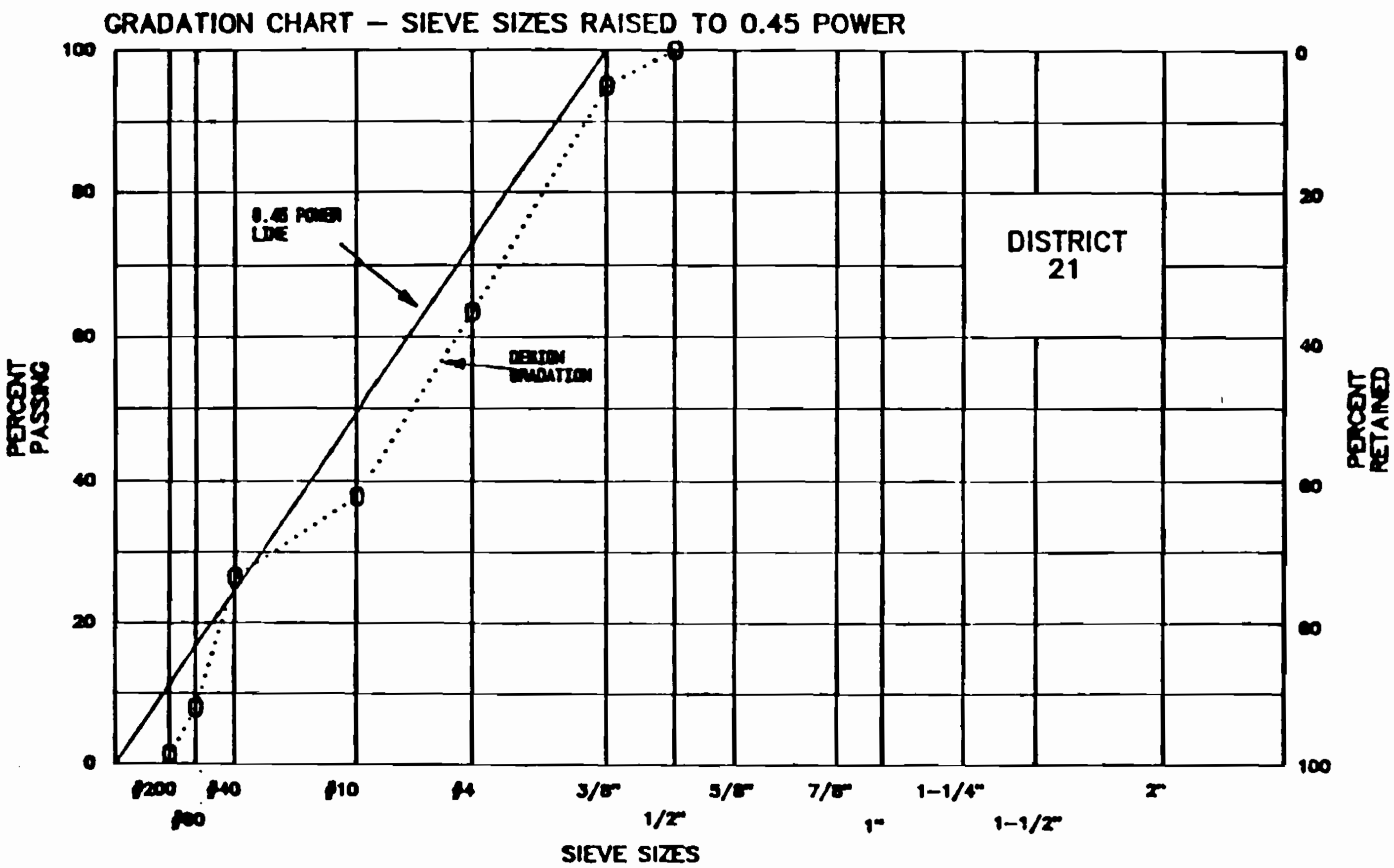


Fig H-3 Aggregate Gradation Chart.

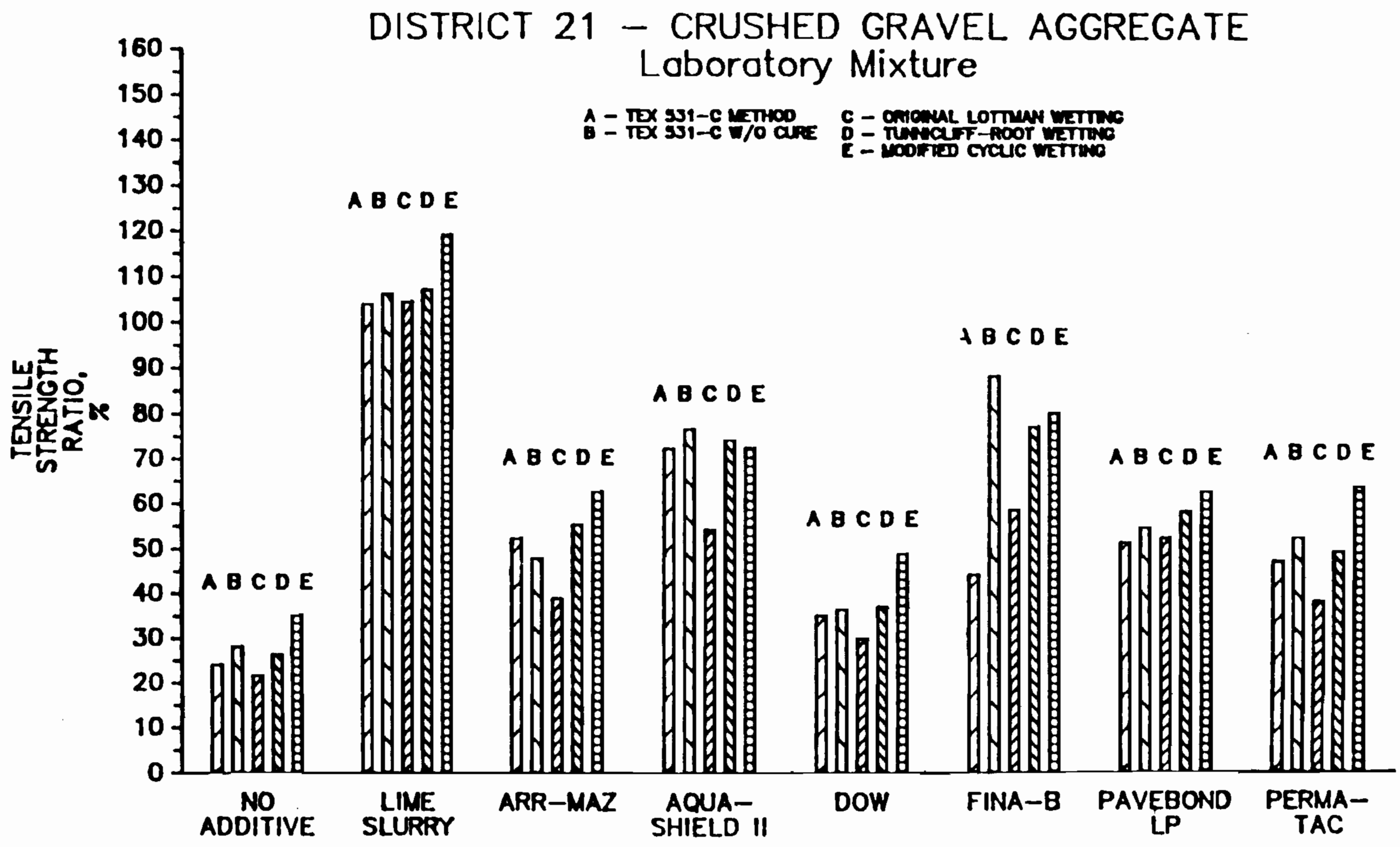


Fig H-4 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Laboratory Mixtures.

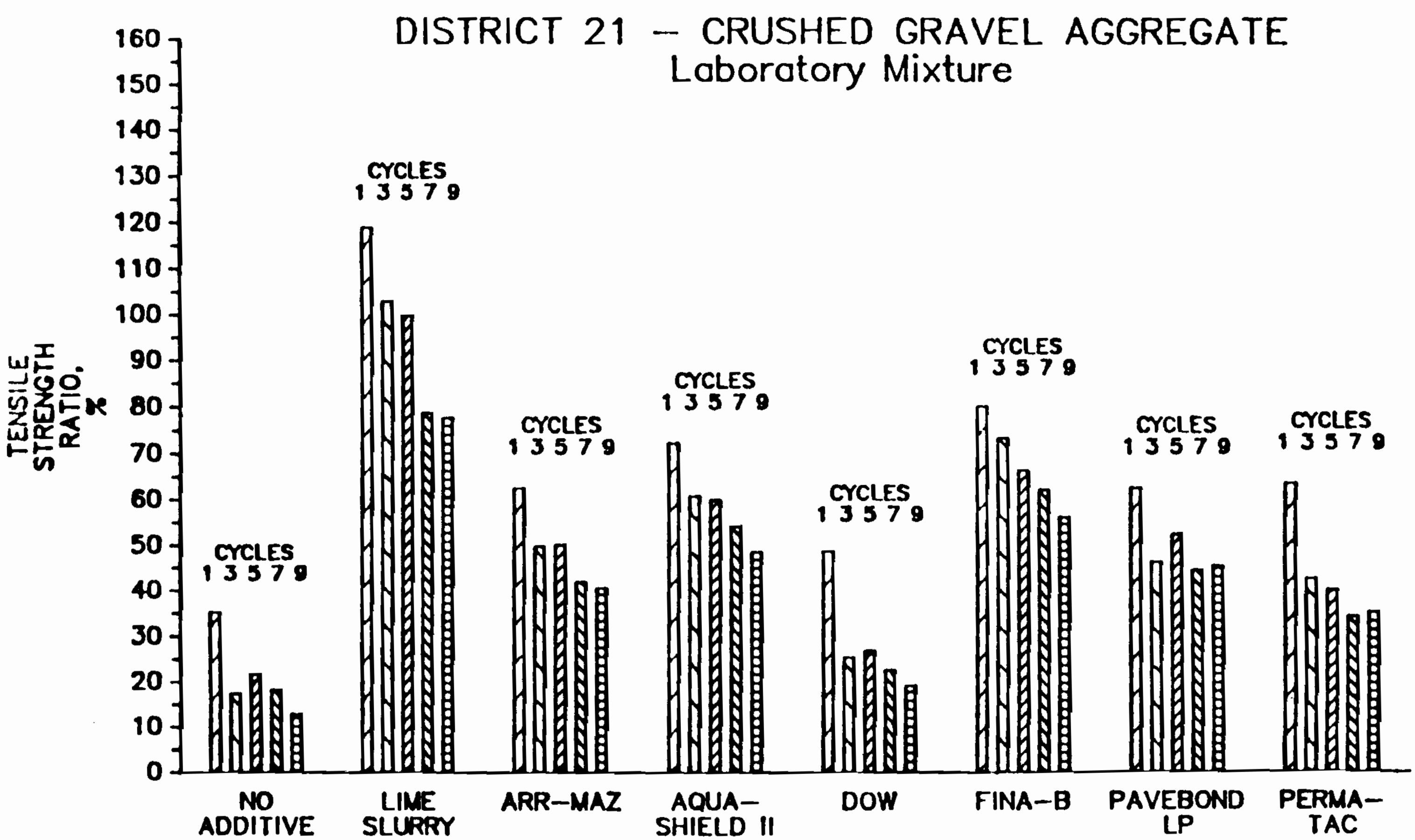


Fig H-5 Wet-Dry Indirect Tensile Cyclic Freeze-Thaw Test Results (Tensile Strength Ratio) for Laboratory Mixtures.

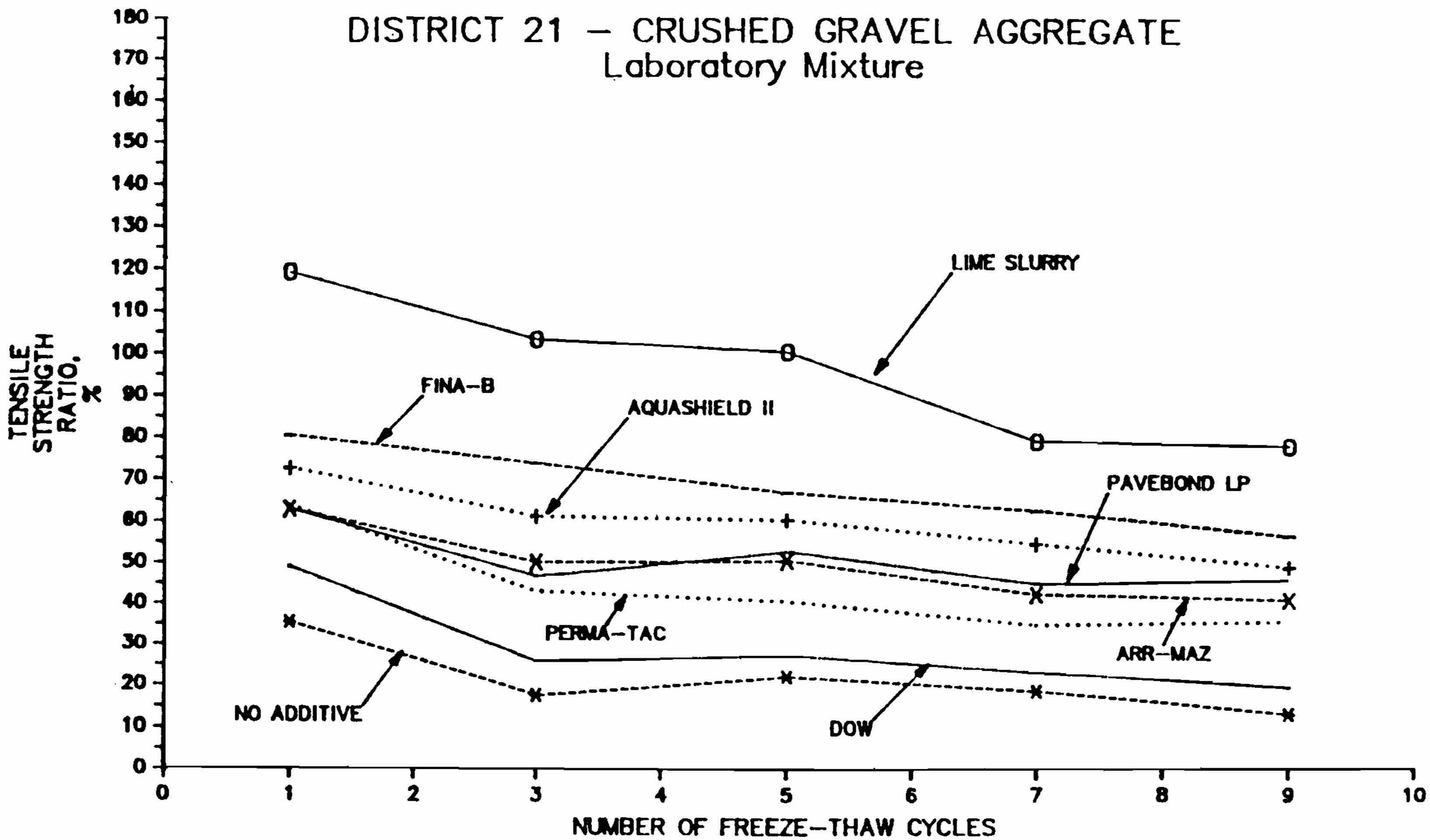


Fig H-6 Tensile Strength Ratio (TSR) Vs. Number of Freeze-Thaw Cycles for Laboratory Mixtures.

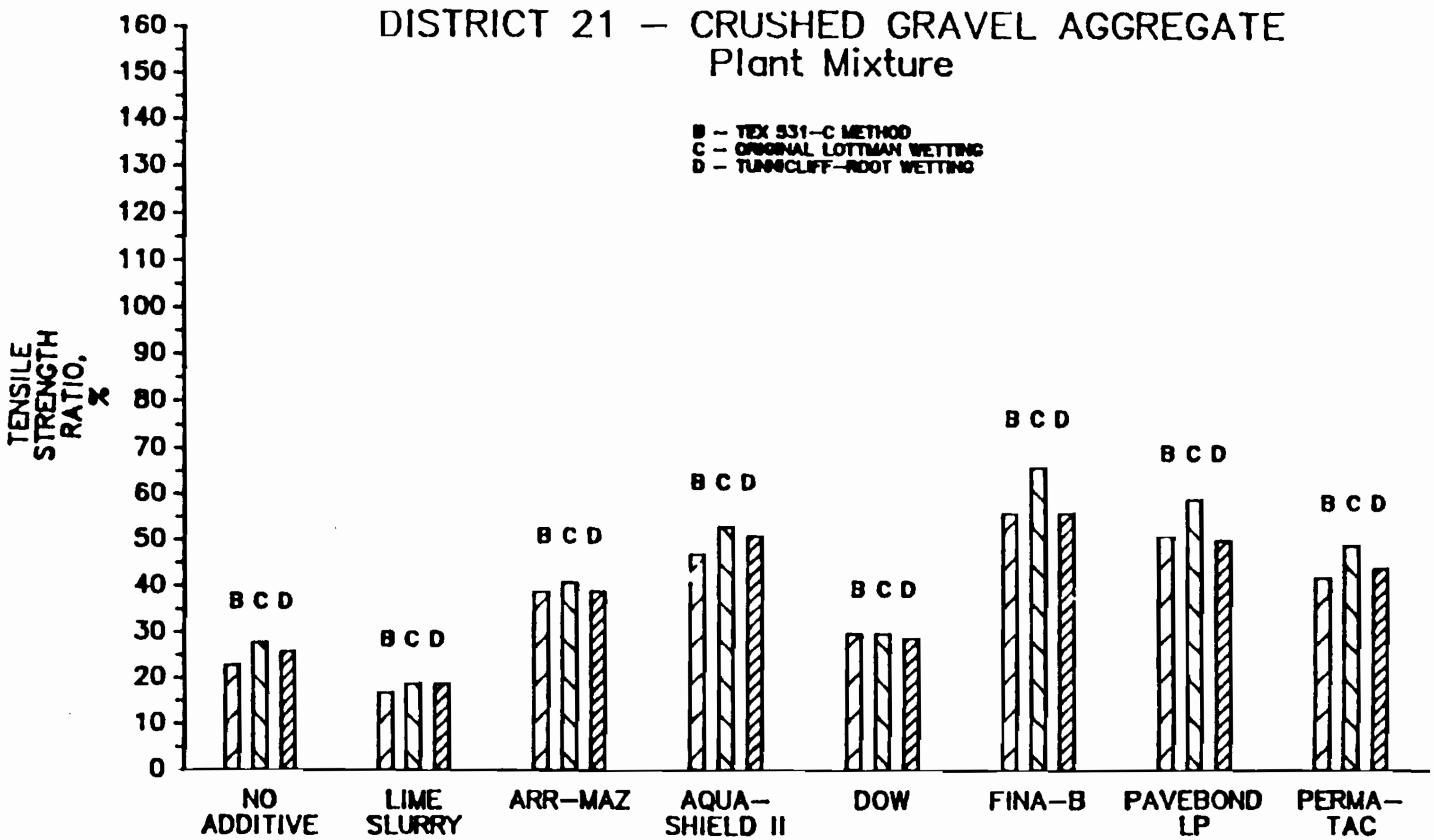


Fig H-7 Wet-Dry Indirect Tensile Test Results
(Tensile Strength Ratio) for Plant Mixtures.

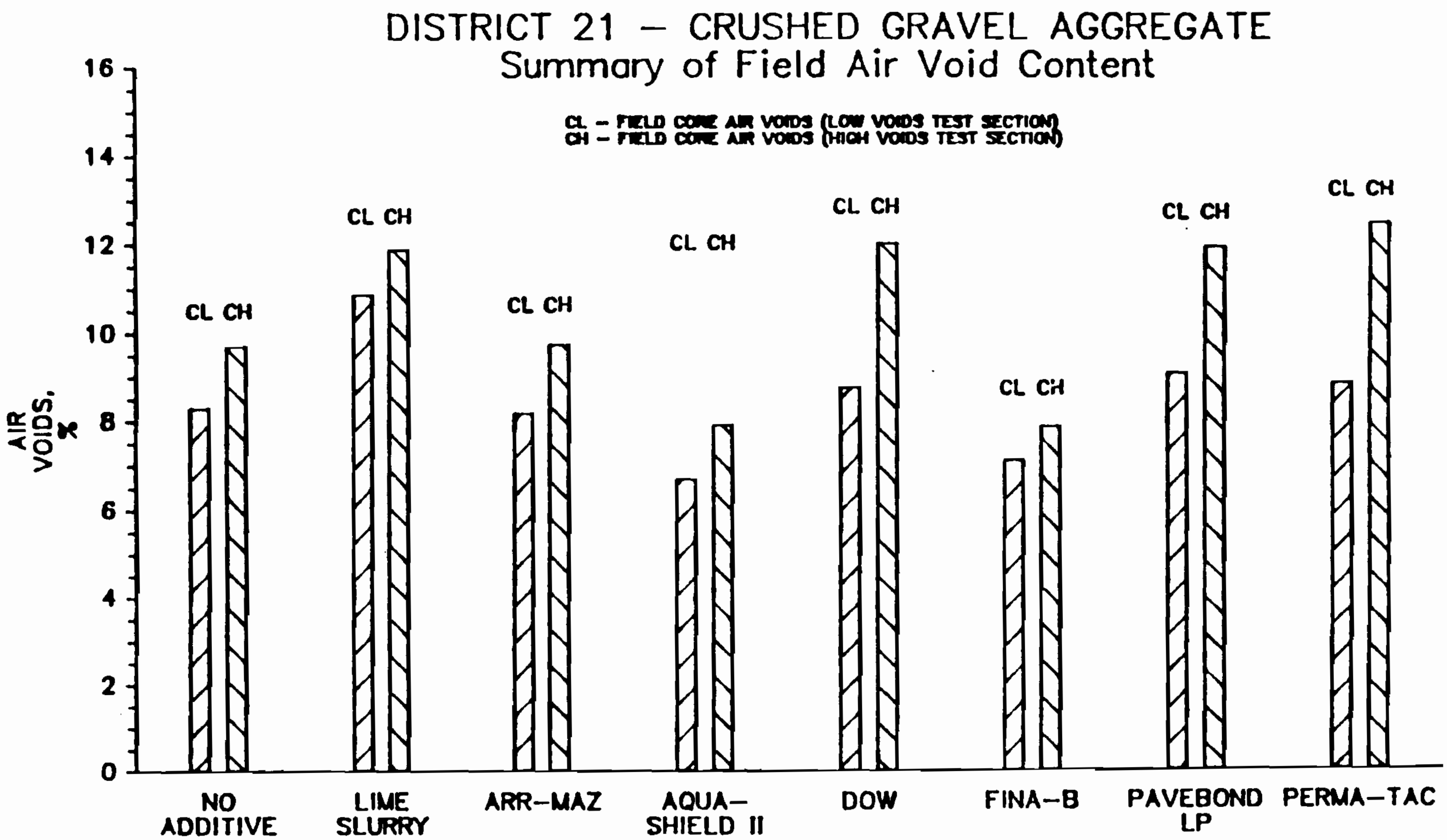


Fig II-8 Summary of Field Core Air Void Content.

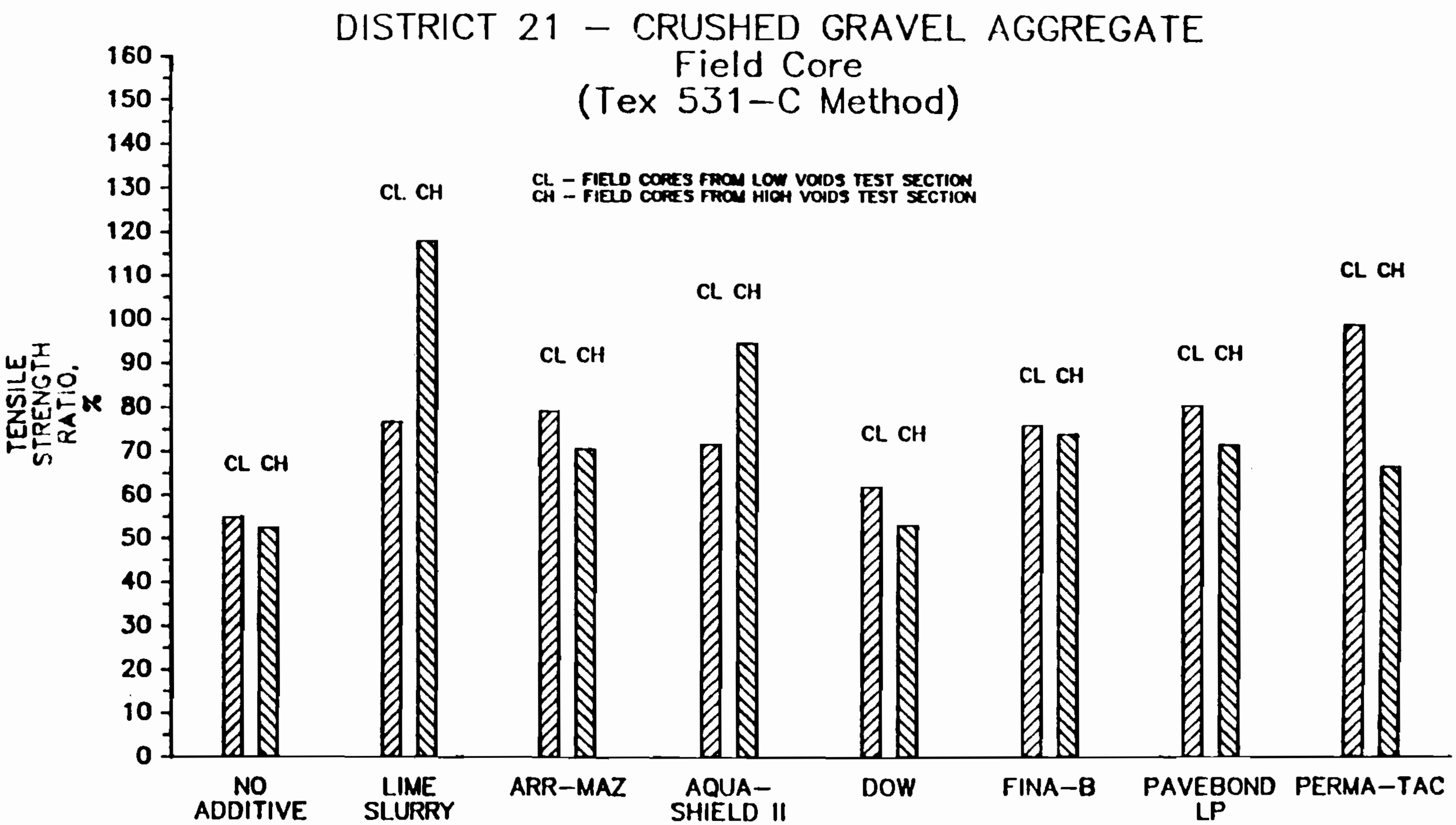


Fig H-9 Wet-Dry Indirect Tensile Test Results (Tensile Strength Ratio) for Field Cores.

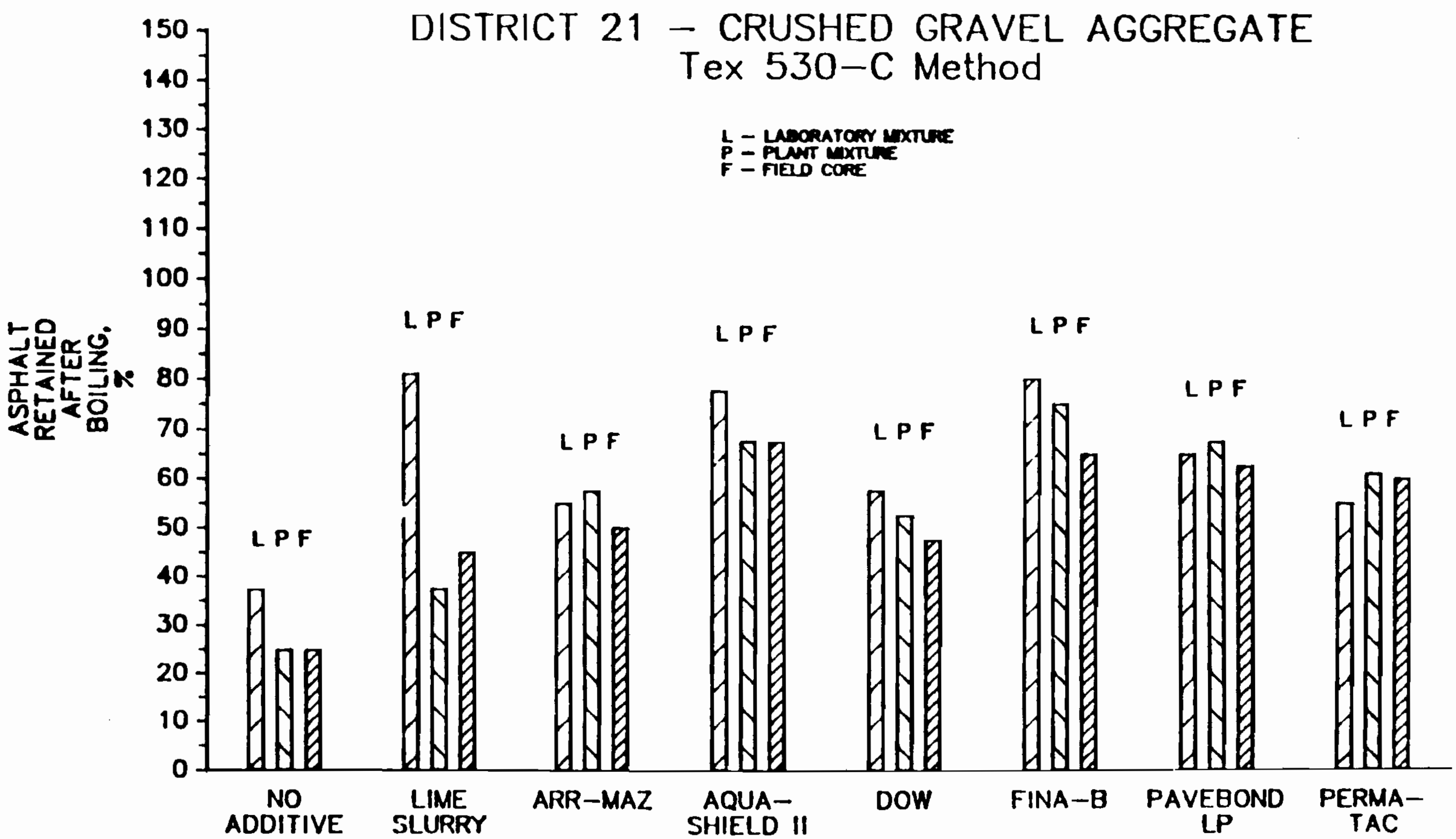


Fig H-10 Texas Boiling Test Results.

APPENDIX I
DETAILED STATISTICAL ANALYSIS

A statistical method was utilized to evaluate the effectiveness of selected liquid additives and hydrated lime. The approach was to use the tensile strength ratios (TSR) and the boiling test results to do the statistical comparisons. The detailed description of the statistical analysis and the comparisons utilized in the evaluation are presented in this appendix.

EVALUATION OF EFFECTIVENESS USING TENSILE STRENGTH RATIOS

The tensile strength ratio (TSR) is defined as:

$$TSR = \frac{\text{Average Wet Tensile Strength}}{\text{Average Dry Tensile Strength}}$$

$$= \frac{\bar{y}}{\bar{x}} = \qquad (I.1)$$

Where, $\bar{y}$ = average wet tensile strength, psi

$= Y_i/n$

$\bar{x}$ = average dry tensile strength, psi

$= X_i/n$

n = sample size

= number of specimens

r = TSR = tensile strength ratio

x, y uncorrelated

Based on this definition, in large samples the estimated standard error (s) of the tensile strength ratio (r) is approximately

$$s(r) = \frac{1}{\bar{x}} \sqrt{\frac{\sum^{n} (Y_i - rX_i)^2}{n(n-1)}} \qquad (I.2)$$

Mathematical Derivation of Equation (I.2)

The tensile strength ratio (r) is to estimate the population mean (ρ) of the ratios $\frac{\mu_y}{\mu_x}$,

Where, μ_y = population mean of the sample y

μ_x = population mean of the sample x

So, $r - \rho = \frac{\bar{y}}{\bar{x}} - \frac{\mu_y}{\mu_x}$

$$= \frac{\mu_y + (\bar{y} - \mu_y)}{\mu_x + (\bar{x} - \mu_x)} - \frac{\mu_y}{\mu_x}$$

$$= \frac{\mu_y - e_{\bar{y}}}{\mu_x - e_{\bar{x}}} - \frac{\mu_y}{\mu_x}$$

$$= \frac{\mu_y + e_{\bar{y}}}{\mu_x \cdot (1 + \frac{e_{\bar{x}}}{\mu_x})} - \frac{\mu_y}{\mu_x}$$

$$= \frac{(\mu_y + e_{\bar{y}})}{\mu_x} (1 + \frac{e_{\bar{x}}}{\mu_x})^{-1} - \frac{\mu_y}{\mu_x}$$

$$= \frac{\mu_y}{\mu_x} (1 + \frac{e_{\bar{y}}}{\mu_y}) (1 - \frac{e_{\bar{x}}}{\mu_x}) - \frac{\mu_y}{\mu_x}$$

$$= \frac{\mu_y}{\mu_x} (1 + \frac{e_{\bar{y}}}{\mu_y} - \frac{e_{\bar{x}}}{\mu_x} + \text{error}) - \frac{\mu_y}{\mu_x}$$

$$\cong \frac{\mu_y}{\mu_x} (\frac{e_{\bar{y}}}{\mu_y} - \frac{e_{\bar{x}}}{\mu_x})$$

$$\therefore \quad r - \rho \cong \frac{1}{\mu_x} (e_{\bar{y}} - \rho e_{\bar{x}}) \qquad \text{(I.3)}$$

Where, $e_{\bar{y}}$ = error term of the estimate $\bar{y}$

$e_{\bar{x}}$ = error term of the estimate $\bar{x}$

Provided, $\frac{e_{\bar{x}}}{\mu_x}$ = small

Standard Error $(r - \rho) \cong \frac{1}{\mu_x}$ - Standard Error $(e_{\bar{y}} - \rho e_{\bar{x}})$

$\cong \frac{1}{\mu_x} \frac{1}{\sqrt{n}}$ Standard Deviation $(e_{\bar{y}} - \rho e_{\bar{x}})$

$$\cong \frac{1}{\mu_x} \frac{1}{\sqrt{n}} \sqrt{\frac{\Sigma \{(y_i - \bar{y}) - \rho (x_i - \bar{x})\}^2}{n - 1}}$$

We estimate ρ by r

μ_x by $\bar{x}$

Therefore, standard Error (r) $= \frac{1}{\bar{x}} \sqrt{\frac{\sum_{i=1}^{n} (y_i - rx_i)^2}{n(n-1)}}$

(I.2)

Other Equations for Estimating Standard Error of TSR Values

Since the wet strength (y) and the dry strength (X) are not correlated, then the estimated standard error (s) can also be derived using the following equation:

$$s(r) = \frac{1}{\bar{x}} \sqrt{\frac{s_y^2 + r^2 s_x^2}{n}} \quad \text{(I.4)}$$

Where, s(r) = standard error of the ratio estimate (r)

s_y^2 = pooled variance of the sample y

s_x^2 = pooled variance of the sample x

n = sample size

or, in the case of different sample sizes,

$$s(r) = \frac{1}{\bar{x}} \sqrt{\frac{s_y^2}{n_y} + r^2 \frac{s_x^2}{n_x}} \qquad (I.5)$$

where, n_y = sample size of y

n_x = sample size of x

It was determined that equation (I.2) did not work well in this study because of small sample size used (n=3) for obtaining Tensile Strength Ratio (TSR). Therefore, the efforts were concentrated on getting pooled variances in order to estimate the standard error of the tensile strength ratio (r) using equations (I.4) and (I.5).

Pooled Variances for TSR Values

The sample variance is defined as the following (Ref 52):

$$s^2 = \sum_{i=1}^{n} (X_i - \bar{x})^2/(n-1) \qquad (I.6)$$

where, s^2 = sample variance

X_i = sample values of variable x

$\bar{x}$ = sample mean of the n sample values

n = sample size

The pooled variance of two samples with equal size n can be obtained as the following (Ref 52):

$$s^2 = \frac{(s_1^2 + s_2^2)}{2} = \frac{(\Sigma x_1^2 + \Sigma x_2^2)}{2(n-1)} \qquad (I.7)$$

Where, s^2 = pooled sample variance of sample x_1 and sample x_2

s_1^2 = sample variances of x_1

$= \Sigma(x_{1i} - \bar{x}_1)^2/(n-1)$

$= \Sigma x_1^2/(n-1)$

s_2^2 = sample variance of x_2

$= \Sigma(x_{2i} - \bar{x}_2)^2/(n-1)$

$= \Sigma x_2^2/(n-1)$

n = sample size of x_1, x_2

With unequal sample sizes n_1 and n_2, the pooled variance of two samples are then:

$$s^2 = \frac{(\Sigma X_1^2 + \Sigma X_2^2)}{(n_1 + n_2 - 2)} \qquad (I.8)$$

where, $\Sigma X_1^2 = \Sigma(X_{1i} - \bar{x}_1)^2$

$\Sigma X_2^2 = \Sigma(X_{2i} - \bar{x}_2)^2$

n_1 = sample size of X_1

n_2 = sample size of X_2

Following these equations (I.6, I.7, and I.8), the pooled variances for the laboratory and plant mixtures of all eight projects were calculated and summarized in Tables I.1 through I.16. For instance, the pooled variances of tensile strength values for the laboratory mixture of District 17 are summarized on Table I.1. As presented on the table, the sample variance of the three wet (or dry) samples for each test method of each treatment level was calculated first, then a pooled variance was obtained by pooling together the sample variances of four test methods for both wet and dry conditions. Finally, a pooled variance was calculated by pooling together the variances of each additive on both wet and dry conditions for the laboratory mixture of District 17 project. The same procedure was followed to compute the pooled variances for both laboratory and plant mixtures for each of the eight projects.

Standard Error Estimate of TSR Values

The standard error estimate of the TSR values was computed using the pooled variances summarized on Tables I.1 through I.16 and the equations (I.4) and (I.5).

Following this procedure, the standard error estimates were calculated and summarized on Tables I.17 through I.32. For instance, the standard error estimates of TSR values for the laboratory mixture of District 17 project are summarized on Table I.17. Average wet and dry tensile strengths are listed on the table for each test method, and the TSR is obtained by dividing the wet strength by the dry strength. Using the pooled variances listed on the table, the standard error estimate can be calculated for each test method from either equation (I.4) or equation (I.5).

Pairwise Comparison of Student-t Test Using TSR Values

The effectiveness of the various liquid antistripping additives and hydrated lime was estimated in terms of the tensile strength ratio (TSR). The TSR values of two additives were compared using the Student-t test. The Student-t test is expressed as

$$t = \frac{(r_1 - r_2)}{\text{Standard Error of } (r_1 - r_2)} \qquad (I.9)$$

Where, r_1 and r_2 = TSR values of two different additives, and

t = Student-t value with degrees of freedom (d.f.) as for the pooled variance of the additives

The standard error (S.E.) of the difference $(r_1 - r_2)$ can be obtained as the following:

$$S.E.\ (r_1 - r_2) = [S.E.\ (r_1)]^2 + [S.E.\ (r_2)]^2 \qquad (I.10)$$

Where, S.E. $(r_1 - r_2)$ = Standard error of the difference $(r_1 - r_2)$

S.E. (r_1) = Standard error of r_1

S.E. (r_2) = Standard error of r_2

The TSR values of any two additives (or control) were compared using equation (I.9) with the standard error estimate of the difference in TSR between two additives (or control) obtained from equation (I.10). The results are summarized on Tables I.33 through I.48 for each test method of the laboratory and plant mixtures for all eight projects.

To illustrate the procedure, the test results of the laboratory mixture, District 17, are used as an example as summarized on Table I.33. The standard error of the difference (r_1 - r_2) for each possible pair were calculated using equation (I.10) and presented as part (a) of the table for each test method. Then, the pairwise comparisons of Student-t test results were obtained using equation (I.9) and presented on part (b) of the table on a four by four matrix for each test method. Each of the four test methods was analyzed separately, and the detailed standard error estimate and the Student-t values were summarized individually for each test method.

Significance Level for Comparison

The α-level of 5% error rate was adopted to test the statistical significance between the difference of two TSR values. An asterisk (*) was added to a critical value on

Tables I.33 through I.48 to denote the significance at the 5% level.

However, objections to use a single α-level in multiple comparisons have been raised among statisticians. The probability that one of the multiple comparisons exceeds the 5% level is bound to happen. There are several methods available to protect against making erroneous decisions in multiple comparisons; however, only one of the methods which is called Bonferroni's Method (Ref 52) is best suited for the particular case of the tensile strength ratio. The Bonferroni method for multiple comparisons is to reset the α -level to α/N, where N is the number of comparisons, and use Student-t table entries for the significance level of α/N. For example, if we want to achieve the α-level of 5% error rate, we should use the t-value of $t_{0.05/N}$ from the t-table with appropriate degrees of freedom to test the statistical significance for N multiple comparisons instead of using the t-value of $t_{0.05}$ from the t-table.

The Bonferroni method for multiple comparisons was used to test the significance between the difference of two TSR values. The outcomes were also presented on Tables I.33 through I.48 with a plus sign (+) to a critical value to denote the significance using the Bonferroni criteria.

Results of Pairwise Comparisons Using TSR Values

The test results of pairwise comparisons using the TSR values are presented in Figures I.1 through I.16 for the laboratory mixture and the plant mixture of each of the eight projects. The TSR values of the various additives (or control) are drawn in increasing order for each test method as shown in the figures. The significance levels are the 5% error rate and the Bonferroni method for multiple comparisons for each of the test methods. When the TSR values are not significantly different from one another, the additives (or control) are grouped together by a bracket to indicate that there are no significant differences in effectiveness among those additives. From the outcomes shown in Figures I.1 through I.16, the two test criterions may not necessarily achieve the same conclusion in statistical significance. As demonstrated in the figures, the criterion using the Bonferroni method is more stringent than the customary 5 percent level of error rate, i.e., the Bonferroni method will achieve less difference in statistical significance among the additives (or control) than the 5 percent level of error rate. However, the differences between the two test criterions are not very noticeable in evaluating the effectiveness of the various additives (or control). Therefore, the advantage of using the Bonferroni method over the 5 percent error rate is not significant in this study.

EVALUATION OF EFFECTIVENESS USING BOILING TEST RESULTS

The effectiveness of the hydrated lime and the various antistripping additives was also evaluated using the percent of asphalt retained after boiling. The statistical analysis and comparisons were similar to what was done to evaluate the effectiveness using the TSR values. The approach is described below.

Pooled Variance and Standard Error Estimate for Boil Values

The samples variances were obtained for each of the additives using equation (I.6), and then a pooled variance was obtained using equation (I.7) from both the laboratory and plant mixtures using the percent of asphalt retained after boiling for each of the eight projects. The results are summarized in Table I.49. The standard error estimate of the boil values was computed using the obtained pooled variance for each project. The results are also summarized in Table I.49.

Pairwise Comparison of Student-t Test Using Boil Values

The effectiveness of the various additives (or control) was evaluated in terms of the boil values using the Student-t test for the laboratory and the plant mixtures of each test project. The boil values of any two additives (or control) were compared using the same type of technique as for the tensile strength ratios. The α-level of 5% error rate and the Bonferroni method for multiple comparisons were also used to test the statistical significance of the various additives. The results are summarized in Tables I.49 through I.56 for both the laboratory and plant mixtures for each of the eight projects.

Results of Pairwise Comparisons Using Boil Values

The test results of pairwise comparisons using the boil values are shown in Figure I.17 through I.24 for both the laboratory and plant mixtures for each of the eight projects. The boil values of the various additives (or control) are shown in increasing order for each project. Brackets are also used to indicate that the additives (or control) are not statistically significant in effectiveness within the same bracket according to the significance level of the 5 percent error rate or the Bonferroni method for multiple comparisons. The Bonferroni method is more strict than the α-level of 5 percent error rate; nevertheless, the two test criterions are again not very different in evaluating the effectiveness of the various additives (or control).

COMPARISON OF RATES OF DETERIORATION

In order to evaluate the rates of deterioration (slopes) for the multiple freeze-thaw cyclic test results, statistical approach was again utilized to do the comparison. The main purpose of the comparison was to confirm that the rates of deterioration (slopes) were not significantly different from one another under the multiple freeze-thaw cyclic testing condition.

The slopes, the associated intercept TSR values at cycle one, and the standard error estimates for the linear regression analysis are summarized in Table I.57. The results of the pairwise comparisons for the rate of deterioration are summarized on Tables I.58 through I.65 for the eight projects. The significance levels were the 5% error rate and the Bonferroni Method for multiple comparisons. There was essentially no statistical difference among those slopes for the projects with the exception of District 1. For District 1, the slopes of the untreated material and the Dow pellets were significantly different from the ARR-MAZ and Indulin AS-1 at the 5% error rate as presented on Table I.63. However, they were not significantly different from one another using the Bonferroni Method of Comparison for District 1. Therefore, the rates of deterioration for the treated and untreated materials were about the same under the multiple freeze-thaw cyclic testing condition.

TABLE I.1 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR LABORATORY MIXTURE, DISTRICT 17

Additive No.	Additive Name	Test Method	Wet Test Condition		Dry Test Condition		Pooled Variance	
			No. Of Specimen	Variance	No. Of Specimen	Variance	Wet	Dry
0	No Additive	A	3	22	3	44		
		B	3	21	3	3		
		C	3	6	-	-		
		D	3	14	-	-		
							16.1	23.7
1	Lime	A	3	36	2	13		
		B	2	1	3	1		
		C	2	32	-	-		
		D	3	6	-	-		
							19.3	5.8
5	BA 2000	A	3	65	3	12		
		B	2	0	3	1		
		C	2	13	-	-		
		D	2	113	-	-		
							49.6	6.7
12	Perma-Tac	A	3	7	3	5		
		B	3	7	3	1		
		C	3	5	-	-		
		D	3	1	-	-		
							5.2	3.2
		Pooled Variance For Laboratory Mixture:					22.5	9.8

TABLE I.2 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR PLANT MIXTURE, DISTRICT 17

Additive No.	Additive Name	Test Method	Wet Test Condition		Dry Test Condition		Pooled Variance	
			No. of Specimen	Variance	No. of Specimen	Variance	Wet	Dry
0	No Additive	B	3	2	3	10		
		C	3	3	-	-		
		D	3	6	-	-		
							3.9	10.3
1	Lime	B	3	4	3	7		
		C	3	13	-	-		
		D	3	52	-	-		
							23.2	7.0
5	BA 2000	B	3	12	3	4		
		C	3	2	-	-		
		D	3	12	-	-		
							9.0	4.0
12	Perma-Tac	B	3	4	3	16		
		C	3	4	-	-		
		D	3	4	-	-		
							4.1	16.0
		Pooled Variance For Plant Mixture:					10.1	9.3

TABLE I.3 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR LABORATORY MIXTURE, DISTRICT 16

Additive No.	Additive Name	Test Method	Wet Test Condition No. of Specimen	Wet Test Condition Variance	Dry Test Condition No. of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	A	3	49	3	333		
		B	3	233	3	17		
		C	3	32	-	-		
		D	3	16	-	-		
							82.8	175.2
1	Lime	A	3	24	3	0		
		B	3	79	3	30		
		C	3	44	-	-		
		D	3	25	-	-		
							43.3	15.3
3	Aquashield	A	3	112	3	56		
		B	3	1	3	19		
		C	3	9	-	-		
		D	3	3	-	-		
							31.3	37.7
6	Dow	A	3	36	3	281		
		B	3	100	3	121		
		C	3	52	-	-		
		D	3	82	-	-		
							67.8	201.3
10	Pavebond LP	A	3	97	3	57		
		B	3	22	3	116		
		C	3	7	-	-		
		D	3	52	-	-		
							44.6	86.8
	Pooled Variance For Laboratory Mixture:						54.0	103.3

TABLE I.4 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR PLANT MIXTURE, DISTRICT 16

Additive No.	Additive Name	Test Method	Wet Test Condition No. of Specimen	Wet Test Condition Variance	Dry Test Condition No. of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	B	3	37	3	56		
		C	3	56	-	-		
		D	3	44	-	-		
							46.0	56.3
1	Lime	B	3	136	3	16		
		C	3	70	-	-		
		D	3	237	-	-		
							147.9	16.3
3	Aquashield	B	3	97	3	6		
		C	3	10	-	-		
		D	3	12	-	-		
							39.8	6.3
6	Dow	B	3	22	3	89		
		C	3	36	-	-		
		D	3	97	-	-		
							51.9	89.3
10	Pavebond LP	B	3	40	3	8		
		C	3	6	-	-		
		D	3	1	-	-		
							16.0	8.3
		Pooled Variance For Plant Mixture					60.3	35.3

TABLE I.5 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR LABORATORY MIXTURE, DISTRICT 13

Additive No.	Additive Name	Test Method	Wet Test Condition No. Of Specimen	Wet Test Condition Variance	Dry Test Condition No. Of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	A	3	13	3	8		
		B	3	14	3	23		
		C	3	13	-	-		
		D	3	7	-	-		
							11.7	15.7
1	Lime	A	3	142	3	79		
		B	3	17	3	5		
		C	3	9	-	-		
		D	3	23	-	-		
							47.9	41.9
5	BA 2000	A	3	60	3	5		
		B	3	3	3	34		
		C	3	10	-	-		
		D	3	16	-	-		
							22.3	19.7
13	Perma-Tac Plus	A	3	1	3	2		
		B	3	9	3	10		
		C	3	23	-	-		
		D	3	12	-	-		
							11.1	6.1
		Pooled Variance For Laboratory Mixture:					23.2	20.9

TABLE I.6 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR PLANT MIXTURE, DISTRICT 13

Additive No.	Additive Name	Test Method	Wet Test Condition No. of Specimen	Wet Test Condition Variance	Dry Test Condition No. of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	B	3	10	3	2		
		C	3	49	-	-		
		D	3	41	-	-		
							23.7	2.3
1	Lime	B	3	100	2	41		
		C	3	14	-	-		
		D	3	14	-	-		
							43.0	40.5
5	BA 2000	B	3	112	3	0		
		C	3	7	-	-		
		D	3	56	-	-		
							58.6	0.3
13	Perma-Tac Plus	B	3	4	3	6		
		C	3	56	-	-		
		D	3	32	-	-		
							31.0	6.3
		Pooled Variance For Plant Mixture:					41.5	12.4

TABLE I.7 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR LABORATORY MIXTURE, DISTRICT 6

Additive No.	Additive Name	Test Method	Wet Test Condition No. of Specimen	Wet Test Condition Variance	Dry Test Condition No. of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	A	3	9	3	63		
		B	3	66	2	5		
		C	3	1	-	-		
		D	3	82	-	-		
							39.8	39.6
1	Lime	A	3	57	2	5		
		B	3	0	3	184		
		C	3	2	-	-		
		D	3	142	-	-		
							50.5	112.4
10	Pavebond LP	A	3	217	3	17		
		B	3	101	3	17		
		C	3	10	-	-		
		D	3	380	-	-		
							177.3	17.3
12	Perma-Tac	A	3	36	3	4		
		B	3	50	2	61		
		C	3	21	-	-		
		D	3	236	-	-		
							85.9	26.6
14	Unichem	A	3	46	3	76		
		B	3	134	2	128		
		C	3	4	-	-		
		D	3	134	-	-		
							79.8	97.0
		Pooled Variance For Laboratory Mixture:					86.7	58.6

TABLE I.8 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR PLANT MIXTURE, DISTRICT 6

Additive No.	Additive Name	Test Method	Wet Test Condition		Dry Test Condition		Pooled Variance	
			No. of Specimen	Variance	No. of Specimen	Variance	Wet	Dry
0	No Additive	B	3	39	3	14		
		C	3	49	-	-		
		D	3	6	-	-		
							31.4	14.3
1	Lime	B	3	43	3	28		
		C	3	49	-	-		
		D	3	49	-	-		
							47.1	28.0
10	Pavebond LP	B	3	14	3	49		
		C	3	28	-	-		
		D	3	14	-	-		
							18.9	49.0
12	Perma-Tac	B	3	28	3	147		
		C	3	17	-	-		
		D	3	3	-	-		
							16.1	147.0
14	Unichem	B	3	52	3	111		
		C	3	9	-	-		
		D	3	24	-	-		
							28.7	111.0
		Pooled Variance For Plant Mixture:					28.4	69.9

TABLE I.9 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR LABORATORY MIXTURE, DISTRICT 25

Additive No.	Additive Name	Test Method	Wet Test Condition No. of Specimen	Wet Test Condition Variance	Dry Test Condition No. of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	A	3	114	2	13		
		B	3	12	2	85		
		C	3	4	-	-		
		D	3	7	-	-		
							34.5	48.5
1	Lime	A	3	31	3	26		
		B	3	30	3	7		
		C	3	42	-	-		
		D	2	5	-	-		
							29.1	16.7
4	Aquashield II	A	3	64	3	61		
		B	3	20	3	20		
		C	3	49	-	-		
		D	3	9	-	-		
							35.8	40.7
7	Fina-A	A	3	57	3	6		
		B	3	0	2	2		
		C	3	14	-	-		
		D	3	3	-	-		
							18.8	4.6
12	Perma-Tac	A	3	52	3	9		
		B	3	8	3	72		
		C	3	22	-	-		
		D	3	6	-	-		
							22.3	40.7
14	Unichem	A	3	92	3	4		
		B	3	36	3	30		
		C	3	7	-	-		
		D	3	4	-	-		
							34.9	17.3
		Pooled Variance For Laboratory Mixture:					29.2	28.1

TABLE I.10 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR PLANT MIXTURE, DISTRICT 25

Additive No.	Additive Name	Test Method	Wet Test Condition: No. of Specimen	Wet Test Condition: Variance	Dry Test Condition: No. of Specimen	Dry Test Condition: Variance	Pooled Variance: Wet	Pooled Variance: Dry
0	No Additive	B	3	49	3	52		
		C	3	9	-	-		
		D	3	12	-	-		
							23.4	52.3
1	Lime	B	3	19	3	0		
		C	3	7	-	-		
		D	3	6	-	-		
							10.8	0.0
4	Aquashield II	B	3	2	3	21		
		C	3	1	-	-		
		D	3	1	-	-		
							1.4	21.0
7	Fina-A	B	3	42	3	21		
		C	3	6	-	-		
		D	3	13	-	-		
							20.6	21.3
12	Perma-Tac	B	3	27	3	40		
		C	3	4	-	-		
		D	3	6	-	-		
							12.4	40.3
14	Unichem	B	3	13	3	1		
		C	3	7	-	-		
		D	3	33	-	-		
							17.8	1.3
		Pooled Variance For Plant Mixture:					14.4	22.7

TABLE I.11 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR LABORATORY MIXTURE, DISTRICT 1

Additive No.	Additive Name	Test Method	Wet Test Condition: No. of Specimen	Wet Test Condition: Variance	Dry Test Condition: No. of Specimen	Dry Test Condition: Variance	Pooled Variance: Wet	Pooled Variance: Dry
0	No Additive	A	3	61	3	9		
		B	3	91	2	0		
		C	3	6	-	-		
		D	3	134	-	-		
							73.2	5.6
1	Lime	A	3	156	3	42		
		B	3	44	3	75		
		C	3	26	-	-		
		D	3	116	-	-		
							85.8	58.7
2	ARR-MAZ	A	3	156	3	36		
		B	2	18	3	30		
		C	3	27	-	-		
		D	3	236	-	-		
							117.7	33.2
6	Dow	A	3	1	3	81		
		B	3	32	2	1		
		C	3	25	-	-		
		D	3	25	-	-		
							20.9	49.0
7	Fina-A	A	3	16	3	8		
		B	3	74	3	6		
		C	3	26	-	-		
		D	3	22	-	-		
							34.8	7.3
9	Indulin AS-1	A	3	37	3	17		
		B	2	50	3	70		
		C	2	61	-	-		
		D	2	98	-	-		
							58.8	43.8
11	Pavebond Special	A	2	32	2	32		
		B	3	0	3	22		
		C	3	10	-	-		
		D	3	49	-	-		
							21.1	26.2
13	Perma-Tac Plus	A	3	86	3	20		
		B	3	180	3	126		
		C	2	1	-	-		
		D	3	13	-	-		
							76.4	73.3
	Pooled Variance For Laboratory Mixture:						61.2	37.1

TABLE I.12 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR PLANT MIXTURE, DISTRICT 1

Additive No.	Additive Name	Test Method	Wet Test Condition No. of Specimen	Wet Test Condition Variance	Dry Test Condition No. of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	B	3	80	3	50		
		C	3	52	-	-		
		D	3	31	-	-		
							54.6	50.3
1	Lime	B	3	6	3	4		
		C	3	13	-	-		
		D	3	5	-	-		
							8.2	4.3
2	ARR-MAZ	B	3	1	3	12		
		C	3	43	-	-		
		D	3	26	-	-		
							23.4	12.3
6	Dow	B	3	2	3	41		
		C	3	16	-	-		
		D	3	1	-	-		
							6.7	41.3
7	Fina-A	B	3	1	3	7		
		C	3	1	-	-		
		D	3	31	-	-		
							11.1	7.0
9	Indulin AS-1	B	3	39	3	10		
		C	3	2	-	-		
		D	3	14	-	-		
							18.6	10.3
11	Pavebond Special	B	3	4	3	8		
		C	3	1	-	-		
		D	3	7	-	-		
							4.1	8.3
13	Perma-Tac Plus	B	3	86	3	30		
		C	3	21	-	-		
		D	3	37	-	-		
							48.1	30.3
		Pooled Variance For Plant Mixture:					21.9	20.5

TABLE I.13 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR LABORRATORY MIXTURE, DISTRICT 19

Additive No.	Additive Name	Test Method	Wet Test Condition No. of Specimen	Wet Test Condition Variance	Dry Test Condition No. of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	A	3	101	3	37		
		B	3	49	2	0		
		C	3	27	-	-		
		D	3	32	-	-		
							52.4	22.4
1	Lime	A	3	122	3	29		
		B	3	57	2	5		
		C	3	93	-	-		
		D	3	44	-	-		
							79.2	7.4
2	ARR-MAZ	A	3	79	3	43		
		B	3	30	3	6		
		C	3	14	-	-		
		D	3	111	-	-		
							58.7	24.7
4	Aquashield II	A	3	8	3	25		
		B	3	166	3	19		
		C	3	31	-	-		
		D	3	162	-	-		
							92.0	22.0
5	BA 2000	A	3	79	3	49		
		B	3	33	3	9		
		C	3	10	-	-		
		D	3	0	-	-		
							30.8	29.0
12	Perma-Tac	A	3	4	3	12		
		B	3	84	3	12		
		C	3	1	-	-		
		D	3	129	-	-		
							54.6	12.3
		Pooled Variance For Laboratory Mixture:					61.3	19.6

TABLE I.14 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR PLANT MIXTURE, DISTRICT 19

Additive No.	Additive Name	Test Method	Wet Test Condition		Dry Test Condition		Pooled Variance	
			No. of Specimen	Variance	No. of Specimen	Variance	Wet	Dry
0	No Additive	B	3	26	3	14		
		C	3	22	-	-		
		D	3	16	-	-		
							21.7	14.3
1	Lime	B	3	25	3	57		
		C	3	70	-	-		
		D	3	134	-	-		
							82.9	57.3
2	ARR-MAZ	B	2	1	3	9		
		C	3	82	-	-		
		D	3	97	-	-		
							67.4	9.3
4	Aquashield II	B	3	28	3	80		
		C	3	156	-	-		
		D	3	336	-	-		
							173.4	80.3
5	BA 2000	B	3	12	3	136		
		C	3	28	-	-		
		D	3	49	-	-		
							29.8	136.3
12	Perma-Tac	B	3	114	3	14		
		C	3	37	-	-		
		D	3	104	-	-		
							85.2	14.3
		Pooled Variance For Plant Mixture:					76.7	52.0

TABLE I.15 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH FOR LABORATORY MIXTURE, DISTRICT 21

Additive No.	Additive Name	Test Method	Wet Test Condition No. of Specimen	Wet Test Condition Variance	Dry Test Condition No. of Specimen	Dry Test Condition Variance	Pooled Variance Wet	Pooled Variance Dry
0	No Additive	A	3	9	3	72		
		B	3	20	3	22		
		C	3	9	-	-		
		D	3	54	-	-		
							23.3	47.3
1	Lime	A	3	70	3	14		
		B	3	17	3	14		
		C	3	22	-	-		
		D	3	54	-	-		
							41.1	14.3
2	ARR-MAZ	A	3	64	3	7		
		B	3	4	3	7		
		C	3	5	-	-		
		D	3	7	-	-		
							20.3	7.0
4	Aquashield II	A	3	28	3	9		
		B	3	1	3	17		
		C	3	12	-	-		
		D	3	33	-	-		
							18.7	13.2
6	Dow	A	3	2	3	30		
		B	3	44	3	66		
		C	3	0	-	-		
		D	3	28	-	-		
							18.8	48.3
8	Fina-B	A	3	5	3	0		
		B	3	32	3	17		
		C	3	9	-	-		
		D	3	10	-	-		
							14.3	8.8
10	Pavebond LP	A	3	9	3	0		
		B	3	30	3	7		
		C	3	44	-	-		
		D	3	20	-	-		
							26.0	3.7
12	Perma-Tac	A	3	25	3	16		
		B	3	52	3	13		
		C	3	20	-	-		
		D	3	31	-	-		
							32.2	14.7
	Pooled Variance For Laboratory Mixture:						24.3	19.7

TABLE I.16 SUMMARY OF POOLED VARIANCE OF TENSILE STRENGTH VALUES FOR PLANT MIXTURE, DISTRICT 21

Additive No.	Additive Name	Test Method	Wet Test Condition: No. of Specimen	Wet Test Condition: Variance	Dry Test Condition: No. of Specimen	Dry Test Condition: Variance	Pooled Variance: Wet	Pooled Variance: Dry
0	No Additive	B	3	1	3	10		
		C	3	26	-	-		
		D	3	6	-	-		
							11.2	10.3
1	Lime	B	3	0	3	16		
		C	3	6	-	-		
		D	3	2	-	-		
							2.9	16.3
2	ARR-MAZ	B	3	4	3	4		
		C	3	1	-	-		
		D	3	16	-	-		
							7.1	4.3
4	Aquashield II	B	3	0	3	7		
		C	3	0	-	-		
		D	3	5	-	-		
							2.0	7.0
6	Dow	B	3	9	3	9		
		C	3	12	-	-		
		D	3	8	-	-		
							10.0	9.3
8	Fina-B	B	3	17	3	2		
		C	3	1	-	-		
		D	3	16	-	-		
							11.6	2.3
10	Pavebond LP	B	3	7	3	25		
		C	3	14	-	-		
		D	3	1	-	-		
							7.6	25.0
12	Perma-Tac	B	3	2	3	85		
		C	3	100	-	-		
		D	3	1	-	-		
							34.6	85.3
		Pooled Variance For Plant Mixture:					10.9	20.0

TABLE I.17 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR LABORATORY MIXTURE, DISTRICT 17

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength, psi	No. of Specimen	Average Tensile Strength, psi		
0	A	3	39	3	76	0.51	0.038
	B	3	38	3	75	0.51	0.039
	C	3	35	3	75	0.47	0.038
	D	3	39	3	75	0.52	0.039
1	A	3	95	2	81	1.18	0.047
	B	2	94	3	78	1.19	0.051
	C	2	88	3	78	1.12	0.050
	D	3	97	3	78	1.23	0.045
5	A	3	87	3	107	0.82	0.029
	B	2	100	3	104	0.96	0.036
	C	2	92	3	104	0.88	0.036
	D	2	114	3	104	1.09	0.037
12	A	3	58	3	70	0.82	0.044
	B	3	67	3	71	0.94	0.045
	C	3	65	3	71	0.91	0.045
	D	3	69	3	71	0.97	0.046

*Note: Pooled Variance for Wet Test Condition = 22.5
**Note: Pooled Variance for Dry Test Condition = 9.8

TABLE I.18 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR PLANT MIXTURE, DISTRICT 17

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength, psi	No. of Specimen	Average Tensile Strength, psi		
0	B	3	42	3	67	0.64	0.032
	C	3	34	3	67	0.51	0.031
	D	3	41	3	67	0.61	0.032
1	B	3	92	3	78	1.18	0.036
	C	3	79	3	78	1.01	0.033
	D	3	85	3	78	1.09	0.034
5	B	3	102	3	95	1.07	0.028
	C	3	93	3	95	0.98	0.026
	D	3	96	3	95	1.01	0.027
12	B	3	40	3	78	0.51	0.026
	C	3	33	3	78	0.43	0.025
	D	3	39	3	78	0.50	0.026

*Note: Pooled Variance for Wet Test Condition = 10.1
**Note: Pooled Variance for Dry Test Condition = 9.3

TABLE I.19 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR LABORATORY MIXTURE, DISTRICT 16

Additive No.	Test Method	Wet Test Condition* No. of Specimen	Wet Test Condition* Average Tensile Strength, psi	Dry Test Condition** No. of Specimen	Dry Test Condition** Average Tensile Strength, psi	TSR	Standard Error Estimate
	A	3	52	3	118	0.44	0.042
	B	3	57	3	123	0.47	0.041
0	C	3	54	3	123	0.44	0.041
	D	3	65	3	123	0.53	0.043
	A	3	76	3	102	0.74	0.059
	B	3	90	3	108	0.83	0.060
1	C	3	83	3	108	0.77	0.057
	D	3	100	3	108	0.93	0.064
	A	3	65	3	116	0.56	0.046
	B	3	66	3	106	0.62	0.053
3	C	3	64	3	106	0.60	0.052
	D	3	74	3	106	0.70	0.056
	A	3	70	3	132	0.53	0.040
	B	3	80	3	137	0.58	0.040
6	C	3	62	3	137	0.45	0.036
	D	3	93	3	137	0.68	0.042
	A	3	66	3	110	0.60	0.050
	B	3	58	3	105	0.55	0.051
10	C	3	60	3	105	0.57	0.052
	D	3	70	3	105	0.67	0.055

*Note: Pooled Variance for Wet Test Condition = 54.0
**Note: Pooled Variance for Dry Test Condition = 103.3

TABLE I.20 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR PLANT MIXTURE, DISTRICT 16

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength, psi	No. of Specimen	Average Tensile Strength, psi		
	B	3	119	3	151	0.79	0.035
0	C	3	109	3	151	0.72	0.034
	D	3	132	3	151	0.87	0.036
	B	3	129	3	126	1.02	0.045
1	C	3	110	3	126	0.87	0.043
	D	3	128	3	126	1.01	0.045
	B	3	125	3	144	0.87	0.037
	C	3	109	3	144	0.76	0.036
3	D	3	125	3	144	0.87	0.037
	B	3	96	3	128	0.75	0.041
6	C	3	92	3	128	0.72	0.040
	D	3	112	3	128	0.87	0.042
	B	3	101	3	132	0.77	0.039
10	C	3	99	3	132	0.75	0.039
	D	3	120	3	132	0.90	0.041

*Note: Pooled Variance for Wet Test Condition = 60.3
**Note: Pooled Variance for Dry Test Condition = 35.3

TABLE I.21 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR LABORATORY MIXTURE, DISTRICT 13

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength,psi	No. of Specimen	Average Tensile Strength,psi		
	A	3	31	3	72	0.43	0.042
	B	3	48	3	87	0.55	0.036
0	C	3	46	3	87	0.53	0.036
	D	3	62	3	87	0.70	0.033
	A	3	109	3	77	1.42	0.061
	B	3	100	3	79	1.27	0.055
1	C	3	96	3	79	1.22	0.054
	D	3	99	3	79	1.26	0.055
	A	3	69	3	108	0.64	0.030
	B	3	65	3	99	0.66	0.033
5	C	3	78	3	99	0.79	0.035
	D	3	84	3	99	0.85	0.036
	A	3	54	3	88	0.61	0.037
	B	3	55	3	80	0.69	0.042
13	C	3	62	3	80	0.78	0.043
	D	3	70	3	80	0.88	0.045

*Note: Pooled Variance for Wet Test Condition = 23.2
**Note: Pooled Variance for Dry Test Condition = 20.9

TABLE I.22 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR PLANT MIXTURE, DISTRICT 13

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength, psi	No. of Specimen	Average Tensile Strength, psi		
0	B	3	95	3	92	1.03	0.046
	C	3	94	3	92	1.02	0.046
	D	3	90	3	92	0.98	0.046
1	B	3	106	2	104	1.03	0.044
	C	3	106	2	104	1.02	0.044
	D	3	100	2	104	0.97	0.044
5	B	3	137	3	128	1.08	0.034
	C	3	123	3	128	0.96	0.033
	D	3	127	3	128	0.99	0.033
13	B	3	103	3	103	1.00	0.041
	C	3	102	3	103	0.98	0.041
	D	3	99	3	103	0.96	0.041

*Note: Pooled Variance for Wet Test Condition = 41.5
**Note: Pooled Variance for Dry Test Condition = 12.4

TABLE I.23 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR LABORATORY MIXTURE, DISTRICT 6

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength,psi	No. of Specimen	Average Tensile Strength,psi		
0	A	3	31	3	156	0.20	0.035
	B	3	33	2	142	0.23	0.039
	C	3	21	2	142	0.15	0.038
	D	3	46	2	142	0.32	0.040
1	A	3	94	2	121	0.78	0.057
	B	3	73	3	118	0.62	0.051
	C	3	68	3	118	0.58	0.051
	D	3	91	3	118	0.78	0.054
10	A	3	57	3	143	0.40	0.039
	B	3	48	3	136	0.35	0.041
	C	3	36	3	136	0.26	0.040
	D	3	57	3	136	0.42	0.042
12	A	3	58	3	118	0.49	0.049
	B	3	52	2	140	0.37	0.041
	C	3	42	2	140	0.30	0.040
	D	3	59	2	140	0.42	0.041
14	A	3	55	3	148	0.37	0.038
	B	3	59	2	140	0.42	0.042
	C	3	41	2	140	0.30	0.040
	D	3	76	2	140	0.54	0.044

*Note: Pooled Variance for Wet Test Condition = 86.7
**Note: Pooled Variance for Dry Test Condition = 58.6

TABLE I.24 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR PLANT MIXTURE, DISTRICT 6

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength, psi	No. of Specimen	Average Tensile Strength, psi		
0	B	3	61	3	129	0.47	0.030
	C	3	49	3	129	0.38	0.028
	D	3	69	3	129	0.54	0.031
1	B	3	55	3	102	0.54	0.040
	C	3	44	3	102	0.43	0.036
	D	3	67	3	102	0.66	0.043
10	B	3	96	3	116	0.83	0.044
	C	3	76	3	116	0.66	0.038
	D	3	93	3	116	0.80	0.043
12	B	3	93	3	120	0.78	0.040
	C	3	78	3	120	0.65	0.037
	D	3	102	3	120	0.85	0.043
14	B	3	83	3	129	0.64	0.034
	C	3	79	3	129	0.61	0.033
	D	3	101	3	129	0.78	0.038

*Note: Pooled Variance for Wet Test Condition = 28.4
**Note: Pooled Variance for Dry Test Condition = 69.9

TABLE I.25 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR LABORATORY MIXTURE, DISTRICT 25

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength, psi	No. of Specimen	Average Tensile Strength, psi		
0	A	3	56	2	83	0.67	0.049
	B	3	50	2	80	0.62	0.049
	C	3	37	2	80	0.46	0.045
	D	3	51	2	80	0.64	0.050
1	A	3	112	3	86	1.30	0.058
	B	3	97	3	79	1.23	0.062
	C	3	73	3	79	0.93	0.053
	D	2	85	3	79	1.07	0.064
4	A	3	97	3	81	1.19	0.059
	B	3	92	3	75	1.23	0.065
	C	3	61	3	75	0.82	0.054
	D	3	76	3	75	1.01	0.059
7	A	3	87	3	89	0.98	0.049
	B	3	92	2	78	1.18	0.070
	C	3	64	2	78	0.82	0.056
	D	3	73	2	78	0.94	0.060
12	A	3	90	3	87	1.03	0.051
	B	3	84	3	87	0.97	0.050
	C	3	60	3	87	0.70	0.044
	D	3	75	3	87	0.86	0.047
14	A	3	70	3	76	0.92	0.056
	B	3	76	3	75	1.02	0.059
	C	3	54	3	75	0.72	0.051
	D	3	65	3	75	0.87	0.055

*Note: Pooled Variance for Wet Test Condition = 29.2
**Note: Pooled Variance for Dry Test Condition = 28.1

TABLE I.26 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR PLANT MIXTURE, DISTRICT 25

Additive No.	Test Method	Wet Test Condition* No. of Specimen	Wet Test Condition* Average Tensile Strength, psi	Dry Test Condition** No. of Specimen	Dry Test Condition** Average Tensile Strength, psi	TSR	Standard Error Estimate
0	B	3	69	3	114	0.60	0.024
	C	3	50	3	114	0.44	0.022
	D	3	73	3	114	0.64	0.025
1	B	3	93	3	104	0.89	0.032
	C	3	79	3	104	0.76	0.029
	D	3	93	3	104	0.90	0.032
4	B	3	67	3	111	0.60	0.025
	C	3	53	3	111	0.48	0.023
	D	3	70	3	111	0.63	0.025
7	B	3	91	3	107	0.85	0.030
	C	3	85	3	107	0.79	0.029
	D	3	102	3	107	0.96	0.032
12	B	3	74	3	97	0.76	0.031
	C	3	61	3	97	0.63	0.029
	D	3	74	3	97	0.76	0.031
14	B	3	71	3	95	0.75	0.032
	C	3	63	3	95	0.67	0.030
	D	3	74	3	95	0.78	0.032

*Note: Pooled Variance for Wet Test Condition = 14.4
**Note: Pooled Variance for Dry Test Condition = 22.7

TABLE I.27 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR LABORATORY MIXTURE, DISTRICT 1

Additive No.	Test Method	Wet Test Condition* No. of Specimen	Wet Test Condition* Average Tensile Strength, psi	Dry Test Condition** No. of Specimen	Dry Test Condition** Average Tensile Strength, psi	TSR	Standard Error Estimate
0	A	3	66	3	90	0.74	0.058
	B	3	79	2	82	0.96	0.075
	C	3	66	2	82	0.80	0.069
	D	3	83	2	82	1.01	0.076
1	A	3	94	3	89	1.06	0.066
	B	3	104	3	85	1.22	0.073
	C	3	97	3	85	1.14	0.071
	D	3	106	3	85	1.24	0.074
2	A	3	101	3	89	1.14	0.068
	B	2	108	3	86	1.26	0.083
	C	3	98	3	86	1.14	0.071
	D	3	111	3	86	1.29	0.075
6	A	3	58	3	82	0.70	0.063
	B	3	68	2	80	0.85	0.073
	C	3	65	2	80	0.82	0.072
	D	3	76	2	80	0.95	0.077
7	A	3	96	3	88	1.10	0.068
	B	3	106	3	96	1.10	0.062
	C	3	106	3	96	1.10	0.062
	D	3	116	3	96	1.20	0.064
9	A	3	94	3	88	1.07	0.067
	B	2	99	3	87	1.14	0.079
	C	2	102	3	87	1.17	0.080
	D	2	106	3	87	1.22	0.081
11	A	2	104	2	86	1.21	0.088
	B	3	105	3	77	1.37	0.086
	C	3	115	3	77	1.50	0.091
	D	3	109	3	77	1.42	0.088
13	A	3	90	3	78	1.15	0.078
	B	3	94	3	82	1.15	0.074
	C	2	78	3	82	0.94	0.078
	D	3	93	3	82	1.13	0.073

*Note: Pooled Variance for Wet Test Condition = 61.2
**Note: Pooled Variance for Dry Test Condition = 37.1

TABLE I.28 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR PLANT MIXTURE, DISTRICT 1

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength,psi	No. of Specimen	Average Tensile Strength,psi		
0	B	3	97	3	91	1.06	0.042
	C	3	88	3	91	0.97	0.041
	D	3	98	3	91	1.07	0.043
1	B	3	99	3	88	1.12	0.045
	C	3	112	3	88	1.27	0.048
	D	3	99	3	88	1.12	0.045
2	B	3	99	3	90	1.10	0.044
	C	3	110	3	90	1.23	0.047
	D	3	104	3	90	1.16	0.045
6	B	3	83	3	86	0.97	0.043
	C	3	82	3	86	0.95	0.042
	D	3	83	3	86	0.96	0.043
7	B	3	103	3	92	1.12	0.043
	C	3	110	3	92	1.20	0.045
	D	3	106	3	92	1.15	0.044
9	B	3	95	3	86	1.10	0.046
	C	3	106	3	86	1.22	0.049
	D	3	103	3	86	1.19	0.048
11	B	3	94	3	81	1.15	0.050
	C	3	101	3	81	1.24	0.052
	D	3	97	3	81	1.19	0.051
13	B	3	96	3	94	1.02	0.040
	C	3	101	3	94	1.07	0.041
	D	3	106	3	94	1.12	0.042

*Note: Pooled Variance for Wet Test Condition = 21.9
**Note: Pooled Variance for Dry Test Condition = 20.5

TABLE I.29 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR LABORATORY MIXTURE, DISTRICT 19

Additive No.	Test Method	Wet Test Condition* No. of Specimen	Wet Test Condition* Average Tensile Strength, psi	Dry Test Condition** No. of Specimen	Dry Test Condition** Average Tensile Strength, psi	TSR	Standard Error Estimate
	A	3	97	3	87	1.12	0.062
	B	3	91	2	85	1.07	0.066
0	C	3	79	2	85	0.93	0.063
	D	3	83	2	85	0.98	0.064
	A	3	68	3	63	1.07	0.083
	B	3	91	2	60	1.53	0.111
1	C	3	86	2	60	1.45	0.108
	D	3	98	2	60	1.64	0.115
	A	3	92	3	77	1.19	0.071
	B	3	88	3	80	1.09	0.066
2	C	3	80	3	80	0.99	0.065
	D	3	96	3	80	1.20	0.068
	A	3	104	3	83	1.25	0.067
	B	3	104	3	84	1.24	0.066
4	C	3	93	3	84	1.11	0.063
	D	3	114	3	84	1.36	0.068
	A	3	103	3	89	1.16	0.061
	B	3	106	3	99	1.07	0.053
5	C	3	120	3	99	1.22	0.055
	D	3	129	3	99	1.30	0.057
	A	3	70	3	75	0.93	0.068
	B	3	86	3	74	1.17	0.074
12	C	3	76	3	74	1.03	0.071
	D	3	76	3	74	1.03	0.071

*Note: Pooled Variance for Wet Test Condition = 61.3
**Note: Pooled Variance for Dry Test Condition = 19.6

TABLE I.30 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR PLANT MIXTURE, DISTRICT 19

Additive No.	Test Method	Wet Test Condition* No. of Specimen	Wet Test Condition* Average Tensile Strength, psi	Dry Test Condition** No. of Specimen	Dry Test Condition** Average Tensile Strength, psi	TSR	Standard Error Estimate
0	B	3	52	3	72	0.73	0.082
	C	3	54	3	72	0.75	0.083
	D	3	58	3	72	0.80	0.085
1	B	2	97	3	87	1.11	0.089
	C	3	100	3	87	1.16	0.081
	D	3	105	3	87	1.21	0.082
2	B	2	100	3	89	1.12	0.087
	C	3	96	3	89	1.08	0.076
	D	3	96	3	89	1.08	0.076
4	B	3	124	3	107	1.16	0.066
	C	3	132	3	107	1.24	0.068
	D	3	124	3	107	1.17	0.066
5	B	3	98	3	81	1.21	0.089
	C	3	102	3	81	1.26	0.090
	D	3	102	3	81	1.27	0.091
12	B	3	120	3	120	1.01	0.055
	C	3	136	3	120	1.14	0.058
	D	3	138	3	120	1.15	0.058

*Note: Pooled Variance for Wet Test Condition = 76.7
**Note: Pooled Variance for Dry Test Condition = 52.0

TABLE I.31 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR LABORATORY MIXTURE, DISTRICT 21

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength, psi	No. of Specimen	Average Tensile Strength, psi		
0	A	3	20	3	83	0.24	0.035
	B	3	26	3	93	0.28	0.032
	C	3	20	3	93	0.22	0.031
	D	3	25	3	93	0.27	0.032
1	A	3	79	3	76	1.04	0.051
	B	3	77	3	73	1.06	0.054
	C	3	76	3	73	1.04	0.054
	D	3	78	3	73	1.07	0.054
2	A	3	42	3	80	0.52	0.039
	B	3	38	3	80	0.48	0.039
	C	3	31	3	80	0.39	0.038
	D	3	44	3	80	0.55	0.040
4	A	3	58	3	80	0.73	0.042
	B	3	59	3	77	0.76	0.045
	C	3	42	3	77	0.54	0.041
	D	3	57	3	77	0.74	0.044
6	A	3	31	3	88	0.35	0.034
	B	3	35	3	94	0.37	0.032
	C	3	28	3	94	0.30	0.032
	D	3	35	3	94	0.37	0.032
8	A	3	41	3	91	0.45	0.034
	B	3	75	3	85	0.88	0.043
	C	3	50	3	85	0.59	0.038
	D	3	66	3	85	0.78	0.041
10	A	3	42	3	82	0.51	0.038
	B	3	46	3	85	0.55	0.037
	C	3	45	3	85	0.53	0.037
	D	3	49	3	85	0.58	0.038
12	A	3	40	3	85	0.47	0.037
	B	3	46	3	87	0.52	0.036
	C	3	34	3	87	0.39	0.035
	D	3	43	3	87	0.49	0.036

*Note: Pooled Variance for Wet Test Condition = 24.3
**Note: Pooled Variance for Dry Test Condition = 19.7

TABLE I.32 SUMMARY OF STANDARD ERROR ESTIMATE OF TENSILE STRENGTH RATIO (TSR) FOR PLANT MIXTURE, DISTRICT 21

Additive No.	Test Method	Wet Test Condition*		Dry Test Condition**		TSR	Standard Error Estimate
		No. of Specimen	Average Tensile Strength, psi	No. of Specimen	Average Tensile Strength, psi		
0	B	3	23	3	98	0.23	0.020
	C	3	27	3	98	0.28	0.021
	D	3	26	3	98	0.26	0.021
1	B	3	18	3	107	0.17	0.018
	C	3	20	3	107	0.19	0.018
	D	3	20	3	107	0.19	0.018
2	B	3	37	3	94	0.39	0.023
	C	3	39	3	94	0.41	0.023
	D	3	37	3	94	0.40	0.023
4	B	3	42	3	88	0.47	0.026
	C	3	46	3	88	0.53	0.027
	D	3	44	3	88	0.50	0.026
6	B	3	37	3	123	0.30	0.017
	C	3	37	3	123	0.30	0.017
	D	3	36	3	123	0.29	0.017
8	B	3	50	3	89	0.56	0.027
	C	3	58	3	89	0.65	0.028
	D	3	50	3	89	0.56	0.027
10	B	3	56	3	110	0.51	0.021
	C	3	65	3	110	0.59	0.022
	D	3	56	3	110	0.51	0.021
12	B	3	47	3	111	0.42	0.020
	C	3	55	3	111	0.49	0.021
	D	3	49	3	111	0.44	0.020

*Note: Pooled Variance for Wet Test Condition = 10.9
**Note: Pooled Variance for Dry Test Condition = 20.0

TABLE I.33 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 17 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error	0.038	0.050	0.036	0.045
ADD. 0	-	-	-	-
ADD. 1	0.063	-	-	-
ADD. 5	0.052	0.062	-	-
ADD. 12	0.059	0.067	0.058	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
TSR	0.47	1.12	0.88	0.91
ADD. 0	-	-	-	-
ADD. 1	-10.350*+	-	-	-
ADD. 5	-7.833*+	3.895*+	-	-
ADD. 12	-7.470*+	3.121*+	-0.520	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error	0.039	0.045	0.037	0.046
ADD. 0	-	-	-	-
ADD. 1	0.060	-	-	-
ADD. 5	0.054	0.058	-	-
ADD. 12	0.060	0.064	0.059	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
TSR	0.52	1.23	1.09	0.97
ADD. 0	-	-	-	-
ADD. 1	-11.923*+	-	-	-
ADD. 5	-10.602*+	2.403*	-	-
ADD. 12	-7.461*+	4.040*+	2.032	-

Results significant at the 5%(t=2.131, d.f.=15).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.038).

TABLE I.33 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 17 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error		0.038	0.050	0.036	0.045
	ADD. 0	-	-	-	-
	ADD. 1	0.063	-	-	-
	ADD. 5	0.052	0.062	-	-
	ADD. 12	0.059	0.067	0.058	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 5	ADD. 12
TSR		0.47	1.12	0.88	0.91
	ADD. 0	-	-	-	-
	ADD. 1	-10.350*+	-	-	-
	ADD. 5	-7.833*+	3.895*+	-	-
	ADD. 12	-7.470*+	3.121*+	-0.520	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error		0.039	0.045	0.037	0.046
	ADD. 0	-	-	-	-
	ADD. 1	0.060	-	-	-
	ADD. 5	0.054	0.058	-	-
	ADD. 12	0.060	0.064	0.059	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 5	ADD. 12
TSR		0.52	1.23	1.09	0.97
	ADD. 0	-	-	-	-
	ADD. 1	-11.923*+	-	-	-
	ADD. 5	-10.602*+	2.403*	-	-
	ADD. 12	-7.461*+	4.040*+	2.032	-

Results significant at the 5%(t=2.131, d.f.=15).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.038).

TABLE I.34 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 17

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error		0.032	0.036	0.028	0.026
	ADD. 0	-	-	-	-
	ADD. 1	0.048	-	-	-
	ADD. 5	0.043	0.046	-	-
	ADD. 12	0.041	0.044	0.038	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 5	ADD. 12
TSR		0.64	1.18	1.07	0.51
	ADD. 0	-	-	-	-
	ADD. 1	-11.211*+	-	-	-
	ADD. 5	-10.112*+	2.411*	-	-
	ADD. 12	3.152*	15.087*+	14.655*+	-

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error		0.031	0.033	0.026	0.025
	ADD. 0	-	-	-	-
	ADD. 1	0.045	-	-	-
	ADD. 5	0.040	0.042	-	-
	ADD. 12	0.040	0.041	0.036	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 5	ADD. 12
TSR		0.51	1.01	0.98	0.43
	ADD. 0	-	-	-	-
	ADD. 1	-11.043*+	-	-	-
	ADD. 5	-11.616*+	0.714	-	-
	ADD. 12	2.008	14.009*+	15.248*+	-

Results significant at the 5%(t=2.306, d.f.=8).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.482).

TABLE I.34 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 17 (continued)

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error	0.032	0.034	0.027	0.026
ADD. 0	-	-	-	-
ADD. 1	0.047	-	-	-
ADD. 5	0.042	0.043	-	-
ADD. 12	0.041	0.043	0.037	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
TSR	0.61	1.09	1.01	0.5
ADD. 0	-	-	-	-
ADD. 1	-10.280*+	-	-	-
ADD. 5	-9.553*+	1.842	-	-
ADD. 12	2.667*	13.784*+	13.606*+	-

Results significant at the 5%(t=2.306, d.f.=8).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.482).

TABLE I.35 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 16

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error	0.042	0.059	0.046	0.040	0.050
ADD. 0	-	-	-	-	-
ADD. 1	0.072	-	-	-	-
ADD. 3	0.062	0.075	-	-	-
ADD. 6	0.058	0.071	0.061	-	-
ADD. 10	0.065	0.077	0.068	0.064	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
TSR	0.44	0.74	0.56	0.53	0.60
ADD. 0	-	-	-	-	-
ADD. 1	-4.142*+	-	-	-	-
ADD. 3	-1.926	2.405*	-	-	-
ADD. 6	-1.551	2.946*	0.492	-	-
ADD. 10	-2.450*	1.810	-0.588	-1.093	-

Test Method B: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error	0.041	0.060	0.053	0.040	0.051
ADD. 0	-	-	-	-	-
ADD. 1	0.073	-	-	-	-
ADD. 3	0.067	0.080	-	-	-
ADD. 6	0.057	0.072	0.066	-	-
ADD. 10	0.065	0.079	0.074	0.065	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
TSR	0.47	0.83	0.62	0.58	0.55
ADD. 0	-	-	-	-	-
ADD. 1	-4.953*+	-	-	-	-
ADD. 3	-2.239*	2.623*	-	-	-
ADD. 6	-1.920	3.466*+	0.602	-	-
ADD. 10	-1.222	3.556*+	0.951	0.462	-

Results significant at the 5%(t=2.086, d.f.=20).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.153).

TABLE I.35 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 16 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error		0.041	0.057	0.052	0.036	0.052
	ADD. 0	-	-	-	-	-
	ADD. 1	0.070	-	-	-	-
	ADD. 3	0.066	0.077	-	-	-
	ADD. 6	0.055	0.067	0.063	-	-
	ADD. 10	0.066	0.077	0.074	0.063	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
TSR		0.44	0.77	0.60	0.45	0.57
	ADD. 0	-	-	-	-	-
	ADD. 1	-4.699*+	-	-	-	-
	ADD. 3	-2.416*	2.203*	-	-	-
	ADD. 6	-0.183	4.746*+	2.371*	-	-
	ADD. 10	-1.963	2.592*	0.407	-1.897	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error		0.043	0.064	0.056	0.042	0.055
	ADD. 0	-	-	-	-	-
	ADD. 1	0.077	-	-	-	-
	ADD. 3	0.071	0.085	-	-	-
	ADD. 6	0.060	0.077	0.070	-	-
	ADD. 10	0.070	0.084	0.078	0.069	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
TSR		0.53	0.93	0.70	0.68	0.67
	ADD. 0	-	-	-	-	-
	ADD. 1	-5.187*+	-	-	-	-
	ADD. 3	-2.407*	2.704*	-	-	-
	ADD. 6	-2.495*	3.265*+	0.285	-	-
	ADD. 10	-2.005	3.081*+	0.382	0.144	-

Results significant at the 5%(t=2.086, d.f.=20).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.153).

TABLE 1.36 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 16

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error	0.035	0.045	0.037	0.041	0.039
ADD. 0	-	-	-	-	-
ADD. 1	0.057	-	-	-	-
ADD. 3	0.051	0.058	-	-	-
ADD. 6	0.054	0.061	0.055	-	-
ADD. 10	0.052	0.060	0.054	0.057	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
TSR	0.79	1.02	0.87	0.75	0.77
ADD. 0	-	-	-	-	-
ADD. 1	-4.034*+	-	-	-	-
ADD. 3	-1.570	2.574*	-	-	-
ADD. 6	0.742	4.435*+	2.172	-	-
ADD. 10	0.381	4.198*+	1.860	-0.353	-

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error	0.034	0.043	0.036	0.040	0.039
ADD. 0	-	-	-	-	-
ADD. 1	0.055	-	-	-	-
ADD. 3	0.050	0.056	-	-	-
ADD. 6	0.052	0.059	0.054	-	-
ADD. 10	0.052	0.058	0.053	0.056	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
TSR	0.72	0.87	0.76	0.72	0.75
ADD. 0	-	-	-	-	-
ADD. 1	-2.736*	-	-	-	-
ADD. 3	-0.807	1.961	-	-	-
ADD. 6	0.000	2.554*	0.743	-	-
ADD. 10	-0.579	2.067	0.188	-0.537	-

Results significant at the 5%(t=2.228, d.f.=10).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.581).

TABLE I.36 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 16 (continued)

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error	0.036	0.045	0.037	0.042	0.041
ADD. 0	-	-	-	-	-
ADD. 1	0.058	-	-	-	-
ADD. 3	0.052	0.058	-	-	-
ADD. 6	0.055	0.062	0.056	-	-
ADD. 10	0.055	0.061	0.055	0.059	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
TSR	0.87	1.01	0.87	0.87	0.90
ADD. 0	-	-	-	-	-
ADD. 1	-2.429*	-	-	-	-
ADD. 3	0.000	2.403*	-	-	-
ADD. 6	0.000	2.274*	0.000	-	-
ADD. 10	-0.549	1.807	-0.543	-0.511	-

Results significant at the 5%(t=2.228, d.f.=10).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.581).

TABLE I.37 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 13

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	0.042	0.061	0.030	0.037
ADD. 0	-	-	-	-
ADD. 1	0.074	-	-	-
ADD. 5	0.052	0.068	-	-
ADD. 13	0.056	0.071	0.048	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
TSR	0.43	1.42	0.64	0.61
ADD. 0	-	-	-	-
ADD. 1	-13.367*+	-	-	-
ADD. 5	-4.068*+	11.474*+	-	-
ADD. 13	-3.216*+	11.353*+	0.629	-

Test Method B: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	0.036	0.055	0.033	0.042
ADD. 0	-	-	-	-
ADD. 1	0.066	-	-	-
ADD. 5	0.049	0.064	-	-
ADD. 13	0.055	0.069	0.053	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
TSR	0.55	1.27	0.66	0.69
ADD. 0	-	-	-	-
ADD. 1	-10.953*+	-	-	-
ADD. 5	-2.252*	9.510*+	-	-
ADD. 13	-2.530*	8.381*+	-0.561	-

Results significant at the 5%(t=2.120, d.f.=16).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.010).

TABLE I.37 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 13 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	0.036	0.054	0.035	0.043
ADD. 0	-	-	-	-
ADD. 1	0.065	-	-	-
ADD. 5	0.050	0.064	-	-
ADD. 13	0.056	0.069	0.055	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
TSR	0.53	1.22	0.79	0.78
ADD. 0	-	-	-	-
ADD. 1	-10.631*+	-	-	-
ADD. 5	-5.178*+	6.682*+	-	-
ADD. 13	-4.457*+	6.374*+	0.180	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	0.038	0.055	0.036	0.045
ADD. 0	-	-	-	-
ADD. 1	0.067	-	-	-
ADD. 5	0.052	0.066	-	-
ADD. 13	0.059	0.071	0.058	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
TSR	0.7	1.26	0.85	0.88
ADD. 0	-	-	-	-
ADD. 1	-8.376*+	-	-	-
ADD. 5	-2.866*	6.237*+	-	-
ADD. 13	-3.056*+	5.347*+	-0.520	-

Results significant at the 5%(t=2.120, d.f.=16).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.010).

TABLE I.38 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 13

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	0.046	0.044	0.034	0.041
ADD. 0	-	-	-	-
ADD. 1	0.064	-	-	-
ADD. 5	0.057	0.056	-	-
ADD. 13	0.062	0.060	0.053	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
TSR	1.03	1.03	1.08	1
ADD. 0	-	-	-	-
ADD. 1	0.000	-	-	-
ADD. 5	-0.874	-0.899	-	-
ADD. 13	0.486	0.498	1.501	-

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	0.046	0.044	0.033	0.041
ADD. 0	-	-	-	-
ADD. 1	0.064	-	-	-
ADD. 5	0.057	0.055	-	-
ADD. 13	0.062	0.060	0.053	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
TSR	1.02	1.02	0.96	0.98
ADD. 0	-	-	-	-
ADD. 1	0.000	-	-	-
ADD. 5	1.059	1.090	-	-
ADD. 13	0.649	0.665	-0.380	-

Results significant at the 5%(t=2.365, d.f.=7).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.639).

TABLE I.38 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 13 (continued)

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	0.046	0.043	0.033	0.041
ADD. 0	-	-	-	-
ADD. 1	0.063	-	-	-
ADD. 5	0.057	0.054	-	-
ADD. 13	0.062	0.059	0.053	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
TSR	0.98	0.97	0.99	0.96
ADD. 0	-	-	-	-
ADD. 1	0.158	-	-	-
ADD. 5	-0.176	-0.368	-	-
ADD. 13	0.324	0.168	0.570	-

Results significant at the 5%(t=2.365, d.f.=7).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.639).

TABLE I.39 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 6

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	0.035	0.057	0.039	0.049	0.038
ADD. 0	-	-	-	-	-
ADD. 1	0.067	-	-	-	-
ADD. 10	0.052	0.069	-	-	-
ADD. 12	0.060	0.075	0.063	-	-
ADD. 14	0.052	0.069	0.054	0.062	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
TSR	0.20	0.78	0.40	0.49	0.37
ADD. 0	-	-	-	-	-
ADD. 1	-8.671*+	-	-	-	-
ADD. 10	-3.816*+	5.502*+	-	-	-
ADD. 12	-4.815*+	3.858*+	-1.437	-	-
ADD. 14	-3.290*+	5.985*+	0.550	1.935	-

Test Method B: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	0.039	0.051	0.041	0.041	0.042
ADD. 0	-	-	-	-	-
ADD. 1	0.064	-	-	-	-
ADD. 10	0.057	0.065	-	-	-
ADD. 12	0.057	0.065	0.058	-	-
ADD. 14	0.057	0.066	0.059	0.059	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
TSR	0.23	0.62	0.35	0.37	0.42
ADD. 0	-	-	-	-	-
ADD. 1	-6.074*+	-	-	-	-
ADD. 10	-2.120*	4.126*+	-	-	-
ADD. 12	-2.474*	3.820*+	-0.344	-	-
ADD. 14	-3.315*+	3.027*	-1.192	-0.851	-

Results significant at the 5%(t=2.120, d.f.=16).
+Significant according to the Bonferroni method with the 5% error rate(t+=3.252).

TABLE I.39 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 6 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	0.038	0.051	0.040	0.040	0.040
ADD. 0	-	-	-	-	-
ADD. 1	0.064	-	-	-	-
ADD. 10	0.055	0.065	-	-	-
ADD. 12	0.055	0.065	0.057	-	-
ADD. 14	0.055	0.065	0.057	0.057	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
TSR	0.15	0.58	0.26	0.30	0.30
ADD. 0	-	-	-	-	-
ADD. 1	-6.760*+	-	-	-	-
ADD. 10	-1.993	4.937*+	-	-	-
ADD. 12	-2.718*	4.319*+	-0.707	-	-
ADD. 14	-2.718*	4.319*+	-0.707	0.000	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	0.040	0.054	0.042	0.041	0.044
ADD. 0	-	-	-	-	-
ADD. 1	0.067	-	-	-	-
ADD. 10	0.058	0.068	-	-	-
ADD. 12	0.057	0.068	0.059	-	-
ADD. 14	0.059	0.070	0.061	0.060	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
TSR	0.32	0.78	0.42	0.42	0.54
ADD. 0	-	-	-	-	-
ADD. 1	-6.845*+	-	-	-	-
ADD. 10	-1.724	5.262*+	-	-	-
ADD. 12	-1.745	5.309*+	0.000	-	-
ADD. 14	-3.699*+	3.445*+	-1.972	-1.995	-

Results significant at the 5%(t=2.120, d.f.=16).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.252).

TABLE I.40 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 6

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	0.030	0.040	0.044	0.040	0.034
ADD. 0	-	-	-	-	-
ADD. 1	0.050	-	-	-	-
ADD. 10	0.053	0.059	-	-	-
ADD. 12	0.050	0.057	0.059	-	-
ADD. 14	0.045	0.052	0.056	0.052	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
TSR	0.47	0.54	0.83	0.78	0.64
ADD. 0	-	-	-	-	-
ADD. 1	-1.400	-	-	-	-
ADD. 10	-6.760*+	-4.876*+	-	-	-
ADD. 12	-6.200*+	-4.243*+	0.840	-	-
ADD. 14	-3.749*+	-1.904	3.416*	2.666*	-

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	0.028	0.036	0.038	0.037	0.033
ADD. 0	-	-	-	-	-
ADD. 1	0.046	-	-	-	-
ADD. 10	0.047	0.052	-	-	-
ADD. 12	0.046	0.052	0.053	-	-
ADD. 14	0.043	0.049	0.050	0.050	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
TSR	0.38	0.43	0.66	0.65	0.61
ADD. 0	-	-	-	-	-
ADD. 1	-1.096	-	-	-	-
ADD. 10	-5.931*+	-4.394*+	-	-	-
ADD. 12	-5.818*+	-4.261*+	0.188	-	-
ADD. 14	-5.314*+	-3.685*+	0.993	0.806	-

Results significant at the 5%(t=2.228, d.f.=10).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.581).

TABLE I.40 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 6 (continued)

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	0.031	0.043	0.043	0.043	0.038
ADD. 0	-	-	-	-	-
ADD. 1	0.053	-	-	-	-
ADD. 10	0.053	0.061	-	-	-
ADD. 12	0.053	0.061	0.061	-	-
ADD. 14	0.049	0.057	0.057	0.057	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
TSR	0.54	0.66	0.80	0.85	0.78
ADD. 0	-	-	-	-	-
ADD. 1	-2.263*	-	-	-	-
ADD. 10	-4.904*+	-2.302*	-	-	-
ADD. 12	-5.848*+	-3.124*	-0.822	-	-
ADD. 14	-4.893*+	-2.091	0.348	1.219	-

Results significant at the 5%(t=2.228, d.f.=10).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.581).

TABLE I.41 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 25

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	0.049	0.058	0.059	0.049	0.051	0.056
ADD. 0	-	-	-	-	-	-
ADD. 1	0.076	-	-	-	-	-
ADD. 4	0.077	0.083	-	-	-	-
ADD. 7	0.069	0.076	0.077	-	-	-
ADD. 12	0.071	0.077	0.078	0.071	-	-
ADD. 14	0.074	0.081	0.081	0.074	0.076	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
TSR	0.67	1.30	1.19	0.98	1.03	0.92
ADD. 0	-	-	-	-	-	-
ADD. 1	-8.297*+	-	-	-	-	-
ADD. 4	-6.780*+	1.329	-	-	-	-
ADD. 7	-4.473*+	4.214*+	2.738*	-	-	-
ADD. 12	-5.090*+	3.495*+	2.051	-0.706	-	-
ADD. 14	-3.360*+	4.713*+	3.319*+	0.806	1.452	-

Test Method B: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	0.049	0.062	0.065	0.070	0.050	0.059
ADD. 0	-	-	-	-	-	-
ADD. 1	0.079	-	-	-	-	-
ADD. 4	0.081	0.090	-	-	-	-
ADD. 7	0.085	0.094	0.096	-	-	-
ADD. 12	0.070	0.080	0.082	0.086	-	-
ADD. 14	0.077	0.086	0.088	0.092	0.077	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
TSR	0.62	1.23	1.23	1.18	0.97	1.02
ADD. 0	-	-	-	-	-	-
ADD. 1	-7.719*+	-	-	-	-	-
ADD. 4	-7.493*+	0.000	-	-	-	-
ADD. 7	-6.553*+	0.534	0.523	-	-	-
ADD. 12	-4.999*+	3.264*	3.170*	2.441*	-	-
ADD. 14	-5.215*+	2.453*	2.392*	1.747	-0.646	-

Results significant at the 5%(t=2.080, d.f.=21).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.314).

TABLE I.41 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 25 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	0.045	0.053	0.054	0.056	0.044	0.051
ADD. 0	-	-	-	-	-	-
ADD. 1	0.070	-	-	-	-	-
ADD. 4	0.070	0.076	-	-	-	-
ADD. 7	0.072	0.077	0.078	-	-	-
ADD. 12	0.063	0.069	0.070	0.071	-	-
ADD. 14	0.068	0.074	0.074	0.076	0.067	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
TSR	0.46	0.93	0.82	0.82	0.70	0.72
ADD. 0	-	-	-	-	-	-
ADD. 1	-6.759*+	-	-	-	-	-
ADD. 4	-5.121*+	1.453	-	-	-	-
ADD. 7	-5.011*+	1.426	0.000	-	-	-
ADD. 12	-3.813*+	3.338*+	1.722	1.684	-	-
ADD. 14	-3.822*+	2.855*	1.346	1.320	-0.296	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	0.050	0.064	0.059	0.060	0.047	0.055
ADD. 0	-	-	-	-	-	-
ADD. 1	0.081	-	-	-	-	-
ADD. 4	0.077	0.087	-	-	-	-
ADD. 7	0.078	0.088	0.084	-	-	-
ADD. 12	0.069	0.079	0.075	0.076	-	-
ADD. 14	0.074	0.084	0.081	0.081	0.072	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
TSR	0.64	1.07	1.01	0.94	0.86	0.87
ADD. 0	-	-	-	-	-	-
ADD. 1	-5.294*+	-	-	-	-	-
ADD. 4	-4.784*+	0.689	-	-	-	-
ADD. 7	-3.841*+	1.481	0.831	-	-	-
ADD. 12	-3.205*	2.644*	1.988	1.049	-	-
ADD. 14	-3.094*	2.370*	1.735	0.860	-0.138	-

Results significant at the 5%(t=2.080, d.f.=21).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.314).

TABLE I.42 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 25

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	0.024	0.032	0.025	0.030	0.031	0.032
ADD. 0	-	-	-	-	-	-
ADD. 1	0.040	-	-	-	-	-
ADD. 4	0.035	0.041	-	-	-	-
ADD. 7	0.038	0.044	0.039	-	-	-
ADD. 12	0.039	0.045	0.040	0.043	-	-
ADD. 14	0.040	0.045	0.041	0.044	0.045	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
TSR	0.60	0.89	0.60	0.85	0.76	0.75
ADD. 0	-	-	-	-	-	-
ADD. 1	-7.250*+	-	-	-	-	-
ADD. 4	0.000	7.141*+	-	-	-	-
ADD. 7	-6.507*+	0.911	-6.401*+	-	-	-
ADD. 12	-4.081*+	2.917*	-4.017*+	2.086	-	-
ADD. 14	-3.750*+	3.093*	-3.693*+	2.279*	0.224	-

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	0.022	0.029	0.023	0.029	0.029	0.03
ADD. 0	-	-	-	-	-	-
ADD. 1	0.036	-	-	-	-	-
ADD. 4	0.032	0.037	-	-	-	-
ADD. 7	0.036	0.041	0.037	-	-	-
ADD. 12	0.036	0.041	0.037	0.041	-	-
ADD. 14	0.037	0.042	0.038	0.042	0.042	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
TSR	0.44	0.76	0.48	0.79	0.63	0.67
ADD. 0	-	-	-	-	-	-
ADD. 1	-8.791*+	-	-	-	-	-
ADD. 4	-1.256	7.564*+	-	-	-	-
ADD. 7	-9.615*+	-0.731	-8.375*+	-	-	-
ADD. 12	-5.219*+	3.169*	-4.052*+	3.901*+	-	-
ADD. 14	-6.182*+	2.156	-5.026*+	2.875*	-0.958	-

*Results significant at the 5%(t^*=2.179, d.f.=12).

+Significant according to the Bonferroni method with the 5% error rate(t^+=3.654).

TABLE I.42 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 25 (continued)

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	0.025	0.032	0.025	0.032	0.031	0.032
ADD. 0	-	-	-	-	-	-
ADD. 1	0.041	-	-	-	-	-
ADD. 4	0.035	0.041	-	-	-	-
ADD. 7	0.041	0.045	0.041	-	-	-
ADD. 12	0.040	0.045	0.040	0.045	-	-
ADD. 14	0.041	0.045	0.041	0.045	0.045	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
TSR	0.64	0.90	0.63	0.96	0.76	0.78
ADD. 0	-	-	-	-	-	-
ADD. 1	-6.402*+	-	-	-	-	-
ADD. 4	0.282	6.648*+	-	-	-	-
ADD. 7	-7.880*+	-1.325	-8.126*+	-	-	-
ADD. 12	-3.013*	3.142*	-3.264*	4.489*+	-	-
ADD. 14	-3.447*	2.651*	-3.694*+	3.977*+	-0.448	-

Results significant at the 5%(t=2.179, d.f.=12).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.654).

TABLE 1.43 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 1

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive Standard Error	ADD. 0 0.058	ADD. 1 0.066	ADD. 2 0.068	ADD. 6 0.063	ADD. 7 0.068	ADD. 9 0.067	ADD. 11 0.088	ADD. 13 0.078
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.088	-	-	-	-	-	-	-
ADD. 2	0.089	0.095	-	-	-	-	-	-
ADD. 6	0.086	0.091	0.093	-	-	-	-	-
ADD. 7	0.089	0.095	0.096	0.093	-	-	-	-
ADD. 9	0.089	0.094	0.095	0.092	0.095	-	-	-
ADD. 11	0.105	0.110	0.111	0.108	0.111	0.111	-	-
ADD. 13	0.097	0.102	0.103	0.100	0.103	0.103	0.118	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive TSR	ADD. 0 0.74	ADD. 1 1.06	ADD. 2 1.14	ADD. 6 0.70	ADD. 7 1.10	ADD. 9 1.07	ADD. 11 1.21	ADD. 13 1.15
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-3.642*+	-	-	-	-	-	-	-
ADD. 2	-4.475*+	-0.844	-	-	-	-	-	-
ADD. 6	0.467	3.946*+	4.747*+	-	-	-	-	-
ADD. 7	-4.027*+	-0.422	0.416	-4.315*+	-	-	-	-
ADD. 9	-3.724*+	-0.106	0.733	-4.023*+	0.314	-	-	-
ADD. 11	-4.459*+	-1.364	-0.629	-4.712*+	-0.989	-1.266	-	-
ADD. 13	-4.218*+	-0.880	-0.097	-4.488*+	-0.483	-0.778	0.510	-

Test Method B: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive Standard Error	ADD. 0 0.075	ADD. 1 0.073	ADD. 2 0.083	ADD. 6 0.073	ADD. 7 0.062	ADD. 9 0.079	ADD. 11 0.086	ADD. 13 0.074
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.105	-	-	-	-	-	-	-
ADD. 2	0.112	0.111	-	-	-	-	-	-
ADD. 6	0.105	0.103	0.111	-	-	-	-	-
ADD. 7	0.097	0.096	0.104	0.096	-	-	-	-
ADD. 9	0.109	0.108	0.115	0.108	0.100	-	-	-
ADD. 11	0.114	0.113	0.120	0.113	0.106	0.117	-	-
ADD. 13	0.105	0.104	0.111	0.104	0.097	0.108	0.113	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive TSR	ADD. 0 0.96	ADD. 1 1.22	ADD. 2 1.26	ADD. 6 0.85	ADD. 7 1.10	ADD. 9 1.14	ADD. 11 1.37	ADD. 13 1.15
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-2.484*	-	-	-	-	-	-	-
ADD. 2	-2.682*	-0.362	-	-	-	-	-	-
ADD. 6	1.051	3.583*+	3.709*+	-	-	-	-	-
ADD. 7	-1.439	1.253	1.544	-2.610*	-	-	-	-
ADD. 9	-1.652	0.744	1.047	-2.596*	-0.398	-	-	-
ADD. 11	-3.593*+	-1.330	-0.920	-4.610*+	-2.547*	-1.969	-	-
ADD. 13	-1.803	0.673	0.989	-2.886*	-0.518	-0.092	1.939	-

Results significant at the 5%(t=2.045, d.f.=29).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.4[illegible]7).

TABLE I.43 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST
RESULTS FOR LABORATORY MIXTURE, DISTRICT 1 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
Standard Error		0.069	0.071	0.071	0.072	0.062	0.08	0.091	0.078
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	0.099	-	-	-	-	-	-	-
	ADD. 2	0.099	0.100	-	-	-	-	-	-
	ADD. 6	0.100	0.101	0.101	-	-	-	-	-
	ADD. 7	0.093	0.094	0.094	0.095	-	-	-	-
	ADD. 9	0.106	0.107	0.107	0.108	0.101	-	-	-
	ADD. 11	0.114	0.115	0.115	0.116	0.110	0.121	-	-
	ADD. 13	0.104	0.105	0.105	0.106	0.100	0.112	0.120	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
TSR		0.80	1.14	1.14	0.82	1.10	1.17	1.5	0.94
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	-3.434*	-	-	-	-	-	.	-
	ADD. 2	-3.434*	0.000	-	-	-	-	-	-
	ADD. 6	-0.200	3.164*	3.164*	-	-	-	-	-
	ADD. 7	-3.234*	0.424	0.424	-2.946*	-	-	-	-
	ADD. 9	-3.502*+	-0.280	-0.280	-3.252*	-0.692	-	-	-
	ADD. 11	-6.129*+	-3.119*	-3.119*	-5.860*+	-3.633*+	-2.723*	-	-
	ADD. 13	-1.344	1.896	1.896	-1.130	1.606	2.058*	4.672*+	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
Standard Error		0.076	0.074	0.075	0.077	0.064	0.081	0.088	0.073
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	0.106	-	-	-	-	-	-	-
	ADD. 2	0.107	0.105	-	-	-	-	-	-
	ADD. 6	0.108	0.107	0.107	-	-	-	-	-
	ADD. 7	0.099	0.098	0.099	0.100	-	-	-	-
	ADD. 9	0.111	0.110	0.110	0.112	0.103	-	-	-
	ADD. 11	0.116	0.115	0.116	0.117	0.109	0.120	-	-
	ADD. 13	0.105	0.104	0.105	0.106	0.097	0.109	0.114	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
TSR		1.01	1.24	1.29	0.95	1.20	1.22	1.42	1.13
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	-2.168*	-	-	-	-	-	-	-
	ADD. 2	-2.622*	-0.474	-	-	-	-	-	-
	ADD. 6	0.554	2.715*	3.163*	-	-	-	-	-
	ADD. 7	-1.912	0.408	0.912	-2.497*	-	-	-	-
	ADD. 9	-1.890	0.182	0.634	-2.416*	-0.193	-	-	-
	ADD. 11	-3.576*+	-1.565	-1.124	-4.019*+	-2.022	-1.672	-	-
	ADD. 13	-1.139	1.058	1.529	-1.696	0.721	0.825	2.536*	-

Results significant at the 5%(t=2.045, d.f.=29).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.437).

TABLE I.44 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 1

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
Standard Error	0.042	0.045	0.044	0.043	0.043	0.046	0.05	0.04
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.062	-	-	-	-	-	-	-
ADD. 2	0.061	0.063	-	-	-	-	-	-
ADD. 6	0.060	0.062	0.062	-	-	-	-	-
ADD. 7	0.060	0.062	0.062	0.061	-	-	-	-
ADD. 9	0.062	0.064	0.064	0.063	0.063	-	-	-
ADD. 11	0.065	0.067	0.067	0.066	0.066	0.068	-	-
ADD. 13	0.058	0.060	0.059	0.059	0.059	0.061	0.064	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
TSR	1.06	1.12	1.10	0.97	1.12	1.1	1.15	1.02
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-0.974	-	-	-	-	-	-	-
ADD. 2	-0.657	0.317	-	-	-	-	-	-
ADD. 6	1.497	2.409*	2.113	-	-	-	-	-
ADD. 7	-0.998	0.000	-0.325	-2.466*	-	-	-	-
ADD. 9	-0.642	0.310	0.000	-2.064	0.317	-	-	-
ADD. 11	-1.378	-0.445	-0.750	-2.729*	-0.455	-0.735	-	-
ADD. 13	0.689	1.660	1.345	-0.851	1.702	1.312	2.030	-

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
Standard Error	0.041	0.048	0.047	0.042	0.045	0.049	0.052	0.041
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.063	-	-	-	-	-	-	-
ADD. 2	0.062	0.067	-	-	-	-	-	-
ADD. 6	0.059	0.064	0.063	-	-	-	-	-
ADD. 7	0.061	0.066	0.065	0.062	-	-	-	-
ADD. 9	0.064	0.069	0.068	0.065	0.067	-	-	-
ADD. 11	0.066	0.071	0.070	0.067	0.069	0.071	-	-
ADD. 13	0.058	0.063	0.062	0.059	0.061	0.064	0.066	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
TSR	0.97	1.27	1.23	0.95	1.20	1.22	1.24	1.07
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-4.752*+	-	-	-	-	-	-	-
ADD. 2	-4.168*+	0.595	-	-	-	-	-	-
ADD. 6	0.340	5.017*+	4.442*+	-	-	-	-	-
ADD. 7	-3.778*+	1.063	0.461	-4.061*+	-	-	-	-
ADD. 9	-3.912*+	0.728	0.147	-4.184*+	-0.300	-	-	-
ADD. 11	-4.077*+	0.423	-0.142	-4.338*+	-0.582	-0.279	-	-
ADD. 13	-1.724	3.168*	2.565*	-2.044	2.135*	2.347*	2.567*	-

*Results significant at the 5%(t^*=2.120, d.f.=16).

+Significant according to the Bonferroni method with the 5% error rate(t^+=3.736).

TABLE I.44 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 1 (continued)

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
Standard Error	0.043	0.045	0.045	0.043	0.044	0.048	0.051	0.042
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.062	-	-	-	-	-	-	-
ADD. 2	0.062	0.064	-	-	-	-	-	-
ADD. 6	0.061	0.062	0.062	-	-	-	-	-
ADD. 7	0.062	0.063	0.063	0.062	-	-	-	-
ADD. 9	0.064	0.066	0.066	0.064	0.065	-	-	-
ADD. 11	0.067	0.068	0.068	0.067	0.067	0.070	-	-
ADD. 13	0.060	0.062	0.062	0.060	0.061	0.064	0.066	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
TSR	1.07	1.12	1.16	0.96	1.15	1.19	1.19	1.12
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-0.803	-	-	-	-	-	-	-
ADD. 2	-1.445	-0.628	-	-	-	-	-	-
ADD. 6	1.808	2.570*	3.213*	-	-	-	-	-
ADD. 7	-1.300	-0.476	0.158	-3.088*	-	-	-	-
ADD. 9	-1.862	-1.063	-0.455	-3.569*	-0.614	-	-	-
ADD. 11	-1.798	-1.029	-0.441	-3.447*	-0.593	0.000	-	-
ADD. 13	-0.831	0.000	0.649	-2.662*	0.493	1.097	1.059	-

Results significant at the 5%(t=2.120, d.f.=16).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.736).

TABLE I.45 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 19

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
Standard Error		0.062	0.083	0.071	0.067	0.061	0.068
	ADD. 0	-	-	-	-	-	-
	ADD. 1	0.104	-	-	-	-	-
	ADD. 2	0.094	0.109	-	-	-	-
	ADD. 4	0.091	0.107	0.098	-	-	-
	ADD. 5	0.087	0.103	0.094	0.091	-	-
	ADD. 12	0.092	0.107	0.098	0.095	0.091	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
TSR		1.12	1.07	1.19	1.25	1.16	0.93
	ADD. 0	-	-	-	-	-	-
	ADD. 1	0.482	-	-	-	-	-
	ADD. 2	-0.742	-1.098	-	-	-	-
	ADD. 4	-1.424	-1.687	-0.614	-	-	-
	ADD. 5	-0.459	-0.873	0.320	0.993	-	-
	ADD. 12	2.064	1.304	2.644*	3.352*+	2.517*	-

Test Method B: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
Standard Error		0.066	0.111	0.066	0.066	0.053	0.074
	ADD. 0	-	-	-	-	-	-
	ADD. 1	0.129	-	-	-	-	-
	ADD. 2	0.093	0.129	-	-	-	-
	ADD. 4	0.093	0.129	0.093	-	-	-
	ADD. 5	0.085	0.123	0.085	0.085	-	-
	ADD. 12	0.099	0.133	0.099	0.099	0.091	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
TSR		1.07	1.53	1.09	1.24	1.07	1.17
	ADD. 0	-	-	-	-	-	-
	ADD. 1	-3.562*+	-	-	-	-	-
	ADD. 2	-0.214	3.407*+	-	-	-	-
	ADD. 4	-1.821	2.245*	-1.607	-	-	-
	ADD. 5	0.000	3.739*+	0.236	2.008	-	-
	ADD. 12	-1.008	2.698*	-0.806	0.705	-1.098	-

Results significant at the 5%(t=2.074, d.f.=22).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.295).

TABLE I.45 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 19 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
Standard Error	0.063	0.108	0.065	0.063	0.055	0.071
ADD. 0	-	-	-	-	-	-
ADD. 1	0.125	-	-	-	-	-
ADD. 2	0.091	0.126	-	-	-	-
ADD. 4	0.089	0.125	0.091	-	-	-
ADD. 5	0.084	0.121	0.085	0.084	-	-
ADD. 12	0.095	0.129	0.096	0.095	0.090	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
TSR	0.93	1.45	0.99	1.11	1.22	1.03
ADD. 0	-	-	-	-	-	-
ADD. 1	-4.158*+	-	-	-	-	-
ADD. 2	-0.662	3.649*+	-	-	-	-
ADD. 4	-2.020	2.719*	-1.325	-	-	-
ADD. 5	-3.467*+	1.897	-2.701*	-1.315	-	-
ADD. 12	-1.053	3.249*	-0.415	0.842	2.115*	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
Standard Error	0.064	0.115	0.068	0.068	0.057	0.071
ADD. 0	-	-	-	-	-	-
ADD. 1	0.132	-	-	-	-	-
ADD. 2	0.093	0.134	-	-	-	-
ADD. 4	0.093	0.134	0.096	-	-	-
ADD. 5	0.086	0.128	0.089	0.089	-	-
ADD. 12	0.096	0.135	0.098	0.098	0.091	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
TSR	0.98	1.64	1.20	1.36	1.30	1.03
ADD. 0	-	-	-	-	-	-
ADD. 1	-5.014*+	-	-	-	-	-
ADD. 2	-2.355*	3.293*	-	-	-	-
ADD. 4	-4.069*+	2.095*	-1.663	-	-	-
ADD. 5	-3.733*+	2.648*	-1.127	0.676	-	-
ADD. 12	-0.523	4.513*+	1.729	3.356*+	2.965*	-

Results significant at the 5%(t=2.074, d.f.=22).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.295).

TABLE I.46 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 19

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
Standard Error	0.082	0.089	0.087	0.066	0.089	0.055
ADD. 0	-	-	-	-	-	-
ADD. 1	0.121	-	-	-	-	-
ADD. 2	0.120	0.124	-	-	-	-
ADD. 4	0.105	0.111	0.109	-	-	-
ADD. 5	0.121	0.126	0.124	0.111	-	-
ADD. 12	0.099	0.105	0.103	0.086	0.105	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
TSR	0.73	1.11	1.12	1.16	1.21	1.01
ADD. 0	-	-	-	-	-	-
ADD. 1	-3.140*	-	-	-	-	-
ADD. 2	-3.262*	-0.080	-	-	-	-
ADD. 4	-4.085*+	-0.451	-0.366	-	-	-
ADD. 5	-3.966*+	-0.794	-0.723	-0.451	-	-
ADD. 12	-2.835*	0.956	1.068	1.745	1.911	-

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
Standard Error	0.083	0.081	0.076	0.068	0.090	0.058
ADD. 0	-	-	-	-	-	-
ADD. 1	0.116	-	-	-	-	-
ADD. 2	0.113	0.111	-	-	-	-
ADD. 4	0.107	0.106	0.102	-	-	-
ADD. 5	0.122	0.121	0.118	0.113	-	-
ADD. 12	0.101	0.100	0.096	0.089	0.107	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
TSR	0.75	1.16	1.08	1.24	1.26	1.14
ADD. 0	-	-	-	-	-	-
ADD. 1	-3.535*	-	-	-	-	-
ADD. 2	-2.932*	0.720	-	-	-	-
ADD. 4	-4.567*+	-0.756	-1.568	-	-	-
ADD. 5	-4.165*+	-0.826	-1.528	-0.177	-	-
ADD. 12	-3.851*+	0.200	-0.627	1.118	1.120	-

Results significant at the 5%(t=2.179, d.f.=12).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.654).

TABLE I.46 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 19 (continued)

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
Standard Error	0.085	0.082	0.076	0.066	0.091	0.058
ADD. 0	-	-	-	-	-	-
ADD. 1	0.118	-	-	-	-	-
ADD. 2	0.114	0.112	-	-	-	-
ADD. 4	0.108	0.105	0.101	-	-	-
ADD. 5	0.125	0.122	0.119	0.112	-	-
ADD. 12	0.103	0.100	0.096	0.088	0.108	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
TSR	0.80	1.21	1.08	1.17	1.27	1.15
ADD. 0	-	-	-	-	-	-
ADD. 1	-3.471*	-	-	-	-	-
ADD. 2	-2.455*	1.162	-	-	-	-
ADD. 4	-3.438*	0.380	-0.894	-	-	-
ADD. 5	-3.774*+	-0.489	-1.602	-0.889	-	-
ADD. 12	-3.401*	0.597	-0.732	0.227	1.112	-

Results significant at the 5%(t=2.179, d.f.=12).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.654).

TABLE 1.47 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR LABORATORY MIXTURE, DISTRICT 21

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error	0.035	0.051	0.039	0.042	0.034	0.034	0.038	0.037
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.062	-	-	-	-	-	-	-
ADD. 2	0.052	0.064	-	-	-	-	-	-
ADD. 4	0.055	0.066	0.057	-	-	-	-	-
ADD. 6	0.049	0.061	0.052	0.054	-	-	-	-
ADD. 8	0.049	0.061	0.052	0.054	0.048	-	-	-
ADD. 10	0.052	0.064	0.054	0.057	0.051	0.051	-	-
ADD. 12	0.051	0.063	0.054	0.056	0.050	0.050	0.053	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
TSR	0.24	1.04	0.52	0.73	0.35	0.45	0.51	0.47
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-12.934*+	-	-	-	-	-	-	-
ADD. 2	-5.343*+	8.099*+	-	-	-	-	-	-
ADD. 4	-8.962*+	4.692*+	-3.663*+	-	-	-	-	-
ADD. 6	-2.254*	11.257*+	3.285*	7.032*+	-	-	-	-
ADD. 8	-4.303*+	9.625*+	1.352	5.181*+	-2.079*	-	-	-
ADD. 10	-5.226*+	8.333*+	0.183	3.884*+	-3.137*	-1.176	-	-
ADD. 12	-4.516*+	9.046*+	0.930	4.645*+	-2.388*	-0.398	0.754	-

Test Method B: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error	0.032	0.054	0.039	0.045	0.032	0.043	0.037	0.036
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.063	-	-	-	-	-	-	-
ADD. 2	0.050	0.067	-	-	-	-	-	-
ADD. 4	0.055	0.070	0.060	-	-	-	-	-
ADD. 6	0.045	0.063	0.050	0.055	-	-	-	-
ADD. 8	0.054	0.069	0.058	0.062	0.054	-	-	-
ADD. 10	0.049	0.065	0.054	0.058	0.049	0.057	-	-
ADD. 12	0.048	0.065	0.053	0.058	0.048	0.056	0.052	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
TSR	0.28	1.06	0.48	0.76	0.37	0.88	0.55	0.52
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-12.425*+	-	-	-	-	-	-	-
ADD. 2	-3.964*+	8.707*+	-	-	-	-	-	-
ADD. 4	-8.692*+	4.267*+	-4.702*+	-	-	-	-	-
ADD. 6	-1.988	10.992*+	2.180*	7.063*+	-	-	-	-
ADD. 8	-11.193*+	2.607*	-6.890*+	-1.927	-9.514*+	-	-	-
ADD. 10	-5.519*+	7.791*+	-1.302	3.604*+	-3.679*+	5.817*+	-	-
ADD. 12	-4.982*+	8.320*+	-0.754	4.164*+	-3.114*	6.419*+	0.581	-

Results significant at the 5%(t=2.037, d.f.=32).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.405).

TABLE I.47 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST
RESULTS FOR LABORATORY MIXTURE, DISTRICT 21 (continued)

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error	0.031	0.054	0.038	0.041	0.032	0.038	0.037	0.035
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.062	-	-	-	-	-	-	-
ADD. 2	0.049	0.066	-	-	-	-	-	-
ADD. 4	0.051	0.068	0.056	-	-	-	-	-
ADD. 6	0.045	0.063	0.050	0.052	-	-	-	-
ADD. 8	0.049	0.066	0.054	0.056	0.050	-	-	-
ADD. 10	0.048	0.065	0.053	0.055	0.049	0.053	-	-
ADD. 12	0.047	0.064	0.052	0.054	0.047	0.052	0.051	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
TSR	0.22	1.04	0.39	0.54	0.30	0.59	0.53	0.39
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-13.169*+	-	-	-	-	-	-	-
ADD. 2	-3.466*+	9.843*+	-	-	-	-	-	-
ADD. 4	-6.225*+	7.374*+	-2.683*	-	-	-	-	-
ADD. 6	-1.795	11.789*+	1.812	4.614*+	-	-	-	-
ADD. 8	-7.545*+	6.815*+	-3.721*+	-0.894	-5.837*+	-	-	-
ADD. 10	-6.422*+	7.791*+	-2.640*	0.181	-4.702*+	1.131	-	-
ADD. 12	-3.635*+	10.101*+	0.000	2.782*	-1.897	3.871*+	2.748*	-

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error	0.032	0.054	0.040	0.044	0.032	0.041	0.038	0.036
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.063	-	-	-	-	-	-	-
ADD. 2	0.051	0.067	-	-	-	-	-	-
ADD. 4	0.054	0.070	0.059	-	-	-	-	-
ADD. 6	0.045	0.063	0.051	0.054	-	-	-	-
ADD. 8	0.052	0.068	0.057	0.060	0.052	-	-	-
ADD. 10	0.050	0.066	0.055	0.058	0.050	0.056	-	-
ADD. 12	0.048	0.065	0.054	0.057	0.048	0.055	0.052	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
TSR	0.27	1.07	0.55	0.74	0.38	0.78	0.58	0.49
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-12.745*+	-	-	-	-	-	-	-
ADD. 2	-5.466*+	7.737*+	-	-	-	-	-	-
ADD. 4	-8.638*+	4.737*+	-3.195*	-	-	-	-	-
ADD. 6	-2.430*	10.992*+	3.318*	6.617*+	-	-	-	-
ADD. 8	-9.805*+	4.277*+	-4.015*+	-0.665	-7.690*+	-	-	-
ADD. 10	-6.240*+	7.420*+	-0.543	2.752*	-4.026*+	3.577*+	-	-
ADD. 12	-4.567*+	8.936*+	1.115	4.397*+	-2.283*	5.315*+	1.719	-

*Results significant at the 5%(t^*=2.037, d.f.=32).

+Significant according to the Bonferroni method with the 5% error rate(t^+=3.405).

TABLE I.48 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST
RESULTS FOR PLANT MIXTURE, DISTRICT 21

Test Method A: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error		0.020	0.018	0.023	0.026	0.017	0.027	0.021	0.02
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	0.027	-	-	-	-	-	-	-
	ADD. 2	0.030	0.029	-	-	-	-	-	-
	ADD. 4	0.033	0.032	0.035	-	-	-	-	-
	ADD. 6	0.026	0.025	0.029	0.031	-	-	-	-
	ADD. 8	0.034	0.032	0.035	0.037	0.032	-	-	-
	ADD. 10	0.029	0.028	0.031	0.033	0.027	0.034	-	-
	ADD. 12	0.028	0.027	0.030	0.033	0.026	0.034	0.029	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
TSR		0.23	0.17	0.39	0.47	0.30	0.56	0.51	0.42
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	2.229*	-	-	-	-	-	-	-
	ADD. 2	-5.249*+	-7.532*+	-	-	-	-	-	-
	ADD. 4	-7.316*+	-9.486*+	-2.304*	-	-	-	-	-
	ADD. 6	-2.666*	-5.250*+	3.146*	5.472*+	-	-	-	-
	ADD. 8	-9.821*+	-12.019*+	-4.793*+	-2.401*	-8.148*+	-	-	-
	ADD. 10	-9.655*+	-12.292*+	-3.852*+	-1.196	-7.772*+	1.461	-	-
	ADD. 12	-6.717*+	-9.291*+	-0.984	1.524	-4.572*+	4.166*+	3.103*	-

Test Method C: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error		0.021	0.018	0.023	0.027	0.017	0.028	0.022	0.021
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	0.028	-	-	-	-	-	-	-
	ADD. 2	0.031	0.029	-	-	-	-	-	-
	ADD. 4	0.034	0.032	0.035	-	-	-	-	-
	ADD. 6	0.027	0.025	0.029	0.032	-	-	-	-
	ADD. 8	0.035	0.033	0.036	0.039	0.033	-	-	-
	ADD. 10	0.030	0.028	0.032	0.035	0.028	0.036	-	-
	ADD. 12	0.030	0.028	0.031	0.034	0.027	0.035	0.030	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
TSR		0.28	0.19	0.41	0.53	0.30	0.65	0.59	0.49
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	3.253*	-	-	-	-	-	-	-
	ADD. 2	-4.174*+	-7.532*+	-	-	-	-	-	-
	ADD. 4	-7.308*+	-10.477*+	-3.383*	-	-	-	-	-
	ADD. 6	-0.740	-4.442*+	3.846*+	7.208*+	-	-	-	-
	ADD. 8	-10.571*+	-13.819*+	-6.623*+	-3.085*	-10.684*+	-	-	-
	ADD. 10	-10.192*+	-14.071*+	-5.655*+	-1.722	-10.430*+	1.684	-	-
	ADD. 12	-7.071*+	-10.846*+	-2.568*	1.169	-7.032*+	4.571*+	3.287*	-

Results significant at the 5%(t=2.120, d.f.=16).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.736).

TABLE I.48 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR PLANT MIXTURE, DISTRICT 21 (continued)

Test Method D: (a) Standard Error of the Difference in TSR Between Two Additives.

Additive Standard Error	ADD. 0 0.021	ADD. 1 0.018	ADD. 2 0.023	ADD. 4 0.026	ADD. 6 0.017	ADD. 8 0.027	ADD. 10 0.021	ADD. 12 0.02
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	0.028	-	-	-	-	-	-	-
ADD. 2	0.031	0.029	-	-	-	-	-	-
ADD. 4	0.033	0.032	0.035	-	-	-	-	-
ADD. 6	0.027	0.025	0.029	0.031	-	-	-	-
ADD. 8	0.034	0.032	0.035	0.037	0.032	-	-	-
ADD. 10	0.030	0.028	0.031	0.033	0.027	0.034	-	-
ADD. 12	0.029	0.027	0.030	0.033	0.026	0.034	0.029	-

(b) Student-t Test Results of the Difference in TSR Between Two Additives.

Additive TSR	ADD. 0 0.26	ADD. 1 0.19	ADD. 2 0.40	ADD. 4 0.50	ADD. 6 0.29	ADD. 8 0.56	ADD. 10 0.51	ADD. 12 0.44
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	2.530*	-	-	-	-	-	-	-
ADD. 2	-4.495*+	-7.190*+	-	-	-	-	-	-
ADD. 4	-7.180*+	-9.803*+	-2.880*	-	-	-	-	-
ADD. 6	-1.110	-4.038*+	3.846*+	6.760*+	-	-	-	-
ADD. 8	-8.770*+	-11.402*+	-4.511*+	-1.600	-8.462*+	-	-	-
ADD. 10	-8.417*+	-11.570*+	-3.531*	-0.299	-8.142*+	1.461	-	-
ADD. 12	-6.206*+	-9.291*+	-1.312	1.829	-5.714*+	3.571*	2.413*	-

Results significant at the 5%(t=2.120, d.f.=16).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.736).

TABLE 1.49 SUMMARY OF POOLED VARIANCE AND STANDARD ERROR ESTIMATE FOR BOILING TEST RESULTS

District	Additive Name	Degree of Freedom	Pooled Variance	Standard Error Estimate
	No Additive	8	14.94	3.86
17	Lime	8	14.94	3.86
	BA 2000	8	14.94	3.86
	Perma-Tac	8	14.94	3.86
	No Additive	10	12.50	3.54
	Lime	10	12.50	3.54
16	Aquashield	10	12.50	3.54
	Dow	10	12.50	3.54
	Pavebond LP	10	12.50	3.54
	No Additive	8	19.44	4.41
13	Lime	8	19.44	4.41
	BA 2000	8	19.44	4.41
	Perma-Tac	8	19.44	4.41
	No Additive	10	28.75	5.36
	Lime	10	28.75	5.36
6	Pavebond LP	10	28.75	5.36
	Perma-Tac	10	28.75	5.36
	Unichem	10	28.75	5.36
	No Additive	12	34.42	5.87
	Lime	12	34.42	5.87
25	Aquashield II	12	34.42	5.87
	Fina-A	12	34.42	5.87
	Perma-Tac	12	34.42	5.87
	Unichem	12	34.42	5.87
	No Additive	16	65.72	8.11
	Lime	16	65.72	8.11
	ARR-MAZ	16	65.72	8.11
1	Dow	16	65.72	8.11
	Fina-A	16	65.72	8.11
	Indulin AS-1	16	65.72	8.11
	PVBD Special	16	65.72	8.11
	Perma-Tac Plus	16	65.72	8.11
	No Additive	12	59.88	7.74
	Lime	12	59.88	7.74
19	ARR-MAZ	12	59.88	7.74
	Aquashield II	12	59.88	7.74
	BA 2000	12	59.88	7.74
	Perma-Tac	12	59.88	7.74
	No Additive	16	33.38	5.78
	Lime	16	33.38	5.78
	ARR-MAZ	16	33.38	5.78
21	Aquashield II	16	33.38	5.78
	Dow	16	33.38	5.78
	Fina-B	16	33.38	5.78
	Pavebond LP	16	33.38	5.78
	Perma-Tac	16	33.38	5.78

TABLE I.50 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR BOILING TEST, DISTRICT 17

Laboratory Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error	3.86	3.86	3.86	3.86
ADD. 0	-	-	-	-
ADD. 1	5.46	-	-	-
ADD. 5	5.46	5.46	-	-
ADD. 12	5.46	5.46	5.46	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
Asphalt, %	50.0	85.0	92.5	90.0
ADD. 0	-	-	-	-
ADD. 1	-6.412*+	-	-	-
ADD. 5	-7.786*+	-1.374	-	-
ADD. 12	-7.328*+	-0.916	0.458	-

Plant Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error	3.86	3.86	3.86	3.86
ADD. 0	-	-	-	-
ADD. 1	5.46	-	-	-
ADD. 5	5.46	5.46	-	-
ADD. 12	5.46	5.46	5.46	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
Asphalt, %	52.5	94.0	92.5	50.0
ADD. 0	-	-	-	-
ADD. 1	-7.602*+	-	-	-
ADD. 5	-7.328*+	0.275	-	-
ADD. 12	0.458	8.060*+	7.786*+	-

Results significant at the 5%(t=2.306, d.f.=8).

+Significant according to the Bonferroni method with the 5% error rate(t+=3.482).

TABLE I.51 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR BOILING TEST, DISTRICT 16

Laboratory Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error	3.54	3.54	3.54	3.54	3.54
ADD. 0	-	-	-	-	-
ADD. 1	5.01	-	-	-	-
ADD. 3	5.01	5.01	-	-	-
ADD. 6	5.01	5.01	5.01	-	-
ADD. 10	5.01	5.01	5.01	5.01	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Asphalt, %	77.5	75.0	77.5	77.5	77.5
ADD. 0	-	-	-	-	-
ADD. 1	0.499	-	-	-	-
ADD. 3	0.000	-0.499	-	-	-
ADD. 6	0.000	-0.499	0.000	-	-
ADD. 10	0.000	-0.499	0.000	0.000	-

Plant Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error	3.54	3.54	3.54	3.54	3.54
ADD. 0	-	-	-	-	-
ADD. 1	5.01	-	-	-	-
ADD. 3	5.01	5.01	-	-	-
ADD. 6	5.01	5.01	5.01	-	-
ADD. 10	5.01	5.01	5.01	5.01	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Asphalt, %	82.5	82.5	85.0	85.0	85.0
ADD. 0	-	-	-	-	-
ADD. 1	0.000	-	-	-	-
ADD. 3	-0.499	-0.499	-	-	-
ADD. 6	-0.499	-0.499	0.000	-	-
ADD. 10	-0.499	-0.499	0.000	0.000	-

Results significant at 5%(t=2.228, d.f.=10).

+Significant according to the Bonferroni method with 5% error rate(t+=3.581).

TABLE I.52 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR BOILING TEST, DISTRICT 13

Laboratory Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	4.41	4.41	4.41	4.41
ADD. 0	-	-	-	-
ADD. 1	6.24	-	-	-
ADD. 5	6.24	6.24	-	-
ADD. 13	6.24	6.24	6.24	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Asphalt, %	77.5	96.5	97.5	96.5
ADD. 0	-	-	-	-
ADD. 1	-3.046*	-	-	-
ADD. 5	-3.207*	-0.160	-	-
ADD. 13	-3.046*	0.000	0.160	-

Plant Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	4.41	4.41	4.41	4.41
ADD. 0	-	-	-	-
ADD. 1	6.24	-	-	-
ADD. 5	6.24	6.24	-	-
ADD. 13	6.24	6.24	6.24	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Asphalt, %	77.5	96.5	96.5	95.0
ADD. 0	-	-	-	-
ADD. 1	-3.046*	-	-	-
ADD. 5	-3.046*	0.000	-	-
ADD. 13	-2.806*	0.241	0.241	-

Results significant at 5%(t=2.306, d.f.=8).

+Significant according to the Bonferroni method with 5% error rate(t+=3.482).

TABLE I.53 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR BOILING TEST, DISTRICT 6

Laboratory Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	5.36	5.36	5.36	5.36	5.36
ADD. 0	-	-	-	-	-
ADD. 1	7.58	-	-	-	-
ADD. 10	7.58	7.58	-	-	-
ADD. 12	7.58	7.58	7.58	-	-
ADD. 14	7.58	7.58	7.58	7.58	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Asphalt, %	50.0	72.5	60.0	65.0	67.5
ADD. 0	-	-	-	-	-
ADD. 1	-2.968*	-	-	-	-
ADD. 10	-1.319	1.649	-	-	-
ADD. 12	-1.979	0.989	-0.660	-	-
ADD. 14	-2.309*	0.660	-0.989	-0.330	-

Plant Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	5.36	5.36	5.36	5.36	5.36
ADD. 0	-	-	-	-	-
ADD. 1	7.58	-	-	-	-
ADD. 10	7.58	7.58	-	-	-
ADD. 12	7.58	7.58	7.58	-	-
ADD. 14	7.58	7.58	7.58	7.58	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Asphalt, %	70.0	72.5	85.0	80.0	85.0
ADD. 0	-	-	-	-	-
ADD. 1	-0.330	-	-	-	-
ADD. 10	-1.979	-1.649	-	-	-
ADD. 12	-1.319	-0.989	0.660	-	-
ADD. 14	-1.979	-1.649	0.000	-0.660	-

Results significant at 5%(t=2.228, d.f.=10).

+Significant according to the Bonferroni method with 5% error rate(t+=3.581).

TABLE I.54 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR BOILING TEST, DISTRICT 25

Laboratory Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	5.87	5.87	5.87	5.87	5.87	5.87
ADD. 0	-	-	-	-	-	-
ADD. 1	8.30	-	-	-	-	-
ADD. 4	8.30	8.30	-	-	-	-
ADD. 7	8.30	8.30	8.30	-	-	-
ADD. 12	8.30	8.30	8.30	8.30	-	-
ADD. 14	8.30	8.30	8.30	8.30	8.30	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Asphalt, %	50.0	85.0	96.5	94.0	90.0	94.0
ADD. 0	-	-	-	-	-	-
ADD. 1	-4.216*+	-	-	-	-	-
ADD. 4	-5.601*+	-1.385	-	-	-	-
ADD. 7	-5.300*+	-1.084	0.301	-	-	-
ADD. 12	-4.818*+	-0.602	0.783	0.482	-	-
ADD. 14	-5.300*+	-1.084	0.301	0.000	-0.482	-

Plant Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	5.87	5.87	5.87	5.87	5.87	5.87
ADD. 0	-	-	-	-	-	-
ADD. 1	8.30	-	-	-	-	-
ADD. 4	8.30	8.30	-	-	-	-
ADD. 7	8.30	8.30	8.30	-	-	-
ADD. 12	8.30	8.30	8.30	8.30	-	-
ADD. 14	8.30	8.30	8.30	8.30	8.30	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Asphalt, %	77.5	87.5	77.5	94.0	92.5	87.5
ADD. 0	-	-	-	-	-	-
ADD. 1	-1.205	-	-	-	-	-
ADD. 4	0.000	1.205	-	-	-	-
ADD. 7	-1.988	-0.783	-1.988	-	-	-
ADD. 12	-1.807	-0.602	-1.807	0.181	-	-
ADD. 14	-1.205	0.000	-1.205	0.783	0.602	-

Results significant at 5%(t=2.179, d.f.=12).

+Significant according to the Bonferroni method with 5% error rate(t+=3.654).

TABLE 1.55 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR BOILING TEST, DISTRICT 1

Laboratory Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive Standard Error	ADD. 0 8.11	ADD. 1 8.11	ADD. 2 8.11	ADD. 6 8.11	ADD. 7 8.11	ADD. 9 8.11	ADD. 11 8.11	ADD. 13 8.11
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	11.47	-	-	-	-	-	-	-
ADD. 2	11.47	11.47	-	-	-	-	-	-
ADD. 6	11.47	11.47	11.47	-	-	-	-	-
ADD. 7	11.47	11.47	11.47	11.47	-	-	-	-
ADD. 9	11.47	11.47	11.47	11.47	11.47	-	-	-
ADD. 11	11.47	11.47	11.47	11.47	11.47	11.47	-	-
ADD. 13	11.47	11.47	11.47	11.47	11.47	11.47	11.47	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive Asphalt, %	ADD. 0 82.50	ADD. 1 92.50	ADD. 2 90.00	ADD. 6 82.50	ADD. 7 92.50	ADD. 9 92.50	ADD. 11 92.50	ADD. 13 92.50
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-0.872	-	-	-	-	-	-	-
ADD. 2	-0.654	0.218	-	-	-	-	-	-
ADD. 6	0.000	0.872	0.654	-	-	-	-	-
ADD. 7	-0.872	0.000	-0.218	-0.872	-	-	-	-
ADD. 9	-0.872	0.000	-0.218	-0.872	0.000	-	-	-
ADD. 11	-0.872	0.000	-0.218	-0.872	0.000	0.000	-	-
ADD. 13	-0.872	0.000	-0.218	-0.872	0.000	0.000	0.000	-

Plant Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive Standard Error	ADD. 0 8.11	ADD. 1 8.11	ADD. 2 8.11	ADD. 6 8.11	ADD. 7 8.11	ADD. 9 8.11	ADD. 11 8.11	ADD. 13 8.11
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	11.47	-	-	-	-	-	-	-
ADD. 2	11.47	11.47	-	-	-	-	-	-
ADD. 6	11.47	11.47	11.47	-	-	-	-	-
ADD. 7	11.47	11.47	11.47	11.47	-	-	-	-
ADD. 9	11.47	11.47	11.47	11.47	11.47	-	-	-
ADD. 11	11.47	11.47	11.47	11.47	11.47	11.47	-	-
ADD. 13	11.47	11.47	11.47	11.47	11.47	11.47	11.47	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive Asphalt, %	ADD. 0 90.00	ADD. 1 92.50	ADD. 2 97.50	ADD. 6 91.50	ADD. 7 95.00	ADD. 9 96.50	ADD. 11 95.00	ADD. 13 95.00
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-0.218	-	-	-	-	-	-	-
ADD. 2	-0.654	-0.436	-	-	-	-	-	-
ADD. 6	-0.131	0.087	0.523	-	-	-	-	-
ADD. 7	-0.436	-0.218	0.218	-0.305	-	-	-	-
ADD. 9	-0.567	-0.349	0.087	-0.436	-0.131	-	-	-
ADD. 11	-0.436	-0.218	0.218	-0.305	0.000	0.131	-	-
ADD. 13	-0.436	-0.218	0.218	-0.305	0.000	0.131	0.000	-

Results significant at 5%(t=2.120, d.f.=16).

+Significant according to the Bonferroni method with 5% error rate(t+=3.736).

TABLE 1.56 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR BOILING TEST, DISTRICT 19

Laboratory Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive Standard Error	ADD. 0 7.74	ADD. 1 7.74	ADD. 2 7.74	ADD. 4 7.74	ADD. 5 7.74	ADD. 12 7.74
ADD. 0	-	-	-	-	-	-
ADD. 1	10.95	-	-	-	-	-
ADD. 2	10.95	10.95	-	-	-	-
ADD. 4	10.95	10.95	10.95	-	-	-
ADD. 5	10.95	10.95	10.95	10.95	-	-
ADD. 12	10.95	10.95	10.95	10.95	10.95	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive Asphalt, %	ADD. 0 85.0	ADD. 1 94.0	ADD. 2 92.5	ADD. 4 92.5	ADD. 5 92.5	ADD. 12 92.5
ADD. 0	-	-	-	-	-	-
ADD. 1	-0.822	-	-	-	-	-
ADD. 2	-0.685	0.137	-	-	-	-
ADD. 4	-0.685	0.137	0.000	-	-	-
ADD. 5	-0.685	0.137	0.000	0.000	-	-
ADD. 12	-0.685	0.137	-0.000	0.000	0.000	-

Plant Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive Standard Error	ADD. 0 7.74	ADD. 1 7.74	ADD. 2 7.74	ADD. 4 7.74	ADD. 5 7.74	ADD. 12 7.74
ADD. 0	-	-	-	-	-	-
ADD. 1	10.95	-	-	-	-	-
ADD. 2	10.95	10.95	-	-	-	-
ADD. 4	10.95	10.95	10.95	-	-	-
ADD. 5	10.95	10.95	10.95	10.95	-	-
ADD. 12	10.95	10.95	10.95	10.95	10.95	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive Asphalt, %	ADD. 0 85.0	ADD. 1 90.0	ADD. 2 90.0	ADD. 4 94.0	ADD. 5 96.5	ADD. 12 90.0
ADD. 0	-	-	-	-	-	-
ADD. 1	-0.457	-	-	-	-	-
ADD. 2	-0.457	0.000	-	-	-	-
ADD. 4	-0.822	-0.365	-0.365	-	-	-
ADD. 5	-1.051	-0.594	-0.594	-0.228	-	-
ADD. 12	-0.457	0.000	0.000	0.365	0.594	-

Results significant at 5%(t=2.179,d.f.=12).

+Significant according to the Bonferroni method with 5% error rate(t+=3.654).

TABLE I-57 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR BOILING TEST, DISTRICT 21

Laboratory Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	8.17	-	-	-	-	-	-	-
ADD. 2	8.17	8.17	-	-	-	-	-	-
ADD. 4	8.17	8.17	8.17	-	-	-	-	-
ADD. 6	8.17	8.17	8.17	8.17	-	-	-	-
ADD. 8	8.17	8.17	8.17	8.17	8.17	-	-	-
ADD. 10	8.17	8.17	8.17	8.17	8.17	8.17	-	-
ADD. 12	8.17	8.17	8.17	8.17	8.17	8.17	8.17	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Asphalt, %	37.50	81.00	55.00	77.50	57.50	80.00	65.00	55.00
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-5.322*+	-	-	-	-	-	-	-
ADD. 2	-2.141*	3.181*	-	-	-	-	-	-
ADD. 4	-4.893*+	0.428	-2.753*	-	-	-	-	-
ADD. 6	-2.447*	2.875*	-0.306	2.447*	-	-	-	-
ADD. 8	-5.199*+	0.122	-3.058*	-0.306	-2.753*	-	-	-
ADD. 10	-3.364*	1.957	-1.223	1.529	-0.918	1.835	-	-
ADD. 12	-2.141*	3.181*	0.000	2.753*	0.306	3.058*	1.223	-

Plant Mixture: (a) Standard Error of the Difference Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error	5.78	5.78	5.78	5.78	5.78	5.78	5.78	5.78
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	8.17	-	-	-	-	-	-	-
ADD. 2	8.17	8.17	-	-	-	-	-	-
ADD. 4	8.17	8.17	8.17	-	-	-	-	-
ADD. 6	8.17	8.17	8.17	8.17	-	-	-	-
ADD. 8	8.17	8.17	8.17	8.17	8.17	-	-	-
ADD. 10	8.17	8.17	8.17	8.17	8.17	8.17	-	-
ADD. 12	8.17	8.17	8.17	8.17	8.17	8.17	8.17	-

(b) Pairwise Student-t Test Results Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Asphalt, %	25.00	37.50	57.50	67.50	52.50	75.00	67.50	61.00
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-1.529	-	-	-	-	-	-	-
ADD. 2	-3.976*+	-2.447*	-	-	-	-	-	-
ADD. 4	-5.199*+	-3.670*	-1.223	-	-	-	-	-
ADD. 6	-3.364*	-1.835	0.612	1.835	-	-	-	-
ADD. 8	-6.117*+	-4.588*+	-2.141*	-0.918	-2.753*	-	-	-
ADD. 10	-5.199*+	-3.670*	-1.223	0.000	-1.835	0.918	-	-
ADD. 12	-4.404*+	-2.875*	-0.428	0.795	-1.040	1.713	0.795	-

Results significant at 5%(t=2.120, d.f.=16).

+Significant according to the Bonferroni method with 5% error rate(t+=3.736).

TABLE I.58 SUMMARY OF RESULTS OF LINEAR REGRESSION ANSLYSIS FOR MULTIPLE FREEZE-THAW CYCLIC TEST

District	Additive Name	TSR at Cycle One		Rate of Deterioration		R-Square
		TSR, %	Standard Error	TSR, %/Cycle	Standard Error	
17	No Additive	46	2.87	3.57	0.499	0.94
	Lime	102	6.44	2.88	1.122	0.69
	BA 2000	82	5.61	3.50	0.977	0.81
	Perma-Tac	75	1.68	3.05	0.292	0.97
16	No Additive	56	6.75	3.14	1.175	0.70
	Lime	115	7.55	7.14	1.314	0.91
	Aquashield	80	4.54	3.13	0.790	0.84
	Dow	65	4.59	4.26	0.799	0.90
	Pavebond LP	75	7.63	4.32	1.329	0.78
13	No Additive	73	6.94	5.85	1.208	0.89
	Lime	114	6.74	2.33	1.173	0.57
	BA 2000	118	15.49	6.60	2.696	0.67
	Perma-Tac Plus	104	10.66	3.05	1.855	0.47
6	No Additive	48	14.83	5.60	2.581	0.61
	Lime	103	6.97	6.75	1.213	0.91
	Pavebond LP	52	5.97	4.30	1.039	0.85
	Perma-Tac	51	3.58	3.45	0.624	0.91
	Unichem	59	2.77	4.65	0.482	0.97
25	No Additive	62	9.60	5.70	1.671	0.79
	Lime	111	8.03	3.10	1.398	0.62
	Aquashield II	97	7.57	2.85	1.318	0.61
	Fina-A	93	6.72	2.40	1.170	0.58
	Perma-Tac	81	3.27	4.40	0.569	0.95
	Unichem	95	6.36	6.05	1.107	0.91
1	No Additive	86	4.94	7.09	0.860	0.96
	Lime	118	6.83	4.21	1.188	0.81
	ARR-MAZ	121	4.25	4.29	0.740	0.92
	Dow	87	2.56	7.20	0.446	0.99
	Fina-A	112	5.15	4.02	0.896	0.87
	Indulin AS-1	108	1.82	3.63	0.317	0.98
	Pavebond Special	129	5.20	4.00	0.906	0.87
	Perma-Tac Plus	108	6.11	5.60	1.064	0.90
19	No Additive	101	15.71	8.16	2.734	0.75
	Lime	159	17.41	8.53	3.031	0.73
	ARR-MAZ	114	10.54	6.40	1.834	0.80
	Aquashield II	123	9.14	2.68	1.591	0.49
	BA 2000	125	5.12	5.70	0.891	0.93
	Perma-Tac	104	7.38	6.32	1.284	0.89
21	No Additive	30	5.20	2.20	0.904	0.66
	Lime	117	4.82	5.34	0.839	0.93
	ARR-MAZ	60	3.21	2.60	0.558	0.89
	Aquashield II	70	2.37	2.70	0.412	0.93
	Dow	41	6.61	3.10	1.151	0.71
	Fina-B	80	0.77	2.97	0.135	0.99
	Pavebond LP	58	5.14	1.80	0.896	0.57
	Perma-Tac	56	6.29	3.25	1.096	0.75

TABLE I.59 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR MULTIPLE FREEZE-THAW CYCLIC TEST, DISTRICT 17

RATE OF DETERIORATION:

(a) Standard Error of the Difference in TSR/Cycle Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
Standard Error	0.499	1.122	0.977	0.292
ADD. 0	-	-	-	-
ADD. 1	1.228	-	-	-
ADD. 5	1.097	1.488	-	-
ADD. 12	0.578	1.159	1.020	-

(b) Student-t Test Results of the Difference in Rate of Deterioration Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 12
TSR(%)/CYCLE	3.57	2.88	3.50	3.05
ADD. 0	-	-	-	-
ADD. 1	0.562	-	-	-
ADD. 5	0.064	-0.417	-	-
ADD. 12	0.899	-0.147	0.441	-

Results significant at the 5%(t=3.182, d.f.=3).
+Significant according to the Bonferroni method with the 5% error rate(t+=6.240).

TABLE I.60 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR MULTIPLE FREEZE-THAW CYCLIC TEST, DISTRICT 16

RATE OF DETERIORATION:

(a) Standard Error of the Difference in TSR/Cycle Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
Standard Error	1.175	1.314	0.790	0.799	1.329
ADD. 0	-	-	-	-	-
ADD. 1	1.763	-	-	-	-
ADD. 3	1.416	1.533	-	-	-
ADD. 6	1.421	1.538	1.124	-	-
ADD. 10	1.774	1.869	1.546	1.551	-

(b) Student-t Test Results of the Difference in Rate of Deterioration Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 3	ADD. 6	ADD. 10
TSR(%)/CYCLE	3.14	7.14	3.13	4.26	4.32
ADD. 0	-	-	-	-	-
ADD. 1	-2.269	-	-	-	-
ADD. 3	0.007	2.615	-	-	-
ADD. 6	-0.788	1.873	-1.006	-	-
ADD. 10	-0.665	1.509	-0.770	-0.039	-

Results significant at the 5%(t=3.182, d.f.=3).

+Significant according to the Bonferroni method with the 5% error rate(t+=7.453).

TABLE I.61 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR MULTIPLE FREEZE-THAW CYCLIC TEST, DISTRICT 13

RATE OF DETERIORATION:

(a) Standard Error of the Difference in TSR/Cycle Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
Standard Error	1.208	1.173	2.696	1.855
ADD. 0	-	-	-	-
ADD. 1	1.684	-	-	-
ADD. 5	2.954	2.940	-	-
ADD. 13	2.214	2.195	3.273	-

(b) Student-t Test Results of the Difference in Rate of Deterioration Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 5	ADD. 13
TSR(%)/CYCLE	5.85	2.33	6.60	3.05
ADD. 0	-	-	-	-
ADD. 1	2.091	-	-	-
ADD. 5	-0.254	-1.452	-	-
ADD. 13	1.265	-0.328	1.085	-

Results significant at the 5%(t=3.182, d.f.=3).

+Significant according to the Bonferroni method with the 5% error rate(t+=6.240).

TABLE I.62 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR MULTIPLE FREEZE-THAW CYCLIC TEST, DISTRICT 6

RATE OF DETERIORATION:

(a) Standard Error of the Difference in TSR/Cycle Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
Standard Error	2.581	1.213	1.039	0.624	0.482
ADD. 0	-	-	-	-	-
ADD. 1	2.852	-	-	-	-
ADD. 10	2.782	1.597	-	-	-
ADD. 12	2.655	1.364	1.212	-	-
ADD. 14	2.626	1.305	1.145	0.788	-

(b) Student-t Test Results of the Difference in Rate of Deterioration Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 10	ADD. 12	ADD. 14
TSR(%)/CYCLE	5.60	6.75	4.30	3.45	4.65
ADD. 0	-	-	-	-	-
ADD. 1	-0.403	-	-	-	-
ADD. 10	0.467	1.534	-	-	-
ADD. 12	0.810	2.419	0.701	-	-
ADD. 14	0.362	1.609	-0.306	-1.522	-

Results significant at the 5%(t=3.182, d.f.=3).

+Significant according to the Bonferroni method with the 5% error rate(t+=7.453).

TABLE 1.63 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR MULTIPLE FREEZE-THAW CYCLIC TEST, DISTRICT 25

RATE OF DETERIORATION:

(a) Standard Error of the Difference in TSR/Cycle Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
Standard Error	1.671	1.398	1.318	1.170	0.569	1.107
ADD. 0	-	-	-	-	-	-
ADD. 1	2.179	-	-	-	-	-
ADD. 4	2.128	1.921	-	-	-	-
ADD. 7	2.040	1.823	1.762	-	-	-
ADD. 12	1.765	1.509	1.436	1.301	-	-
ADD. 14	2.004	1.783	1.721	1.611	1.245	-

(b) Student-t Test Results of the Difference in Rate of Deterioration Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 4	ADD. 7	ADD. 12	ADD. 14
TSR(%)/CYCLE	5.70	3.10	2.85	2.40	4.40	6.05
ADD. 0	-	-	-	-	-	-
ADD. 1	1.193	-	-	-	-	-
ADD. 4	1.339	0.130	-	-	-	-
ADD. 7	1.618	0.384	0.255	-	-	-
ADD. 12	0.736	-0.861	-1.080	-1.537	-	-
ADD. 14	-0.175	-1.654	-1.859	-2.266	-1.326	-

Results significant at the 5%(t=3.182, d.f.=3).

+Significant according to the Bonferroni method with the 5% error rate(t+=8.605).

TABLE I.64 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR MULTIPLE FREEZE-THAW CYCLIC TEST, DISTRICT 1

RATE OF DETERIORATION:

(a) Standard Error of the Difference in TSR/Cycle Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
Standard Error		0.860	1.188	0.740	0.446	0.896	0.317	0.906	1.064
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	1.467	-	-	-	-	-	-	-
	ADD. 2	1.135	1.400	-	-	-	-	-	-
	ADD. 6	0.969	1.269	0.864	-	-	-	-	-
	ADD. 7	1.242	1.488	1.162	1.001	-	-	-	-
	ADD. 9	0.917	1.230	0.805	0.547	0.950	-	-	-
	ADD. 11	1.249	1.494	1.170	1.010	1.274	0.960	-	-
	ADD. 13	1.368	1.595	1.296	1.154	1.391	1.110	1.397	-

(b) Student-t Test Results of the Difference in Rate of Deterioration Between Two Additives.

Additive		ADD. 0	ADD. 1	ADD. 2	ADD. 6	ADD. 7	ADD. 9	ADD. 11	ADD. 13
TSR(%)/CYCLE		7.09	4.21	4.29	7.20	4.02	3.63	4.00	5.60
	ADD. 0	-	-	-	-	-	-	-	-
	ADD. 1	1.964	-	-	-	-	-	-	-
	ADD. 2	2.468	-0.057	-	-	-	-	-	-
	ADD. 6	-0.114	-2.356	-3.368	-	-	-	-	-
	ADD. 7	2.472	0.128	0.232	3.177	-	-	-	-
	ADD. 9	3.775	0.472	0.820	6.524	0.410	-	-	-
	ADD. 11	2.474	0.141	0.248	3.169	0.016	-0.385	-	-
	ADD. 13	1.089	-0.872	-1.011	1.387	-1.136	-1.774	-1.145	-

Results significant at the 5%(t=3.182, d.f.=3).

+Significant according to the Bonferroni method with the 5% error rate(t+=10.588).

TABLE I.65 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR MULTIPLE FREEZE-THAW CYCLIC TEST, DISTRICT 19

RATE OF DETERIORATION:

(a) Standard Error of the Difference in TSR/Cycle Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
Standard Error	2.734	3.031	1.834	1.591	0.891	1.284
ADD. 0	-	-	-	-	-	-
ADD. 1	4.082	-	-	-	-	-
ADD. 2	3.292	3.543	-	-	-	-
ADD. 4	3.163	3.423	2.428	-	-	-
ADD. 5	2.876	3.159	2.039	1.824	-	-
ADD. 12	3.020	3.292	2.239	2.044	1.563	-

(b) Student-t Test Results of the Difference in Rate of Deterioration Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 5	ADD. 12
TSR(%)/CYCLE	8.16	8.53	6.40	2.68	5.70	6.32
ADD. 0	-	-	-	-	-	-
ADD. 1	-0.091	-	-	-	-	-
ADD. 2	0.535	0.601	-	-	-	-
ADD. 4	1.732	1.709	1.532	-	-	-
ADD. 5	0.855	0.896	0.343	-1.656	-	-
ADD. 12	0.609	0.671	0.036	-1.780	-0.397	-

Results significant at the 5%(t=3.182, d.f.=3).

+Significant according to the Bonferroni method with the 5% error rate(t+=8.605).

TABLE I.66 SUMMARY OF PAIRWISE COMPARISON STUDENT-t TEST RESULTS FOR MULTIPLE FREEZE-THAW CYCLIC TEST, DISTRICT 21

RATE OF DETERIORATION:

(a) Standard Error of the Difference in TSR/Cycle Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
Standard Error	0.904	0.839	0.558	0.412	1.151	0.135	0.896	1.096
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	1.233	-	-	-	-	-	-	-
ADD. 2	1.062	1.008	-	-	-	-	-	-
ADD. 4	0.993	0.935	0.694	-	-	-	-	-
ADD. 6	1.464	1.424	1.279	1.223	-	-	-	-
ADD. 8	0.914	0.850	0.574	0.434	1.159	-	-	-
ADD. 10	1.273	1.227	1.056	0.986	1.459	0.906	-	-
ADD. 12	1.421	1.380	1.230	1.171	1.589	1.104	1.416	-

(b) Student-t Test Results of the Difference in Rate of Deterioration Between Two Additives.

Additive	ADD. 0	ADD. 1	ADD. 2	ADD. 4	ADD. 6	ADD. 8	ADD. 10	ADD. 12
TSR(%)/CYCLE	2.20	5.34	2.60	2.70	3.10	2.97	1.80	3.25
ADD. 0	-	-	-	-	-	-	-	-
ADD. 1	-2.546	-	-	-	-	-	-	-
ADD. 2	-0.377	2.719	-	-	-	-	-	-
ADD. 4	-0.503	2.824	-0.144	-	-	-	-	-
ADD. 6	-0.615	1.573	-0.391	-0.327	-	-	-	-
ADD. 8	-0.842	2.789	-0.644	-0.623	0.112	-	-	-
ADD. 10	0.314	2.884	0.758	0.913	0.891	1.291	-	-
ADD. 12	-0.739	1.514	-0.529	-0.470	-0.094	-0.254	-1.024	-

Results significant at the 5%(t=3.182, d.f.=3).

+Significant according to the Bonferroni method with the 5% error rate(t+=10.588).

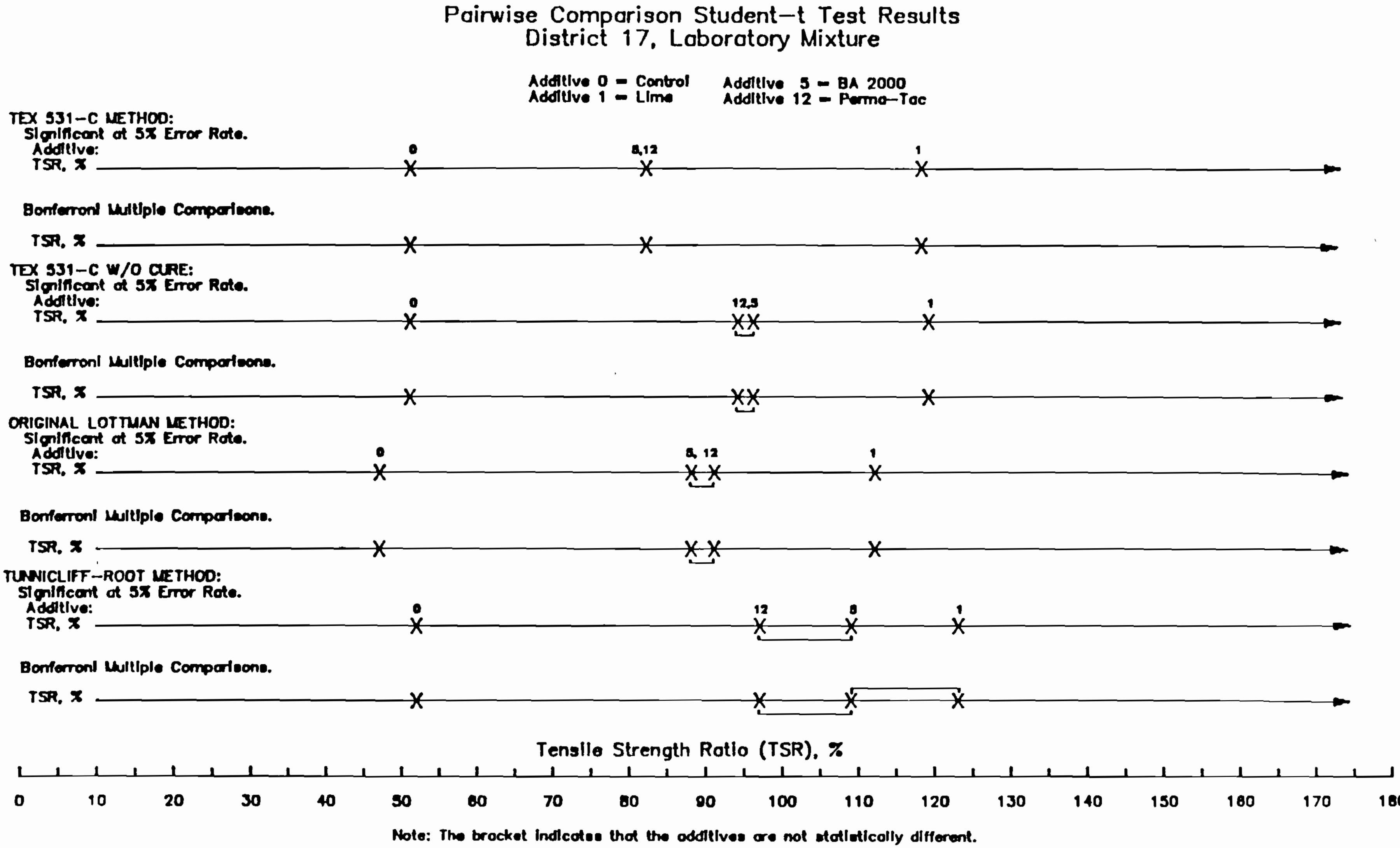


Fig. I-1 Comparison of statistical significance on TSR test results for District 17, laboratory mixture.

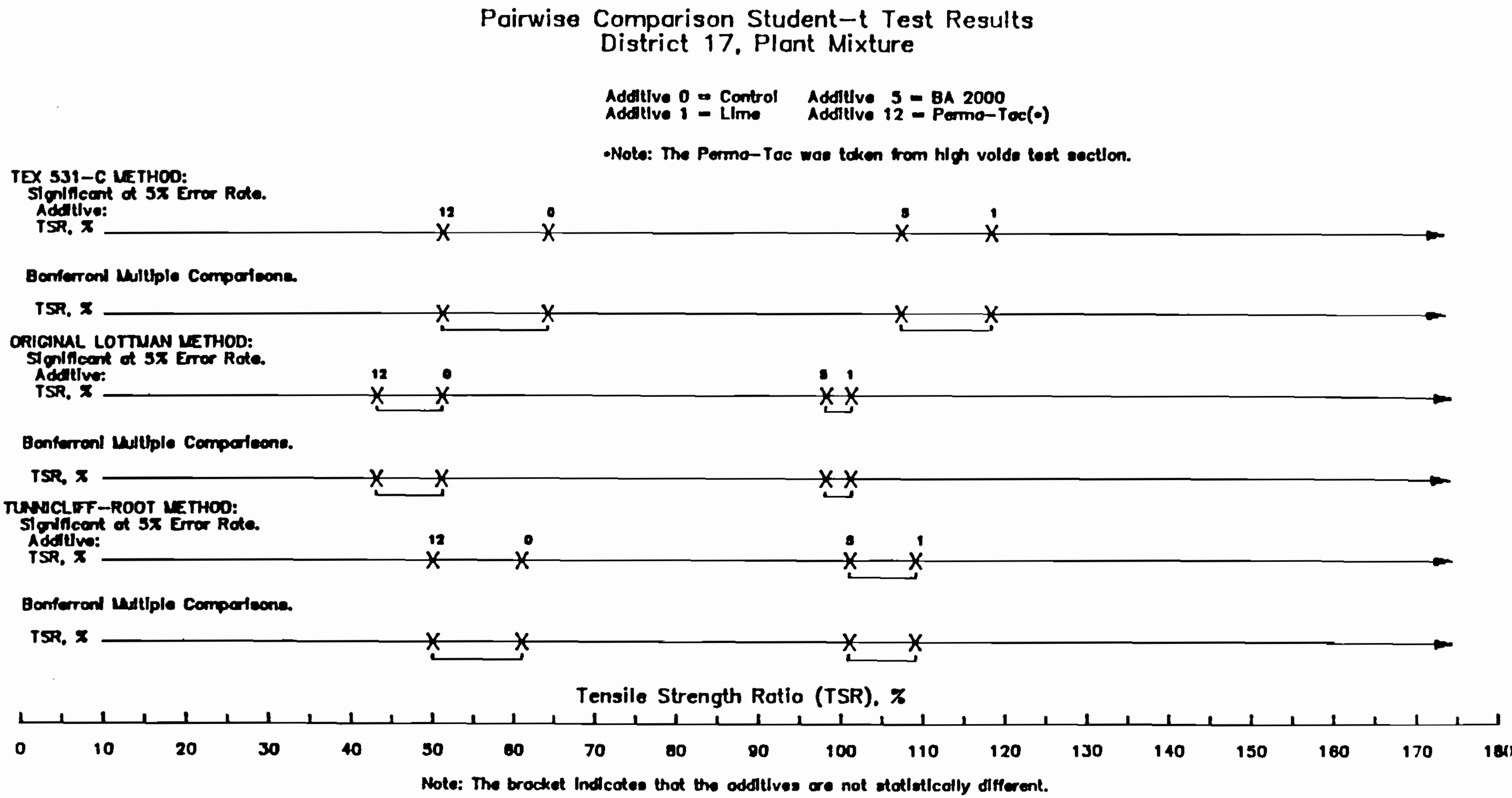


Fig. I-2 Comparison of statistical significance on TSR test results for District 17, plant mixture.

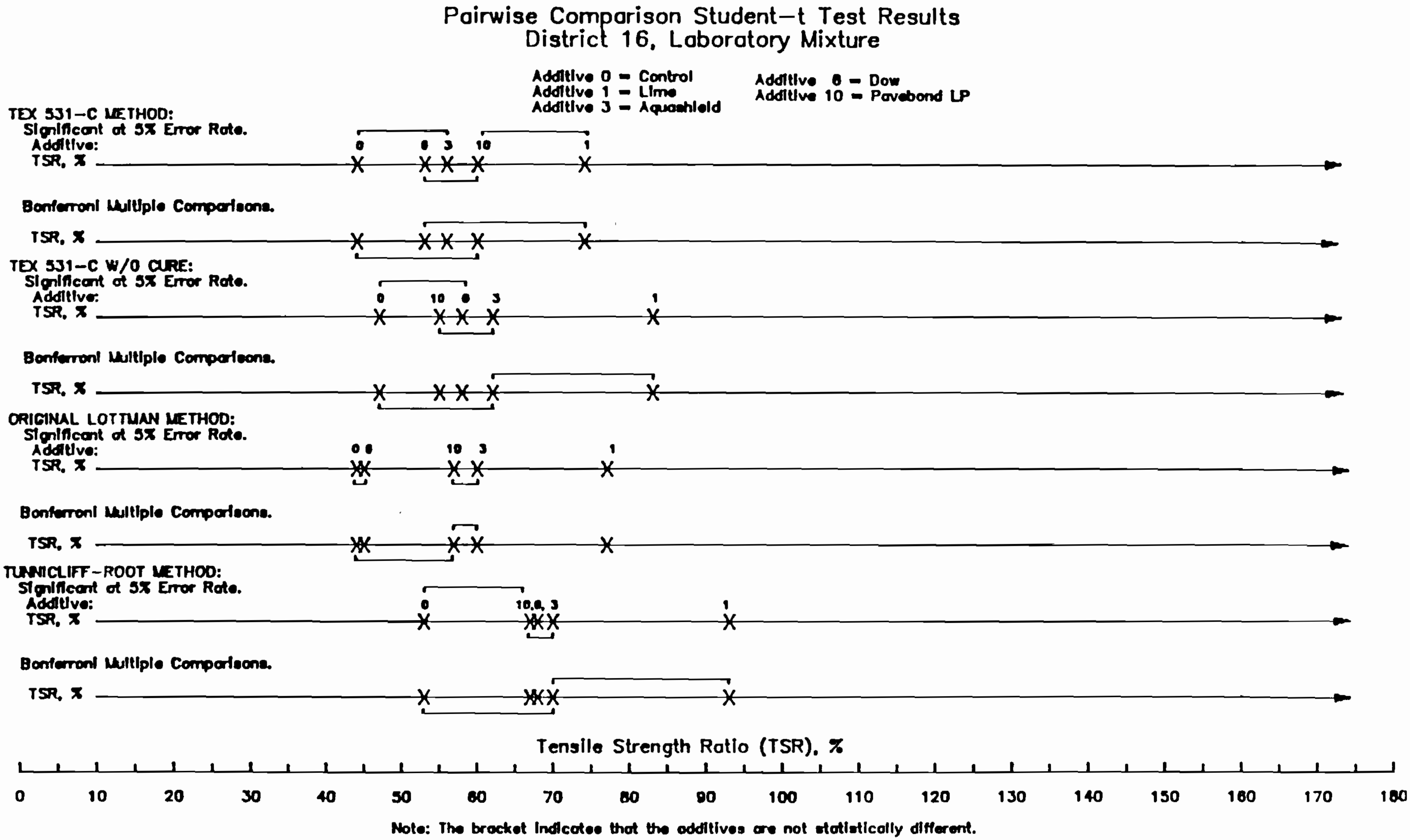


Fig. I-3 Comparison of statistical significance on TSR test results for District 16, laboratory mixture.

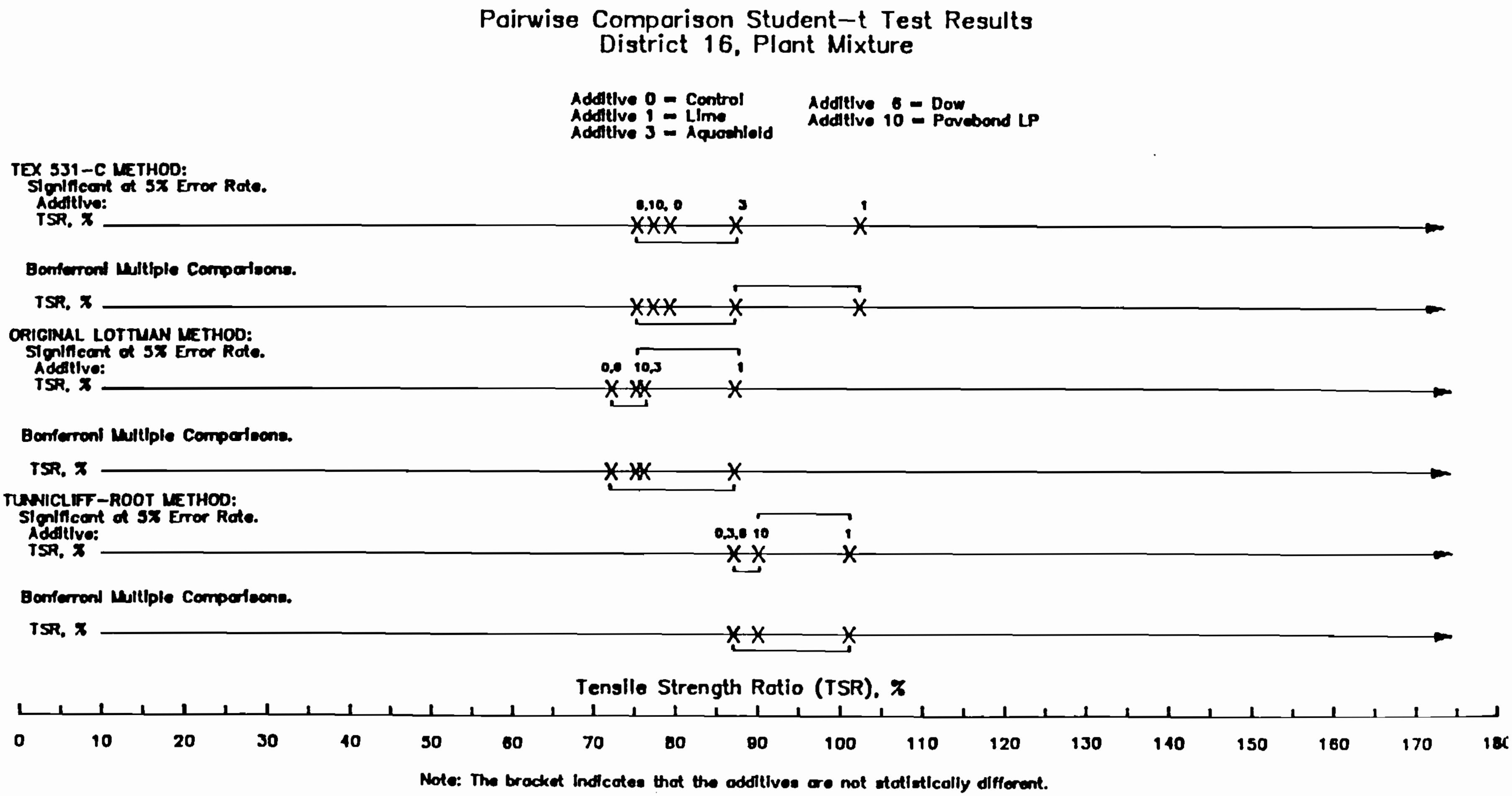


Fig. I-4 Comparison of statistical significance on TSR test results for District 16, plant mixture.

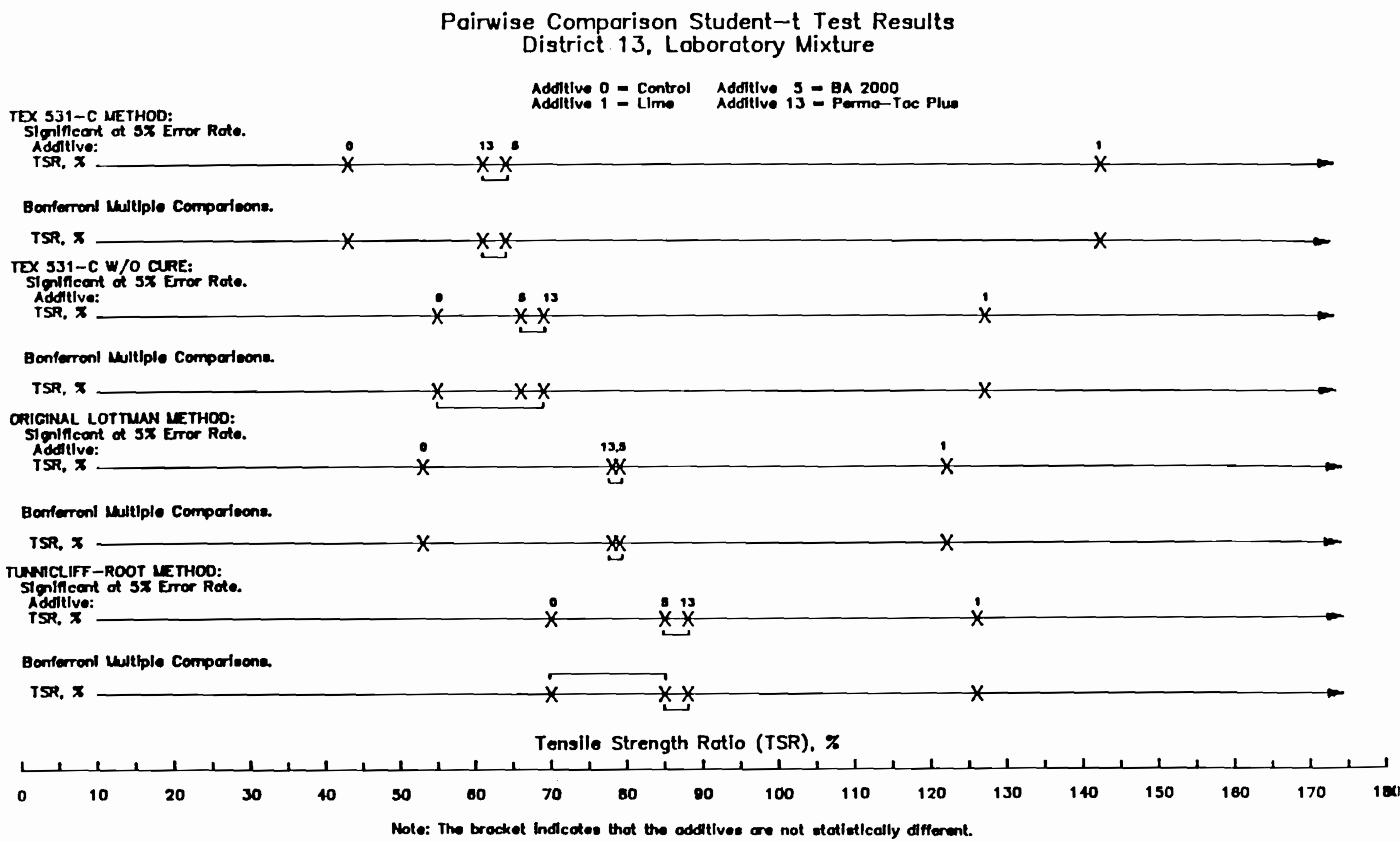


Fig. I-5 Comparison of statistical significance on TSR test results for District 13, laboratory mixture.

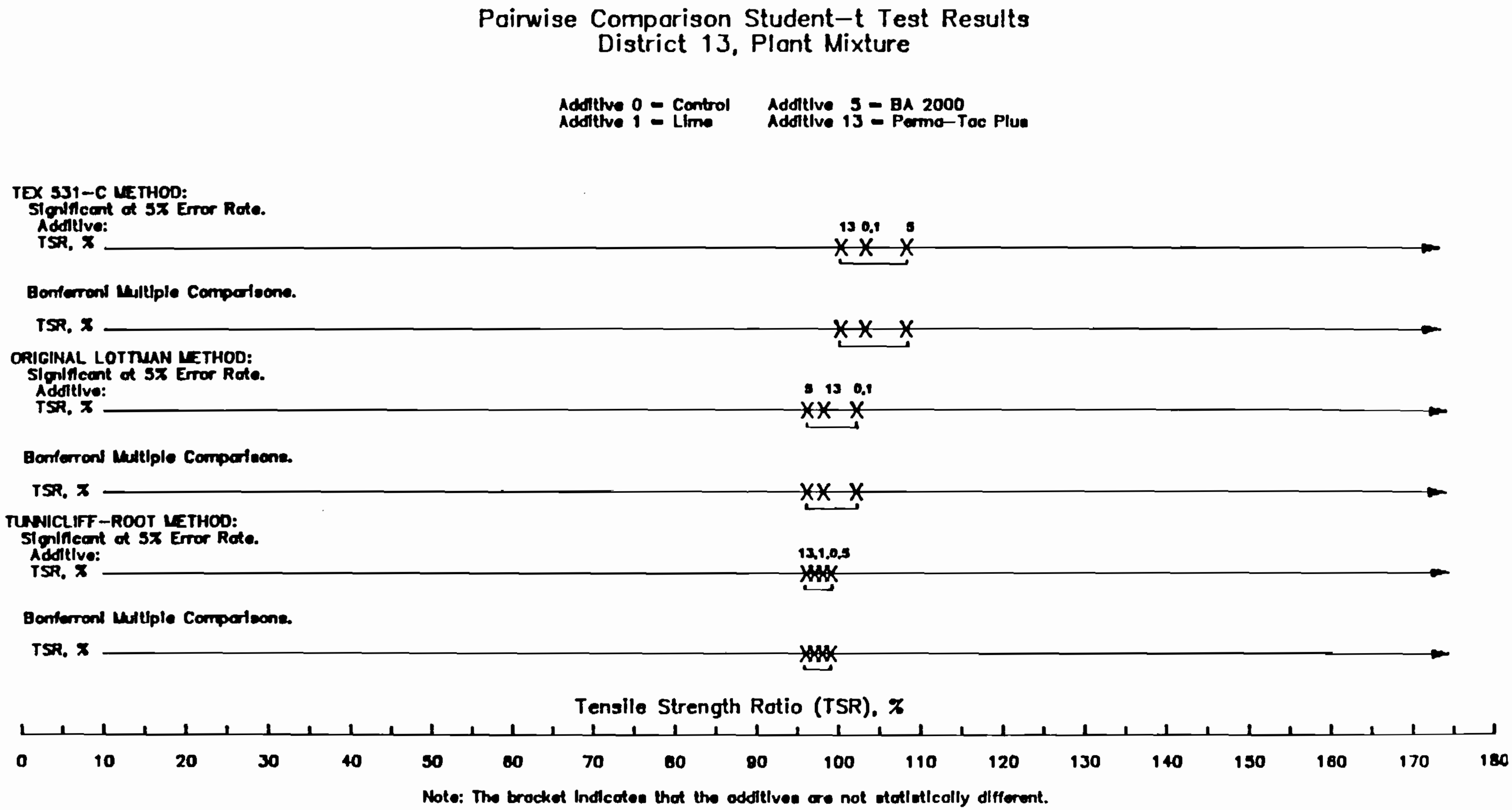


Fig. I-6 Comparison of statistical significance on TSR test results for District 13, plant mixture.

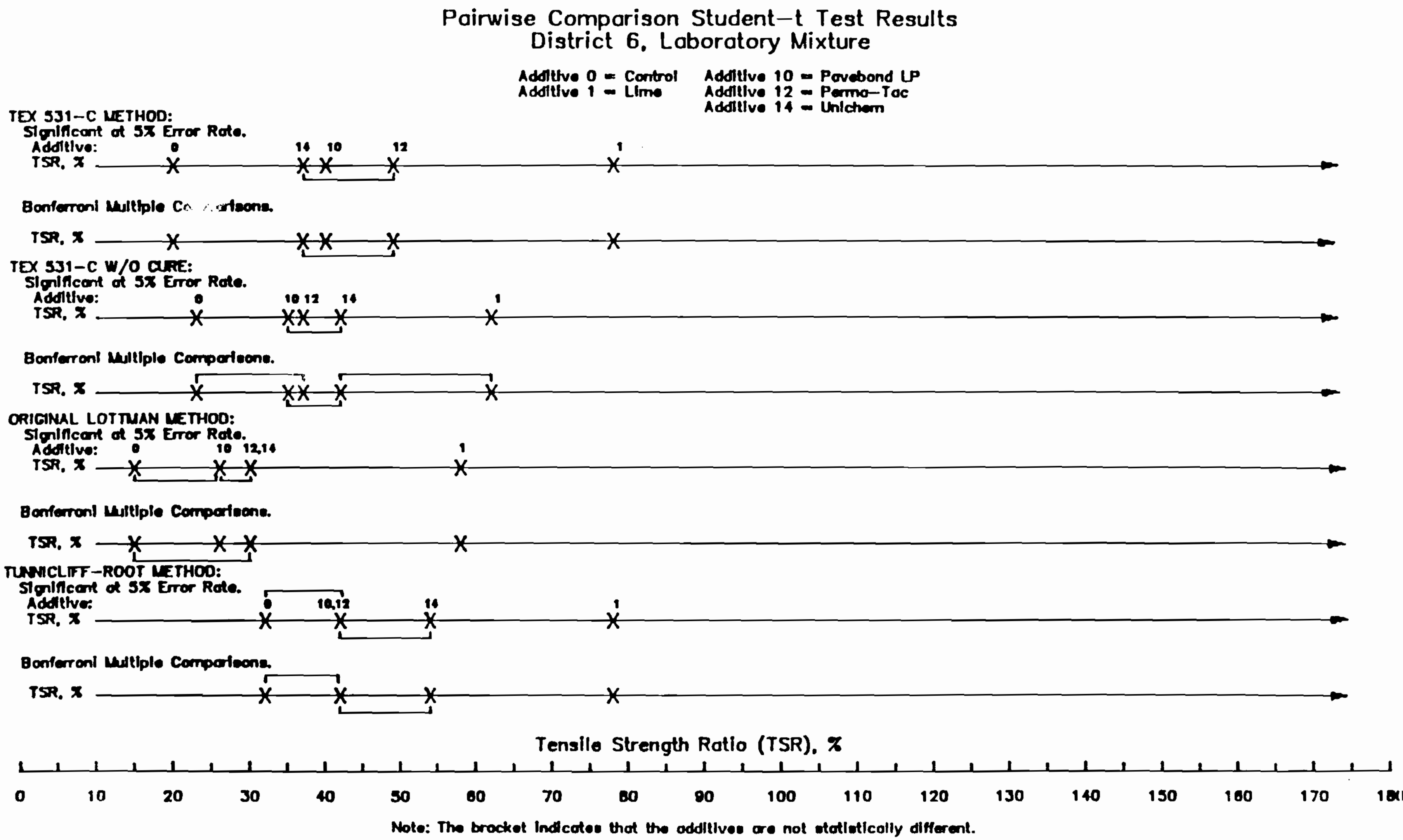


Fig. I-7 Comparison of statistical significance on TSR test results for District 6, laboratory mixtures.

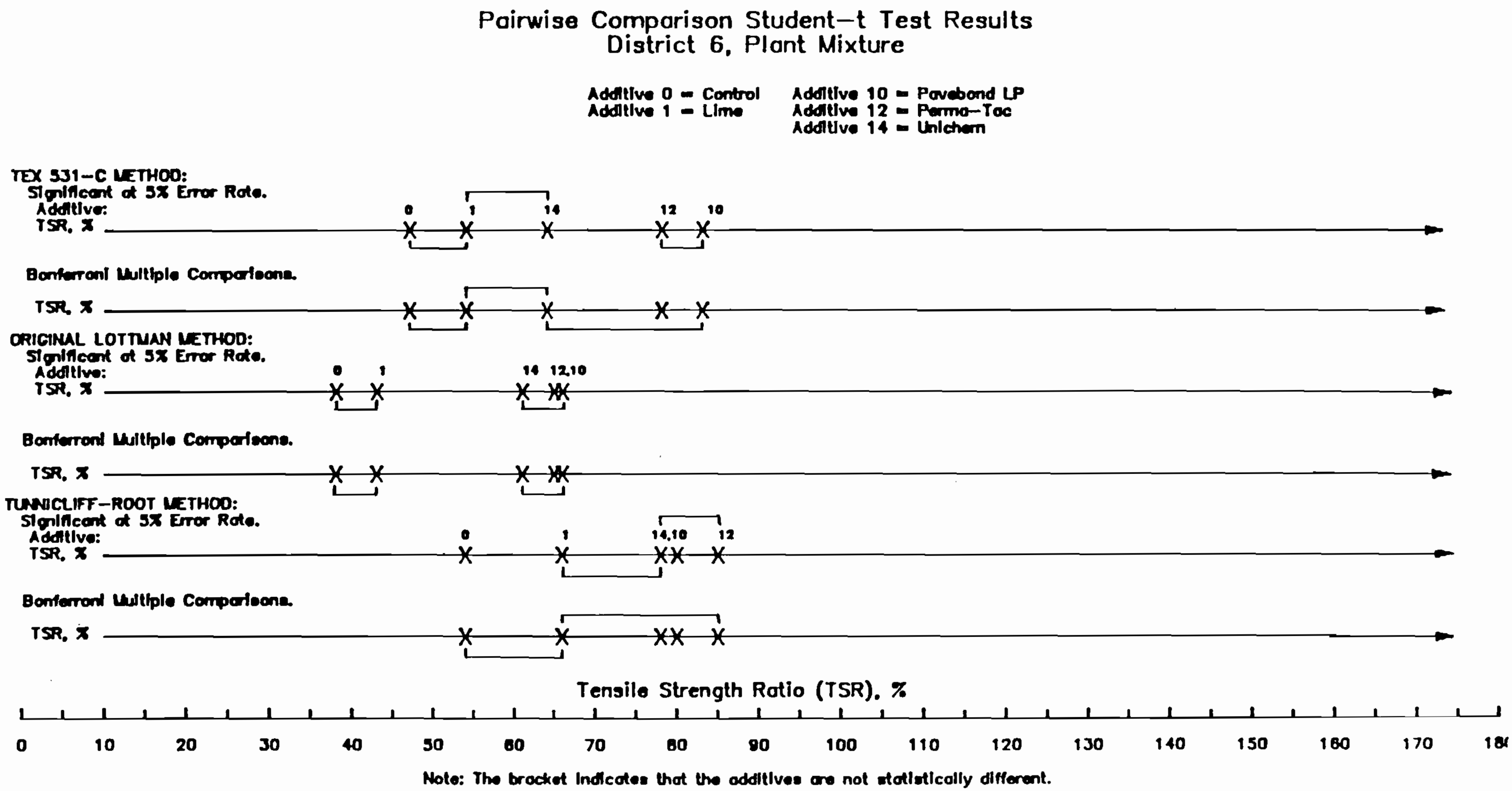


Fig. I-8 Comparison of statistical significance on TSR test results for District 6, plant mixture.

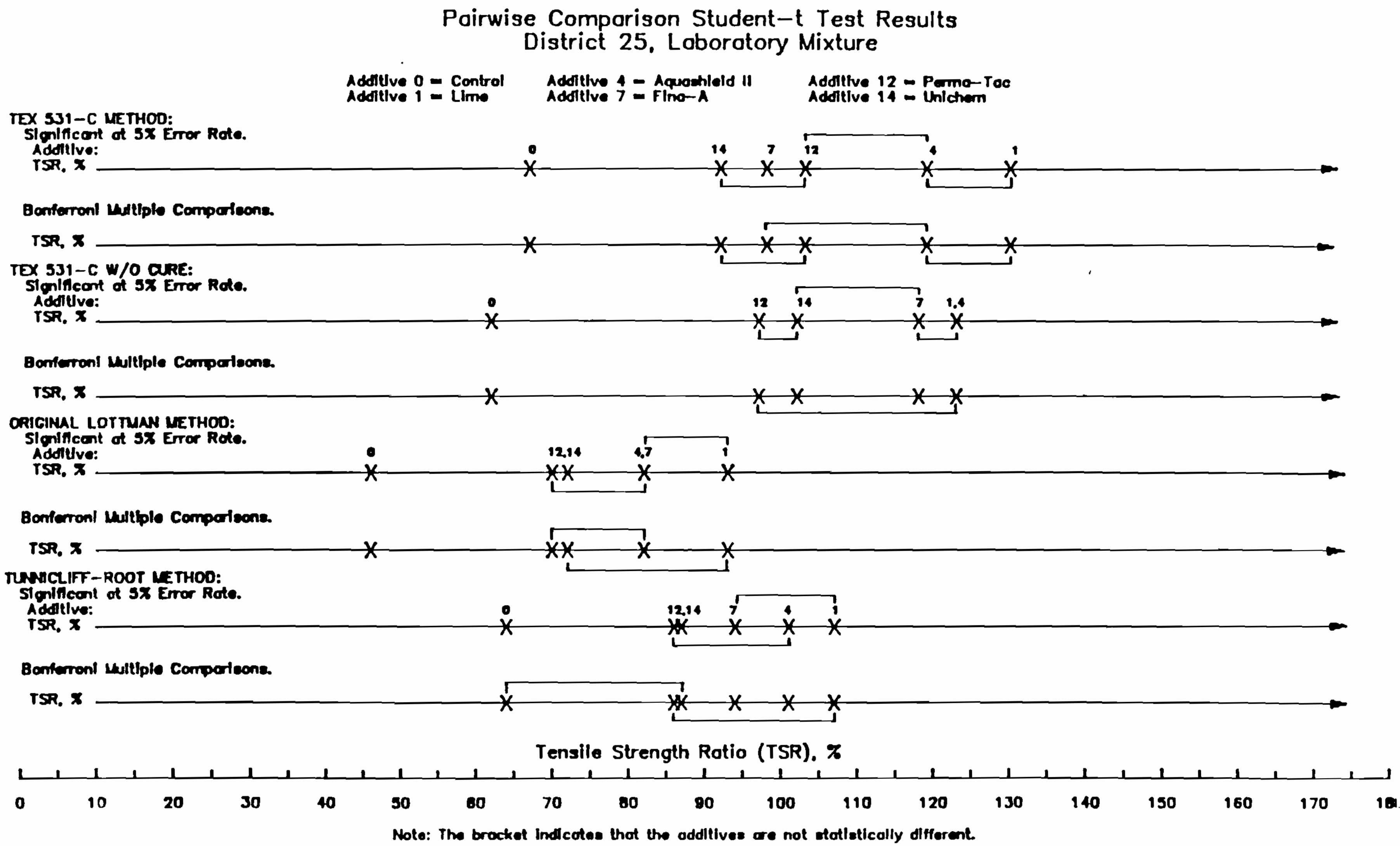


Fig. I-9 Comparison of statistical significance on TSR test results for District 25, laboratory mixture.

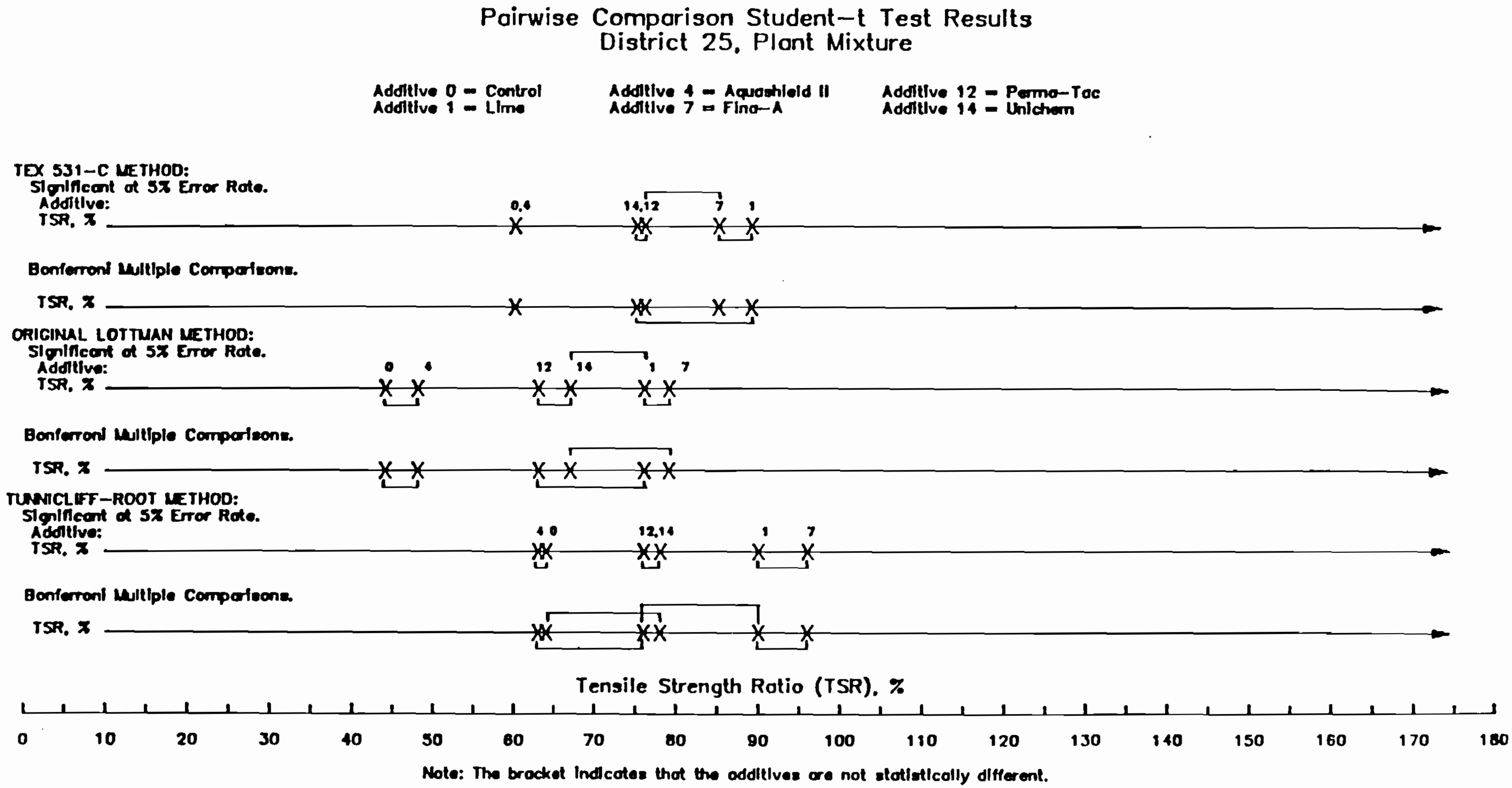


Fig. I-10 Comparison of statistical significance on TSR test results for District 25, plant mixture.

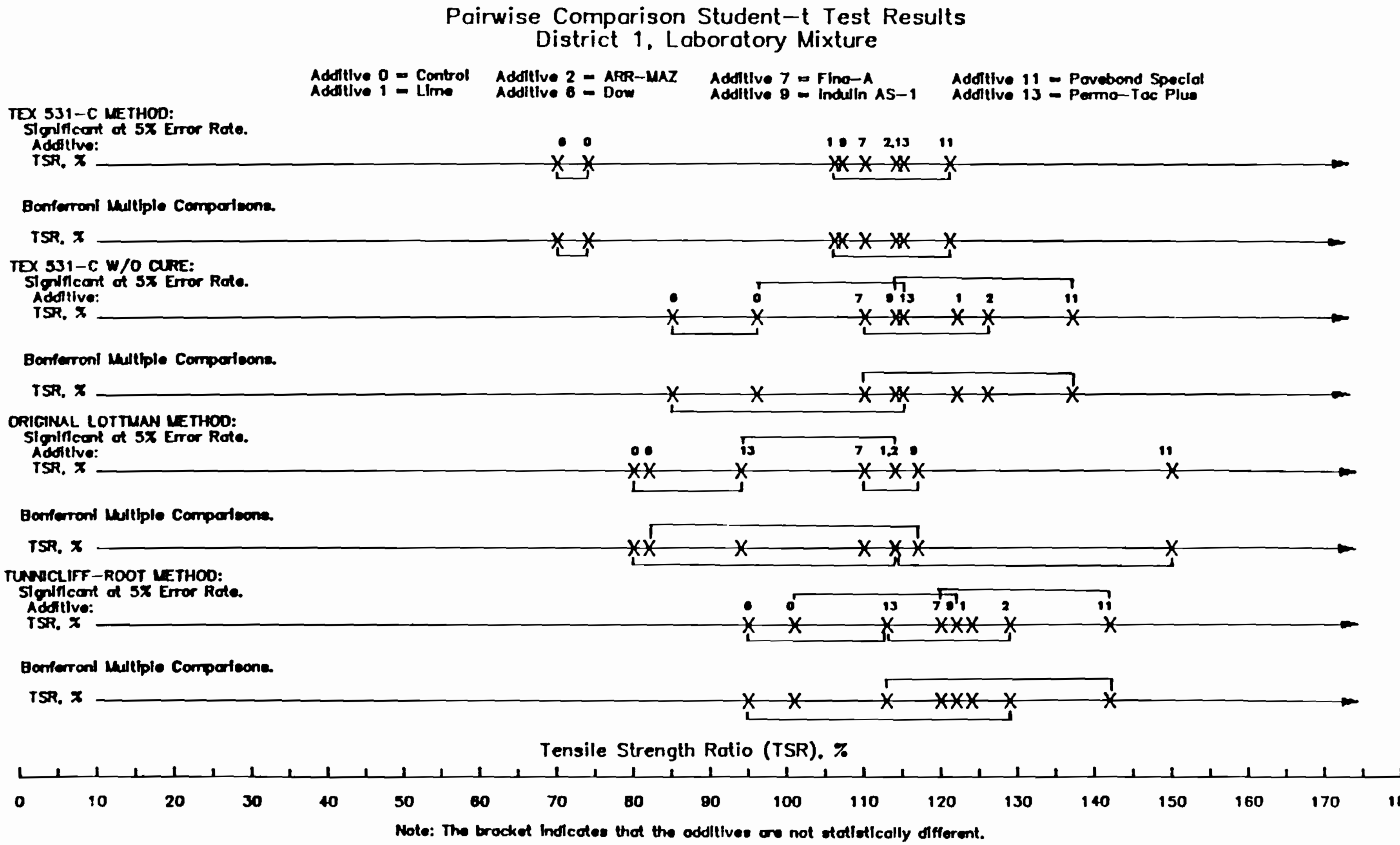


Fig. I-11 Comparison of statistical significance on TSR test results for District 1, laboratory mixture.

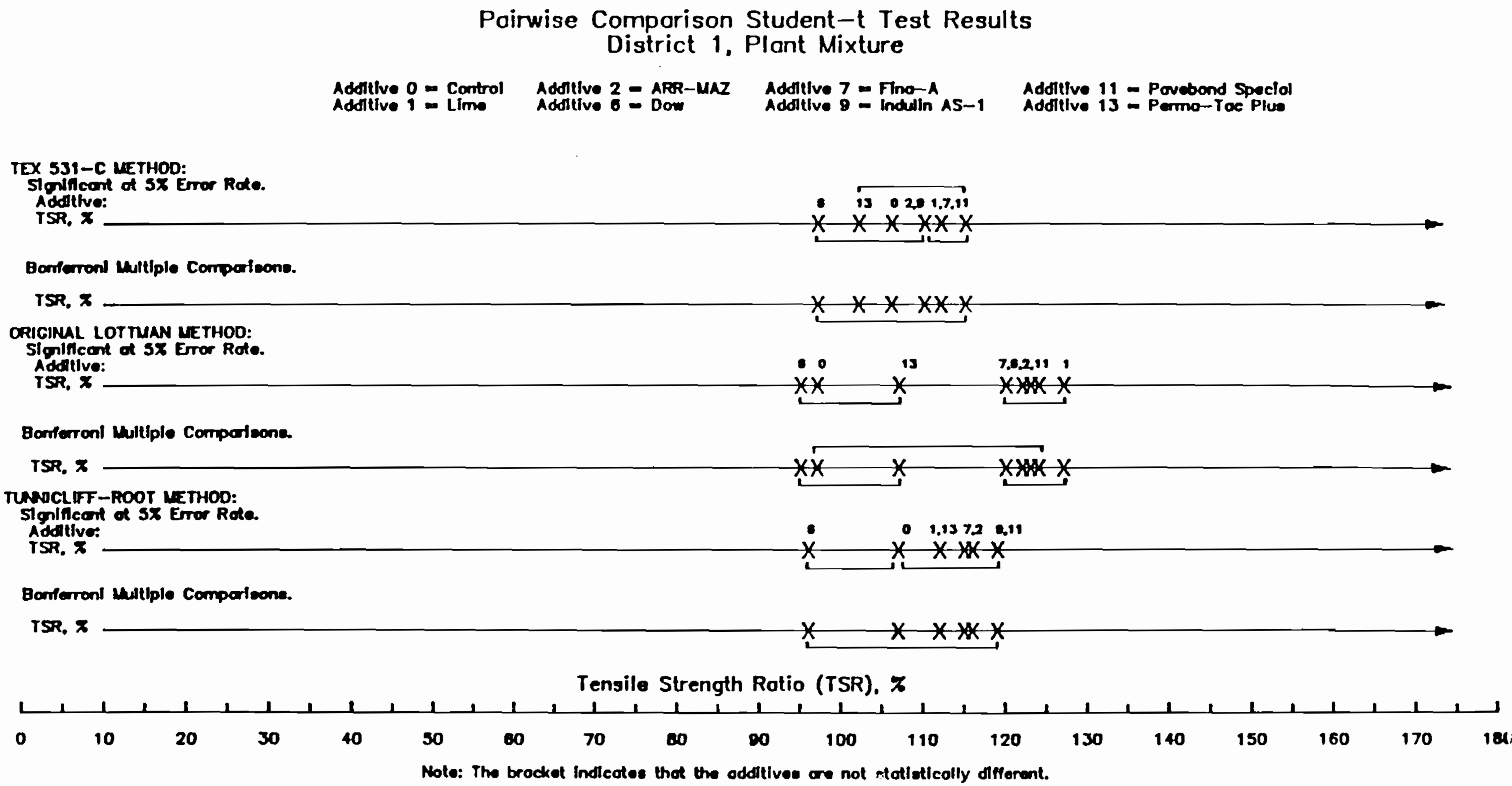


Fig. I-12 Comparison of statistical significance on TSR test results for District 1, plant mixture.

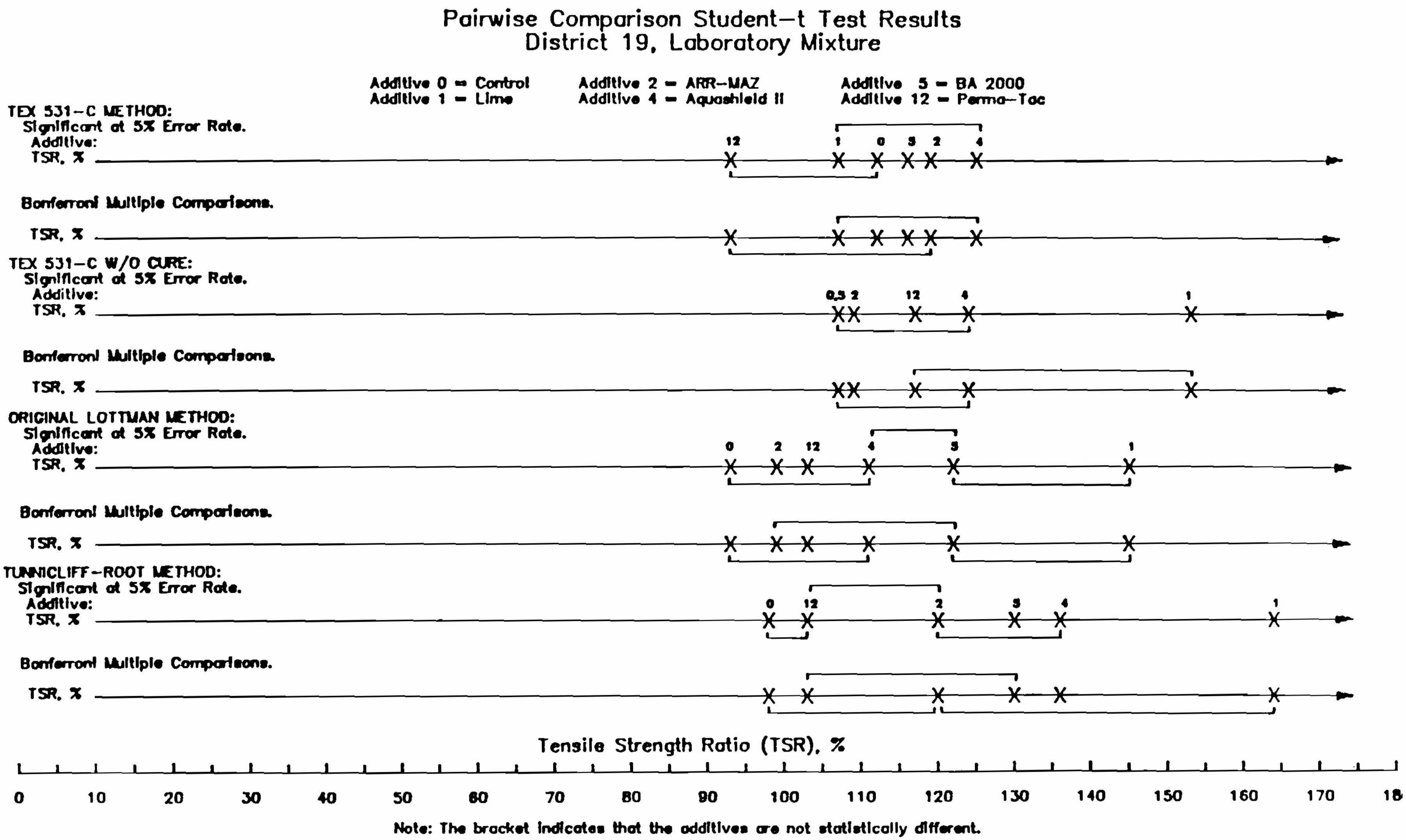


Fig. I-13 Comparison of statistical significance on TSR test reports for District 19, laboratory mixture.

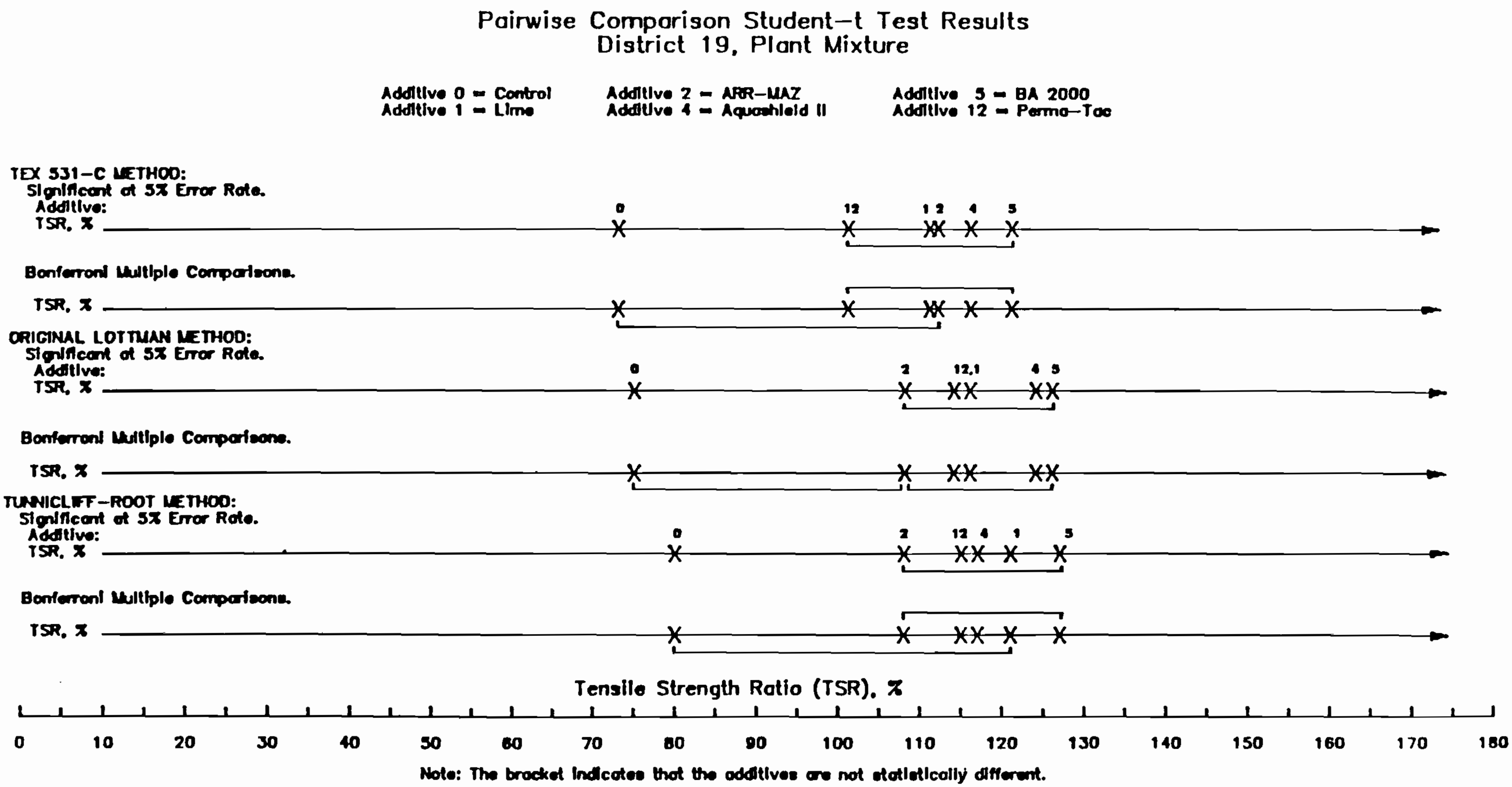


Fig. I-14 Comparison of statistical significance on TSR test results for District 19, plant mixture.

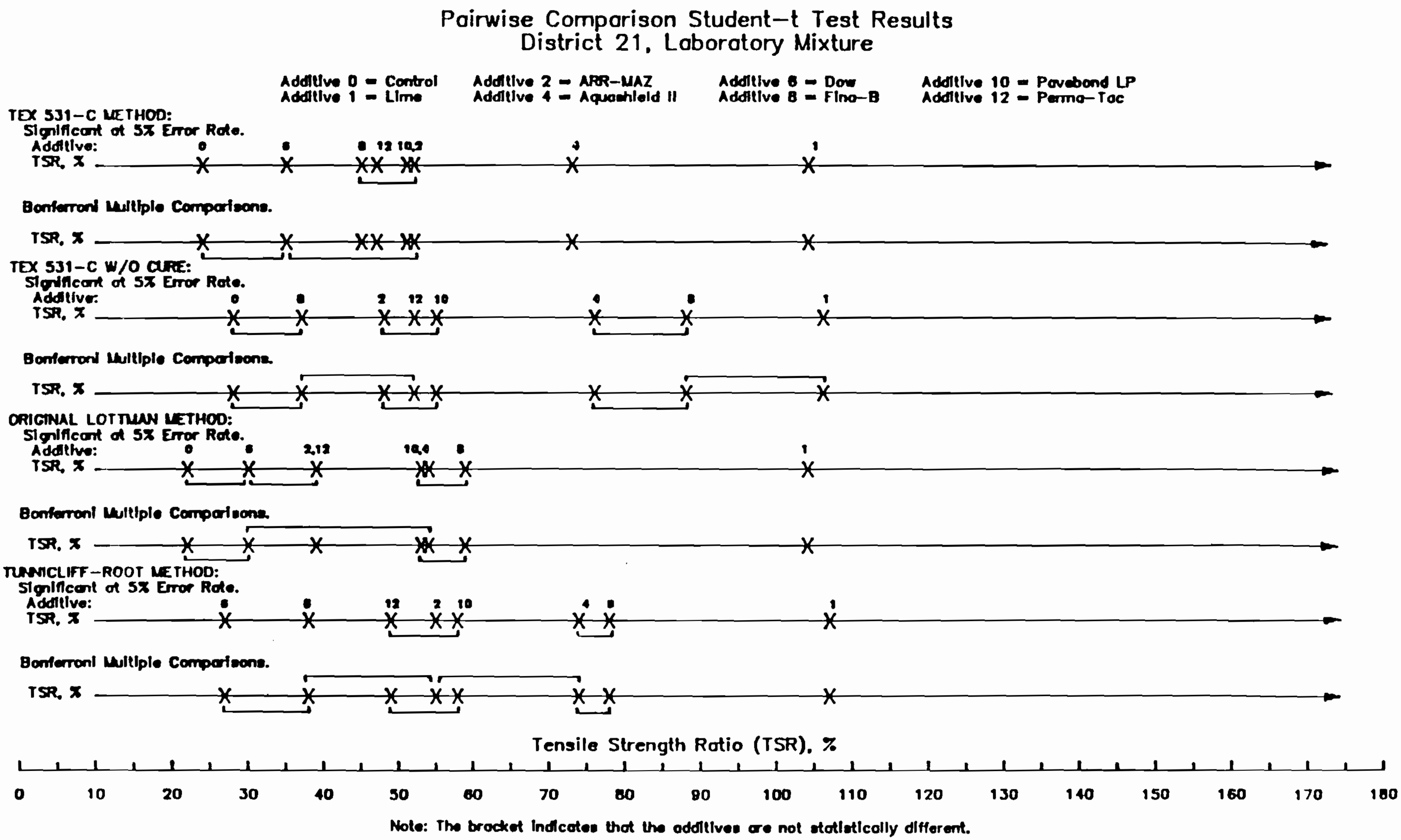


Fig. I-15 Comparison of statistical significance on TSR test results for District 21, laboratory mixture.

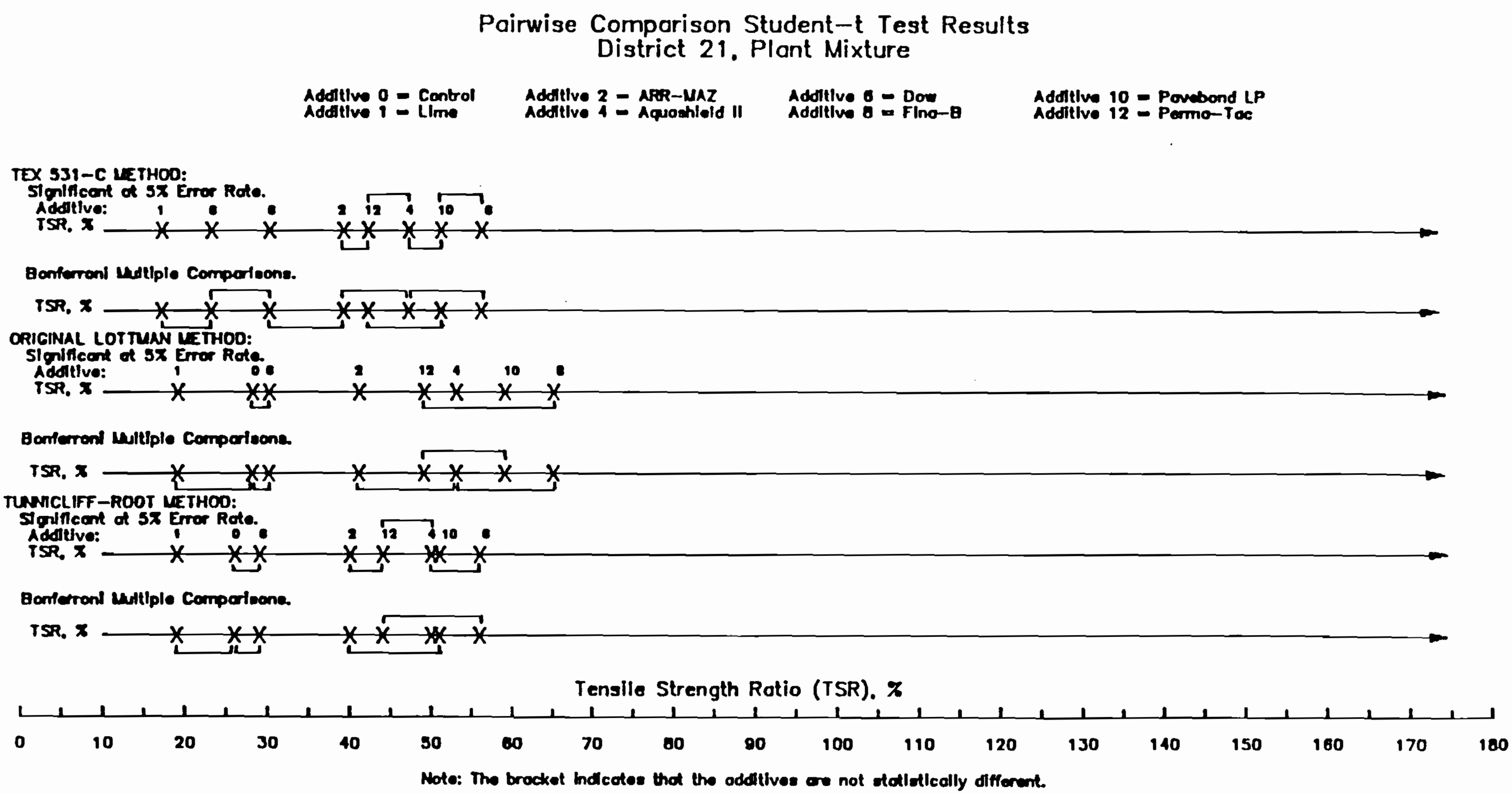


Fig. I-16 Comparison of statistical significance on TSR test results for District 21, plant mixture.

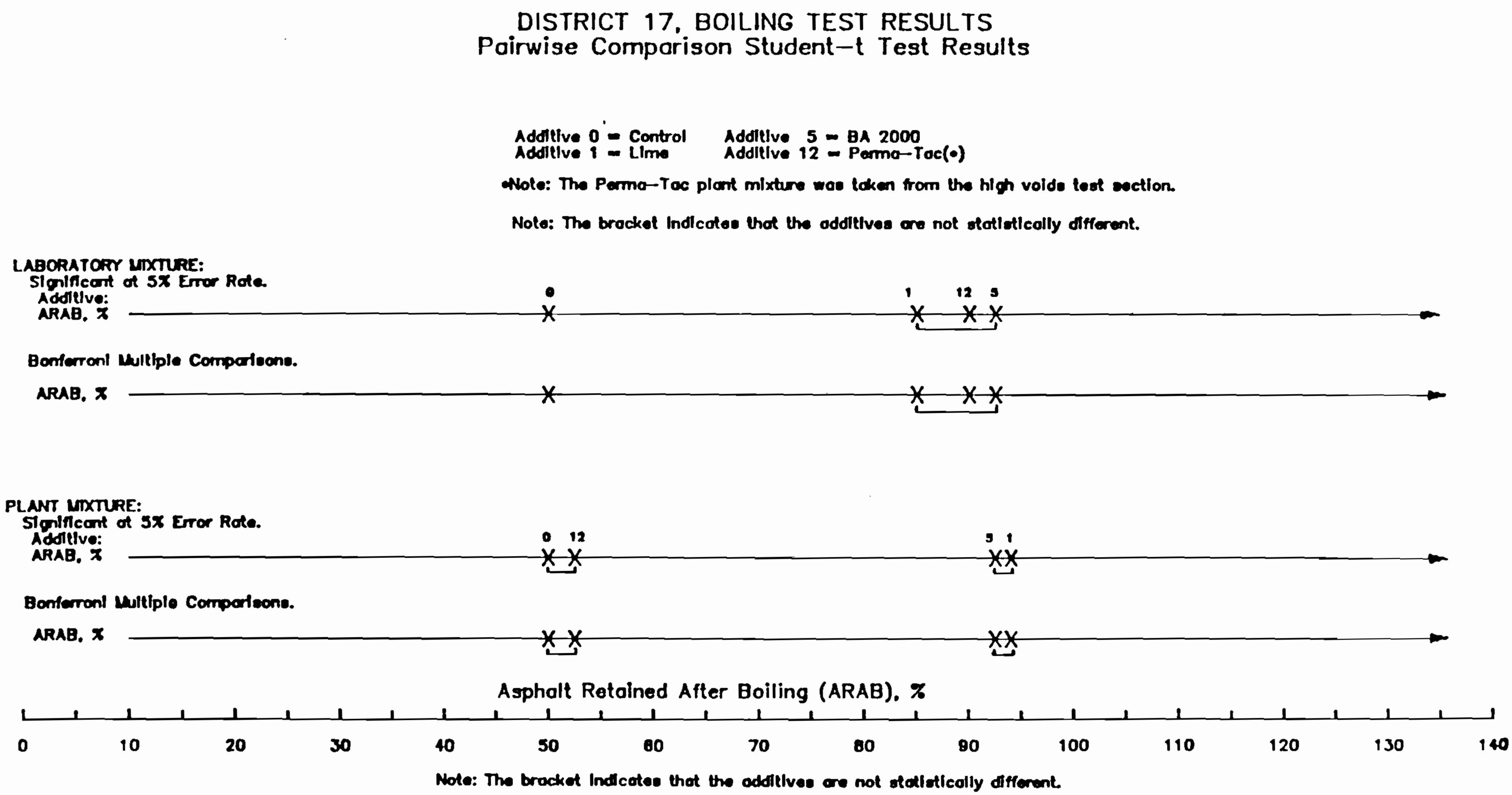


Fig. I-17 Comparison of statistical significance on boiling test results for District 17, laboratory and plant mixtures.

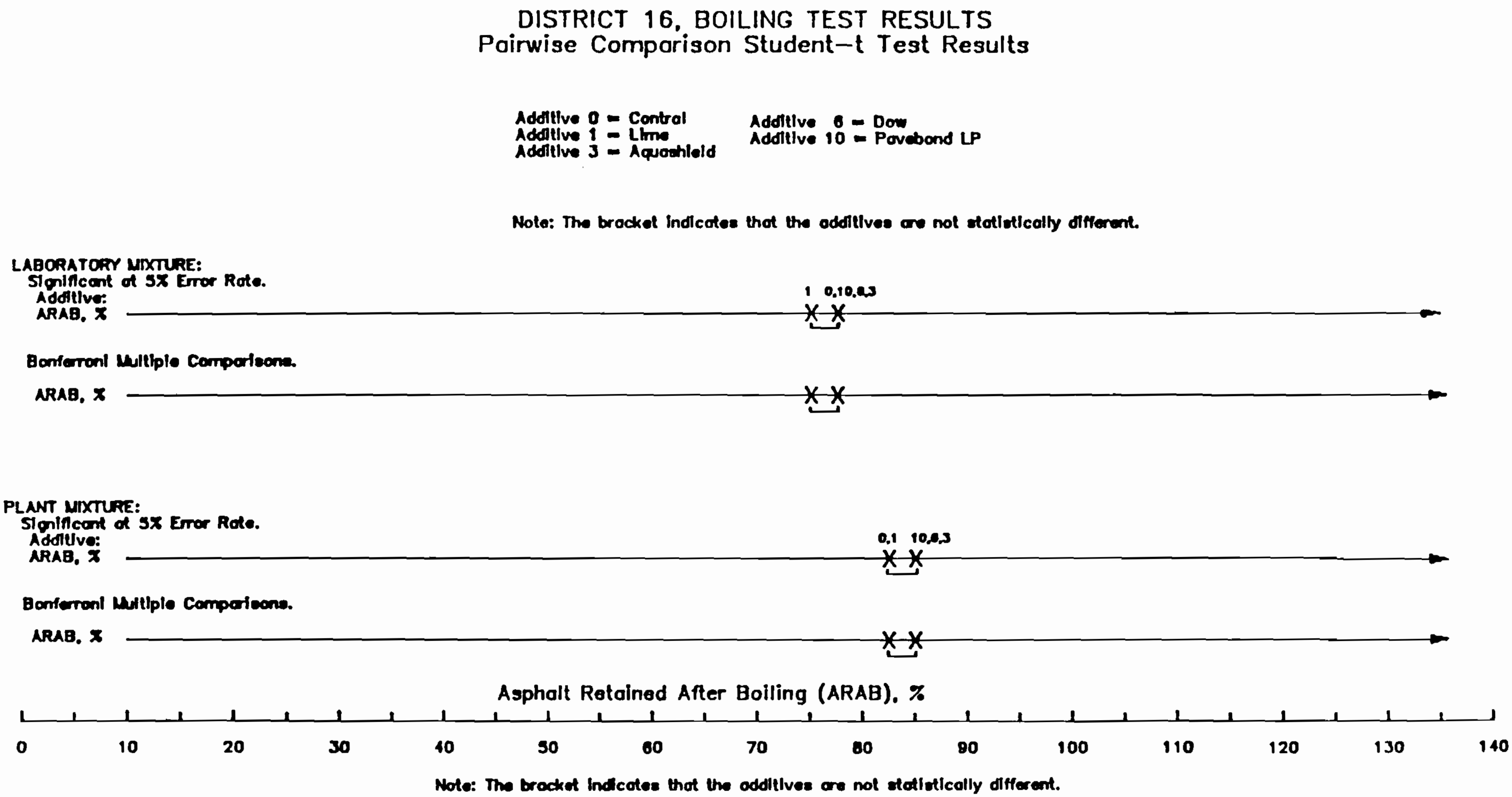


Fig. I-18 Comparison of statistical significance on boiling test results for District 16, laboratory and plant mixtures.

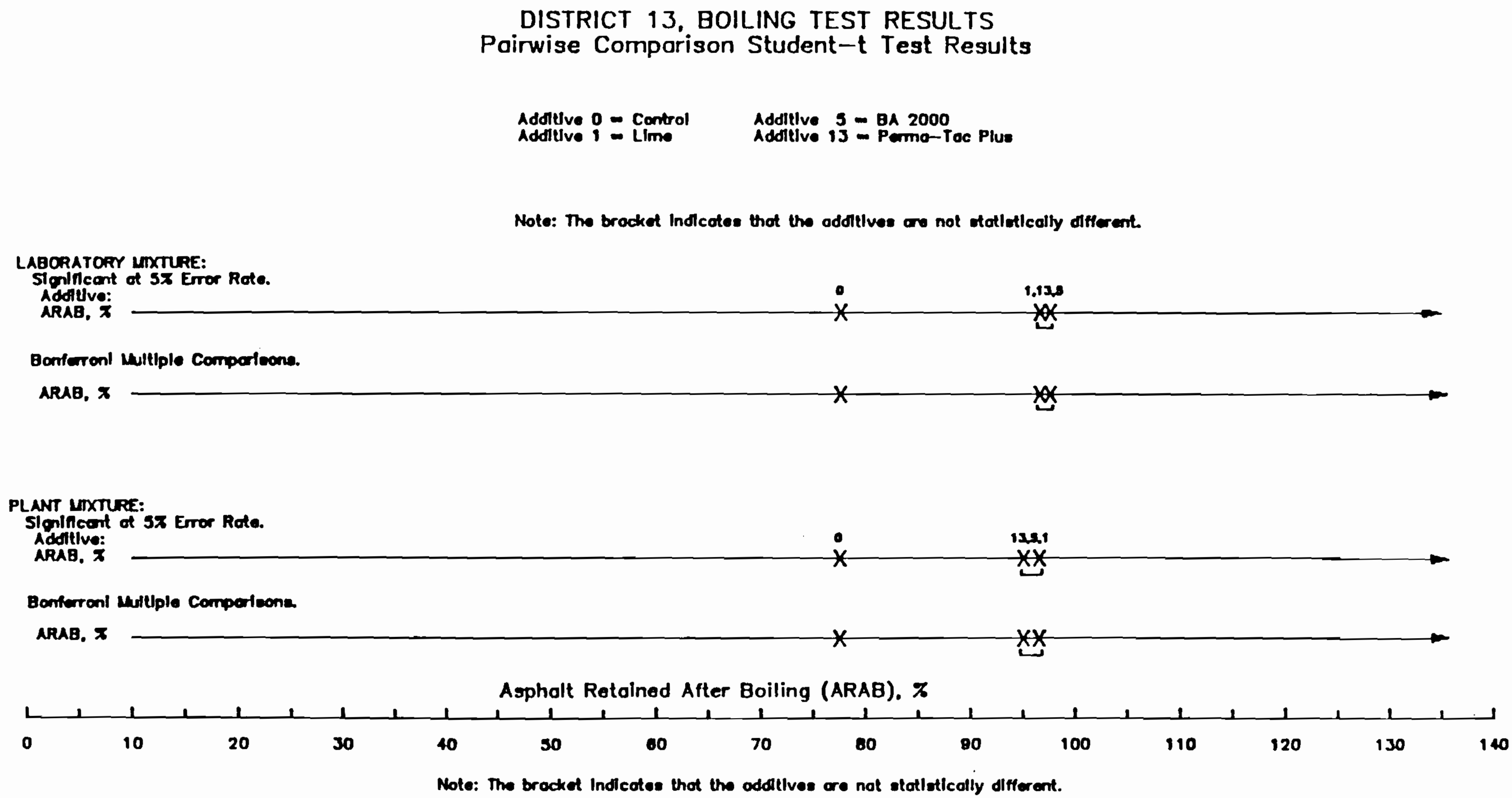


Fig. I-19 Comparison of statistical significance on boiling test results for District 13, laboratory and plant mixtures.

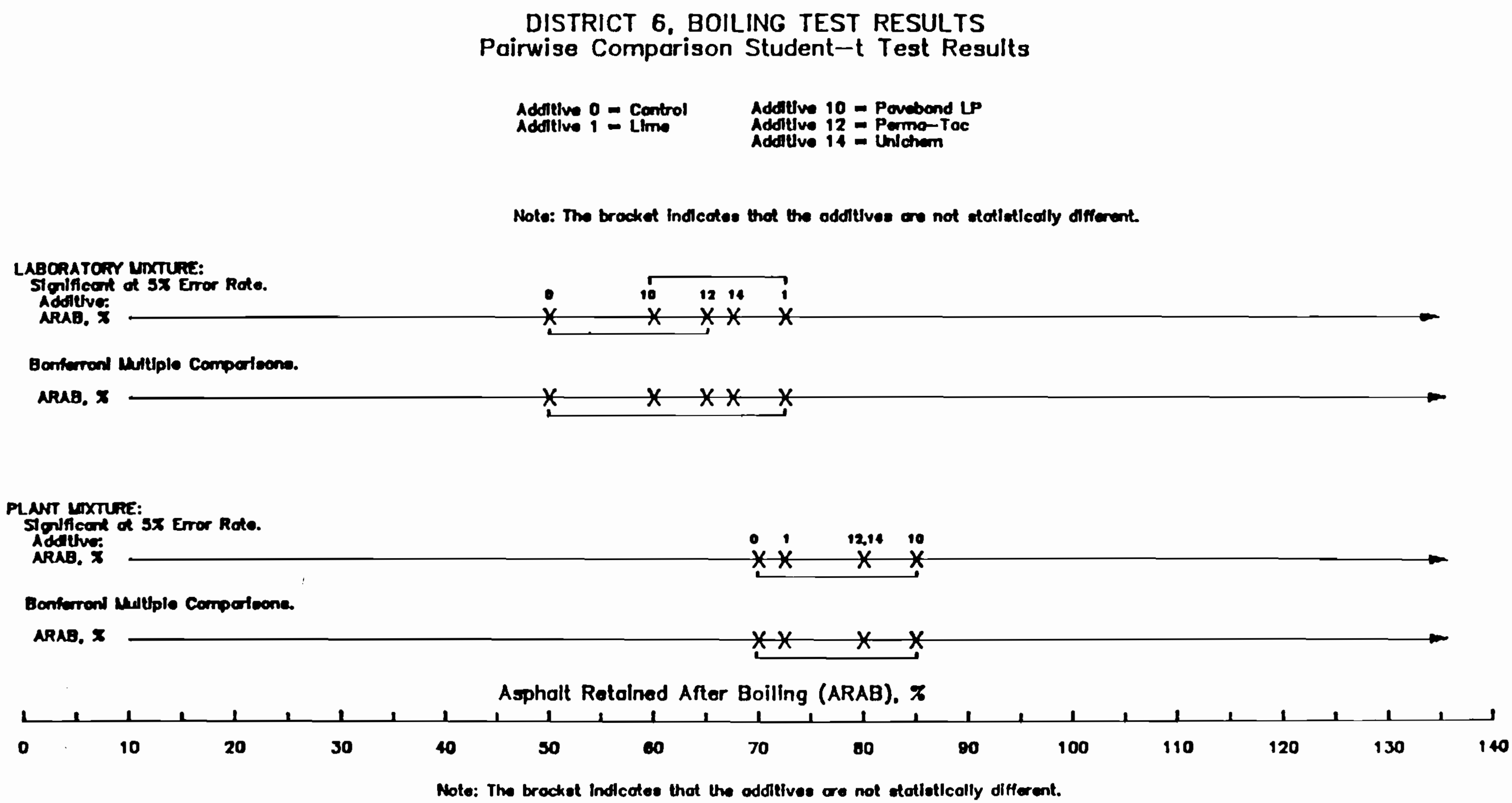


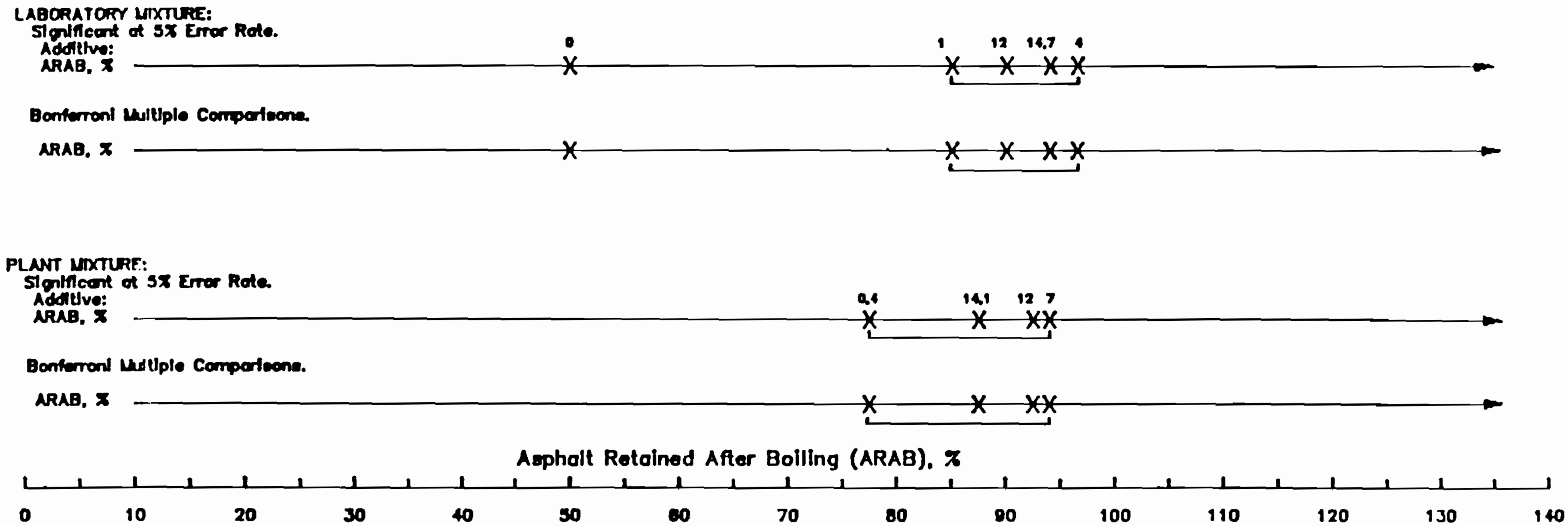
Fig. I-20 Comparison of statistical significance on boiling test results for District 6, laboratory and plant mixtures.

DISTRICT 25, BOILING TEST RESULTS
Pairwise Comparison Student–t Test Results

Additive 0 = Control Additive 4 = Aquashield II(*) Additive 12 = Perma–Tac
Additive 1 = Lime Additive 7 = Fina–A Additive 14 = Unichem

*Note: The Aquashield II plant mixture was taken from the low voids test section.

Note: The bracket indicates that the additives are not statistically different.



Note: The bracket indicates that the additives are not statistically different.

Fig. I-21 Comparison of statistical significance on boiling test results for District 25, laboratory and plant mixtures.

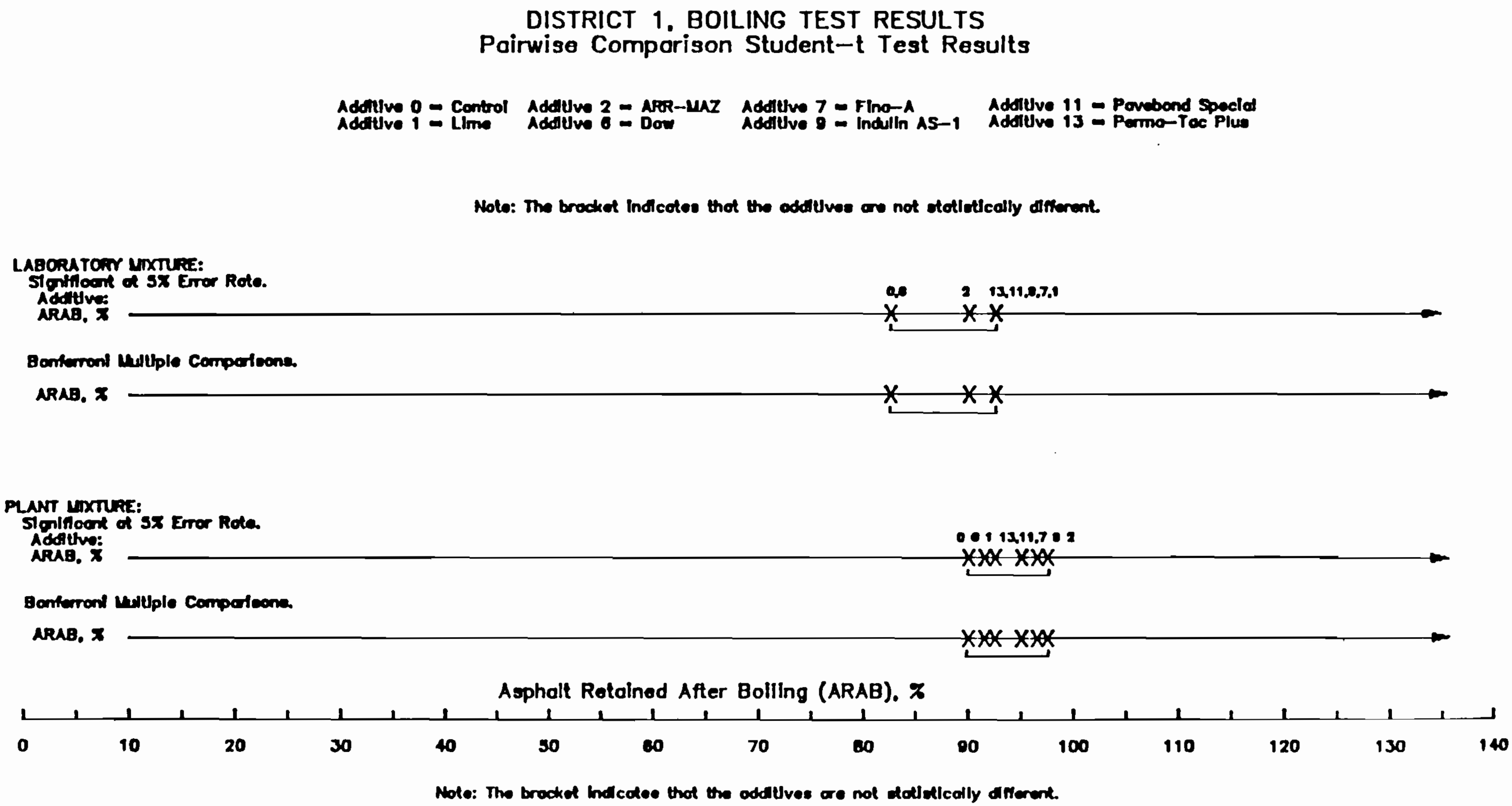


Fig. I-22 Comparison of statistical significance on boiling test results for District 1, laboratory and plant mixtures.

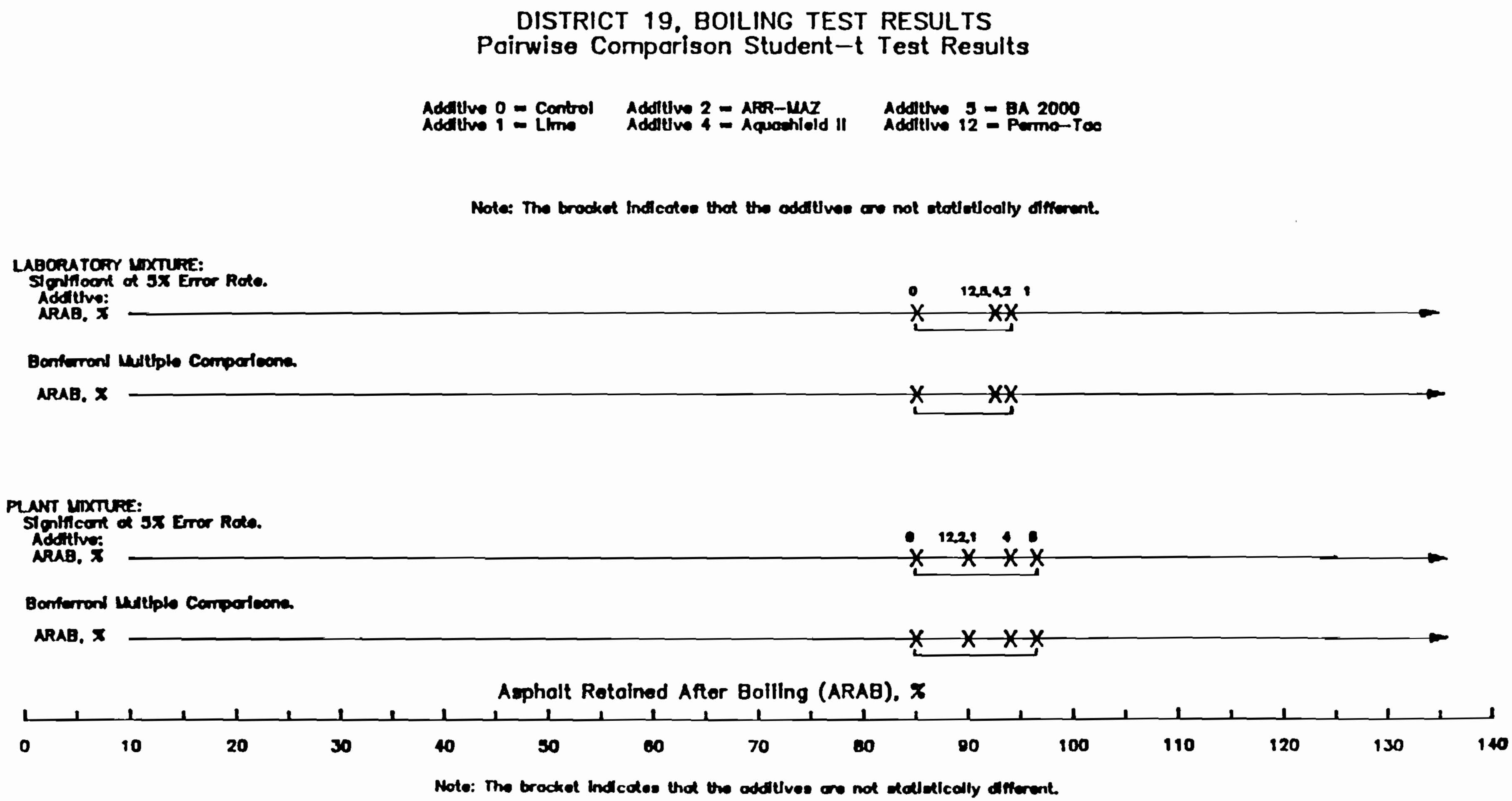
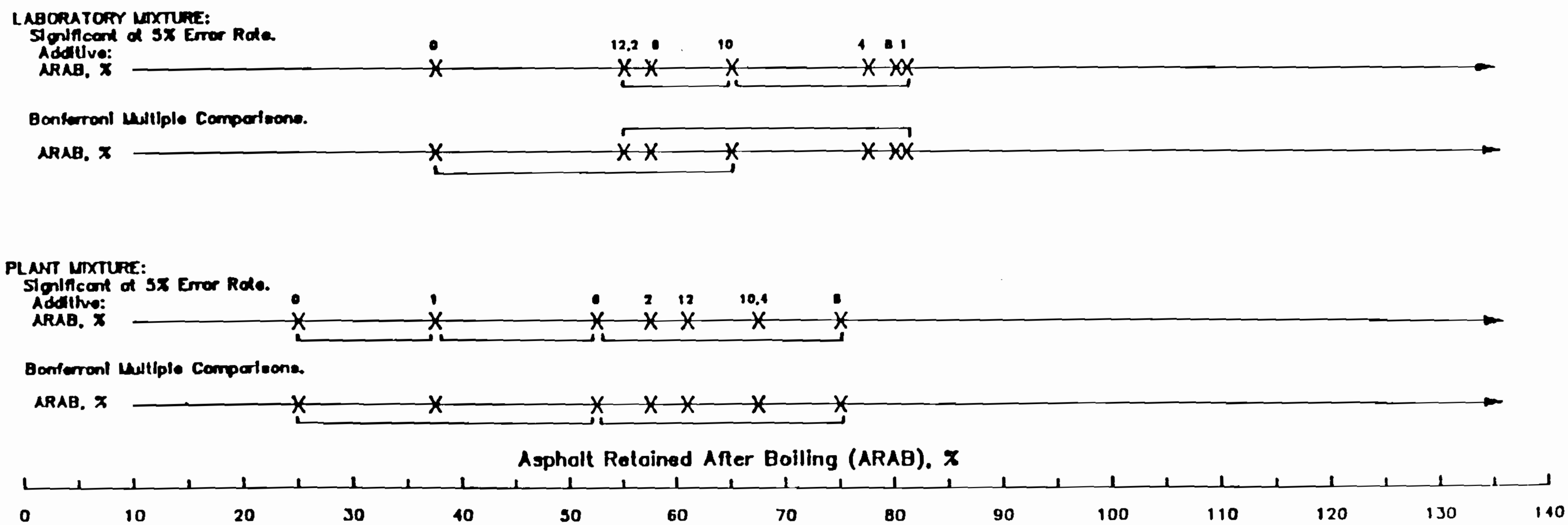


Fig. I-23 Comparison of statistical significance on boiling test results for District 19, laboratory and plant mixtures.

DISTRICT 21, BOILING TEST RESULTS
Pairwise Comparison Student–t Test Results

Additive 0 = Control **Additive 1 = Lime** **Additive 2 = ARR–MAZ** **Additive 4 = Aquashield II** **Additive 6 = Dow** **Additive 8 = Fina–B** **Additive 10 = Pavebond LP** **Additive 12 = Perma–Tac**

Note: The bracket indicates that the additives are not statistically different.



Note: The bracket indicates that the additives are not statistically different.

Fig. I-24 Comparison of statistical significance on boiling test results for District 21, laboratory and plant mixtures.

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