FIELD SAMPLES OF HOT MIX AS AN ACCEPTANCE PROCEDURE

Final Report

by

HAROLD R. PAUL
BITUMINOUS RESEARCH ENGINEER

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ABSTRACT

Shifting the sampling site of asphalt concrete from the plant to the roadway necessitates a modification of the Marshall procedure. The effect of such a modification on the Marshall properties and resultant process levels in a Statistically Oriented End-Result Specification requires a feasibility determination. The variation associated with a modified test procedure was examined in this study.

Loose mix samples from the roadway were secured from the same trucks sampled at the plant in four districts, which represented two mix types (low and high stability) and four different asphalt cement sources. These materials were tested at the district laboratories in duplicate and at the research laboratory where samples were compacted similarly to the district, by a means of compaction different from the district, and at a reduced compaction temperature. Marshall briquettes were tested and the Marshall properties were analyzed using standard statistical procedures.

It was found that the Marshall properties' statistical parameters of mean levels and variation were significantly different from the parameters basic to the current specifications. These differences create new process levels which would demand a revision of specifications upon implementation of the modified test procedure. In general, the data demonstrates within lab and between lab repeatability. Also, that manual and automatic compaction hammers will provide significantly different results.

METRIC CONVERSION FACTORS*

To Convert from	To	Multiply by
	Length	
foot	meter (m)	0.3048
inch	millimeter (mm)	25.4
yard	meter (m)	0.9144
mile (statute)	kilometer (km)	1.609
	Area	
square foot	square meter (m^2)	0.0929
square inch	square centimeter (cm^2)	6.451
square yard	square meter (m^2)	0.8361
	Volume (Capacity)	
cubic foot	cubic meter (m^3)	0.02832
gallon (U.S. liquid)**	cubic meter (m^3)	0.003785
gallon (Can. liquid)**	cubic meter (m^3)	0.004546
ounce (U.S. liquid)	cubic centimeter (cm^3)	29.57
	Mass	
ounce-mass (avdp)	gram (g)	28.35
pound-mass (avdp)	kilogram (kg)	0.4536
ton (metric)	kilogram (kg)	1000
ton (short, 2000 lbs)	kilogram (kg)	907.2
	Mass per Volume	
pound-mass/cubic foot	kilogram/cubic meter (kg/m^3)	16.02
pound-mass/cubic yard	kilogram/cubic meter (kg/m^3)	0.5933
pound-mass/gallon (U.S.)**	kilogram/cubic meter (kg/m^3)	119.8
pound-mass/gallon (Can.)**	kilogram/cubic meter (kg/m^3)	99.78
	Temperature	
deg Celsius (C)	kelvin (K)	$t_K=(t_C+273.15)$
deg Fahrenheit (F)	kelvin (K)	$t_K=(t_F+459.67)/1.8$
deg Fahrenheit (F)	deg Celsius (C)	$t_C=(t_F-32)/1.8$

*The reference source for information on SI units and more exact conversion factors is "Metric Practice Guide" ASTM E 380.

**One U.S. gallon equals 0.8327 Canadian gallon.

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IMPLEMENTATION STATEMENT

Implementing a shift in sampling location from the plant site to the roadway is not deemed feasible at this time. Such a change would require a major rewriting of specifications and a subsequent retraining program. Consideration should be given to discontinue the use of manual compaction hammers.

INTRODUCTION

In 1971 Louisiana initiated full implementation of a Statistically Oriented End-Result Specification for asphaltic concrete. This specification defined responsibilities for the contractor and the Department for control and/or acceptance testing, defined quality criteria for control and acceptance and structured price adjustments for non-conforming materials. Quality assurance under such a statistically oriented program is rooted in the randomness of sampling and testing.

Currently, asphaltic concrete is sampled and tested at the asphalt plant. Random number tables have been generated for use in determining sampling times. However, it is believed that familiarity with plant operations can, at times, lead to a biasing of sampling time. It is further believed that sampling in the field at the laydown site could remove this bias. With this in mind, it was felt that sampling at the field site should be investigated.

Changing the sampling site necessarily causes problems in the Marshall design procedure, as the mix will subsequently lose temperature when transported back to the plant lab for testing. Questions arise concerning the method of reheating the mixture and the resultant Marshall properties. How should the mix be reheated? How long? Are Marshall properties the same? If not, can they be correlated? Can acceptance limits be modified to accommodate field sampling?

This study was initiated to determine the feasibility of changing the point of acceptance from the plant to the roadway. This report contains the results of this study.

SCOPE

The scope of this evaluation was to determine, both in a selected number of district laboratories and in the research laboratory, the relationship and variation to be expected between plant and roadway test results with respect to Marshall properties (stability, air voids, voids filled with asphalt) on different Louisiana mix types and composition. As part of this effort, the effect of manual versus automatic compaction upon resulting Marshall properties was examined.

The study encompassed the selection of two mix types (or stability levels) in each of four districts for a total of eight projects with twenty samples collected per project at the roadway.

METHODOLOGY

Sampling and Testing Program

Each of four districts with different asphalt cement sources were requested to select two ongoing hot-mix construction projects representing a Type 1 (low stability) wearing course mix and a Type 3 (high stability) wearing course mix from which loose mix samples could be secured. From each of the selected projects 20 sets of duplicate loose mix samples (a total of 40 samples per project) were taken at the roadway, each set (2 one-gallon cans) coming from the identical transport previously sampled for acceptance at the plant. One gallon of each set was retained at the district for testing and the other gallon was forwarded to the research section.

At the district laboratory each sample was reheated to obtain a mix at the job mix formula temperature, followed by compaction (manual or automatic) by identical means as was used at the plant. Two specimens labelled D1 and D2 were prepared from each gallon can according to the procedure provided below. Marshall properties were then determined.

Three Marshall briquettes were fabricated from each gallon can shipped to the research laboratory. Two of these specimens were compacted by identical means as the district and the plant (one being heated to the job mix formula temperature--R1, the second being reheated to a temperature 25°F cooler--R3). The third specimen--R2--was reheated to the job mix formula temperature but compacted (manual or automatic) by means different from what was used at the plant. The fabrication of briquettes and subsequent testing was identical to the district laboratory.

A primary concern in shifting the sampling site was the effect of binder viscosity on the Marshall properties of the specimens formed after reheating the mix. Generally, an increased binder viscosity will provide a tougher mix which will increase stability but will resist compaction, thus lowering the specific gravity and voids filled with asphalt (VFA) of a mix and increasing air voids. Binder viscosities normally increase to some extent due to plant processing and the inherent properties of the particular asphalt cement utilized (measured by an asphalt's viscosity index). The effect upon viscosity of allowing the mix to cool to ambient and then reheating in order to compact the specimen was unknown. With this in mind two assumptions were made: (1) with the field samples cooling to ambient temperature prior to reheating, any increase in binder viscosity would be similar within each asphalt type; and (2) that the binder viscosity would not significantly increase once the sample had cooled so that a time lapse between sampling and testing would not affect the results.

Test Procedure

Preliminary work in the district and research laboratories resulted in the following standardized procedure utilized for this study:

1. Allow gallon can to cool to ambient temperature.
2. Place uncovered can into preheated oven (set at 5°F above the job mix formula temperature) for 40 minutes.
3. Remove can from oven and split and quarter mix into two approximately 1200-gram samples.
4. Place each split sample into a pan and return to oven, along with a conical mixing bowl, for two hours.
5. Remove one sample pan from the oven, empty mix into bowl and stir, add mix to Marshall mold and compact, returning mixing bowl to oven.

6. Immediately upon completion of Step 5, remove second sample pan and mixing bowl from oven and make second briquette.

7. Test briquettes for all Marshall design properties--specific gravities, stability, flow and voids filled with asphalt.

If more than one gallon can of mix was to be tested, the split samples from these cans were placed into the oven (Step 4) at 10-minute intervals such that the 2-hour oven exposure was maintained, allowing 10 minutes to complete Steps 5 and 6 for the two briquettes made from each gallon can.

The following nomenclature will be used in this analysis:

P = Plant data

D1 = District data: compacted same method as plant at JMF temperature

D2 = Replicate district data

R1 = Research data: compacted same method as plant at JMF temperature

R2 = Research data: compacted by different method from plant at JMF temperature

R3 = Research data: compacted same method as plant at JMF temperature minus 25°F.

Data Analysis

Each reheated and compacted briquette was tested for apparent specific gravity and Marshall stability, and then the percent air voids based on a theoretically voidless mixture and voids filled with asphalt were calculated. This raw data was compiled and is presented in Appendix A (page 39). The data is arranged by source (plant: P; district: D1, D2; research: R1, R2, R3) within each project (defined by the mix type and the asphalt cement utilized). It should be noted that one project included only 13 samples, one project had 15 samples and two projects had 21 samples. This variation with the sampling plan was due to plant production schedules and the study time constraints.

Louisiana's current acceptance and control limits for Marshall properties were developed from known process levels with respect to the mean and variability of the material and/or test. These levels were determined from historical sources. As such, there exists a definite relationship between the specifications and the statistical parameters of the associated properties. Any change in test procedure which would cause the values of the statistical parameters to change must necessarily be examined to determine the validity of the statistically oriented specifications.

Specifically, the specifications were developed so that the contractor would maintain process control; that is, he would maintain his operations to achieve a specified mean level and also keep his variability within a prescribed limit. These actions would be rewarded with 100% pay and the state would be statistically assured of a quality controlled mix. A change in the mean or variability due to the test procedure under consideration must therefore be examined to assure compatibility with the specifications.

The Department's Statistical Analysis System (SAS) computer program was used to analyze the data. Number of samples, means, standard deviations, minimum values, maximum values and coefficients of variation are presented in Appendix B (page 49). This data was used to examine the variability of the test data within the testing program for consistency and to examine its validity with respect to the statistical parameters used to develop the specfications.

A t-statistic was used to compare the Marshall properties determined for the field samples with those found at the plant. This statistic tests the hypothesis at some preselected significance level that samples from two populations have the same mean. The t-statistic is based upon the means, variance (dispersion about the mean) and the degrees of freedom of the two sets of samples examined and assumes that the data is normally distributed. The calculated t-statistic* is then compared to the tabulated t value. If the calculated value is larger than the tabulated t at the preselected probability or significance level, then it is concluded that the tested means are not equal. For this study a significance level of 0.05 was chosen.

Another statistical technique used to evaluate the field and plant data was analysis of variance (ANOVA). The ANOVA technique differs from the t-statistic in that more than two means can be tested at the same time. This increased utility allows several influential factors or effects to be studied simultaneously. The basis for this analysis rests on the premise that if the means of data groups are greatly different, then the variance of the combined groups is larger than the variance of the separate groups. ANOVA separates the variance of all observations into parts with each part measuring the variability due to some specific effect. The hypothesis of equal means is accepted if the observed data means are close. ANOVA uses the F-statistic which, similar to the t-statistic, depends on the mean, variance and the degrees of freedom of the various populations examined. A significant F value would indicate that the hypothesis is false, or that the means are not equal. The significance level used for this evaluation was 0.05.

$$*t = |\bar{x}_1 - \bar{x}_2| \,/\, \bar{s}(x)\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}$$

where $\bar{x}_1$, $\bar{x}_2$ = means from two independent samples

$\bar{s}$ = pooled variance of the two samples

n_1, n_2 = number of values in each sample

These statistics were used to compare the plant-generated data with the data associated with the briquettes constructed using the developed test procedure. Direct comparisons were made between the plant (P) and the district (D1) and research (R1), which examined the possibility of differing means and their associated variances. Within lab (D1 versus D2) and between lab (R1 versus D1) variations were also evaluated along with the effect of compaction temperature (R3 versus P, R3 versus R1). Finally, the method of compaction (automatic versus manual) was studied.

DISCUSSION OF RESULTS

Variation - Prior Research

In the early 1960s Louisiana completed a study--Quality Control Analysis Part I - Asphaltic Concrete (1)*--which established engineering tolerance limits for materials test properties such as Marshall stability, gradation, voids and asphalt cement content. The establishment of these limits based on the concept of process levels--statistically determined means and variation--marked the beginning of the state's Statistically Oriented End-Result Specifications.

Generally, in order to be assured that a test value is due to the randomness generated within a given process and not due to a loss of control in materials, production or sampling and testing, the process should maintain that test value at a certain mean and within some allowable set limits. Figure 1A depicts a proper level of control for a particular test value; the values are distributed normally about a mean within the prescribed limits so that all values can be assumed to occur by the randomness of the process. Figures 1B and 1C, however, show the situation when either the mean shifts while maintaining the same variability or the variability is increased while the mean remains stable. Either of these situations would occur from other than random causes and the material would be considered deficient.

A modification to a test procedure must necessarily produce test values which retain similar statistical parameters to the unmodified procedure or the specification limits become invalidated. New specifications must then be identified or the modification should be discarded.

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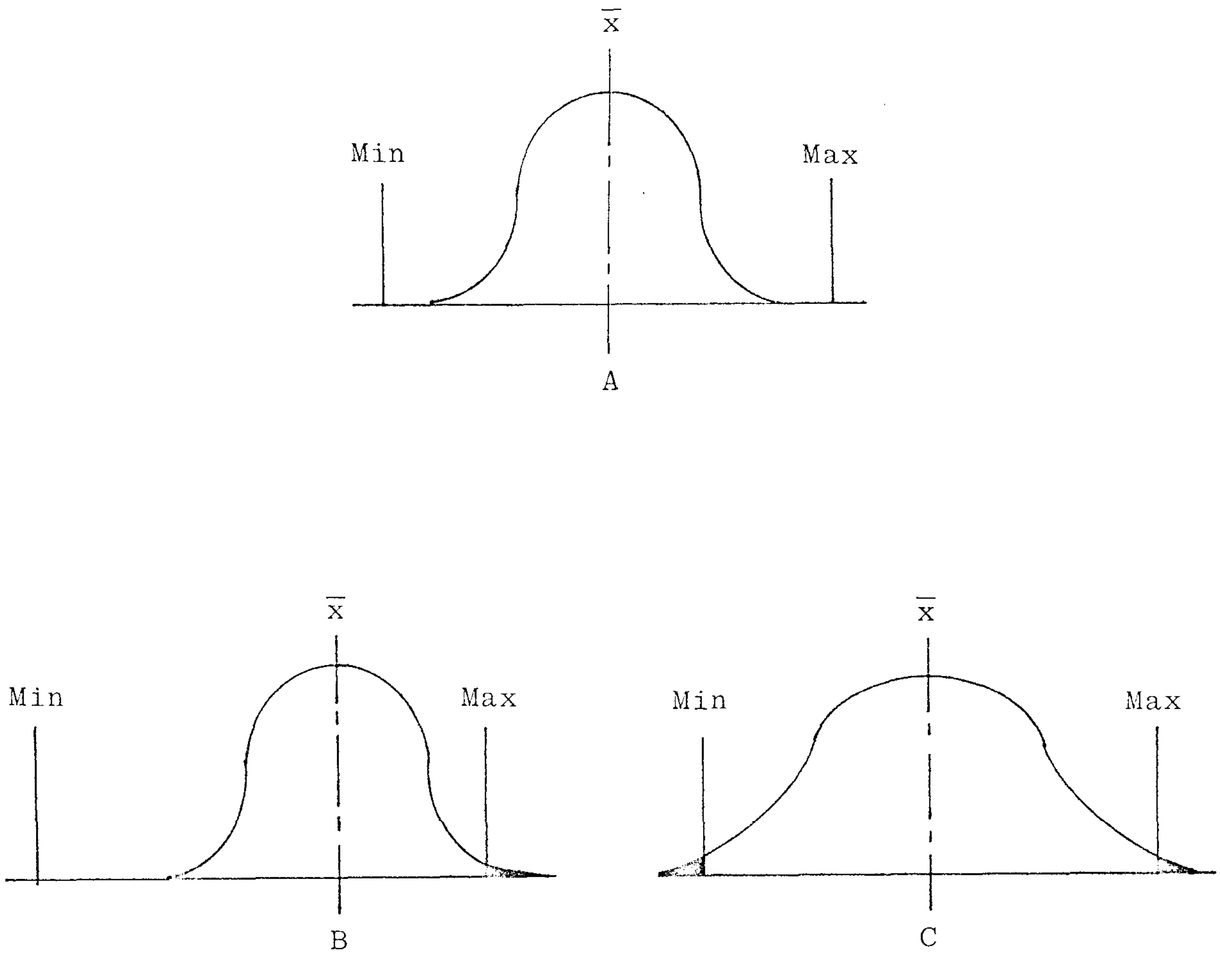
*Underlined numbers in parentheses refer to the list of references.



Process Level Distributions

FIGURE 1

Later studies (References 2 and 3) investigating the data generated by the introduction of Statistically Oriented End-Result Specifications provide a comparative base for the statistical parameters developed with the modified test procedure. This base is limited to Marshall stability as the emphasis in these studies was acceptance tests. Marshall properties of voids, specific gravity and VFAs used as control tests were not examined in these studies. Mean stabilities and standard deviations from these studies are presented in Table 1.

TABLE 1

MARSHALL STABILITY STATISTICAL PARAMETERS
PRIOR RESEARCH

Source Parameters	Reference 2 $\bar{x}$	Reference 2 s	Reference 3 $\bar{x}$	Reference 3 s
Mix Type				
1	1676	271	1553	290
3	1950	356	1888	303

Marshall Stability Variation

The statistical parameters for the plant data, determined by the conventional procedure, and the district (D1) and research (R1) data generated with the modified procedure are presented in Table 2 for each mix type by project (identified by asphalt cement). This data has been extracted from Appendix B (page 49).

TABLE 2

MARSHALL STABILITY STATISTICAL PARAMETERS
PLANT, DISTRICT, RESEARCH

Source	Plant (P)		District (D1)		Research (R1)	
Parameters	$\overline{x}$	s	$\overline{x}$	s	$\overline{x}$	s
Mix Type/ Asphalt						
Type 1						
E	1528	156	1650	221	1661	197
L	1582	247	2219	404	1795	184
S	1968	299	2494	263	2650	383
T	1692	212	2027	183	1967	198
All Type 1	1702	290	2128	406	2040	460
Type 3						
E	1935	249	2201	378	2452	187
L	2280	289	3668	549	2971	183
S	2282	331	2776	279	2441	238
T	1730	133	2504	162	2276	316
All Type 3	2071	356	2843	650	2542	361

The plant samples for both Type 1 and Type 3 mixes maintained slightly higher mean stabilities, 1702 and 2071, respectively, than those obtained from prior research. Also, the sample standard deviations of 290 and 356 for the Type 1 and Type 3 mixes, respectively, were very similar, demonstrating that the mixes produced for this study were typical of those being produced under current specifications.

All mean stabilities for both mix types determined at either the district or at research were considerably higher than those found at the plant. Likewise, there was more variation with the new procedure as indicated by the standard deviations except for the Type 3 mix tested at the research lab.

The hypothesis that the mean plant samples and the mean district and research samples were not different was examined with the t-test. An example of the computer output for this test is presented in Table 3, which shows the results between the plant and research data for all Type 1 specimens. Appendix C (page 63) provides a summary of the t-test results for all of the Marshall properties. Those results in italics are significant at the 0.05 level. Table 4 repeats the t-test values for Marshall stability.

TABLE 4

t-TEST - MARSHALL STABILITY

Source	Plant vs District (P/D1)	Plant vs Research (P/R1)
Mix		
Type 1	*7.4516**	*8.9484*
Type 3	*-5.3897*	*-7.9830*

It can be observed that, overall, the hypothesis of equal means cannot be accepted at the 0.05 significance level. Generally, this is also true for each individual project with the Type 1, E asphalt and the Type 3, S asphalt as exceptions (Appendix C, page 63).

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*Italicized numbers are significant at 0.05 level.

TABLE 3

t-TEST - COMPUTER OUTPUT

VARIABLE: SPGR

SOURCE	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
D1	76	2.31000000	0.02545584	0.00291999	2.25000000	2.36000000	UNEQUAL	-5.9074	147.8	0.0001
P	76	2.33302632	0.02251043	0.00258212	2.27000000	2.38000000	EQUAL	-5.9074	150.0	0.0001

FOR HO: VARIANCES ARE EQUAL, F'= 1.28 WITH 75 AND 75 DF PROB > F'= 0.2890

VARIABLE: VOID

SOURCE	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
D1	76	4.94342105	0.86892048	0.09967202	3.30000000	7.00000000	UNEQUAL	7.4617	142.7	0.0001
P	76	3.99342105	0.69057185	0.07921402	2.50000000	6.20000000	EQUAL	7.4617	150.0	0.0001

FOR HO: VARIANCES ARE EQUAL, F'= 1.58 WITH 75 AND 75 DF PROB > F'= 0.0484

VARIABLE: VFA

SOURCE	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
D1	76	70.63157895	3.52455049	0.40429367	64.00000000	79.00000000	UNEQUAL	-8.6202	142.6	0.0001
P	76	75.07894737	2.79410407	0.32050572	66.00000000	82.00000000	EQUAL	-8.6202	150.0	0.0001

FOR HO: VARIANCES ARE EQUAL, F'= 1.59 WITH 75 AND 75 DF PROB > F'= 0.0460

VARIABLE: STAB

SOURCE	N	MEAN	STD DEV	STD ERROR	MINIMUM	MAXIMUM	VARIANCES	T	DF	PROB > |T|
D1	76	2128.47368421	406.19008600	46.59319834	1316.00000000	3203.00000000	UNEQUAL	7.4516	135.6	0.0001
P	76	1702.00000000	289.74890279	33.23647859	1118.00000000	2506.00000000	EQUAL	7.4516	150.0	0.0001

FOR HO: VARIANCES ARE EQUAL, F'= 1.97 WITH 75 AND 75 DF PROB > F'= 0.0039

The difference in stability level observed between the plant results and the results based on the new procedure was anticipated, as it was believed that the reheated samples would have a more viscous asphalt cement due to plant aging and the reheating process. An attempt was made to correlate these results. A SAS General Linear Models procedure which is composed of ANOVA and a regression analysis was used for this purpose. Tables 5 and 6 report the analysis for Type 1 and Type 3 mixes, respectively, and correspond to Figures 2 and 3. These figures reflect both plant versus research (identified as 1 in the figure) and plant versus district (identified as 2 in the figure) data along with the estimated correlation lines (identified as R and D in the figure). The tables demonstrate very good correlation as indicated by the high R^2 values. For Type 1 mix there is similarity between the district and research sample correlation, generally showing an increase of stability of approximately 20 percent in the specimens fabricated with the new procedure. The Type 3 mix also displays this 20 percent increase for the research specimens but is considerably higher (36 percent) for the district specimens. This disparity in correlation would pose problems in establishing minimum stability requirements for Type 3 mix and therefore would require further study. Perhaps most distressing, though, is the large spread of data evidenced in Figures 2 and 3. This graphic depiction reiterates the high standard deviations reported in Table 2. Standard deviations of 406 (district) and 460 (research) are much higher than the sample standard deviation of 290 from prior research for the Type 1 mix. Also, while the Type 3 deviations at research of 361 seem comparable to the 356 found in prior research, the district specimens were almost double at 650. From the perspective of process levels, then, a much higher mean value would have to be maintained in order to be assured that variation was due to randomness and not a change in the quality of the mix. Such a mean would be higher than the values found in this study.

TABLE 5

MARSHALL STABILITY CORRELATION OUTPUT - TYPE 1 MIX

DEPENDENT VARIABLE: R1STAB

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	327675607.78674512	327675607.78674512	2063.05	0.0001	0.963119	19.8200
ERROR	79	12547602.21325487	158830.40776272		STD DEV		R1STAB MEAN
UNCORRECTED TOTAL	80	340223210.00000000			398.53532812		2010.77500000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
PSTAB	1	327675607.78674512	2063.05	0.0001	1	327675607.78674518	2063.05	0.0001

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=O	PR > |T|	STD ERROR OF ESTIMATE
PSTAB	1.17983457	45.42	0.0001	0.02597562

DEPENDENT VARIABLE: D1STAB

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	359468768.00317674	359468768.00317674	2755.74	0.0001	0.971789	17.2216
ERROR	80	10435473.99682325	130443.42496029		STD DEV		D1STAB MEAN
UNCORRECTED TOTAL	81	369904242.00000000			361.16952385		2097.18518519

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
PSTAB	1	359468768.00317674	2755.74	0.0001	1	359468768.00317668	2755.74	0.0001

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=O	PR > |T|	STD ERROR OF ESTIMATE
PSTAB	1.23112329	52.50	0.0001	0.02345212

TABLE 6

MARSHALL STABILITY CORRELATION OUTPUT - TYPE 3 MIX

DEPENDENT VARIABLE: R1STAB

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	473407758.83922640	473407758.83922640	2423.95	0.0001	0.970764	17.3857
ERROR	73	14257200.16077357	195304.11179142		STD DEV		R1STAB MEAN
UNCORRECTED TOTAL	74	487664959.00000000			441.93224797		2541.93243243

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE IV SS	F VALUE	PR > F
PSTAB	1	473407758.83922640	2423.95	0.0001	1	473407758.83922630	2423.95	0.0001

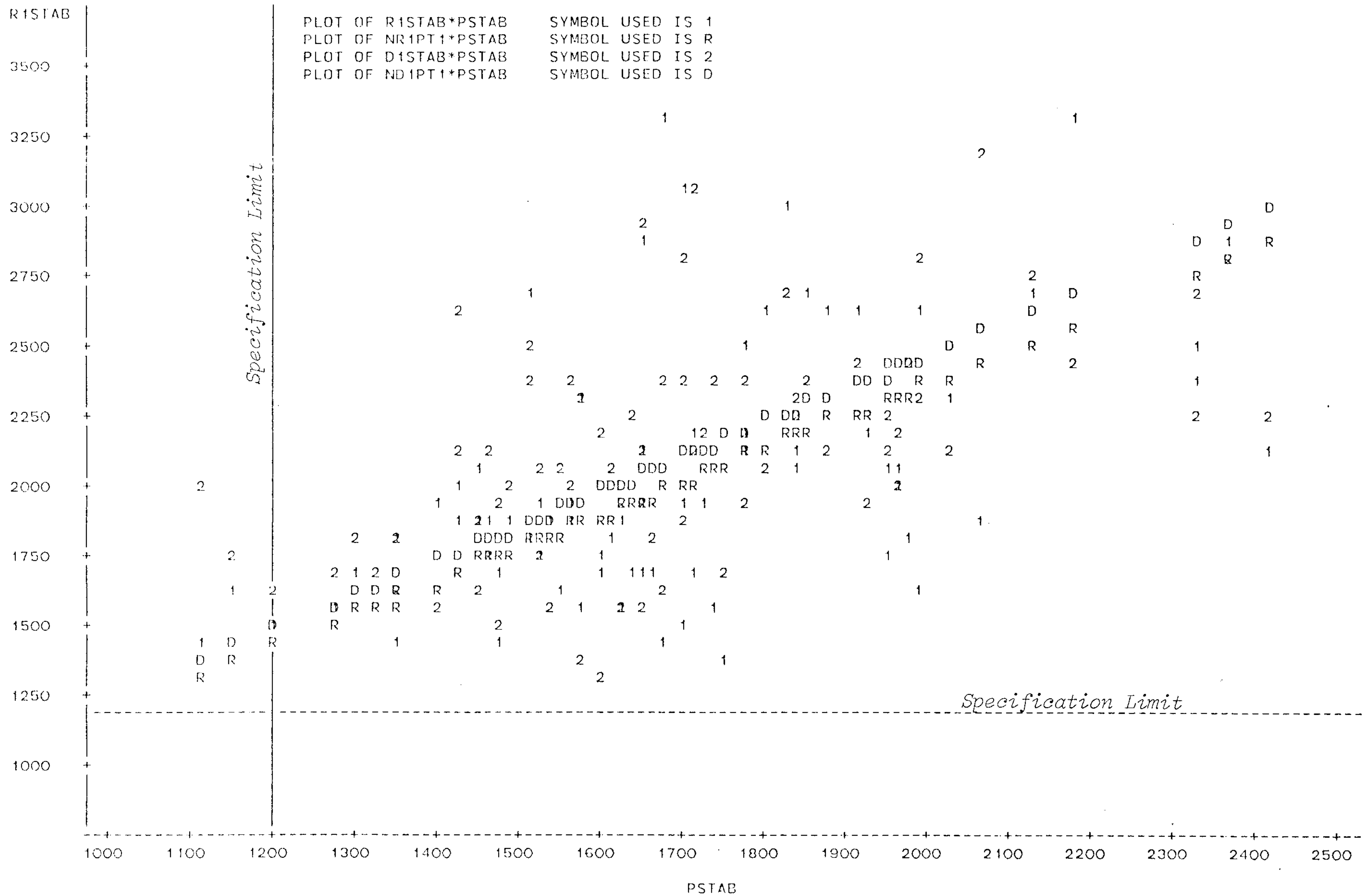
PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
PSTAB	1.20366949	49.23	0.0001	0.02444811

DEPENDENT VARIABLE: D1STAB

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	603464973.27127450	603464973.27127450	1738.31	0.0001	0.959698	20.7277
ERROR	73	25342344.72872543	347155.40724281		STD DEV		D1STAB MEAN
UNCORRECTED TOTAL	74	628807318.00000000			589.19895387		2842.56756757

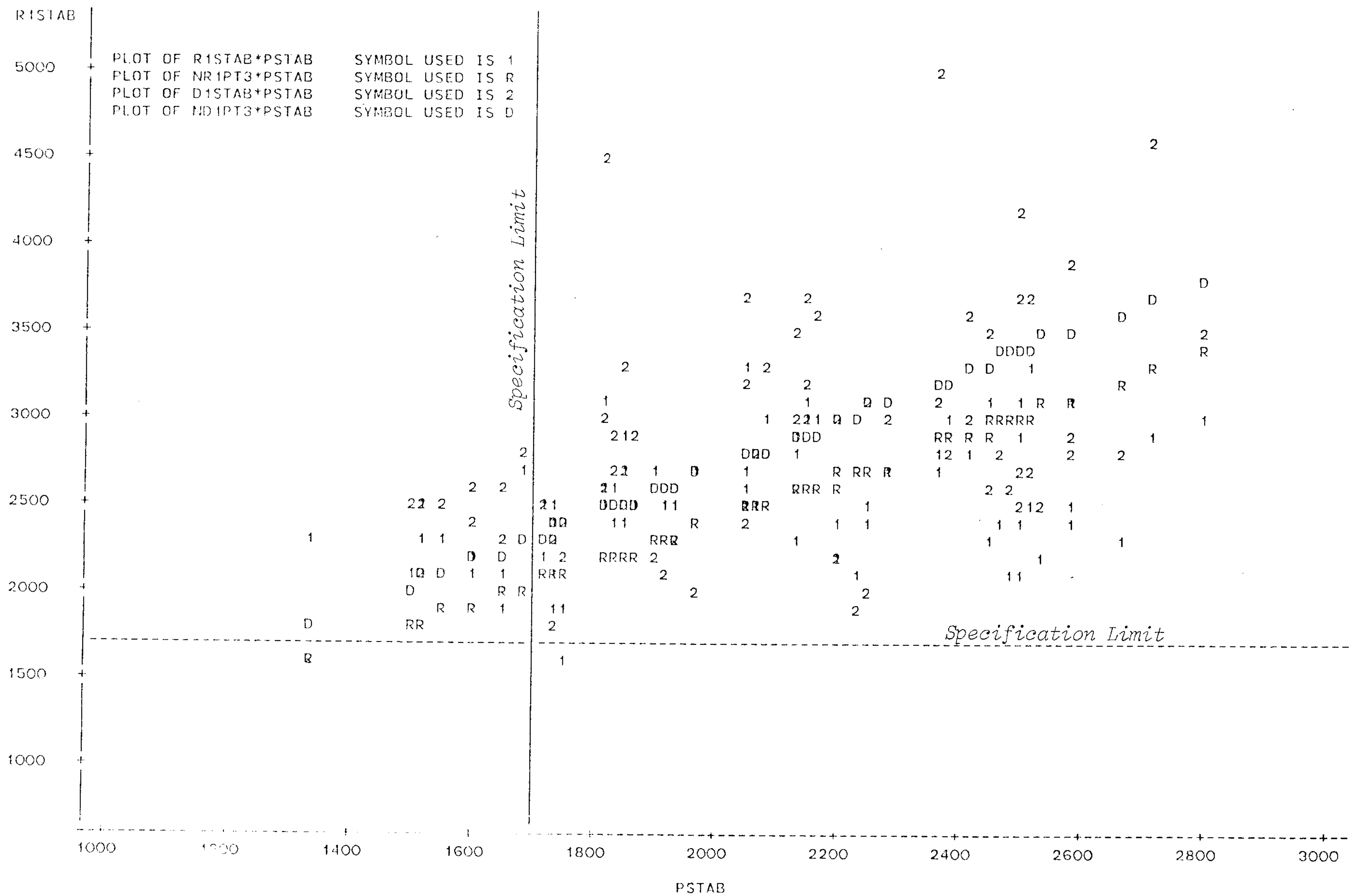
SOURCE	DF	TYPE I SS	F VALUE	PR > F	TYPE IV SS	F VALUE	PR > F
PSTAB	1	603464973.27127450	1738.31	0.0001	603464973.27127440	1738.31	0.0001

PARAMETER	ESTIMATE	T FOR HO: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
PSTAB	1.35898794	41.69	0.0001	0.03259504



Marshall Stability Correlation - Type 1 Mix

FIGURE 2



Marshall Stability Correlation - Type 3 Mix

FIGURE 3

Variation in Air Voids, Specific Gravities, Voids Filled with Asphalt

These Marshall properties are interrelated and dependent upon aggregate/asphalt cement proportioning and the amount of compaction. Louisiana uses these properties to control mix types at the plant and partially to determine acceptance with respect to roadway density (95 percent minimum of plant specific gravity). Specific gravity is a tested property which is used to calculate the air void content of a mixture and along with asphalt cement content to determine voids filled with asphalt (VFA). Louisiana specifications require an air void content of 3-5 percent and a VFA of 70-80 for its Type 1 and Type 3 wearing course mixtures.

For reasoning similar to the expectation of higher stability values, it was also anticipated that the compaction of the specimens produced by the new procedure would be diminished. This is observed in the specific gravities presented in Table 7. In each case the mix gravities are less than those found in mix tested at the plant. The plant variation is generally less.

When consideration is given to a process level for air voids given the 3-5 specification limits, it is obvious that a mean level of 4 should be targeted. A standard deviation of 0.5 would then allow only 2.5 percent of all test values to be discarded as occurring from other than random effects. A summary of the statistical parameters for air voids is presented in Table 8. It is observed that the plant processes are being maintained at or near the mean of specification limits for both mix types. Further, the standard deviations are maintained near the 0.5 level. An increase in voids is indicated for the specimens fabricated at both research and the districts. Also, the variation is increased approximately 30 percent for the Type 1 mix and 100 percent for the Type 3 mix. The higher air void levels are consistent with the lower specific gravities of these specimens and as such would require both a change in specification mean and expanded limits.

TABLE 7

SPECIFIC GRAVITY STATISTICAL PARAMETERS
PLANT, DISTRICT, RESEARCH

Source	P		D1		R1	
Parameters	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Mix Type/ Asphalt						
Type 1						
E	2.333	0.009	2.326	0.017	2.306	0.016
L	2.361	0.015	2.334	0.017	2.339	0.017
S	2.310	0.015	2.285	0.016	2.289	0.019
T	2.326	0.007	2.297	0.011	2.289	0.011
All Type 1	2.333	0.023	2.310	0.025	2.306	0.026
Type 3						
E	2.312	0.006	2.288	0.018	2.282	0.018
L	2.347	0.008	2.327	0.011	2.331	0.013
S	2.331	0.009	2.293	0.009	2.293	0.010
T	2.347	0.009	2.311	0.016	2.294	0.012
All Type 3	2.336	0.016	2.307	0.020	2.302	0.023

TABLE 8

AIR VOIDS STATISTICAL PARAMETERS
PLANT, DISTRICT, RESEARCH

Source	P		D1		R1	
Parameters	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Mix Type/ Asphalt						
Type 1						
E	4.0	0.35	4.3	0.72	5.1	0.66
L	3.3	0.59	4.3	0.66	4.2	0.67
S	4.5	0.63	5.6	0.66	5.4	0.79
T	4.2	0.30	5.4	0.47	5.8	0.50
All Type 1	4.0	0.69	4.9	0.87	5.1	0.91
Type 3						
E	4.0	0.26	5.0	0.75	5.3	0.72
L	3.4	0.32	4.2	0.43	4.0	0.56
S	4.1	0.38	5.6	0.41	5.6	0.45
T	3.8	0.35	5.2	0.64	6.0	0.53
All Type 3	3.8	0.42	5.0	0.77	5.2	0.94

TABLE 9

VOIDS FILLED WITH ASPHALT STATISTICAL PARAMETERS
PLANT, DISTRICT, RESEARCH

Source	P		D1		R1	
Parameters	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Mix Type/ Asphalt						
Type 1						
E	75	1.5	74	3.2	70	3.0
L	77	3.1	72	3.3	73	3.4
S	73	2.8	69	2.8	70	3.3
T	74	1.5	69	2.0	67	2.0
All Type 1	75	2.8	70	3.5	70	3.5
Type 3						
E	75	1.2	71	3.1	70	3.0
L	78	1.6	74	2.0	74	2.5
S	74	1.9	67	1.6	68	1.8
T	75	1.7	69	2.5	66	1.9
All Type 3	76	2.1	70	3.4	69	3.9

Additionally, since roadway densities are based on plant specific gravities, refinements would have to be made with respect to the percent of compliance to plant gravity (currently 95 percent) and to the pay adjustment tables.

Similar to the process level for air voids, VFA should be maintained at 75 with a standard deviation of 2.5 (discarding of 2.5 percent of data for other than random effects). Table 9 reports that such process levels were generally maintained at the plant for both Type 1 ($\overline{x}$ = 75, s = 2.8) and Type 3 ($\overline{x}$ = 76, s = 2.1) mix. Again, consistent with the data found for specific gravity and air voids, the VFAs at research and the districts were lower than those found at the plant along with a higher level of variation. A change in the specification limits would be necessary.

A t-test was used to examine the hypothesis that there was no difference in the mean values of specific gravity, air voids and VFA for the plant versus research data and the plant versus district data (Appendix C, page 63). Large t-values were found indicating that the mean Marshall property values for both the research and district samples were not equal to the associated plant samples.

Within Laboratory Variation

Two specimens were fabricated from each gallon can of loose mix at each district laboratory to examine within laboratory variation for the new test procedure. This data is labelled in the appendices and Table 10 as D1 and D2. Table 10 reports the statistical parameters and t-test values for the Marshall properties under consideration. The hypothesis of no difference in means for each of the properties examined was true for both mix types, indicating that within each laboratory the test procedure results are repeatable. This hypothesis is also true for each Marshall property when the data was examined by each project (Appendix C, page 63).

TABLE 10

STATISTICAL PARAMETERS - WITHIN LAB

Source	D1		D2		
Statistical Parameter	$\bar{x}$	s	x	s	t-test
Marshall Property					
Type 1					
Specific Gravity	2.310	0.025	2.313	0.025	-0.5790
Air Voids	4.9	0.87	4.9	0.83	0.6875
VFA	70	3.5	71	3.4	-0.7278
Stability	2128	406	2151	391	-0.8287
Type 3					
Specific Gravity	2.307	0.020	2.305	0.023	0.4919
Air Voids	5.0	0.77	5.1	0.81	-0.1666
VFA	70	3.4	70	3.7	0.0723
Stability	2843	650	2966	753	-1.0684

Between Laboratory Variation

Research samples, R1, and district samples, D1, were used to examine variation between laboratories. Table 11 summarizes the statistical parameters found in Appendix B (page 49) and Appendix C (page 63). The t-test proved the hypothesis of equal means for most of the Marshall properties when the data for each mix type was considered. The exception was stability for Type 3 mix. This result reinforces the information obtained while attempting to correlate the research and district stabilities with those of the plant. When the t-test data is evaluated on a project basis it was found that: three Type 3 projects had equal means for specific gravity, air voids and VFA; no Type 3 projects had equal means for stability; two Type 1 projects had equal means for specific gravity, air voids and VFA; and, three Type 1 projects had equal means for stability. These results generally agree with the overall t-test evaluation by mix type, but show that there may be a need for further study of between-lab variation.

TABLE 11

STATISTICAL PARAMETERS - BETWEEN LAB

Source	D1		R1		
Statistical Parameter	$\bar{x}$	s	$\bar{x}$	s	t-test
Marshall Property					
Type 1					
Specific Gravity	2.310	0.025	2.306	0.026	0.8532
Air Voids	4.9	0.87	5.1	0.91	-1.0154
VFA	70	3.5	70	3.5	1.0297
Stability	2128	406	2040	460	1.2527
Type 3					
Specific Gravity	2.307	0.020	2.302	0.023	1.3760
Air Voids	5.0	0.77	5.2	0.94	-1.4293
VFA	70	3.4	69	3.9	0.8661
Stability	2843	650	2542	361	3.4767

Variation with Reduction of Job Mix Formula (JMF) Temperature

With the anticipation of higher stabilities when reheating at the JMF temperature, it was decided that a reduction of temperature might lower stabilities to the current specification range. At the research lab, specimens denoted R3 were fabricated at a reheat tempeature of JMF minus 25°F. Statistical parameters for these samples along with the plant data are summarized in Table 12. The expected drop in stability and the mean stability and standard deviation is similar to the plant parameters. The t-test agrees in its acceptance of the hypothesis of equal means. The other Marshall properties do not show equality of means with the plant specimens. Similar to the earlier discussion of these properties, a modification would need to be effected in specifications to accommodate the change in mean value and greater variation in order to keep process levels equivalent to current specifications.

TABLE 12

STATISTICAL PARAMETERS - REDUCTION OF JMF TEMPERATURE

Source	P		R3		
Statistical Parameter	$\bar{x}$	s	$\bar{x}$	s	t-test
Marshall Property					
Type 1					
Specific Gravity	2.333	0.023	2.299	0.028	8.2189
Air Voids	4.0	0.69	5.4	0.94	-10.3841
VFA	75	2.8	67	3.4	12.2498
Stability	1702	290	1690	284	0.2556
Type 3					
Specific Gravity	2.336	0.016	2.296	0.024	12.2780
Air Voids	3.8	0.42	5.5	0.95	-13.8673
VFA	76	2.1	68	3.9	14.1248
Stability	2071	356	2150	390	-1.2778

Effect of Asphalt Cement on Marshall Properties

ANOVA was used to examine the influence of asphalt cement on the data from the within-lab evaluation, D1 versus D2, and the between-lab evaluation, R1 versus D1. Source (D1, D2, R1) and asphalt cement (E, L, S, T) were considered as primary effects along with the interactive effect of source and asphalt. Table 13 reports the F-values found in this analysis. Those F-values in italics represent significance; i.e., that the hypothesis of equal means is false.

For the within-lab data, the analysis shows that the effect of source and the interaction of source and asphalt cement exhibit little influence on the variation. The asphalt cement as an effect on the variation is highly significant. The between-lab data also shows that a significant amount of variation can be expected due to the asphalt cement utilized. Additionally, the source effect and interactive effect for the Type 3 mix and the interactive effect for the Type 1 mix contribute to the variation.

In spite of the high significance attributed to the asphalt cement in this analysis, it could not be determined whether this significance was due to the characteristics of each asphalt cement or was typical of some other influence such as job mix formula or laboratory technique. To examine the situation further, ANOVA was applied to the plant data which were not affected by the new test procedure (i.e., oxidation effects) to determine the influence of asphalt cement (such influence would be indicative of some influence other than oxidation of asphalt cement). Table 14 presents this data. As this data also shows a variation due to asphalt cement, the influence of asphalt cement on the data from the new test procedure cannot then be isolated to show an oxidation effect.

TABLE 13

F-STATISTIC - WITHIN LAB AND BETWEEN LAB

Data Set	Within Lab		Between Lab	
Mix Type	Type 1	Type 3	Type 1	Type 3
Marshall Property/ Effect				
Specific Gravity				
Source (S)	0.94	0.61	2.00	4.98
Asphalt (A)	92.29	75.14	83.69	76.21
Source X Asphalt (SXA)	0.36	0.96	4.85	5.04
Air Voids				
S	0.90	0.07	1.96	4.92
A	47.36	70.45	41.81	65.62
SXA	0.35	0.75	4.68	4.86
VFA				
S	0.80	0.02	1.55	1.98
A	27.18	93.89	20.32	76.45
SXA	0.43	0.91	4.60	5.65
Stability				
S	1.37	3.95	3.99	34.42
A	51.27	118.86	69.99	79.54
SXA	0.17	2.72	8.36	12.40

TABLE 14

F-STATISTIC - EFFECT OF ASPHALT CEMENT ON PLANT BRIQUETTES

Marshall Property	Specific Gravity	Air Voids	VFA	Stability
Mix Type				
Type 1	61.85	24.03	9.63	12.72
Type 3	62.52	15.69	13.94	21.04

Automatic and Manual Compaction Variation

A t-test was used to examine the hypothesis of equal means for the Marshall properties of specimens compacted by automatic and manual hammers. The data was generated from the R1 and R2 samples compacted from the same loose mix can in the research laboratory. The statistical parameters extracted from Appendices B and C are reported in Table 15. It is observed that the hypothesis of equal means cannot be accepted with respect to any of the Marshall properties regardless of mix type. This result is also evident upon examination of the means. Clearly, the use of a manual hammer can change the outcome of the Marshall properties testing by increasing stability, specific gravity and VFA while decreasing the air void content.

TABLE 15

STATISTICAL PARAMETERS
AUTOMATIC VERSUS MANUAL COMPACTION

Method	Automatic		Manual		
Statistical Parameter	$\overline{x}$	s	$\overline{x}$	s	t-test
Marshall Property					
Type 1					
Specific Gravity	2.302	0.030	2.315	0.029	-2.7665
Air Voids	5.3	1.00	4.7	0.98	3.3995
VFA	69.3	3.73	71.8	3.84	-4.0567
Stability	1949	318	2181	412	-3.8579
Type 3					
Specific Gravity	2.295	0.027	2.310	0.026	-3.3873
Air Voids	5.5	1.13	4.9	0.99	3.5148
VFA	68.4	4.8	70.9	4.3	-3.3443
Stability	2421	430	2753	375	-4.9934

CONCLUSIONS

A change in sampling site from the plant to the field necessitates a modification of the standard Marshall test procedure. In general, the statistical parameters found in this study utilizing a modified test procedure were different from those parameters determined from plant samples. The direct consequence of these different parameters would be a change in the process levels used to identify specification limits in Louisiana's Statistically Oriented End-Result Specifications. Therefore, shifting the sampling site from the plant to the field would involve a change in current specifications.

Specific conclusions constrained by the data obtained for this study are:

1. The modified test procedure developed due to the change in sampling site changed the mean values and increased the variation of all Marshall properties for both Type 1 (low stability) and Type 3 (high stability) mix; stability and air void contents increased - specific gravity and voids filled with asphalt decreased.

2. Modified test procedure Marshall stabilities can be correlated with plant stabilities for Type 1 hot mix, but Type 3 mix stability correlation coefficient was different between the research and district samples.

3. All Marshall properties and variation were similar for tests conducted within the same laboratory.

4. All Marshall properties and variation with the exception of Type 3 stability were similar for tests conducted between laboratories.

5. Reducing the compaction temperature in the modified procedure to job mix formula minus 25°F reduces Marshall stability means and variation to levels similar to plant samples; all other Marshall properties have increased mean values and variation.

6. An analysis of variation due to asphalt cement oxidation caused by reheating the mix proved inconclusive.

7. The use of a manual Marshall compaction hammer can influence test results by increasing specific gravity, voids filled with asphalt and Marshall stability and decreasing air void content of Marshall briquettes.

RECOMMENDATIONS

Based on the conclusions drawn in this study, a shift in the sampling site from the plant to the field is not recommended. The variation due to the modified test procedure is much greater than the variation currently found under present specifications. A shift in sampling site would involve an increase in tolerance limits for Marshall properties. While the increase in tolerance limits is relative to the test procedure used and the quality of the hot mix would be the same, it is believed that the increased tolerance limits might create confusion among the plant technicians. Further, the increased tolerance limits might create a false sense of security for the contractor leading to an increase in deficient hot mix. Other factors to be considered would include a retraining program for plant technicians, the addition of ovens to field labs and a delay in obtaining Marshall test results.

Should the field sampling of hot mix be implemented, the following specific recommendations would need investigation.

1. Examine the between-lab variation utilizing samples compacted at the job mix formula temperature minus 25°F.

2. Examine the quality (as defined by absolute viscosity at 140°F) of the asphalt cement of specimens after reheating in an effort to determine its effect on Marshall properties.

3. Eliminate the use of the manual Marshall compaction hammer in the plant labs.

LIST OF REFERENCES

1. Shah, S. C., Quality Control Analysis Part I - Asphaltic Concrete, Louisiana Department of Highways, Research Report No. 15, November 1964.

2. Shah, S. C. and Yoches, Veto, Quality Control Analysis Part V, Louisiana Department of Highways, Research Report No. 94, December 1975.

3. Shah, S. C., Evaluation of Data Generated by Statistically Oriented End-Result Specifications, Louisiana Department of Transportation and Development, Research Report No. 125, January 1979.

APPENDIX A

TEST DATA

TABLE A-1

MIX TYPE 1 - ASPHALT E

SOURCE=P TYPE=1 ASPH=E					SOURCE=D1 TYPE=1 ASPH=E					SOURCE=D2 TYPE=1 ASPH=E				
SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB
1	2.33	4.1	75	1681	1	2.33	4.1	75	1604	1	2.34	3.7	76	1717
2	2.34	3.7	76	1532	2	2.32	4.5	73	1563	2	2.33	4.1	75	1604
3	2.33	4.1	75	1600	3	2.29	5.8	67	1316	3	2.29	5.8	67	1558
4	2.33	4.1	75	1726	4	2.33	4.1	75	2171	4	2.34	3.7	76	1839
5	2.34	3.7	76	1750	5	2.34	3.7	76	1717	5	2.34	3.7	76	1887
6	2.32	4.5	73	1481	6	2.29	5.8	67	1523	6	2.29	5.8	67	1628
7	2.32	4.5	73	1627	7	2.33	4.1	75	1571	7	2.33	4.1	75	2171
8	2.33	4.1	75	1654	8	2.32	4.5	73	1588	8	2.32	4.5	73	1976
14	2.33	4.1	75	1356	14	2.33	4.1	75	1636	14	2.32	4.5	73	1612
15	2.32	4.5	73	1573	15	2.32	4.5	73	1377	15	2.30	5.3	69	1588
16	2.34	3.7	76	1344	16	2.34	3.7	76	1814	16	2.34	3.7	76	1669
17	2.34	3.7	76	1199	17	2.35	3.3	79	1604	17	2.34	3.7	76	1588
18	2.34	3.7	76	1451	18	2.34	3.7	76	1636	18	2.34	3.7	76	1782
19	2.33	4.1	75	1551	19	2.32	4.5	73	2041	19	2.33	4.1	75	2041
20	2.35	3.3	79	1396	20	2.34	3.7	76	1588	20	2.34	3.7	76	1814

SOURCE=R1 TYPE=1 ASPH=E					SOURCE=R2 TYPE=1 ASPH=E					SOURCE=R3 TYPE=1 ASPH=E				
SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB
1	2.30	5.3	69	1466	1	2.32	4.5	73	1700	1	2.29	5.8	67	1320
2	2.32	4.5	73	1856	2	2.33	4.1	75	1763	2	2.31	4.9	71	1451
3	2.30	5.3	69	1747	3	2.31	4.9	71	2230	3	2.29	5.8	67	1320
4	2.32	4.5	73	1919	4	2.32	4.5	73	1903	4	2.30	5.3	69	1622
5	2.30	5.3	69	1357	5	2.32	4.5	73	1643	5	2.30	5.3	69	1357
6	2.26	7.0	62	1455	6	2.28	6.2	65	1755	6	2.27	6.6	64	1200
7	2.31	4.9	71	1576	7	2.31	4.9	71	1779	7	2.31	4.9	71	1435
8	2.31	4.9	71	1716	8	2.31	4.9	71	1981	8	2.31	4.9	71	1279
14	2.31	4.9	71	1810	14	2.32	4.5	73	1669	14	2.29	5.8	67	1373
15	2.30	5.3	69	1544	15	2.29	5.8	67	1763	15	2.28	6.2	65	1380
16	2.33	4.1	75	1435	16	2.32	4.5	73	1622	16	2.31	4.9	71	1295
17	2.31	4.9	71	1529	17	2.33	4.1	75	1716	17	2.30	5.3	69	1466
18	2.32	4.5	73	1903	18	2.33	4.1	75	1810	18	2.31	4.9	71	1544
19	2.30	5.3	69	1643	19	2.31	4.9	71	2137	19	2.30	5.3	69	1513
20	2.30	5.3	69	1960	20	2.33	4.1	75	2262	20	2.30	5.3	69	1544

TABLE A-2

MIX TYPE 1 - ASPHALT L

------ SOURCE=P TYPE=1 ASPH=L ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.36	3.3	77	1704
2	2.34	4.1	73	1151
3	2.35	3.7	75	1274
4	2.38	2.5	82	1461
5	2.35	3.7	75	1475
6	2.37	2.9	79	2058
7	2.37	2.9	79	1945
8	2.37	2.9	79	1646
9	2.37	2.9	79	1637
10	2.34	4.1	73	1459
11	2.38	2.5	82	1431
12	2.36	3.3	77	1521
13	2.37	2.9	79	1600
14	2.35	3.7	75	1429
15	2.37	2.9	79	1508
16	2.36	3.3	77	1566
17	2.37	2.9	79	1708
18	2.36	3.3	77	1960
19	2.32	4.9	69	1118
20	2.37	2.9	79	1835
21	2.37	2.9	79	1735

------ SOURCE=D1 TYPE=1 ASPH=L ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.36	3.3	77	2360
2	2.33	4.5	71	1778
3	2.32	4.9	69	1699
4	2.36	3.3	77	2109
5	2.32	4.9	69	1938
6	2.33	4.5	71	3203
7	2.35	3.7	75	2098
8	2.33	4.5	71	1926
9	2.34	4.1	73	2280
10	2.30	5.7	65	1733
11	2.35	3.7	75	2143
12	2.33	4.5	71	1721
13	2.33	4.5	71	2200
14	2.34	4.1	73	2645
15	2.35	3.7	75	2508
16	2.34	4.1	73	2359
17	2.35	3.7	75	3089
18	2.33	4.5	71	2189
19	2.30	5.7	65	1984
20	2.34	4.1	73	2257
21	2.32	4.9	69	2371

------ SOURCE=D2 TYPE=1 ASPH=L ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.35	3.7	75	2326
2	2.33	4.5	71	2622
3	2.32	4.9	69	2052
4	2.36	3.3	77	2382
5	2.31	5.3	67	1767
6	2.33	4.5	71	2348
7	2.35	3.7	75	2440
8	2.33	4.5	71	2166
9	2.35	3.7	75	2679
10	2.32	4.9	69	2428
11	2.36	3.3	77	2485
12	2.33	4.5	71	1630
13	2.34	4.1	73	2200
14	2.35	3.7	75	2280
15	2.35	3.7	75	1984
16	2.34	4.1	73	2622
17	2.36	3.3	77	2587
18	2.34	4.1	73	2257
19	2.31	5.3	67	2394
20	2.34	4.1	73	2075
21	2.33	4.5	71	1927

------ SOURCE=R1 TYPE=1 ASPH=L ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.34	4.1	73	1498
2	2.32	4.9	69	1622
3	2.32	4.9	69	1560
4	2.37	2.9	79	1738
5	2.31	5.3	67	1716
6	2.34	4.1	73	1888
7	2.36	3.3	77	2064
8	2.34	4.1	73	1960
9	2.35	3.7	75	1685
10	2.32	4.9	69	1888
11	2.36	3.3	77	1981
12	2.34	4.1	73	1934
13	2.33	4.5	71	1669
14	2.34	4.1	73	1872
15	2.36	3.3	77	1836
16	2.34	4.1	73	1966
17	2.35	3.7	75	1716
18	2.33	4.5	71	1997
19	2.31	5.3	67	1466
20	2.35	3.7	75	2044
21	2.33	4.5	71	1591

------ SOURCE=R2 TYPE=1 ASPH=L ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.36	3.3	77	1674
2	2.33	4.5	71	1763
3	2.35	3.7	75	1747
4	2.38	2.5	82	2064
5	2.34	4.1	73	1919
6	2.36	3.3	77	2129
7	2.37	2.9	79	2323
8	2.36	3.3	77	2226
9	2.37	2.9	79	1885
10	2.33	4.5	71	1841
11	2.37	2.9	79	2161
12	2.36	3.3	77	2177
13	2.34	4.1	73	1607
14	2.35	3.7	75	1825
15	2.37	2.9	79	2048
16	2.35	3.7	75	2044
17	2.36	3.3	77	1841
18	2.35	3.7	75	1779
19	2.33	4.5	71	1685
20	2.35	3.7	75	2059
21	2.34	4.1	73	1856

------ SOURCE=R3 TYPE=1 ASPH=L ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.34	4.1	73	1466
2	2.32	4.9	69	1310
3	2.32	4.9	69	1170
4	2.37	2.9	79	1711
5	2.31	5.3	67	1310
6	2.33	4.5	71	1513
7	2.35	3.7	75	1669
8	2.33	4.5	71	1607
9	2.35	3.7	75	1373
10	2.31	5.3	67	1498
11	2.36	3.3	77	1888
12	2.34	4.1	73	1716
13	2.33	4.5	71	1498
14	2.35	3.7	75	1747
15	2.34	4.1	73	1685
16	2.34	4.1	73	1903
17	2.34	4.1	73	1622
18	2.33	4.5	71	1622
19	2.31	5.3	67	1217
20	2.34	4.1	73	1700
21	2.33	4.5	71	1373

TABLE A-3

MIX TYPE 1 - ASPHALT S

------ SOURCE=P TYPE=1 ASPH=S ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.31	4.5	74	1983
2	2.32	4.1	75	1804
3	2.30	5.0	71	1874
4	2.32	4.1	75	1579
5	2.31	4.5	74	2417
6	2.30	5.0	71	1852
7	2.31	4.5	74	2506
8	2.27	6.2	66	1516
9	2.33	3.7	77	1993
10	2.30	5.0	71	2359
11	2.31	4.5	74	2329
12	2.31	4.5	74	2124
13	2.30	5.0	71	2328
14	2.31	4.5	74	2172
15	2.33	3.7	77	1779
16	2.33	3.7	77	1821
17	2.30	5.0	71	1916
18	2.32	4.1	75	1670
19	2.33	3.7	77	1697
20	2.30	5.0	71	1656

------ SOURCE=D1 TYPE=1 ASPH=S ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.29	5.4	70	2287
2	2.30	5.0	71	2064
3	2.29	5.4	70	2122
4	2.31	4.5	74	2311
5	2.27	6.2	66	2244
6	2.28	5.8	68	2366
7	2.28	5.8	68	2688
8	2.25	7.0	64	2349
9	2.30	5.0	71	2827
10	2.29	5.4	70	2835
11	2.27	6.2	66	2668
12	2.29	5.4	70	2763
13	2.27	6.2	66	2260
14	2.27	6.2	66	2436
15	2.31	4.5	74	2350
16	2.30	5.0	71	2718
17	2.27	6.2	66	2420
18	2.27	6.2	66	2405
19	2.30	5.0	71	2843
20	2.29	5.4	70	2922

------ SOURCE=D2 TYPE=1 ASPH=S ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.28	5.8	68	2199
2	2.29	5.4	70	2064
3	2.29	5.4	70	2122
4	2.32	4.1	75	2152
5	2.28	5.8	68	1611
6	2.30	5.0	71	2717
7	2.29	5.4	70	2425
8	2.26	6.6	65	2667
9	2.31	4.5	74	2533
10	2.30	5.0	71	2916
11	2.28	5.8	68	2843
12	2.29	5.4	70	282[illegible]
13	2.28	5.8	68	2459
14	2.28	5.8	68	2939
15	2.32	4.1	75	2270
16	2.29	5.4	70	2596
17	2.28	5.8	68	2901
18	2.28	5.8	68	2878
19	2.29	5.4	70	2644
20	2.30	5.0	71	2922

--- SOURCE=R1 TYPE=1 ASPH=S ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.29	5.4	70	1650
2	2.31	4.5	74	2621
3	2.29	5.4	70	2605
4	2.31	4.5	74	2293
5	2.28	5.8	68	2100
6	2.28	5.8	68	2670
7	2.28	5.8	68	2550
8	2.25	7.0	64	2670
9	2.31	4.5	71	2636
10	2.28	5.8	68	2877
11	2.29	5.4	70	2385
12	2.29	5.4	70	2714
13	2.27	6.2	66	2520
14	2.27	6.2	66	3304
15	2.33	3.7	77	2512
16	2.30	5.0	71	3026
17	2.28	5.8	68	2656
18	2.27	6.2	66	3289
19	2.31	4.5	74	3036
20	2.30	5.0	71	2892

------ SOURCE=R2 TYPE=1 ASPH=S ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.27	6.2	66	1620
2	2.28	5.8	68	2205
3	2.27	6.2	66	2130
4	2.30	5.0	71	2028
5	2.27	6.2	66	2370
6	2.28	5.8	68	2325
7	2.27	6.2	66	2355
8	2.23	7.9	60	2280
9	2.29	5.4	70	2160
10	2.27	6.2	66	2250
11	2.27	6.2	66	2400
12	2.28	5.8	68	2205
13	2.26	6.6	65	2250
14	2.26	6.6	65	2656
15	2.31	4.5	74	2278
16	2.28	5.8	68	2416
17	2.25	7.0	64	2265
18	2.26	6.6	65	2460
19	2.29	5.4	70	2774
20	2.28	5.8	68	2745

------ SOURCE=R3 TYPE=1 ASPH=S ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.29	5.4	70	1695
2	2.31	4.5	74	2340
3	2.29	5.4	70	1825
4	2.29	5.4	70	2090
5	2.26	6.6	65	1980
6	2.26	6.6	65	2220
7	2.26	6.6	65	2100
8	2.25	7.0	64	2100
9	2.29	5.4	70	2055
10	2.28	5.8	68	2324
11	2.28	5.8	68	2235
12	2.28	5.8	68	1885
13	2.26	6.6	65	1725
14	2.26	6.6	65	1905
15	2.32	4.1	75	1919
16	2.29	5.4	70	1860
17	2.27	6.2	66	2086
18	2.26	6.6	65	2205
19	2.30	5.0	71	2059
20	2.28	5.8	68	2144

TABLE A-4

MIX TYPE 1 - ASPHALT T

SOURCE=P TYPE=1 ASPH=T					SOURCE=D1 TYPE=1 ASPH=T					SOURCE=D2 TYPE=1 ASPH=T				
SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB
1	2.34	3.7	77	1331	1	2.32	4.5	73	1716	1	2.32	4.5	73	1814
2	2.32	4.5	73	1299	2	2.30	5.3	69	1810	2	2.32	4.5	73	1875
3	2.32	4.5	73	1531	3	2.29	5.8	67	2043	3	2.30	5.3	69	1891
4	2.32	4.5	73	1711	4	2.31	4.9	71	2104	4	2.30	5.3	69	2485
5	2.33	4.1	75	1974	5	2.29	5.8	67	2455	5	2.30	5.3	69	2455
6	2.32	4.5	73	2019	6	2.30	5.3	69	2112	6	2.29	5.8	67	2005
7	2.33	4.1	75	1774	7	2.29	5.8	67	1921	7	2.29	5.8	67	1891
8	2.34	3.7	77	1608	8	2.31	4.9	71	2080	8	2.30	5.3	69	1982
9	2.32	4.5	73	1489	9	2.30	5.3	69	2028	9	2.29	5.8	67	2155
10	2.32	4.5	73	1563	10	2.30	5.3	69	2013	10	2.30	5.3	69	2023
11	2.33	4.1	75	1837	11	2.30	5.3	69	2331	11	2.30	5.3	69	2165
12	2.32	4.5	73	1922	12	2.29	5.8	67	1936	12	2.30	5.3	69	2119
13	2.32	4.5	73	1952	13	2.29	5.8	67	2229	13	2.28	6.2	66	2118
14	2.32	4.5	73	1780	14	2.28	6.2	66	2196	14	2.28	6.2	66	2243
15	2.32	4.5	73	1621	15	2.29	5.8	67	1921	15	2.29	5.8	67	1997
16	2.33	4.1	75	1655	16	2.29	5.8	67	2104	16	2.30	5.3	69	1814
17	2.33	4.1	75	1657	17	2.30	5.3	69	1830	17	2.29	5.8	67	1862
18	2.33	4.1	75	1964	18	2.28	6.2	66	1982	18	2.29	5.8	67	2229
19	2.33	4.1	75	1696	19	2.31	4.9	71	1845	19	2.29	5.8	67	1979
20	2.34	3.7	77	1452	20	2.31	4.9	71	1891	20	2.31	4.9	71	1860

SOURCE=R1 TYPE=1 ASPH=T					SOURCE=R2 TYPE=1 ASPH=T					SOURCE=R3 TYPE=1 ASPH=T				
SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB
1	.	.	.	.	1	.	.	.	.	1	.	.	.	.
2	2.31	4.9	71	1669	2	2.31	4.9	71	1622	2	2.30	5.3	70	1530
3	2.31	4.9	71	1732	3	2.30	5.3	70	1841	3	2.28	6.2	66	1530
4	2.29	5.8	67	2190	4	2.29	5.8	67	2130	4	2.28	6.2	66	1770
5	2.28	6.2	66	1815	5	2.29	5.8	67	2390	5	2.28	6.2	66	1845
6	2.28	6.2	66	2325	6	2.30	5.3	70	2293	6	2.28	6.2	66	1890
7	2.29	5.8	67	2184	7	2.30	5.3	70	2527	7	2.29	5.8	67	1830
8	2.30	5.3	70	1794	8	2.29	5.8	67	2280	8	2.29	5.8	67	1530
9	2.29	5.8	67	1903	9	2.31	4.9	71	2138	9	2.28	6.2	66	1545
10	2.29	5.8	67	1890	10	2.31	4.9	71	2309	10	2.28	6.2	66	1669
11	2.29	5.8	67	2100	11	2.30	5.3	70	2309	11	2.28	6.2	66	1885
12	2.28	6.2	66	2190	12	2.29	5.8	67	2278	12	2.28	6.2	66	1711
13	2.27	6.6	64	1725	13	2.30	5.3	70	2153	13	2.27	6.6	64	1580
14	2.29	5.8	67	2130	14	2.29	5.8	67	1923	14	2.27	6.6	64	1711
15	2.28	6.2	66	1890	15	2.28	6.2	66	2250	15	2.28	6.2	66	1770
16	2.29	5.8	67	2100	16	2.30	5.3	70	2246	16	2.29	5.8	67	1770
17	2.28	6.2	66	1695	17	2.32	4.5	73	2153	17	2.28	6.2	66	1635
18	2.28	6.2	66	2085	18	2.31	4.9	71	2340	18	2.27	6.6	64	1725
19	2.28	6.2	66	1920	19	2.31	4.9	71	2730	19	2.28	6.2	66	1680
20	2.31	4.9	71	2044	20	2.32	4.5	73	2262	20	2.30	5.3	70	1700

TABLE A-5

MIX TYPE 3 - ASPHALT E

------ SOURCE=P TYPE=3 ASPH=E

SAMPLE	SPGR	VOID	VFA	STAB
1	2.31	4.1	75	2208
2	2.31	4.1	75	1940
3	2.32	3.7	77	1726
4	2.31	4.1	75	2059
5	2.31	4.1	75	1838
6	2.32	3.7	77	1896
7	2.31	4.1	75	1973
8	2.30	4.6	73	1918
9	2.31	4.1	75	2230
10	2.32	3.7	77	2044
11	2.31	4.1	75	1338
12	2.31	4.1	75	1737
13	2.32	3.7	77	2252

------------ SOURCE=D1 TYPE=3 ASPH=E

SAMPLE	SPGR	VOID	VFA	STAB
1	2.25	6.6	65	2155
2	2.28	5.4	70	2252
3	2.28	5.4	70	1814
4	2.31	4.1	75	2754
5	2.30	4.6	73	2948
6	2.30	4.6	73	2171
7	2.28	5.4	70	2025
8	2.26	6.2	66	2090
9	2.29	5.0	71	1944
10	2.29	5.0	71	2543
11	2.31	4.1	75	1555
12	2.30	4.6	73	2333
13	2.30	4.6	73	2025

-------------- SOURCE=D2 TYPE=3 ASPH=E ------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.27	5.8	68	2576
2	2.28	5.4	70	2980
3	2.29	5.0	71	2057
4	2.29	5.0	71	2560
5	2.30	4.6	73	2754
6	2.21	4.1	75	2236
7	2.29	5.0	71	2592
8	2.25	6.6	65	2495
9	2.29	5.0	71	2268
10	2.28	5.4	70	2786
11	2.31	4.1	75	2025
12	2.30	4.6	73	2657
13	2.30	4.6	73	2187

----- SOURCE=R1 TYPE=3 ASPH=E

SAMPLE	SPGR	VOID	VFA	STAB
1	2.26	6.2	66	2175
2	2.28	5.4	70	2520
3	2.30	4.6	73	2370
4	2.29	5.0	71	2535
5	2.27	5.8	68	2445
6	2.29	5.0	71	2745
7	2.28	5.4	70	2700
8	2.25	6.6	65	2475
9	2.26	6.2	66	2115
10	2.28	5.4	70	2640
11	2.31	4.1	75	2309
12	2.30	4.6	73	2480
13	2.29	5.0	71	2370

------------ SOURCE=R2 TYPE=3 ASPH=E

SAMPLE	SPGR	VOID	VFA	STAB
1	2.26	6.2	66	2325
2	2.27	5.8	68	2415
3	2.29	5.0	71	2460
4	2.30	4.6	73	2667
5	2.28	5.4	70	2610
6	2.29	5.0	71	2475
7	2.27	5.8	68	2850
8	2.25	6.6	65	2475
9	2.27	5.8	68	2444
10	2.29	5.0	71	2848
11	2.31	4.1	75	2418
12	2.30	4.6	73	2605
13	2.30	4.6	73	2636

-------------- SOURCE=R3 TYPE=3 ASPH=E -----

SAMPLE	SPGR	VOID	VFA	STAB
1	2.25	6.6	65	1740
2	2.26	6.2	66	2055
3	2.28	5.4	70	1995
4	2.27	5.8	68	1995
5	2.28	5.4	70	2160
6	2.27	5.8	68	2190
7	2.28	5.4	70	2190
8	2.25	6.6	65	1860
9	2.25	6.6	65	1950
10	2.26	6.2	66	2040
11	2.30	4.6	73	2137
12	2.29	5.0	71	2085
13	2.28	5.4	70	2280

TABLE A-6

MIX TYPE 3 - ASPHALT L

SOURCE=P TYPE=3 ASPH=L					SOURCE=D1 TYPE=3 ASPH=L					SOURCE=D2 TYPE=3 ASPH=L				
SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB
1	2.35	3.3	78	1811	1	2.34	3.7	76	2997	1	2.34	3.7	76	3323
2	2.33	4.1	74	2084	2	2.31	4.9	70	3349	2	2.32	4.5	72	3668
3	2.34	3.7	76	2131	3	2.33	4.1	74	3535	3	2.32	4.5	72	4572
4	2.33	4.1	74	1847	4	2.33	4.1	74	3296	4	2.33	4.1	74	2990
5	2.36	2.9	80	2802	5	2.33	4.1	74	3495	5	2.34	3.7	76	3987
6	2.35	3.3	78	2051	6	2.33	4.1	74	3654	6	2.33	4.1	74	4426
7	2.35	3.3	78	2456	7	2.32	4.5	72	3482	7	2.33	4.1	74	4439
8	2.35	3.3	78	2148	8	2.32	4.5	72	3721	8	2.33	4.1	74	4200
9	2.35	3.3	78	2724	9	2.30	5.3	69	4598	9	2.31	4.9	70	4425
10	2.35	3.3	78	2158	10	2.33	4.1	74	3163	10	2.33	4.1	74	3269
11	2.35	3.3	78	2375	11	2.33	4.1	74	2817	11	2.34	3.7	76	3696
12	2.35	3.3	78	1814	12	2.31	4.9	70	4505	12	2.30	5.3	69	5409
13	2.34	3.7	76	2373	13	2.33	4.1	74	4957	13	2.34	3.7	76	5157
14	2.35	3.3	78	2152	14	2.33	4.1	74	3043	14	2.34	3.7	76	4067
15	2.34	3.7	76	2581	15	2.34	3.7	76	3867	15	2.34	3.7	76	3894
16	2.35	3.3	78	2501	16	2.33	4.1	74	3721	16	2.34	3.7	76	3708
17	2.35	3.3	78	2503	17	2.34	3.7	76	4226	17	2.34	3.7	76	3827
18	2.35	3.3	78	2522	18	2.34	3.7	76	3721	18	2.33	4.1	74	3934
19	2.35	3.3	78	2159	19	2.33	4.1	74	3628	19	2.34	3.7	76	4423
20	2.36	2.9	80	2423	20	2.33	4.1	74	3588	20	2.34	3.7	76	2897

SOURCE=R1 TYPE=3 ASPH=L					SOURCE=R2 TYPE=3 ASPH=L					SOURCE=R3 TYPE=3 ASPH=L				
SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB
1	2.33	4.1	74	2574	1	2.35	3.3	78	3010	1	2.33	4.1	74	2496
2	2.33	4.1	74	2992	2	2.34	3.7	76	3258	2	2.32	4.5	72	2527
3	2.32	4.5	72	2792	3	2.34	3.7	76	3421	3	2.33	4.1	74	2761
4	2.35	3.3	78	2714	4	2.34	3.7	76	2714	4	2.33	4.1	74	2652
5	2.33	4.1	74	2964	5	2.36	2.9	80	3110	5	2.33	4.1	74	2558
6	2.33	4.1	74	3288	6	2.34	3.7	76	3377	6	2.33	4.1	74	2823
7	2.34	3.7	76	3080	7	2.34	3.7	76	3347	7	2.33	4.1	74	2902
8	2.33	4.1	74	2995	8	2.34	3.7	76	3584	8	2.32	4.5	72	2902
9	2.29	5.8	67	2939	9	2.32	4.5	72	3643	9	2.29	5.8	67	2910
10	2.33	4.1	74	3095	10	2.35	3.3	78	3214	10	2.33	4.1	74	2870
11	2.34	3.7	76	2995	11	2.35	3.3	78	2917	11	2.34	3.7	76	2667
12	2.35	3.3	78	3072	12	2.35	3.3	78	3080	12	2.34	3.7	76	2885
13	2.32	4.5	72	2746	13	2.35	3.3	78	3036	13	2.32	4.5	72	2450
14	2.33	4.1	74	2995	14	2.35	3.3	78	3072	14	2.33	4.1	74	2667
15	2.35	3.3	78	3057	15	2.35	3.3	78	3080	15	2.33	4.1	74	2652
16	2.34	3.7	76	2933	16	2.35	3.3	78	3406	16	2.33	4.1	74	2777
17	2.33	4.1	74	3051	17	2.34	3.7	76	3199	17	2.33	4.1	74	2543
18	2.32	4.5	72	3347	18	2.33	4.1	74	3466	18	2.32	4.5	72	2714
19	2.34	3.7	76	3011	19	2.35	3.3	78	2978	19	2.34	3.7	76	2184
20	2.33	4.1	74	2793	20	2.35	3.3	78	3229	20	2.33	4.1	74	2496

TABLE A-7

MIX TYPE 3 - ASPHALT S

------ SOURCE=P	TYPE=3	ASPH=S			------------ SOURCE=D1	TYPE=3	ASPH=S			-------------- SOURCE=D2	TYPE=3	ASPH=S -----		
SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB
1	2.33	4.1	74	2445	1	2.29	5.8	66	2563	1	2.29	5.8	66	2703
2	2.33	4.1	74	2129	2	2.29	5.8	66	3001	2	2.29	5.8	66	2906
3	2.33	4.1	74	2541	3	2.30	5.3	68	2465	3	2.28	6.2	65	2252
4	2.32	4.5	72	1512	4	2.31	4.9	70	2104	4	2.30	5.3	68	2430
5	2.34	3.7	76	2498	5	2.29	5.8	66	2517	5	2.29	5.8	66	2718
6	2.31	4.9	70	1687	6	2.29	5.8	66	2802	6	2.29	5.8	66	2753
7	2.34	3.7	76	2580	7	2.30	5.3	68	2916	7	2.31	4.9	70	3064
8	2.32	4.5	72	2129	8	2.29	5.8	66	2558	8	2.29	5.8	66	2428
9	2.34	3.7	76	2249	9	2.30	5.3	68	3106	9	2.30	5.3	68	3096
10	2.34	3.7	76	2277	10	2.29	5.8	66	3048	10	2.29	5.8	66	2731
11	2.33	4.1	74	2409	11	2.30	5.3	68	2985	11	2.29	5.8	66	2695
12	2.33	4.1	74	2373	12	2.30	5.3	68	3143	12	2.29	5.8	66	2708
13	2.33	4.1	74	2485	13	2.29	5.8	66	2649	13	2.28	6.2	65	2634
14	2.34	3.7	76	2194	14	2.30	5.3	68	2992	14	2.29	5.8	66	2741
15	2.33	4.1	74	2473	15	2.29	5.8	66	2848	15	2.29	5.8	66	2825
16	2.31	4.9	70	1599	16	2.27	6.6	63	2412	16	2.28	6.2	65	2672
17	2.34	3.7	76	2591	17	2.29	5.8	66	2803	17	2.29	5.8	66	2668
18	2.34	3.7	76	2524	18	2.28	6.2	65	2672	18	2.29	5.8	66	2851
19	2.34	3.7	76	2504	19	2.29	5.8	66	2660	19	2.29	5.8	66	2660
20	2.33	4.1	74	2661	20	2.29	5.8	66	2843	20	2.29	5.8	66	2660
21	2.33	4.1	74	2058	21	2.31	4.9	70	3206	21	2.30	5.3	68	2843

----- SOURCE=R1	TYPE=3	ASPH=S			------------ SOURCE=R2	TYPE=3	ASPH=S			-------------- SOURCE=R3	TYPE=3	ASPH=S -----		
SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB	SAMPLE	SPGR	VOID	VFA	STAB
1	2.28	6.2	65	2310	1	2.26	7.0	62	1800	1	2.27	6.6	64	1800
2	2.28	6.2	65	2265	2	2.26	7.0	62	1920	2	2.28	6.2	65	1935
3	2.29	5.8	67	2160	3	2.26	7.0	62	1920	3	2.27	6.6	64	1965
4	2.30	5.3	69	2262	4	2.28	6.2	65	1755	4	2.30	5.3	69	1825
5	2.28	6.2	65	2100	5	2.25	7.4	60	1830	5	2.28	6.2	65	2055
6	2.29	5.8	67	2700	6	2.26	7.0	62	2040	6	2.28	6.2	65	2070
7	2.31	4.9	70	2496	7	2.29	5.8	67	2295	7	2.30	5.3	69	2481
8	2.31	4.9	70	2855	8	2.28	6.2	65	2144	8	2.30	5.3	69	2434
9	2.29	5.8	67	2542	9	2.28	6.2	65	2235	9	2.29	5.8	67	2010
10	2.30	5.3	69	2666	10	2.27	6.6	64	2130	10	2.29	5.8	67	2220
11	2.30	5.3	69	2777	11	2.28	6.2	65	2070	11	2.29	5.8	67	2496
12	2.31	4.9	70	2808	12	2.29	5.8	67	2355	12	2.30	5.3	69	2215
13	2.29	5.8	67	2115	13	2.27	6.6	64	1860	13	2.28	6.2	65	1860
14	2.30	5.3	69	2356	14	2.27	6.6	64	1890	14	2.29	5.8	67	1845
15	2.29	5.8	67	2356	15	2.26	7.0	62	2010	15	2.28	6.2	65	1965
16	2.28	6.2	65	2175	16	2.26	7.0	62	1920	16	2.27	6.6	64	1665
17	2.29	5.8	67	2418	17	2.28	6.2	65	1755	17	2.30	5.3	69	2012
18	2.29	5.8	67	2527	18	2.27	6.6	64	1995	18	2.28	6.2	65	1935
19	2.30	5.3	69	2355	19	2.27	6.6	64	2085	19	2.29	5.8	67	2130
20	2.28	6.2	65	2294	20	2.26	7.0	62	2175	20	2.29	5.8	67	2235
21	2.30	5.3	69	2730	21	2.29	5.8	67	2144	21	2.30	5.3	69	2215

TABLE A-8

MIX TYPE 3 - ASPHALT T

------- SOURCE=P TYPE=3 ASPH=T -------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.36	3.3	78	1738
2	2.34	4.1	74	1744
3	2.36	3.3	78	2056
4	2.36	3.3	78	1846
5	2.35	3.7	76	1856
6	2.35	3.7	76	1520
7	2.34	4.1	74	1734
8	2.34	4.1	74	1717
9	2.34	4.1	74	1599
10	2.34	4.1	74	1824
11	2.35	3.7	76	1728
12	2.34	4.1	74	1835
13	2.34	4.1	74	1652
14	2.35	3.7	76	1721
15	2.35	3.7	76	1712
16	2.35	3.7	76	1651
17	2.34	4.1	74	1749
18	2.35	3.7	76	1543
19	2.33	4.5	72	1498
20	2.36	3.3	78	1867

------- SOURCE=D1 TYPE=3 ASPH=T -------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.30	5.7	67	2415
2	2.28	6.6	64	2192
3	2.29	6.1	66	2375
4	2.32	4.9	70	2507
5	2.29	6.1	66	2668
6	2.33	4.5	72	2546
7	2.31	5.3	69	2440
8	2.31	5.3	69	2470
9	2.30	5.7	67	2577
10	2.33	4.5	72	2638
11	2.32	4.9	70	2288
12	2.30	5.7	67	2668
13	2.32	4.9	70	2318
14	2.34	4.1	74	2501
15	2.31	5.3	69	2507
16	2.33	4.5	72	2624
17	2.30	5.7	67	2389
18	2.32	4.9	70	2507
19	2.31	5.3	69	2522
20	2.32	4.9	70	2933

------- SOURCE=D2 TYPE=3 ASPH=T -------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.31	5.3	69	2389
2	2.28	6.6	64	2028
3	2.30	5.7	67	2394
4	2.32	4.9	70	2653
5	2.30	5.7	67	2639
6	2.31	5.3	69	2318
7	2.30	5.7	67	2379
8	2.32	4.9	70	2654
9	2.31	5.3	69	2456
10	2.31	5.3	69	2668
11	2.31	5.3	69	2361
12	2.31	5.3	69	2551
13	2.31	5.3	69	2546
14	2.32	4.9	70	2492
15	2.30	5.7	67	2610
16	2.30	5.7	67	2592
17	2.31	5.3	69	2440
18	2.32	4.9	70	2379
19	2.32	4.9	70	2389
20	2.30	5.7	67	3034

----- SOURCE=R1 TYPE=3 ASPH=T -------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.28	6.6	64	2055
2	2.27	7.0	62	1950
3	2.29	6.1	66	2550
4	2.29	6.1	66	2370
5	2.28	6.6	64	2880
6	2.29	6.1	66	2465
7	2.31	5.3	69	2542
8	2.32	4.9	70	2480
9	2.29	6.1	66	2070
10	2.30	5.7	67	2542
11	2.28	6.6	64	1860
12	2.31	5.3	69	2574
13	2.30	5.7	67	1888
14	2.30	5.7	67	2480
15	2.29	6.1	66	2168
16	2.28	6.6	64	2085
17	2.30	5.7	67	1607
18	2.30	5.7	67	2309
19	2.30	5.7	67	2122
20	2.30	5.7	67	2527

------- SOURCE=R2 TYPE=3 ASPH=T -------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.30	5.7	67	2542
2	2.27	7.0	62	2625
3	2.30	5.7	67	2995
4	2.30	5.7	67	3026
5	2.32	4.9	70	2855
6	2.32	4.9	70	3007
7	2.31	5.3	69	2964
8	2.33	4.5	72	2933
9	2.32	4.9	70	2293
10	2.32	4.9	70	2854
11	2.31	5.3	69	2683
12	2.31	5.3	69	3010
13	2.33	4.5	72	2340
14	2.32	4.9	70	2590
15	2.31	5.3	69	2964
16	2.30	5.7	67	2777
17	2.31	5.3	69	2434
18	2.32	4.9	70	2527
19	2.32	4.9	70	2636
20	2.31	5.3	69	2995

------- SOURCE=R3 TYPE=3 ASPH=T -------

SAMPLE	SPGR	VOID	VFA	STAB
1	2.27	7.0	62	1580
2	2.26	7.4	61	1665
3	2.28	6.6	64	1755
4	2.27	7.0	62	2070
5	2.28	6.6	64	1711
6	2.30	5.7	67	1997
7	2.29	6.1	66	1785
8	2.30	5.7	67	1997
9	2.30	5.7	67	1685
10	2.30	5.7	67	2122
11	2.28	6.6	64	1740
12	2.31	5.3	69	2044
13	2.30	5.7	67	1685
14	2.30	5.7	67	1997
15	2.30	5.7	67	1669
16	2.28	6.6	64	1740
17	2.28	6.6	64	1440
18	2.30	5.7	67	1685
19	2.30	5.7	67	1576
20	2.29	6.1	66	1665

APPENDIX B

STATISTICAL PARAMETERS

TABLE B-1

MIX TYPE 1 - ASPHALT E

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=1 ASPH=L SOURCE=D1						
SPGR	21	2.334	0.017	2.300	2.360	0.711
VOID	21	4.329	0.664	3.300	5.700	15.344
VFA	21	71.857	3.321	65.000	77.000	4.622
STAB	21	2218.571	403.782	1699.000	3203.000	18.200
TYPE=1 ASPH=L SOURCE=D2						
SPGR	21	2.338	0.015	2.310	2.360	0.657
VOID	21	4.176	0.615	3.300	5.300	14.720
VFA	21	72.619	3.074	67.000	77.000	4.233
STAB	21	2269.095	284.287	1630.000	2679.000	12.529
TYPE=1 ASPH=L SOURCE=P						
SPGR	21	2.361	0.015	2.320	2.380	0.627
VOID	21	3.262	0.592	2.500	4.900	18.149
VFA	21	77.286	3.101	69.000	82.000	4.012
STAB	21	1581.952	246.947	1118.000	2058.000	15.610
TYPE=1 ASPH=L SOURCE=R1						
SPGR	21	2.339	0.017	2.310	2.370	0.719
VOID	21	4.157	0.673	2.900	5.300	16.183
VFA	21	72.714	3.364	67.000	79.000	4.626
STAB	21	1794.810	184.036	1466.000	2064.000	10.254
TYPE=1 ASPH=L SOURCE=R2						
SPGR	21	2.353	0.015	2.330	2.380	0.621
VOID	21	3.567	0.584	2.500	4.500	16.380
VFA	21	75.714	3.019	71.000	82.000	3.987
STAB	21	1935.857	200.673	1607.000	2323.000	10.366
TYPE=1 ASPH=L SOURCE=R3						
SPGR	21	2.335	0.016	2.310	2.370	0.685
VOID	21	4.290	0.640	2.900	5.300	14.922
VFA	21	72.048	3.201	67.000	79.000	4.443
STAB	21	1552.286	205.732	1170.000	1903.000	13.253

TABLE B-2

MIX TYPE 1 - ASPHALT L

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=1 ASPH=E SOURCE=D1						
SPGR	15	2.326	0.017	2.290	2.350	0.741
VOID	15	4.273	0.720	3.300	5.800	16.839
VFA	15	73.933	3.240	67.000	79.000	4.382
STAB	15	1649.933	221.043	1316.000	2171.000	13.397
TYPE=1 ASPH=E SOURCE=D2						
SPGR	15	2.326	0.018	2.290	2.340	0.793
VOID	15	4.273	0.766	3.700	5.800	17.919
VFA	15	73.733	3.327	67.000	76.000	4.512
STAB	15	1764.933	187.790	1558.000	2171.000	10.640
TYPE=1 ASPH=E SOURCE=P						
SPGR	15	2.333	0.009	2.320	2.350	0.379
VOID	15	3.993	0.353	3.300	4.500	8.852
VFA	15	75.200	1.521	73.000	79.000	2.023
STAB	15	1528.067	156.427	1199.000	1750.000	10.237
TYPE=1 ASPH=E SOURCE=R1						
SPGR	15	2.306	0.016	2.260	2.330	0.692
VOID	15	5.067	0.659	4.100	7.000	13.000
VFA	15	70.267	2.987	62.000	75.000	4.251
STAB	15	1661.067	197.808	1357.000	1960.000	11.908
TYPE=1 ASPH=E SOURCE=R2						
SPGR	15	2.315	0.015	2.280	2.330	0.629
VOID	15	4.700	0.613	4.100	6.200	13.042
VFA	15	72.067	2.915	65.000	75.000	4.044
STAB	15	1848.867	209.646	1622.000	2262.000	11.339
TYPE=1 ASPH=E SOURCE=R3						
SPGR	15	2.298	0.012	2.270	2.310	0.525
VOID	15	5.413	0.525	4.900	6.600	9.696
VFA	15	68.667	2.257	64.000	71.000	3.287
STAB	15	1406.600	117.260	1200.000	1622.000	8.336

TABLE B-3

MIX TYPE 1 - ASPHALT S

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=1 ASPH=S SOURCE=D1						
SPGR	20	2.285	0.016	2.250	2.310	0.703
VOID	20	5.590	0.659	4.500	7.000	11.794
VI	20	68.900	2.827	64.000	74.000	4.102
STAB	20	2493.900	263.018	2064.000	2922.000	10.546
TYPE=1 ASPH=S SOURCE=D2						
SPGR	20	2.290	0.015	2.260	2.320	0.641
VOID	20	5.365	0.616	4.100	6.600	11.479
VFA	20	69.900	2.532	65.000	75.000	3.622
STAB	20	2535.650	367.105	1611.000	2939.000	14.478
TYPE=1 ASPH=S SOURCE=P						
SPGR	20	2.310	0.015	2.270	2.330	0.635
VOID	20	4.515	0.625	3.700	6.200	13.846
VFA	20	73.450	2.819	66.000	77.000	3.837
STAB	20	1968.750	298.688	1516.000	2506.000	15.171
TYPE=1 ASPH=S SOURCE=R1						
SPGR	20	2.289	0.019	2.250	2.330	0.820
VOID	20	5.395	0.786	3.700	7.000	14.564
VFA	20	69.700	3.262	64.000	77.000	4.680
STAB	20	2650.300	383.242	1650.000	3304.000	14.460
TYPE=1 ASPH=S SOURCE=R2						
SPGR	20	2.273	0.018	2.230	2.310	0.772
VOID	20	6.060	0.726	4.500	7.900	11.988
VFA	20	67.000	2.938	60.000	74.000	4.385
STAB	20	2308.600	252.941	1620.000	2774.000	10.956
TYPE=1 ASPH=S SOURCE=R3						
SPGR	20	2.279	0.019	2.250	2.320	0.829
VOID	20	5.830	0.776	4.100	7.000	13.311
VFA	20	68.100	3.144	64.000	75.000	4.617
STAB	20	2037.600	184.786	1695.000	2340.000	9.069

TABLE B-4

MIX TYPE 1 - ASPHALT T

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=1 ASPH=T SOURCE=D1						
SPGR	20	2.297	0.011	2.280	2.320	0.466
VOID	20	5.445	0.472	4.500	6.200	8.665
VFA	20	68.600	1.984	66.000	73.000	2.892
STAB	20	2027.350	182.717	1716.000	2455.000	9.013
TYPE=1 ASPH=T SOURCE=D2						
SPGR	20	2.297	0.011	2.280	2.320	0.471
VOID	20	5.465	0.474	4.500	6.200	8.670
VFA	20	68.500	2.013	66.000	73.000	2.939
STAB	20	2048.100	196.730	1814.000	2485.000	9.606
TYPE=1 ASPH=T SOURCE=P						
SPGR	20	2.326	0.007	2.320	2.340	0.320
VOID	20	4.240	0.298	3.700	4.500	7.030
VFA	20	74.300	1.490	73.000	77.000	2.006
STAB	20	1691.750	212.459	1299.000	2019.000	12.559
TYPE=1 ASPH=T SOURCE=R1						
SPGR	19	2.289	0.011	2.270	2.310	0.502
VOID	19	5.821	0.496	4.900	6.600	8.524
VFA	19	67.263	1.996	64.000	71.000	2.967
STAB	19	1967.421	197.805	1669.000	2325.000	10.054
TYPE=1 ASPH=T SOURCE=R2						
SPGR	19	2.301	0.011	2.280	2.320	0.478
VOID	19	5.289	0.479	4.500	6.200	9.064
VFA	19	69.579	2.116	66.000	73.000	3.042
STAB	19	2219.684	240.645	1622.000	2730.000	10.841
TYPE=1 ASPH=T SOURCE=R3						
SPGR	19	2.282	0.009	2.270	2.300	0.375
VOID	19	6.105	0.366	5.300	6.600	5.993
VFA	19	66.263	1.593	64.000	70.000	2.404
STAB	19	1700.316	118.913	1530.000	1890.000	6.994

TABLE B-5

MIX TYPE 3 - ASPHALT E

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
---- TYPE=3	ASPH=E	SOURCE=D1 ----				
SPGR	13	2.288	0.018	2.250	2.310	0.795
VOID	13	5.046	0.748	4.100	6.600	14.821
VFA	13	71.154	3.051	65.000	75.000	4.288
STAB	13	2200.692	377.627	1555.000	2948.000	17.159
---- TYPE=3	ASPH=E	SOURCE=D2 ----				
SPGR	13	2.282	0.026	2.210	2.310	1.158
VOID	13	5.015	0.684	4.100	6.600	13.641
VFA	13	71.231	2.743	65.000	75.000	3.851
STAB	13	2474.846	296.418	2025.000	2980.000	11.977
---- TYPE=3	ASPH=E	SOURCE=P ----				
SPGR	13	2.312	0.006	2.300	2.320	0.259
VOID	13	4.015	0.258	3.700	4.600	6.418
VFA	13	75.462	1.198	73.000	77.000	1.588
STAB	13	1935.308	248.543	1338.000	2252.000	12.843
---- TYPE=3	ASPH=E	SOURCE=R1 ----				
SPGR	13	2.282	0.018	2.250	2.310	0.777
VOID	13	5.331	0.723	4.100	6.600	13.557
VFA	13	69.923	2.985	65.000	75.000	4.269
STAB	13	2452.231	187.031	2115.000	2745.000	7.627
---- TYPE=3	ASPH=E	SOURCE=R2 ----				
SPGR	13	2.283	0.018	2.250	2.310	0.787
VOID	13	5.269	0.732	4.100	6.600	13.890
VFA	13	70.154	2.996	65.000	75.000	4.270
STAB	13	2556.000	164.039	2325.000	2850.000	6.418
---- TYPE=3	ASPH=E	SOURCE=R3 ----				
SPGR	13	2.271	0.016	2.250	2.300	0.707
VOID	13	5.769	0.642	4.600	6.600	11.130
VFA	13	68.231	2.651	65.000	73.000	3.885
STAB	13	2052.077	147.567	1740.000	2280.000	7.191

TABLE B-6

MIX TYPE 3 - ASPHALT L

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=3 ASPH=L SOURCE=D1						
SPGR	20	2.327	0.011	2.300	2.340	0.460
VOID	20	4.200	0.428	3.700	5.300	10.190
VFA	20	73.550	2.012	69.000	76.000	2.736
STAB	20	3668.150	549.499	2817.000	4957.000	14.980
TYPE=3 ASPH=L SOURCE=D2						
SPGR	20	2.331	0.011	2.300	2.340	0.488
VOID	20	4.040	0.455	3.700	5.300	11.255
VFA	20	74.350	2.134	69.000	76.000	2.871
STAB	20	4015.550	648.379	2897.000	5409.000	16.147
TYPE=3 ASPH=L SOURCE=P						
SPGR	20	2.347	0.008	2.330	2.360	0.335
VOID	20	3.400	0.315	2.900	4.100	9.252
VFA	20	77.500	1.573	74.000	80.000	2.029
STAB	20	2280.750	289.049	1811.000	2802.000	12.673
TYPE=3 ASPH=L SOURCE=R1						
SPGR	20	2.331	0.013	2.290	2.350	0.578
VOID	20	4.045	0.556	3.300	5.800	13.741
VFA	20	74.350	2.540	67.000	78.000	3.416
STAB	20	2971.650	183.160	2574.000	3347.000	6.164
TYPE=3 ASPH=L SOURCE=R2						
SPGR	20	2.344	0.009	2.320	2.360	0.378
VOID	20	3.520	0.355	2.900	4.500	10.080
VFA	20	76.900	1.774	72.000	80.000	2.307
STAB	20	3207.050	234.401	2714.000	3643.000	7.309
TYPE=3 ASPH=L SOURCE=R3						
SPGR	20	2.327	0.011	2.290	2.340	0.460
VOID	20	4.205	0.447	3.700	5.800	10.621
VFA	20	73.550	1.959	67.000	76.000	2.664
STAB	20	2671.800	190.763	2184.000	2910.000	7.140

TABLE B-7

MIX TYPE 3 - ASPHALT S

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=3 ASPH=S SOURCE=D1						
SPGR	21	2.293	0.009	2.270	2.310	0.398
VOID	21	5.629	0.406	4.900	6.600	7.220
VFA	21	66.762	1.640	63.000	70.000	2.457
STAB	21	2775.857	278.863	2104.000	3206.000	10.046
TYPE=3 ASPH=S SOURCE=D2						
SPGR	21	2.291	0.007	2.280	2.310	0.306
VOID	21	5.743	0.314	4.900	6.200	5.467
VFA	21	66.333	1.197	65.000	70.000	1.805
STAB	21	2716.095	193.392	2252.000	3096.000	7.120
TYPE=3 ASPH=S SOURCE=P						
SPGR	21	2.331	0.009	2.310	2.340	0.405
VOID	21	4.062	0.377	3.700	4.900	9.293
VFA	21	74.190	1.887	70.000	76.000	2.544
STAB	21	2281.810	331.470	1512.000	2661.000	14.527
TYPE=3 ASPH=S SOURCE=R1						
SPGR	21	2.293	0.010	2.280	2.310	0.443
VOID	21	5.624	0.452	4.900	6.200	8.029
VFA	21	67.524	1.806	65.000	70.000	2.675
STAB	21	2441.286	238.460	2100.000	2855.000	9.768
TYPE=3 ASPH=S SOURCE=R2						
SPGR	21	2.271	0.012	2.250	2.290	0.519
VOID	21	6.562	0.472	5.800	7.400	7.188
VFA	21	63.810	1.940	60.000	67.000	3.040
STAB	21	2015.619	174.047	1755.000	2355.000	8.635
TYPE=3 ASPH=S SOURCE=R3						
SPGR	21	2.287	0.011	2.270	2.300	0.462
VOID	21	5.886	0.460	5.300	6.600	7.810
VFA	21	66.571	1.886	64.000	69.000	2.833
STAB	21	2065.143	227.501	1665.000	2496.000	11.016

TABLE B-8

MIX TYPE 3 - ASPHALT T

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=3 ASPH=T SOURCE=D1						
SPGR	20	2.311	0.016	2.280	2.340	0.677
VOID	20	5.245	0.637	4.100	6.600	12.145
VFA	20	69.000	2.471	64.000	74.000	3.581
STAB	20	2504.250	162.104	2192.000	2933.000	6.473
TYPE=3 ASPH=T SOURCE=D2						
SPGR	20	2.308	0.010	2.280	2.320	0.436
VOID	20	5.385	0.417	4.900	6.600	7.746
VFA	20	68.400	1.569	64.000	70.000	2.295
STAB	20	2498.600	198.820	2028.000	3034.000	7.957
TYPE=3 ASPH=T SOURCE=P						
SPGR	20	2.347	0.009	2.330	2.360	0.368
VOID	20	3.820	0.346	3.300	4.500	9.052
VFA	20	75.400	1.729	72.000	78.000	2.293
STAB	20	1729.500	133.343	1498.000	2056.000	7.710
TYPE=3 ASPH=T SOURCE=R1						
SPGR	20	2.294	0.012	2.270	2.320	0.537
VOID	20	5.965	0.527	4.900	7.000	8.842
VFA	20	66.250	1.943	62.000	70.000	2.933
STAB	20	2276.200	316.449	1607.000	2880.000	13.903
TYPE=3 ASPH=T SOURCE=R2						
SPGR	20	2.311	0.013	2.270	2.330	0.583
VOID	20	5.245	0.556	4.500	7.000	10.597
VFA	20	68.900	2.174	62.000	72.000	3.155
STAB	20	2752.500	241.259	2293.000	3026.000	8.765
TYPE=3 ASPH=T SOURCE=R3						
SPGR	20	2.289	0.014	2.260	2.310	0.592
VOID	20	6.160	0.588	5.300	7.400	9.545
VFA	20	65.450	2.164	61.000	69.000	3.306
STAB	20	1780.400	189.695	1440.000	2122.000	10.655

TABLE B-9

ALL TYPE 1 MIX

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=1 SOURCE=D1						
SPGR	76	2.310	0.025	2.250	2.360	1.102
VOID	76	4.943	0.869	3.300	7.000	17.577
VFA	76	70.632	3.525	64.000	79.000	4.990
STAB	76	2128.474	406.190	1316.000	3203.000	19.084
TYPE=1 SOURCE=D2						
SPGR	76	2.312	0.025	2.260	2.360	1.080
VOID	76	4.847	0.853	3.300	6.600	17.607
VFA	76	71.039	3.384	65.000	77.000	4.764
STAB	76	2181.579	383.569	1558.000	2939.000	17.582
TYPE=1 SOURCE=P						
SPGR	76	2.333	0.023	2.270	2.380	0.965
VOID	76	3.993	0.691	2.500	6.200	17.293
VFA	76	75.079	2.794	66.000	82.000	3.722
STAB	76	1702.000	289.749	1118.000	2506.000	17.024
TYPE=1 SOURCE=R1						
SPGR	75	2.306	0.026	2.250	2.370	1.144
VOID	75	5.091	0.912	2.900	7.000	17.920
VFA	75	70.040	3.535	62.000	79.000	5.048
STAB	75	2039.920	460.403	1357.000	3304.000	22.570
TYPE=1 SOURCE=R2						
SPGR	75	2.311	0.034	2.230	2.380	1.451
VOID	75	4.895	1.127	2.500	7.900	23.024
VFA	75	71.107	4.330	60.000	82.000	6.089
STAB	75	2089.760	292.360	1607.000	2774.000	13.990
TYPE=1 SOURCE=R3						
SPGR	75	2.299	0.028	2.250	2.370	1.199
VOID	75	5.385	0.936	2.900	7.000	17.389
VFA	75	68.853	3.416	64.000	79.000	4.961
STAB	75	1690.067	283.888	1170.000	2340.000	16.797

TABLE B-10

ALL TYPE 3 MIX

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
TYPE=3 SOURCE=D1						
SPGR	74	2.307	0.020	2.250	2.340	0.874
VOID	74	5.036	0.771	3.700	6.600	15.315
VFA	74	69.973	3.448	63.000	76.000	4.928
STAB	74	2842.568	650.324	1555.000	4957.000	22.878
TYPE=3 SOURCE=D2						
SPGR	74	2.305	0.023	2.210	2.340	1.006
VOID	74	5.058	0.807	3.700	6.600	15.958
VFA	74	69.919	3.671	64.000	76.000	5.250
STAB	74	2966.135	752.974	2025.000	5409.000	25.386
TYPE=3 SOURCE=P						
SPGR	74	2.336	0.016	2.300	2.360	0.666
VOID	74	3.809	0.423	2.900	4.900	11.096
VFA	74	75.635	2.051	70.000	80.000	2.712
STAB	74	2071.378	355.946	1338.000	2802.000	17.184
TYPE=3 SOURCE=R1						
SPGR	74	2.302	0.023	2.250	2.350	0.990
VOID	74	5.238	0.935	3.300	7.000	17.845
VFA	74	69.446	3.938	62.000	78.000	5.671
STAB	74	2541.932	361.122	1607.000	3347.000	14.207
TYPE=3 SOURCE=R2						
SPGR	74	2.304	0.032	2.250	2.360	1.383
VOID	74	5.157	1.252	2.900	7.400	24.287
VFA	74	69.838	5.379	60.000	80.000	7.702
STAB	74	2631.716	497.062	1755.000	3643.000	18.887
TYPE=3 SOURCE=R3						
SPGR	74	2.296	0.024	2.250	2.340	1.040
VOID	74	5.485	0.950	3.700	7.400	17.313
VFA	74	68.446	3.868	61.000	76.000	5.651
STAB	74	2149.851	390.381	1440.000	2910.000	18.159

TABLE B-11

AUTOMATIC VERSUS MANUAL COMPACTION
TYPE 1 AND TYPE 3 MIX

TYPE 1 MIX

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
METHOD=A						
SPGR	75	2.30213333	0.02969636	2.23000000	2.37000000	1.290
VOID	75	5.26800000	1.00312485	2.90000000	7.90000000	19.042
VFA	75	69.32000000	3.73138624	60.00000000	79.00000000	5.383
STA	75	1.94880000	0.31794530	1.35700000	2.77400000	16.315
METHOD=H						
SPGR	75	2.31546667	0.02933006	2.25000000	2.38000000	1.267
VOID	75	4.71733333	0.98067452	2.50000000	7.00000000	20.789
VFA	75	71.82666667	3.83572585	64.00000000	82.00000000	5.340
STA	75	2.18088000	0.41269817	1.60700000	3.30400000	18.923

TYPE 3 MIX

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
METHOD=A						
SPGR	74	2.29540541	0.02720743	2.25000000	2.35000000	1.185
VOID	74	5.50405405	1.12620580	3.30000000	7.40000000	20.461
VFA	74	68.39189189	4.75370819	60.00000000	78.00000000	6.951
STA	74	2.42113514	0.43024390	1.60700000	3.34700000	17.770
METHOD=H						
SPGR	74	2.31027027	0.02616978	2.25000000	2.36000000	1.133
VOID	74	4.89054054	0.99315037	2.90000000	7.00000000	20.308
VFA	74	70.89189189	4.33073618	62.00000000	80.00000000	6.109
STA	74	2.75251351	0.37523009	2.10000000	3.64300000	13.632

APPENDIX C

t-TEST ANALYSIS

TABLE C-1

STABILITY

Source	P/D1	P/R1	D1/D2	D1/R1	P/R3	A/H
Mix Type/ Asphalt						
Type 1						
E	1.7430	*-2.0426*	-1.5356	-0.1454	*2.4064*	--
L	*6.1637*	*-3.1672*	-0.4689	*4.3762*	0.4230	--
S	*5.9011*	*-6.2730*	-0.4134	-1.5048	-0.8767	--
T	*5.3559*	*-4.1882*	-0.3456	0.9835	-0.1542	--
All Type 1	*7.4516*	*-5.3897*	-0.8287	1.2527	0.2556	*-3.8579*
Type 3						
E	*2.1166*	*-5.9919*	-2.0590	*-2.1522*	-1.4566	--
L	*9.9932*	*-9.0294*	-1.8280	*5.3776*	*-5.0497*	--
S	*5.2266*	-1.7897	0.8070	*4.1786*	*2.4697*	--
T	*16.5068*	*-7.1198*	0.0985	*2.8684*	-0.9817	--
All Type 3	*8.9484*	*-7.9830*	-1.0684	*3.4767*	-1.2778	*-4.9934*

Note: Italicized numbers indicate significant t values.

TABLE C-2

SPECIFIC GRAVITY

Source	P/D1	P/R1	D1/D2	D1/R1	P/R3	A/H
Mix Type/ Asphalt						
Type 1						
E	-1.3329	*5.6650*	0.0	*3.2986*	*8.9747*	--
L	*-5.4939*	*4.5780*	-0.7716	-0.8310	*5.4054*	--
S	*-5.2412*	*3.9409*	-1.1305	-0.8146	*5.8883*	--
T	*-9.9469*	*12.1676*	0.1470	*2.4064*	*17.3119*	--
All Type 1	*-5.9074*	*6.6737*	-0.5790	0.8532	*8.2189*	*-2.7665*
Type 3						
E	*-4.4901*	*5.9300*	0.7785	0.9830	*8.7408*	--
L	*-6.7360*	*4.5838*	-1.1459	-1.0392	*6.7360*	--
S	*-13.1302*	*12.4290*	0.9483	0.0	*14.1790*	--
T	*-8.8787*	*15.7555*	0.8414	*3.9300*	*15.9881*	--
All Type 3	*-10.0882*	*10.8294*	0.4919	1.3760	*12.2780*	*-3.3873*

Note: Italicized numbers indicate significant t values.

TABLE C-3

AIR VOIDS

Source	P/D1	P/R1	D1/D2	D1/R1	P/R3	A/H
Mix Type/ Asphalt						
Type 1						
E	1.7526	*-5.5612*	0.1668	*-3.1497*	*-8.6950*	--
L	*5.4939*	*-4.5780*	0.7716	-0.8310	*-5.4054*	--
S	*5.2915*	*-3.9195*	1.1154	0.8503	*-5.9015*	--
T	*9.6563*	*-12.1352*	-0.1338	*-2.4262*	*-17.4961*	--
All Type 1	*7.4617*	*-8.3251*	0.6875	-1.0154	*-10.3841*	*3.3995*
Type 3						
E	*4.6981*	*-6.1812*	0.1094	-0.9867	*-9.1395*	--
L	*6.7360*	*14.5166*	1.1459	0.9882	*-6.5905*	--
S	*12.9443*	*-12.1615*	-1.0198	0.0359	*-14.0519*	--
T	*8.7924*	*-15.2100*	-0.8223	*-3.8935*	*-15.3420*	--
All Type 3	*12.0006*	*-11.9782*	-0.1666	-1.4293	*-13.8673*	*3.5148*

Note: Italicized numbers indicate significant t values.

TABLE C-4

VOIDS FILLED WITH ASPHALT

Source	P/D1	P/R1	D1/D2	D1/R1	P/R3	A/H
Mix Type/ Asphalt						
Type 1						
E	-1.3707	*5.6995*	0.0	*3.2226*	*9.2958*	--
L	*-5.4753*	*4.5792*	-0.7716	-0.8310	*5.3861*	--
S	*-5.0975*	*3.8899*	-1.1785	-0.8289	*5.6664*	--
T	*-10.2724*	*12.5201*	0.1582	*2.0972*	*16.2776*	--
All Type 1	*-8.6202*	*9.7088*	-0.7278	1.0297	*12.2498*	*-4.0567*
Type 3						
E	*-4.7385*	*6.2083*	-0.0676	1.0397	*8.9625*	--
L	*-6.9162*	*4.7158*	-1.2196	-1.1041	*7.0305*	--
S	*-13.6142*	*11.6951*	0.9671	-1.4311	*13.0858*	--
T	*-9.4907*	*15.7317*	0.9167	*3.9123*	*16.0661*	--
All Type 3	*-12.1401*	*11.9899*	0.0923	0.8661	*14.1248*	*-3.3443*

Note: Italicized numbers indicate significant t values.