Validation of Contractor HMA Testing Data in the Materials Acceptance Process

Phase II

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by

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16. Abstract

This study conducted an analysis of the SCDOT HMA specification. A Research Steering Committee provided oversight of the process. The research process included extensive statistical analyses of test data supplied by SCDOT.

A total of 2,789 AC tests, 2,234 AV tests, and 2,230 VMA tests were provided from 20 different projects, with some projects having multiple Mix Types and JMFs involved. A total of 2,010 density test results also were provided from 15 of the 20 projects. Relatively small amounts of data from certain Courses and Mix Types limited analyses only to Surface Type A and Surface Type B mixes.

The analyses led to a recommendation that SCDOT switch to using the differences from the AC, AV, and VMA target values rather than the actual AC, AV, and VMA values. This will allow the possibility of combining test results from more than 1 JMF in the Lot payment decision.

In addition, SCDOT verification test results were provided from 16 of the 20 projects. These data consisted of 487 AC and 452 AV and VMA test results from SCDOT. In addition, the data set included 411 AC, and 387 AV and VMA Contractor verification test results. These data were analyzed to evaluate current SCDOT verification procedures and issues concerning them were presented and discussed.

Power curves were developed for various sample sizes for the F-test, the two-sample t-test, and the paired-sample t-test to allow SCDOT to evaluate the risks associated with their current verification procedures as well as any possible changes to the current procedures.

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CHAPTER 1 — INTRODUCTION

Background

A great deal of time and effort was devoted to the development of the SCDOT HMA QA Specification. The initial specification was developed over a 5-year period with significant input from a joint SCDOT/Contractor/FHWA specification development committee (1). The HMA QA Specification was subsequently re-evaluated (2) to establish how well the specification was working in the field and to uncover any problems that users of the specification had encountered. As part of this evaluation, based on statistical evaluation of project data, some modifications were made to the initial specification limits.

After the re-analysis was completed, FHWA issued Technical Advisory T 6120.3 (*T 6120.3*) (3) that provided more detailed and specific "guidance and recommendations for the use and validation of contractor's test results for acceptance, the use of quality measures, and the identification of contractor and department risks." There also had been significant discussion among professionals concerning the risks associated with validation procedures that may not be sufficient for the purposes intended in Title 23, Code of Federal Regulations, Part 637 (*23 CFR 637*) (4) or *T 6120.3*. See, for example, *Burati et al 2004* (5) and *Burati and Lin 2006* (6).

Because SCDOT inspectors no longer performed extensive routine HMA testing, the limited testing they performed was used to accept or reject the Contractor's test data and, consequently, the material it represented. The SCDOT contracted with Clemson University to conduct a study to re-evaluate its then current HMA QC/Acceptance and IA programs to ensure proper SCDOT oversight and validation of the Contractor's HMA testing data in accordance with *23 CFR 637*.

In this study, which can be called Phase I of the current Phase II study presented in this current report, extensive statistical analyses were conducted to determine appropriate standard deviation values to represent the variability of each of the acceptance characteristics used by SCDOT. The Phase I study also analyzed SCDOT verification test results and compared them with their corresponding Contractor acceptance tests. The previous and current SCDOT verification procedures were evaluated and issues concerning each were presented and discussed (7).

The Phase I study conducted a formal and complete analysis of the SCDOT HMA specification in light of information that had become available since it was last analyzed. A Research Steering and Implementation Committee comprised of SCDOT, FHWA, and Industry representatives provided oversight of the process. A number of the findings from that study were implemented by SCDOT. The study also recommended a number of topics that required additional or expanded research.

After the Phase I study an FHWA Quality Assurance (QA) Stewardship Review indicated that changes were needed to the then current QC/Acceptance and Independent Assurance (IA) processes used by SCDOT. The Stewardship Review concluded that the SCDOT allowable differences in HMA test data were 2 to 3 times the current practice in other states and that the IA tolerances were in a similar need of analyzing and updating. This review is what led to the Phase II study presented in this report.

Objectives

The initial objectives of this study were:

- To determine appropriate standard deviation values to use to establish the specification limits that are used when the Contractor acceptance tests do not compare during the verification process and the SCDOT verification tests are subsequently used to determine the payment factors.
- To recommend procedures for SCDOT to use when the last Lot on a project does not have a sufficient number of tests to make a valid comparison with the Contractor's test results.
- To evaluate whether or not SCDOT should modify its acceptance procedures to base acceptance testing on a frequency of production quantities rather than on a daily or Lot basis.
- To determine appropriate standard deviations to use when establishing split-sample allowable tolerances.
- To evaluate the current SCDOT random number table in SC-T-101, and to develop a new statistically-valid procedure, preferably web-based, that provides the random numbers both to the Contractor and to SCDOT along with all identifying information needed by SCDOT.
- To develop new verification procedures that will allow SCDOT to make valid verification decisions in situations in which the job mix formula (JMF) is changed within a Lot or within a given day's production.

Methodology

The major items that needed to be accomplished to achieve the project objectives are discussed in each of the following sections. These major work tasks include:

- Establish a Research Steering and Implementation Committee.
- Analyze data provided by SCDOT.
- Evaluate SCDOT verification test sample sizes.
- Principal Investigator (PI) and Committee decide on test frequencies based on time or production.
- Analyze verification test result data to develop recommended allowable tolerances.
- Develop a new web-based procedure for determining sample locations.
- PI and Committee decide on procedures for dealing with JMF changes.

Committee Oversight. The first step that was taken was to establish a Research Steering and Implementation Committee (the Committee) and a Technical Advisory Group (TAG). The Committee and TAG members were selected by SCDOT. The TAG provided industry input and perspectives on the research project. The Committee was charged to oversee the project on behalf of the SCDOT. The PI served as the facilitator during meetings at which the Committee guided the PI in establishing the final tasks and timeline to meet the project objectives. These meetings were held in Columbia to minimize travel costs for team members. The members of the Committee and TAG are shown in Table 1.1.

Table 1.1. Research Steering and Implementation Committee and Technical Advisory Group Team Members

Name	Position	Organization
Steering & Implementation Committee		
Chad Hawkins (Chair)	State Materials Engineer	SCDOT
Merrill Zwanka	Materials and Research Engineer	SCDOT
John McCarter	District Engineering Administrator	SCDOT
Todd Steagall	Director of Construction	SCDOT
Cliff Selkinghaus	Asphalt Materials Manager	SCDOT
Jim Garling	Pavement and Research Engineer	FHWA
Tad Kitowicz	Operations Team Leader	FHWA
Technical Advisory Group		
Clarke DeHart	Vice President	C.R. Jackson
Michael Crenshaw	President	King Asphalt
Randy Funderburg	Quality Control Manager	Banks Construction

Analyze Data Provided by SCDOT. It was planned that test result data would be supplied in the form of Excel (XLS or XLSX) files or comma separated variables (CSV) files based on a template prepared by the PI and provided by SCDOT to Contractors. The data from these files could be read by Excel and also could be put into a format that could be read directly by Minitab 17, the statistical analysis software to be used for the project.

The new project data for each project were to consist of the Contractor acceptance test results and the corresponding SCDOT verification test results. It was essential that the results from the data sets used for the verification decisions on a large number of projects be obtained. The research proposal for the project contained the following statement:

> To have a sufficient database from which to draw conclusions, it will be necessary to have data from at least 20, and preferably more, projects of relatively large size. The "large size" is necessary so the data are available from projects that had multiple verification data sets.

The variability data from these projects, in terms of standard deviations were to be used to develop appropriate specification limits to use when the SCDOT verification tests are used for the acceptance decision. The risks to both the Contractor and the SCDOT were to be evaluated and used in the evaluation of the existing limits or proposed new limits.

Evaluate SCDOT Verification Test Sample Sizes. Power analysis and power curves were used to evaluate the effect that using various SCDOT sample sizes has on the results when verifying the Contractor acceptance tests. Since a subjective decision is required when determining what levels of risk are appropriate, the simulation results are presented to the SCDOT for a decision regarding the minimum sample size for which the risks to both parties are considered acceptable.

Testing Frequencies. Currently, SCDOT defines a Lot as one day's production. If at least 3 test results are obtained from the day's production, these tests are used to determine the payment factor. If fewer than 3 tests are obtained from the day's production, these results are combined with subsequent days until at least 3 tests are obtained.

SCDOT also obtains verification tests to be compared with the Contractor's acceptance tests. SCDOT procedures require that at least 7 verification tests be used for the comparison with the Contractor tests.

Due to these requirements, the data sets used for comparisons can vary in composition. For example, each Lot in the verification data set could represent a single day's production, but a Lot could also be comprised of several different days' productions. Similarly, the makeup of the SCDOT verification tests can differ from 1 comparison data set to the next.

The project was to consider whether or not the comparison process could be improved, or at least be more standardized, by switching to a testing frequency based on production as opposed to time. Since there are obvious pros and cons to each approach, a subjective decision is required.

Verification Test Allowable Tolerances. The Phase I study strongly recommended that SCDOT implement a new research study to determine appropriate standard deviations to use when establishing split sample allowable tolerances. Without such a study it is difficult to determine the appropriateness of the current tolerances that are the same as the specification tolerance limits. Specification tolerances and allowable differences for split samples serve two totally different purposes and generally are not developed using the same procedures. A 2-step process was used to determine the appropriate tolerances for SCDOT to use.

D2S Analysis. The plan was initially, if available, to use the appropriate multi-laboratory D2S limits from the AASHTO test procedure to help establish the minimum possible allowable split-sample tolerances for the various acceptance characteristics. Since the circumstances under which the D2S limits are established can be considered "ideal," these limits are likely too restrictive for the situation that is encountered on projects under field conditions. They can, however, provide a useful starting point and provide a basis for comparison with data that are obtained from actual projects.

Analysis of Project Data. Results of split-samples tested on actual construction projects were to be supplied by SCDOT to be used for analysis. As noted above, the project data were to be supplied in the form of Excel (XLS or XLSX) files or comma separated variables (CSV) files. The data from these files could be read by Excel and also could be put into a format that could be read directly by Minitab 17, the statistical analysis software that will be used for the project.

The new project data were to consist of the results of the Contractor tests and the SCDOT tests on corresponding split-sample pairs. Under SCDOT procedures, there may also be times when a referee split sample is also tested. In these cases, the results of the referee sample are to be included with the data provided to the PI. To conduct a proper analysis it is necessary to have data not only from a large number of projects, but also to have multiple split-sample results from each project. *To have a sufficient database from which to draw conclusions, it will be necessary to have data from at least 20, and preferably more, projects with at least 5 split-sample comparisons on each project*.

The variability data, in terms of standard deviations of the differences between each split-sample pair, from these projects was to be used to develop appropriate allowable tolerances to use when comparing split-sample results. The allowable tolerances obtained from the field data could then be compared against the baseline minimum established by the D2S limits.

Develop a New Web-Based Procedure for Determining Sample Locations. The current random number table and procedures in SC-T-101 need to be improved due to the relatively limited nature of the tables and the potential to introduce bias into the selection of sample locations. A procedure based on a mathematical algorithm for selecting pseudo random numbers would eliminate the potential issues with bias in the current process.

This new procedure must be statistically-valid. To make it readily available to all locations around the state, preferably the new procedure should be Internet based. This would allow a Contractor working at any location or project to have access to the procedure that identifies when or where random samples are to be obtained for a given project day.

It was anticipated that a web-based system would require the Contractor first to login to the system. Then, the necessary information to identify the project, job mix, and any other information that SCDOT would require would be entered. The program would then provide the random numbers and report this information to both the Contractor and to SCDOT.

It was planned that personnel from the Clemson Computing and Information Technology (CCIT) department would develop the web-based program based on specifications developed by SCDOT. It was anticipated that CCIT would work with information technology representatives provided by SCDOT to ensure that the developed program could be employed successfully on the SCDOT computer system.

Procedures for Dealing with JMF Changes. On a project it is common for the Contractor to modify or change the JMF that is used during the project. These changes can occur between or within a day's production. When the JMF is changed, it is necessary to make one of the following assumptions: (1) this constitutes a new population since it is a new JMF or (2) modifying and changing JMFs is part of the typical production process and is thus incorporated as part of a continuing population.

Which assumption is made may require different ways in which SCDOT needs to respond to the changed JMF. The project was to make recommendations concerning a method or methods to deal with this situation.

Depending upon how often JMF changes are made and documented in the data provided by SCDOT, it was possible that some analyses of project data might be able to provide insight into the better method to use.

CHAPTER 2 — PLANT DATA PROVIDED BY SCDOT

Background

This chapter discusses the data collection procedures along with the data that were provided by SCDOT. There were significant problems encountered during the data collection process. Some of these have serious ramifications concerning the potential validity of the data analyses as well as conclusions and recommendations based on the data analyses results.

Data Collection Procedure

The following statements appear in the proposal for this project:

*It is expected that the test result data will be supplied in the form of Excel (XLS or XLSX) files or comma separated variables (CSV) file*s.

The new project data will consist of the contractor acceptance test results and the corresponding SCDOT verification test results. It is essential that the results from the data sets used for the verification decisions on a large number of projects be obtained. *To have a sufficient database from which to draw conclusions, it will be necessary to have data from at least 20, and preferably more, projects of relatively large size*. *The "large size" is necessary so the data are available from projects that had multiple verification data sets*.

Excel Data Collection Template. The PI prepared a proposed template for receiving the data supplied by SCDOT. This template was approved at a 9/30/2011 meeting of the Committee and a slight modification subsequently was approved by SCDOT. The column headings for the data collection template are shown in Figure 2.1.

Plant Acceptance Tests

File No.	Course	Mix Type	JMF No.	Date	Lot No.	AC-Target	AC Test Result	AV-Target	AV Test Result	VMA-Target	VMA Test Result

Verification Tests

File No.	Course	Mix Type	JMF No.	Date	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	AC-DR	AV-DR	VMA-DR

Figure 2.1. Column Headings for Excel Data Collection Template

Discussion of Data that Were Provided

All of the plant acceptance test data that were provided are included in Appendix A. Tables 2.1-2.3 present summaries of all test results data provided by SCDOT for asphalt content (AC), air voids (AV) and voids in mineral aggregate (VMA), respectively. The values in the tables include all Courses and Mix Types for each project.

Table 2.1. Original Data Set Total Number of Asphalt Content Test Results by Project

Project No.	No. of Lots	No. of Tests	Tests/Lot	No. of JMFs
P01	61	78	1.28	1
P02	21	71	3.38	2
P03	24	81	3.38	2
P04	25	77	3.08	1
P05	55	90	1.64	5
P06	25	89	3.56	1
P07	18	18	1.00	1
P08	19	76	4.00	1
P09	16	64	4.00	2
P10	28	61	2.18	5
P11	85	238	2.80	9
P12	244	655	2.68	23
P13	174	460	2.64	25
P14	42	162	3.86	2
P15	36	107	2.97	4
P16	27	87	3.22	4
P17	19	50	2.63	3
P18	46	175	3.80	2
P19	24	89	3.71	3
P20	19	61	3.21	1
TOTAL **Average**	**1008**	**2789**	**2.95**	**97**

Table 2.2. Original Data Set Total Number of Air Voids Test Results by Project

Project No.	No. of Lots	No. of Tests	Tests/Lot	No. of JMFs
P01	61	78	1.28	1
P02	21	71	3.38	2
P03	24	81	3.38	2
P04	25	77	3.08	1
P05	42	73	1.74	3
P06	25	89	3.56	1
P07	18	18	1.00	1
P08	19	76	4.00	1
P09	16	64	4.00	2
P10	28	61	2.18	5
P11	47	162	3.45	6
P12	120	383	3.19	16
P13	116	337	2.91	20
P14	42	162	3.86	2
P15	36	107	2.97	4
P16	7	20	2.86	2
P17	19	50	2.63	3
P18	46	175	3.80	2
P19	24	89	3.71	3
P20	19	61	3.21	1
TOTAL	**755**	**2234**		**78**
Average			**3.01**	

Table 2.3. Original Data Set Total Number of VMA Test Results by Project

Project No.	No. of Lots	No. of Tests	Tests/Lot	No. of JMFs
P01	61	78	1.28	1
P02	20	67	3.35	2
P03	24	81	3.38	2
P04	25	77	3.08	1
P05	42	73	1.74	3
P06	25	89	3.56	1
P07	18	18	1.00	1
P08	19	76	4.00	1
P09	16	64	4.00	2
P10	28	61	2.18	5
P11	47	162	3.45	6
P12	120	383	3.19	16
P13	116	337	2.91	20
P14	42	162	3.86	2
P15	36	107	2.97	4
P16	7	20	2.86	2
P17	19	50	2.63	3
P18	46	175	3.80	2
P19	24	89	3.71	3
P20	19	61	3.21	1
TOTAL	**754**	**2230**		**78**
Average			**3.01**	

Tables 2.1-2.3 are limited in their usefulness since each project could include some combination of Base, Intermediate, and Surface courses. In addition, most of the projects contain more than a single job mix formula (JMF). While the tables show that a large number of test results were obtained, they also show a number of issues and potential problems with the collected data.

Data by Project. Tables 2.1-2.3 show the distribution of test data among the 20 projects for which data were obtained. Specifically, a large amount of the data comes from a relatively small number of projects. Figures 2.2-2.4 show the number of tests on each project ranked from highest to lowest for AC, AV, and VMA, respectively. This same information also is shown on a percentage basis in Table 2.4.

As can be seen in Table 2.4 and Figures 2.2-2.4, approximately ⅓ or more of the tests for AC, AV, and VMA are from only 2 of the 20 projects. They also show that the 6 largest projects (30% of the projects) account for approximately 60% or greater of the test result data. This distribution of the data has the potential to bias the analyses in favor of these few larger projects that account for most of the data. It raises questions concerning whether the data are representative of "typical" Contractors in the state.

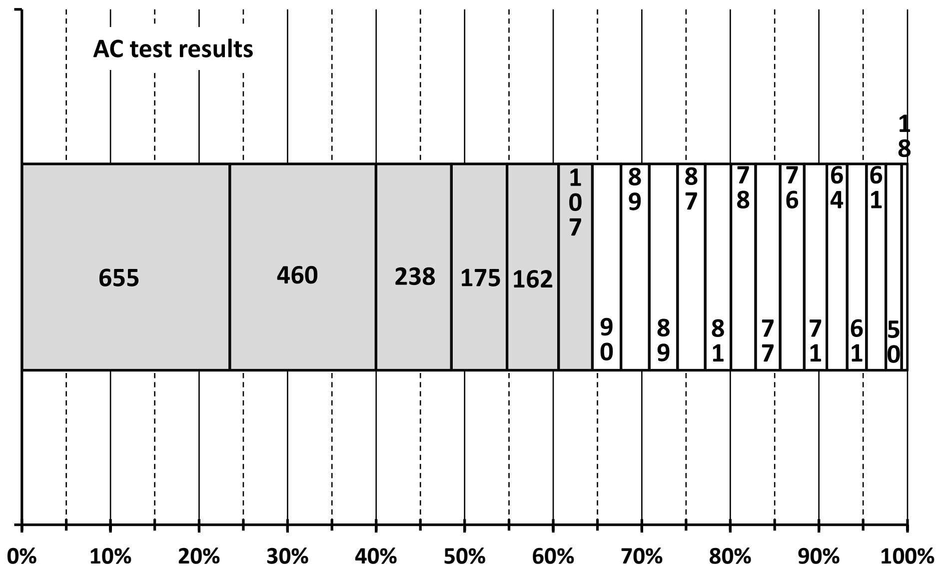


Figure 2.2. Distribution of AC Test Results by Project

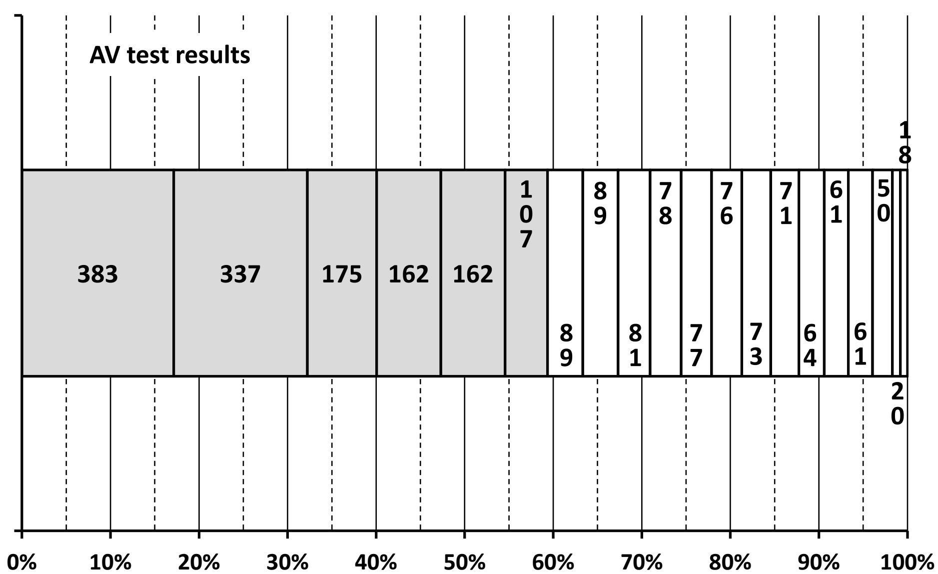


Figure 2.3. Distribution of AV Test Results by Project

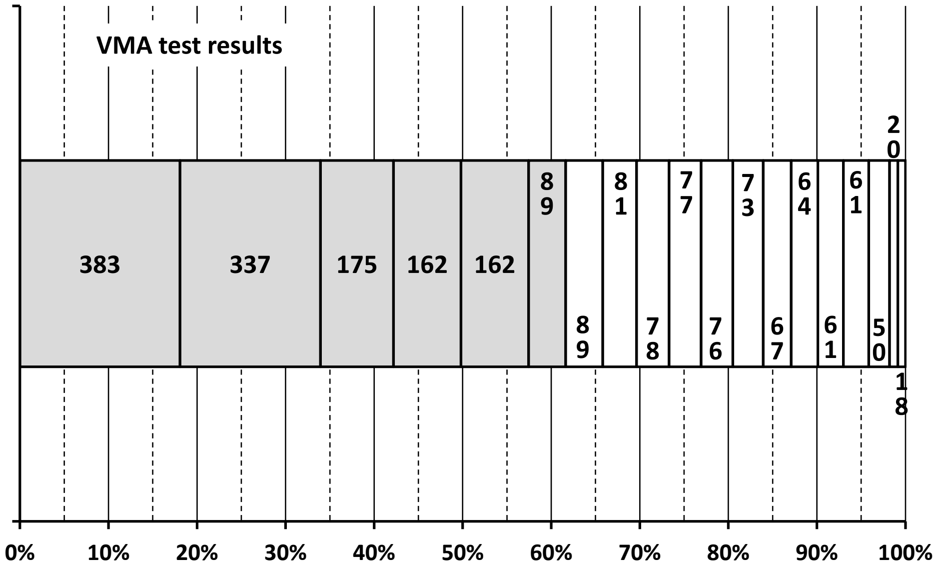


Figure 2.4. Distribution of VMA Test Results by Project

Table 2.4. Original Data Set Percentage Distribution of AC, AV, and VMA Tests by Project

AC			AV			VMA		
Project	No.	%	Project	No.	%	Project	No.	%
P12	655	23.5	**P12**	383	17.1	**P12**	383	17.2
P13	460	16.5	**P13**	337	15.1	**P13**	337	15.1
P11	238	8.5	**P18**	175	7.8	**P18**	175	7.8
P18	175	6.3	**P11**	162	7.3	**P11**	162	7.3
P14	162	5.8	**P14**	162	7.3	**P14**	162	7.3
P15	107	3.8	**P15**	107	4.8	**P15**	107	4.8
Top 6	**1797**	**64.4**	**Top 6**	**1326**	**59.4**	**Top 6**	**1326**	**59.5**
P05	90	3.2	**P06**	89	4.0	**P06**	89	4.0
P06	89	3.2	**P19**	89	4.0	**P19**	89	4.0
P19	89	3.2	**P03**	81	3.6	**P03**	81	3.6
P16	87	3.1	**P01**	78	3.5	**P01**	78	3.5
P03	81	2.9	**P04**	77	3.4	**P04**	77	3.5
P01	78	2.8	**P08**	76	3.4	**P08**	76	3.4
P04	77	2.8	**P05**	73	3.3	**P05**	73	3.3
P08	76	2.7	**P02**	71	3.2	**P02**	67	3.0
P02	71	2.5	**P09**	64	2.9	**P09**	64	2.9
P09	64	2.3	**P10**	61	2.7	**P10**	61	2.7
P10	61	2.2	**P20**	61	2.7	**P20**	61	2.7
P20	61	2.2	**P17**	50	2.2	**P17**	50	2.2
P17	50	1.8	**P16**	20	0.9	**P16**	20	0.9
P07	18	0.6	**P07**	18	0.8	**P07**	18	0.8
Next 14	**992**	**35.5**	**Next 14**	**908**	**40.6**	**Next 14**	**904**	**40.5**
TOTAL	**2789**	**99.9**	**TOTAL**	**2234**	**100**	**TOTAL**	**2230**	**100**

Data by Contractor. Another concern with the provided test result data is the limited number of Contractors on the projects from which data were supplied. While data were obtained from 20 projects, only 7 different Contractors were represented on these projects. Figure 2.5 shows the breakdown of project data by Contractor. Two of the 7 Contractors performed 11 (55%) of the projects for which data were obtained. And, 3 of the 7 Contractors performed 14 (70%) of the projects.

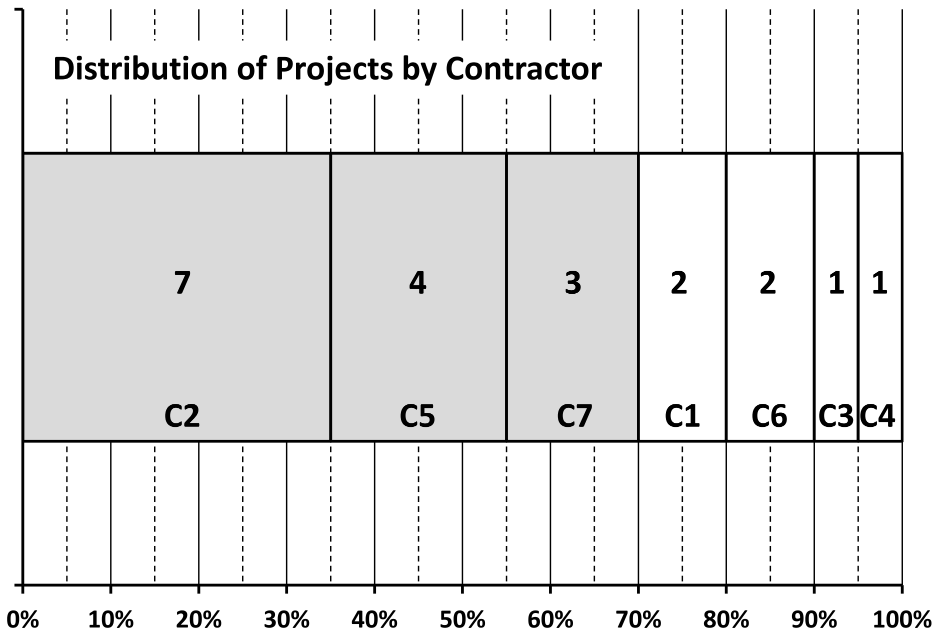


Figure 2.5. Original Data Set Distribution of Projects by Contractor

Table 2.5 presents a summary of the number and percentage of test results sorted by Contractor. The distribution of test result data by Contractor is even more biased than were the data by project. Table 2.5 and Figure 2.6 show that only 2 contractors accounted for greater than 60% of the data for AC, AV, and VMA. And, 3 contractors accounted for nearly 75% (AV and VMA) to nearly 80% (AC) of the data.

The information presented in Table 2.5 and Figure 2.6 casts even more serious doubts regarding how representative the data are for the "typical" Contractor that does work for SCDOT.

Table 2.5. Original Data Set Summary of Amount of Data by Contractor

Contractor	No. of Tests	% of Total Tests	Combined %
AC Data			
C5	1209	43.35%	68.77%
C2	709	25.42%	
C7	286	10.25%	31.23%
C6	251	9.00%	
C1	155	5.56%	
C3	90	3.23%	
C4	89	3.19%	
TOTAL	**2789**	**100.00%**	**100.00%**
AV Data			
C5	814	36.44%	61.78%
C2	566	25.34%	
C7	286	12.80%	38.23%
C6	251	11.24%	
C1	155	6.94%	
C4	89	3.98%	
C3	73	3.27%	
TOTAL	**2234**	**100.01%**	**100.01%**
VMA Data			
C5	814	36.50%	61.70%
C2	562	25.20%	
C7	286	12.83%	38.30%
C6	251	11.26%	
C1	155	6.95%	
C4	89	3.99%	
C3	73	3.27%	
TOTAL	**2230**	**100.00%**	**100.00%**

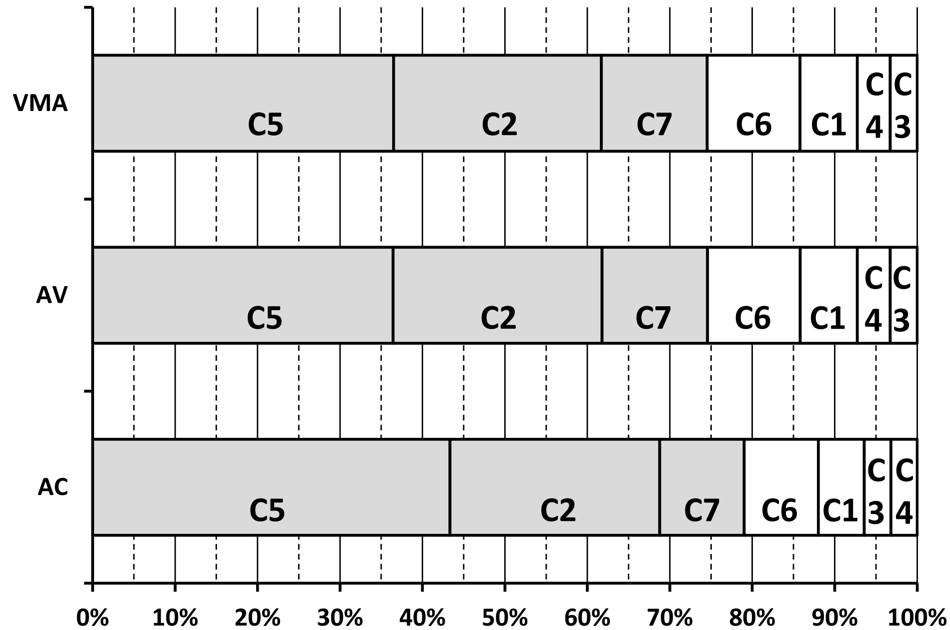


Figure 2.6. Original Data Set Percentage Distribution of Test Results by Contractor

Preliminary Analysis of the Total Data Set for AC

As noted above, the data summaries shown in Tables 2.1-2.5 and Figures 2.2-2.6 for some of the projects combine the results for multiple courses and for most of the projects combine the results for multiple JMFs. Preliminary analyses were conducted on the total data set to investigate potential differences among Projects, Contractors, Mix Types, and JMFs. Tables 2.6-2.8 show the breakdown of the AC data by Base, Intermediate, and Surface Course Mixes. Where appropriate, each course is further broken down by Mix Type, Project, and JMF.

The first thing that stands out in these tables is the small number of test results that were obtained for Base and Intermediate Courses. The breakdown of the total 2,789 AC test results is as follows: 164 Base Course, 136 Intermediate Course, and 2,489 Surface Course. Additionally, the Base Course results came from only 2 Projects and the Intermediate Course results came from only 3 Projects. All 20 Projects had at least some Surface Course results.

Table 2.6. Summary of AC Data for Base Course

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Base A	P12	J14	1	1	35	97
		J29	19	71		
		J30	2	8		
		J92	2	3		
		J93	9	12		
		J94	2	2		
	P16	J77	17	56	20	67
		J78	3	11		
TOTAL			**55**	**164**	**55**	**164**

Table 2.7. Summary of AC Data for Intermediate Course

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Interm C	P05	J07	20	25	20	25
	P12	J35	15	19	54	69
		J36	8	11		
		J37	1	2		
		J38	1	1		
		J39	11	13		
		J40	18	23		
	P13	J57	20	22	26	28
		J58	3	3		
		J59	1	1		
		J60	1	1		
		J61	1	1		
	P19	J88	4	14	4	14
TOTAL			**104**	**136**	**104**	**136**

Table 2.8. Summary of AC Data for Surface Course

Mix Type	Project	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
OGFC	P12	J90	26	87	26	87
	P13	J95	6	17	21	67
		J96	15	50		
Surf A	P02	J02	4	13	21	71
		J03	17	58		
	P03	J03	23	78	24	81
		J06	1	3		
	P06	J12	25	89	25	89
	P07	J14	18	18	18	18
	P09	J16	11	44	16	64
		J17	5	20		
	P10	J18	9	25	9	25
	P11	J23	3	3	26	90
		J24	22	86		
		J25	1	1		
	P13	J13	11	41	54	178
		J14	16	47		
		J44	13	54		
		J45	5	22		
		J46	6	8		
		J47	1	1		
		J48	2	5		
	P14	J62	15	58	42	162
		J63	27	104		
	P18	J85	23	86	23	86
Surf B	P01	J01	61	78	61	78
	P04	J01	25	77	25	77
	P05	J08	9	21	22	48
		J09	13	27		
	P08	J15	19	76	19	76
	P10	J19	2	3	9	25
		J20	3	7		
		J21	4	15		
	P11	J26	1	1	21	72
		J27	7	26		
		J28	13	45		
	P12	J31	1	1	59	259
		J32	56	252		
		J33	1	4		
		J34	1	2		

Table 2.8. Summary of AC Data for Surface Course (*cont*)

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf B (*cont*)	P13	J49	9	37	36	131
		J50	4	12		
		J51	1	6		
		J52	5	20		
		J53	1	1		
		J54	12	41		
		J55	1	3		
		J56	3	11		
	P15	J97	18	51	36	107
		J98	3	9		
		J99	2	3		
		J100	13	44		
	P18	J84	23	89	23	89
	P19	J86	16	61	16	61
	P20	J91	19	61	19	61
Surf C	P10	J22	10	11	10	11
	P12	J41	2	2	9	9
		J42	3	3		
		J43	4	4		
	P16	J79	2	5	7	20
		J80	5	15		
	P17	J81	2	6	19	50
		J82	16	43		
		J83	1	1		
	P19	J87	4	14	4	14
Surf E	P05	J10	9	12	13	17
		J11	4	5		
	P11	J68	22	49	38	76
		J69	15	26		
		J70	1	1		
	P12	J71	10	10	61	134
		J72	48	121		
		J73	3	3		
	P13	J74	17	24	37	56
		J75	10	20		
		J76	10	12		
TOTAL			**849**	**2489**	**849**	**2489**

Comparisons among Courses. Bartlett's test and Levene's test were conducted to see if statistically significant differences existed among the AC standard deviation values for the various courses. Bartlett's test assumes normal populations, while Levene's test does not require normal populations. The results of these tests are shown in Table 2.9.

The plant test data (AC, AV, VMA) had specific target values. Therefore, it was not possible to compare directly the actual test results since each project and each mix design had its own set of target values. It was possible, however, to normalize the data by considering the AC, AV, and VMA values as differences from their target values. This made it possible to make comparisons among the various Projects, Courses, Mix Types, JMFs, and Lots that could not be done on the actual test values.

Table 2.9. Summary of AC Comparisons among Courses

Course	No. of Tests	St Dev	P-value Bartlett's*⁺	P-value Levene's*⁺
Base	164	0.309	**0.000**	**0.000**
Intermediate	136	0.228		
Surface	2489	0.193		
TOTAL	**2789**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

The results from Table 2.9 clearly show that there is a difference in the standard deviation values among Base, Intermediate, and Surface courses. It can be concluded that the standard deviation for Base course is larger than those for Intermediate and Surface. Also, it is possible that the Intermediate course standard deviation is greater than that for Surface course. However, these conclusions must be viewed with a great deal of skepticism due to the extremely small sample size involved. For this reason, no valid conclusions can be drawn.

Comparison among Surface Mix Types. For Surface course there are sufficient data, 2,489 AC tests, to allow for comparison of the standard deviation values for the different Surface course Mix Types. The results for this analysis for AC are shown in Table 2.10 and Figure 2.7.

Table 2.10. Summary of AC Comparisons among Surface Mixes

Mix Type	No. of Tests	St Dev	P-value Bartlett's*⁺	P-value Levene's*⁺
OGFC	154	0.229	**0.003**	0.416
Surface A	864	0.192		
Surface B	1084	0.188		
Surface C	104	0.167		
Surface E	283	0.185		
TOTAL	**2489**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Levene's test does not show a significant difference in standard deviations for the 5 Surface course Mix Types, while Bartlett's test does indicate a significant difference. The confidence intervals for the standard deviation values are shown in Figure 2.7.

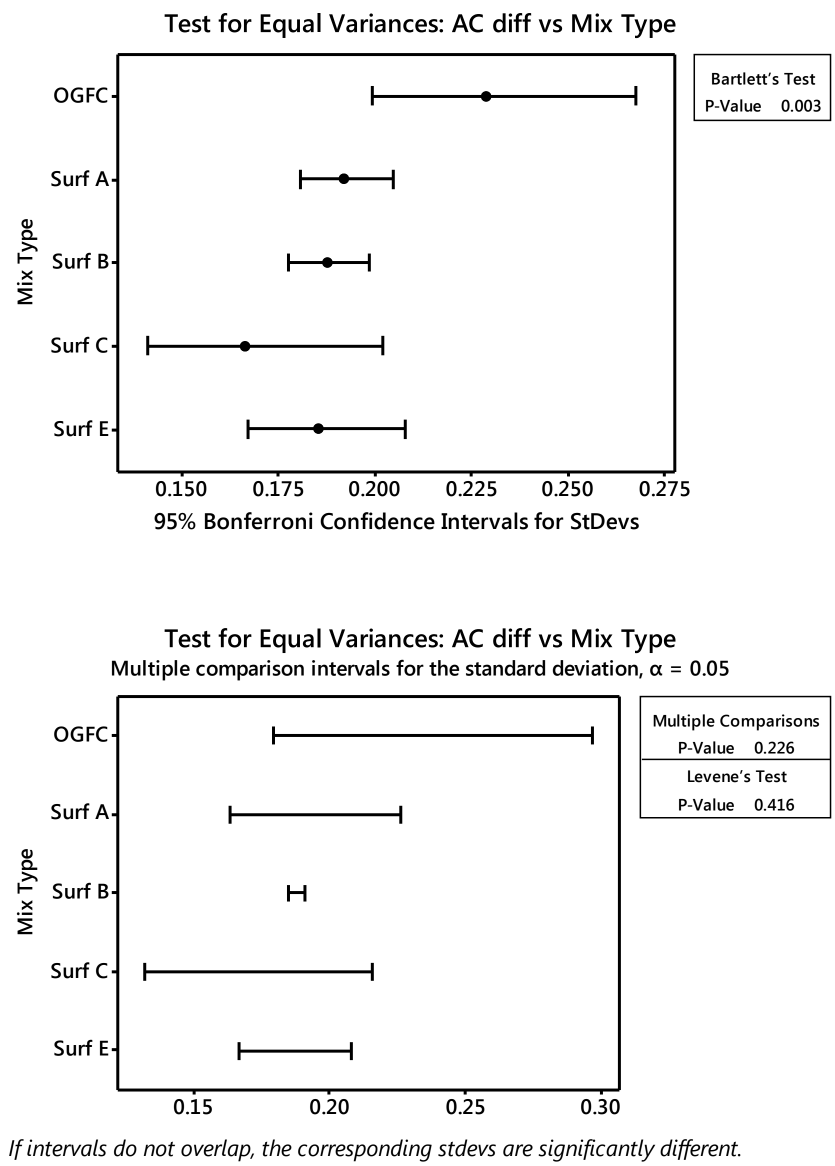


Figure 2.7. Confidence Intervals for AC Standard Deviations on Surface Course Mix Types

Review of Table 2.10 and Figure 2.7 indicates that it is likely that it is the OGFC standard deviation that caused the significant difference in Bartlett's test. The analysis was run again without the OGFC data and these results are shown in Table 2.11. No significant differences were obtained with either test. For this reason, as well as the relatively small sample size, OGFC was not considered in subsequent preliminary analyses of the Surface Mix Types.

Table 2.11. Summary of AC Comparisons among Surface Mixes without OGFC

Mix Type	No. of Tests	St Dev	P-value Bartlett's*+	P-value Levene's*+
Surface A	864	0.192	0.288	0.540
Surface B	1084	0.188		
Surface C	104	0.167		
Surface E	283	0.185		
TOTAL	**2489**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations

+ Values in **bold** are statistically significantly different at the α = 0.05 level.

Comparison of Multiple JMFs within a Project. Many of the projects had more than 1 JMF for each Mix Type on the project. Table 2.12 shows for Base and Intermediate courses the results for standard deviation comparisons when there were multiple JMFs for a Mix Type on a Project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. Table 2.13 shows similar results for Surface courses. The analyses summarized in Tables 2.12 and 2.13 included only JMFs that were represented by at least 5 test results.

While there are too few cases of multiple JMFs to draw any conclusions for Base and Intermediate courses, in 11 of 14 cases for Surface course there was no significant difference in the standard deviation values when multiple JMFs were used on a project.

Table 2.12. Projects with more than one JMF (≥ 5 tests for each JMF) for the Same Mix Type for AC for Base and Intermediate Courses

Mix	Proj	JMF	No. of Tests	St Dev	Levene'sTest P-value+
Base A	P12	J29	71	0.218	**0.020**
		J30	8	0.416	
		J93	12	0.348	
	P16	J77	56	0.368	0.282
		J78	11	0.230	
Interm C	P12	J35	19	0.227	0.891
		J36	11	0.257	
		J39	13	0.180	
		J40	23	0.245	

+ Values in **bold** indicate variances of JMFs are significantly different at the α = 0.05 level.

Table 2.13. Projects with more than one JMF (≥ 5 tests for each JMF) for the Same Mix Type for AC for Surface Courses

Mix	Proj	JMF	No. of Tests	St Dev	Levene'sTest P-value+
OGFC	P13	J95	17	0.271	0.912
		J96	50	0.215	
Surf A	P02	J02	13	0.178	0.155
		J03	58	0.341	
	P09	J16	44	0.176	0.161
		J17	20	0.115	
	P13	J13	41	0.171	**0.042**
		J14	47	0.187	
		J44	54	0.162	
		J45	22	0.122	
		J46	8	0.075	
		J48	5	0.150	
	P14	J62	58	0.190	0.781
		J63	104	0.182	
Surf B	P05	J08	21	0.212	0.126
		J09	27	0.162	
	P10	J20	7	0.109	0.241
		J21	15	0.299	
	P11	J27	26	0.162	0.341
		J28	45	0.178	
	P13	J49	37	0.191	0.712
		J50	12	0.181	
		J51	6	0.128	
		J52	20	0.159	
		J54	41	0.151	
		J56	11	0.210	
Surf C	P16	J79	5	0.139	0.688
		J80	15	0.170	
	P17	J81	6	0.206	0.061
		J82	43	0.118	
Surf E	P11	J68	49	0.200	0.425
		J69	26	0.153	
	P12	J71	10	0.269	**0.001**
		J72	121	0.160	
	P13	J74	24	0.185	**0.021**
		J75	20	0.117	
		J76	12	0.298	

+ Values in **bold** indicate variances of JMFs are significantly different at the α = 0.05 level.

Comparison among Contractors. For Surface course there are sufficient data, 2,489 AC tests, to allow for preliminary comparison of the standard deviation values for the different Contractors for Surface course mixes. Also, all 7 of the Contractors placed some Surface course mixes. The results for this analysis for AC are shown in Table 2.14. The results show clearly that there is a difference among Contractors when it comes to the variability of their Surface course mixes. Keep in mind that in this "gross" analysis it is possible that differences in Mix Types and JMFs could have contributed to the differences identified among Contractors.

Table 2.14. Summary of AC Comparisons for Surface Course among Contractors

Contractor	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
C1	155	0.156	**0.000**	**0.001**
C2	642	0.209		
C3	65	0.185		
C4	89	0.166		
C5	1015	0.198		
C6	237	0.187		
C7	286	0.165		
TOTAL	**2489**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations

+ Values in **bold** are statistically significantly different at the α = 0.05 level.

Preliminary Analysis of the Total Data Set for AV

Similar to AC, preliminary analyses were conducted on the total AV data set to investigate potential differences among Projects, Contractors, Courses, and JMFs. Tables 2.15-2.17 show the breakdown of the AV data by Base, Intermediate, and Surface Course. Where appropriate, each course is further broken down by Mix Type, Project, and JMF.

The first thing that stands out in these tables is the small number of test results data that were obtained for Base and Intermediate Courses. The breakdown of the total 2,234 AV test results is as follows: 80 Base Course, 102 Intermediate Course, and 2,052 Surface Course. Additionally, the Base Course results came from only a single Project and the Intermediate Course results came from only 4 Projects. All 20 Projects had at least some Surface Course results.

Table 2.15. Summary of AV Data for Base Course

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Base A	P12	J14	1	1	22	80
		J29	19	71		
		J30	2	8		
TOTAL			**22**	**80**	**22**	**80**

Table 2.16. Summary of AV Data for Intermediate Course

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Interm C	P05	J07	20	25	20	25
	P12	J35	11	12	30	35
		J36	8	10		
		J37	1	2		
		J38	1	1		
		J39	4	4		
		J40	5	6		
	P13	J57	20	22	26	28
		J58	3	3		
		J59	1	1		
		J60	1	1		
		J61	1	1		
	P19	J88	4	14	4	14
TOTAL			**80**	**102**	**80**	**102**

Table 2.17. Summary of AV Data for Surface Course

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf A	P02	J02	4	13	21	71
		J03	17	58		
	P03	J03	23	78	24	81
		J06	1	3		
	P06	J12	25	89	25	89
	P07	J14	18	18	18	18
	P09	J16	11	44	16	64
		J17	5	20		
	P10	J18	9	25	9	25
	P11	J23	3	3	26	90
		J24	22	86		
		J25	1	1		
	P13	J13	11	41	54	178
		J14	16	47		
		J44	13	54		
		J45	5	22		
		J46	6	8		
		J47	1	1		
		J48	2	5		
	P14	J62	15	58	42	162
		J63	27	104		
	P18	J85	23	86	23	86
Surf B	P01	J01	61	78	61	78
	P04	J01	25	77	25	77
	P05	J08	9	21	22	48
		J09	13	27		
	P08	J15	19	76	19	76
	P10	J19	2	3	9	25
		J20	3	7		
		J21	4	15		
	P11	J26	1	1	21	72
		J27	7	26		
		J28	13	45		

Table 2.17. Summary of AV Data for Surface Course (*cont*)

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf B (cont)	P12	J31	1	1	59	259
		J32	56	252		
		J33	1	4		
		J34	1	2		
	P13	J49	9	37	36	131
		J50	4	12		
		J51	1	6		
		J52	5	20		
		J53	1	1		
		J54	12	41		
		J55	1	3		
		J56	3	11		
	P15	J97	18	51	36	107
		J98	3	9		
		J99	2	3		
		J100	13	44		
	P18	J84	23	89	23	89
	P19	J86	16	61	16	61
Surf C	P20	J91	19	61	19	61
	P10	J22	10	11	10	11
	P12	J41	2	2	9	9
		J42	3	3		
		J43	4	4		
	P16	J79	2	5	7	20
		J80	5	15		
	P17	J81	2	6	19	50
		J82	16	43		
		J83	1	1		
	P19	J87	4	14	4	14
Total			**653**	**2052**	**653**	**2052**

Comparisons among Courses. Bartlett's test and Levene's test were conducted to see if statistically significant differences existed among the AV standard deviation values for the various courses. Bartlett's test assumes normal populations, while Levene's test does not require normal populations. The results of these tests are shown in Table 2.18.

Table 2.18. Summary of AV Comparisons among Courses

Course	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
Base	80	0.589		
Intermediate	102	0.707	**0.011**	**0.001**
Surface	2052	0.577		
TOTAL	**2234**			

***** Bartlett's test assume normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the α = 0.05 level.

The results from Table 2.18 clearly show that there is a difference in the AV standard deviation values among Base, Intermediate, and Surface courses. It can be concluded that the standard deviation for Intermediate course is larger than those for Base and Surface. However, this conclusion must be viewed with skepticism due to the extremely small sample sizes involved for Base and Intermediate.

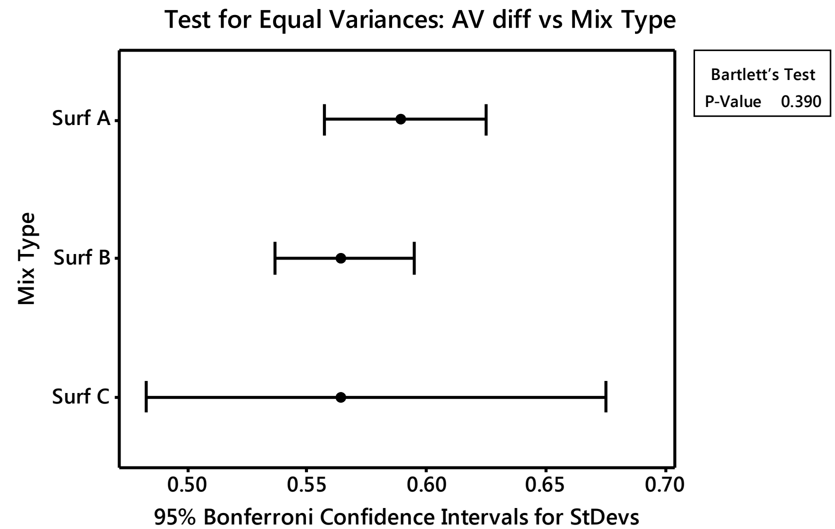
Comparison among Surface Mix Types. For Surface course there are sufficient data, 2,052 AV tests, to allow for comparison of the standard deviation values for the different Surface course Mix Types. The results for this analysis for AV are shown in Table 2.19 and Figure 2.8.

Table 2.19. Summary of AV Comparisons among Surface Mixes

Mix Type	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
Surface A	864	0.590		
Surface B	1084	0.565	0.390	**0.030**
Surface C	104	0.564		
TOTAL	**2052**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bol**d are statistically significantly different at the α = 0.05 level.

Bartlett's test does not show a significant difference in AV standard deviations for the 3 Surface course Mix Types, while Levene's test does indicate a significant difference. It appears that Levene's test has identified a difference due to the standard deviation for the Surface A Mix Type. However, the confidence intervals shown in Figure 2.8 show significant overlap of the 3 Mix Types, thereby supporting the conclusion from Bartlett's test that there is not a significant difference in the AV standard deviations.



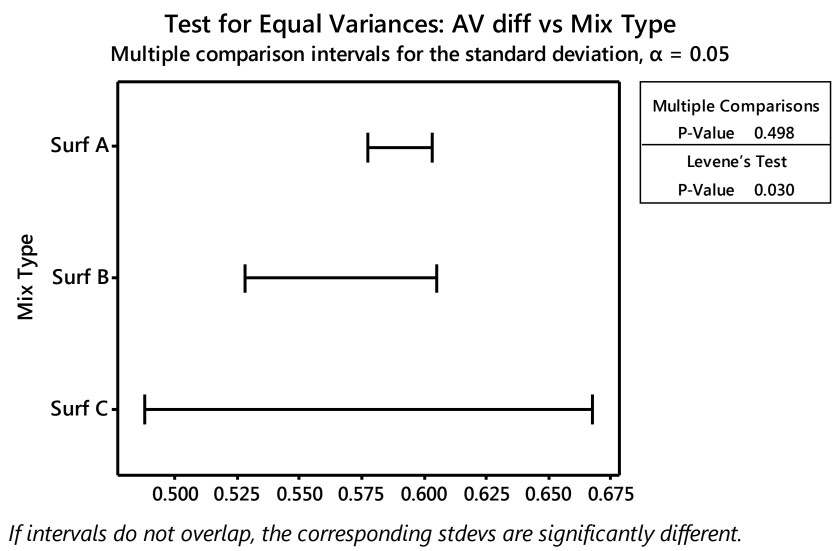


Figure 2.8. Confidence Intervals for AV Standard Deviations on Surface Course Mix Types

Comparison of Multiple JMFs within a Project. Many of the projects had more than 1 JMF for each Mix Type on the project. Table 2.20 shows for Base and Intermediate courses the results for AV standard deviation comparisons when there were multiple JMFs for a Mix Type on a Project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. Table 2.21 shows similar results for Surface courses. The analyses summarized in Tables 2.20 and 2.21 included only JMFs that were represented by at least 5 test results.

None of the projects that had multiple JMFs showed significantly different AV standard deviation values.

Table 2.20. Projects with more than one JMF (≥ 5 tests for each JMF) for the Same Mix Type for AV for Base and Intermediate Courses

Mix	Proj	JMF	No. of Tests	St Dev	Levene'sTest P-value
Base A	P12	J29	71	0.528	0.146
		J30	8	0.947	
Interm C	P12	J35	12	0.618	0.208
		J36	10	0.813	
		J40	6	0.284	

Table 2.21. Projects with more than one JMF (≥ 5 tests for each JMF) for the Same Mix Type for AV for Surface Courses

Mix	Proj	JMF	No. of Tests	St Dev	Levene'sTest P-value
Surf A	P02	J02	13	0.378	0.103
		J03	58	0.664	
	P09	J16	44	0.533	0.188
		J17	20	0.391	
	P13	J13	41	0.376	0.238
		J14	47	0.473	
		J44	54	0.440	
		J45	22	0.314	
		J46	8	0.668	
		J48	5	0.518	
	P14	J62	58	0.599	0.781
		J63	104	0.585	
Surf B	P05	J08	21	0.512	0.874
		J09	27	0.491	
	P10	J20	7	0.380	0.216
		J21	15	0.909	
	P11	J27	26	0.419	0.088
		J28	45	0.577	
	P13	J49	37	0.540	0.283
		J50	12	0.543	
		J51	6	0.553	
		J52	20	0.431	
		J54	41	0.460	
		J56	11	0.651	
Surf C	P16	J79	5	0.664	0.404
		J80	15	0.459	
	P17	J81	6	0.226	0.084
		J82	43	0.575	

Comparison among Contractors. For Surface course there are sufficient data, 2,052 AV tests, to allow for comparison of the standard deviation values for the different Contractors for Surface course mixes. Also, all 7 of the Contractors placed some Surface course mixes. The results for this analysis for AV are shown in Table 2.22. The results show clearly that there is a difference among Contractors when it comes to the variability of their Surface course mixes. Keep in mind that in this "gross" analysis it is possible that differences in Mix Types and JMFs could have contributed to the differences identified among Contractors.

Table 2.22. Summary of AV Comparisons for Surface Course among Contractors

Contractor	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
C1	155	0.550	**0.000**	**0.000**
C2	566	0.610		
C3	48	0.500		
C4	89	0.549		
C5	671	0.584		
C6	237	0.619		
C7	286	0.463		
TOTAL	**2052**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Preliminary Analysis of the Total Data Set for VMA

Similar to AC and AV, preliminary analyses were conducted on the total VMA data set to investigate potential differences among Projects, Contractors, Courses, and JMFs. Tables 2.23-2.25 show the breakdown of the VMA data by Base, Intermediate, and Surface Course. Where appropriate, each course is further broken down by Mix Type, Project, and JMF.

The first thing that stands out in these tables is the small number of test results data that were obtained for Base and Intermediate Courses. The breakdown of the total 2,234 AV test results is as follows: 80 Base Course, 102 Intermediate Course, and 2,048 Surface Course. Additionally, the Base Course results came from only a single Project and the Intermediate Course results came from only 4 Projects. All 20 Projects had at least some Surface Course results.

Table 2.23. Summary of VMA Data for Base Course

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Base A	P12	J14	1	1	22	80
		J29	19	71		
		J30	2	8		
TOTAL			**22**	**80**	**22**	**80**

Table 2.24. Summary of VMA Data for Intermediate Course

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Interm C	P05	J07	20	25	20	25
	P12	J35	11	12	30	35
		J36	8	10		
		J37	1	2		
		J38	1	1		
		J39	4	4		
		J40	5	6		
	P13	J57	20	22	26	28
		J58	3	3		
		J59	1	1		
		J60	1	1		
		J61	1	1		
	P19	J88	4	14	4	14
TOTAL			**80**	**102**	**80**	**102**

Table 2.25. Summary of VMA Data for Surface Course

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf A	P02	J02	3	9	20	67
		J03	17	58		
	P03	J03	23	78	24	81
		J06	1	3		
	P06	J12	25	89	25	89
	P07	J14	18	18	18	18
	P09	J16	11	44	16	64
		J17	5	20		
	P10	J18	9	25	9	25
	P11	J23	3	3	26	90
		J24	22	86		
		J25	1	1		
	P13	J13	11	41	54	178
		J14	16	47		
		J44	13	54		
		J45	5	22		
		J46	6	8		
		J47	1	1		
		J48	2	5		
	P14	J62	15	58	42	162
		J63	27	104		
	P18	J85	23	86	23	86
Surf B	P01	J01	61	78	61	78
	P04	J01	25	77	25	77
	P05	J08	9	21	22	48
		J09	13	27		
	P08	J15	19	76	19	76
	P10	J19	2	3	9	25
		J20	3	7		
		J21	4	15		
	P11	J26	1	1	21	72
		J27	7	26		
		J28	13	45		

Table 2.25. Summary of VMA Data for Surface Course (*cont*)

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf B (cont)	P12	J31	1	1	59	259
		J32	56	252		
		J33	1	4		
		J34	1	2		
	P13	J49	9	37	36	131
		J50	4	12		
		J51	1	6		
		J52	5	20		
		J53	1	1		
		J54	12	41		
		J55	1	3		
		J56	3	11		
	P15	J97	18	51	36	107
		J98	3	9		
		J99	2	3		
		J100	13	44		
	P18	J84	23	89	23	89
	P19	J86	16	61	16	61
Surf C	P20	J91	19	61	19	61
	P10	J22	10	11	10	11
	P12	J41	2	2	9	9
		J42	3	3		
		J43	4	4		
	P16	J79	2	5	7	20
		J80	5	15		
	P17	J81	2	6	19	50
		J82	16	43		
		J83	1	1		
	P19	J87	4	14	4	14
Total			**652**	**2048**	**652**	**2048**

Comparisons among Courses. Bartlett's test and Levene's test were conducted to see if statistically significant differences existed among the VMA standard deviation values for the various courses. Bartlett's test assumes normal populations, while Levene's test does not require normal populations. The results of these tests are shown in Table 2.26.

Table 2.26. Summary of VMA Comparisons among Courses

Course	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
Base	80	0.521	**0.004**	**0.001**
Intermediate	102	0.662		
Surface	2048	0.531		
TOTAL	**2230**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

The results from Table 2.26 clearly show that there is a difference in the VMA standard deviation values among Base, Intermediate, and Surface courses. It can be concluded that the standard deviation for Intermediate course is larger than those for Base and Surface. However, this conclusion must be viewed with skepticism due to the extremely small sample size involved.

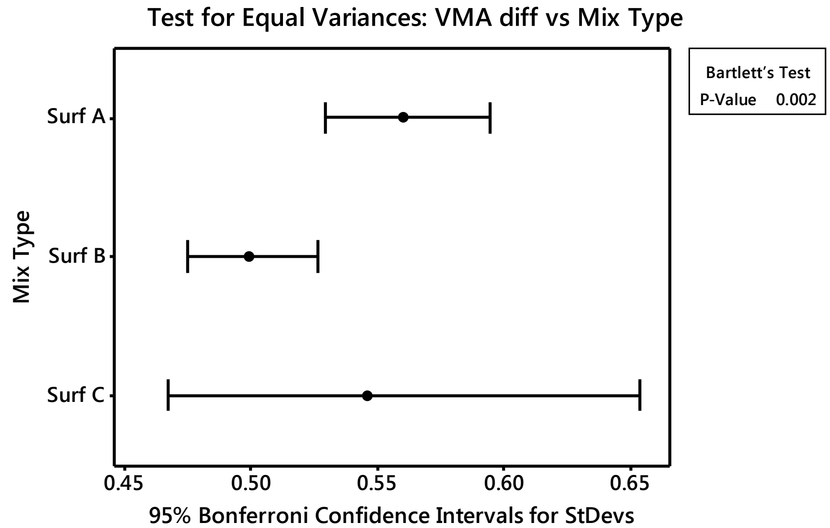
Comparison among Surface Mix Types. For Surface course there are sufficient data, 2,048 VMA tests, to allow for comparison of the standard deviation values for the different Surface course Mix Types. The results for this analysis for VMA are shown in Table 2.27 and Figure 2.9.

Table 2.27. Summary of VMA Comparisons among Surface Mixes

Mix Type	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
Surface A	860	0.561	**0.002**	**0.005**
Surface B	1084	0.500		
Surface C	104	0.546		
TOTAL	**2048**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Both Bartlett's and Levene's tests indicate a significant difference in VMA standard deviations for the 3 Surface course Mix Types. The confidence intervals shown in Figure 2.9 pretty clearly show that the difference in standard deviations stems from the comparison between the Surface A and B Mix Types. There does not appear to be a difference between the Surface A and C or Surface B and C Mix Types.



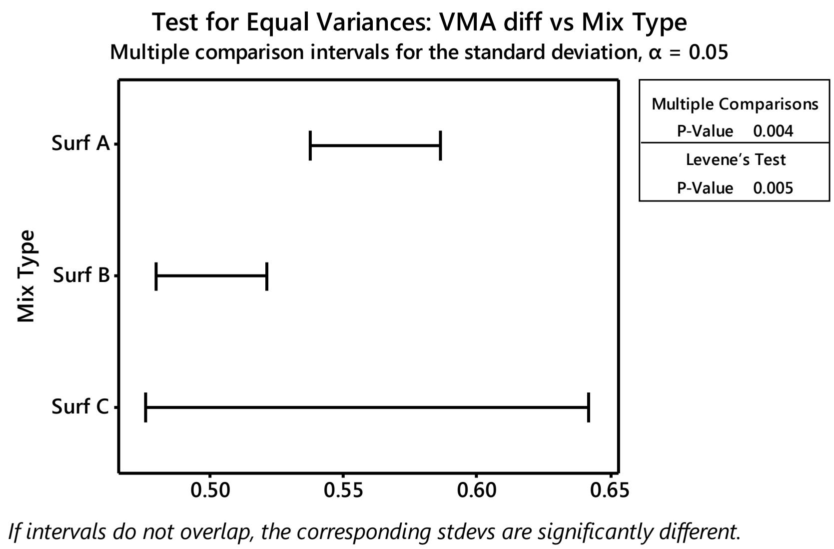


Figure 2.9. Confidence Intervals for VMA Standard Deviations on Surface Course Mix Types

Comparison of Multiple JMFs within a Project. Many of the projects had more than 1 JMF for each Mix Type on the project. Table 2.28 shows for Base and Intermediate courses the results for AV standard deviation comparisons when there were multiple JMFs for a Mix Type on a Project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. Table 2.29 shows similar results for Surface courses. The analyses summarized in Tables 2.28 and 2.29 included only JMFs that were represented by at least 5 test results.

None of the projects that had multiple JMFs showed significantly different VMA standard deviation values.

Table 2.28. Projects with more than one JMF (≥ 5 tests for each JMF) for the Same Mix Type for VMA for Base and Intermediate Courses

Mix	Proj	JMF	No. of Tests	St Dev	Levene'sTest P-value
Base A	P12	J29	71	0.483	0.530
		J30	8	0.471	
Interm C	P12	J35	12	0.488	0.223
		J36	10	0.445	
		J40	6	0.228	

Table 2.29. Projects with more than one JMF (≥ 5 tests for each JMF) for the Same Mix Type for VMA for Surface Courses

Mix	Proj	JMF	No. of Tests	St Dev	Levene'sTest P-value
Surf A	P02	J02	9	0.337	0.115
		J03	58	0.687	
	P09	J16	44	0.396	0.842
		J17	20	0.365	
	P13	J13	41	0.317	0.168
		J14	47	0.341	
		J44	54	0.415	
		J45	22	0.374	
		J46	8	0.545	
		J48	5	0.442	
	P14	J62	58	0.559	0.908
		J63	104	0.532	
Surf B	P05	J08	21	0.434	0.125
		J09	27	0.532	
	P10	J20	7	0.357	0.218
		J21	15	0.587	
	P11	J27	26	0.407	0.135
		J28	45	0.579	
	P13	J49	37	0.446	0.665
		J50	12	0.459	
		J51	6	0.361	
		J52	20	0.384	
		J54	41	0.373	
		J56	11	0.473	
Surf C	P16	J79	5	0.363	0.801
		J80	15	0.432	
	P17	J81	6	0.448	0.942
		J82	43	0.499	

Comparison among Contractors. For Surface course there are sufficient data, 2,048 VMA tests, to allow for comparison of the standard deviation values for the different Contractors for Surface course mixes. Also, all 7 of the Contractors placed some Surface course mixes. The results for this analysis for VMA are shown in Table 2.30. The results show clearly that there is a difference among Contractors when it comes to the variability of their Surface course mixes. Keep in mind that in this "gross" analysis it is possible that differences in Mix Types and JMFs could have contributed to the differences identified among Contractors.

Table 2.30. Summary of VMA Comparisons for Surface Course among Contractors

Contractor	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
C1	155	0.548	**0.000**	**0.000**
C2	562	0.603		
C3	48	0.533		
C4	89	0.508		
C5	671	0.457		
C6	237	0.575		
C7	286	0.484		
TOTALS	**2048**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the α = 0.05 level.

Composition of Data by Lots

One of the objectives of the project is to make a recommendation concerning whether or not SCDOT should consider switching to defining a Lot for acceptance purposes as a specified quantity of production rather than as a day's production as is currently the case. To explore whether or not a recommendation could be made based on the provided data, the data were evaluated on a Lot basis. Three items were considered in this analysis:

- The number of tests per Lot.
- The number of days per Lot.
- The tonnage placed per day.

Number of Tests per Lot. The first thing that became obvious when exploring the number of tests/Lot was the very large number of Lots for which it was not possible to calculate a percent within limits (PWL) value to use for payment determination. You must have at least 3 tests to be able to calculate a PWL value. While SCDOT has other methods for determining payment level when there are fewer than 3 tests in a Lot, PWL-based specifications, such as the 1 being evaluated in this research project, are designed for mainline paving where there is a relatively large and consistent amount of tonnage placed from 1 day to the next. PWL-based specifications are not designed for low volume paving applications.

The number of tests/Lot is directly related to the type of material being placed and to the purpose for which the material is being used (e.g., leveling, mainline paving, tying in driveways, etc.). Therefore, Table 2.31 presents a summary of the number of tests/Lot broken down by Mix Type.

Table 2.31. Summary of the Number of Tests/Lot Broken by Mix Type

Mix Type	Lots	Tests/Lot							
		1	2	3	4	5	6	7	8
Base A	55	10	6	23	7	9	0	0	0
Interm C	104	80	18	4	2	0	0	0	0
OGFC	31	9	2	14	6	0	0	0	0
Surface A	278	39	5	108	80	25	18	3	0
Surface B	275	68	28	81	45	29	17	6	1
Surface C	49	26	3	11	7	2		0	0
Surface E	179	90	33	36	15	4	1	0	0
Total	971	322	95	277	162	69	36	9	1
Percent	100.0	33.2	9.8	28.5	16.7	7.1	3.7	0.9	0.1

What is immediately obvious from reviewing the table is the very high percentage of Lots (i.e., 33.2 + 9.8 = 43%) for which there were not sufficient test results to allow a PWL value to be calculated. Another 28.5% of the Lots had 3 tests/Lot, the minimum number of tests required. This left only 28.5% of the Lots with 4 or more tests/Lot. Typically, 4 or more tests/Lot are expected when using PWL-based specifications. Figure 2.10 presents histograms of the distributions for tests/Lot for each Mix Type.

Three of the Mix Types had at least half of their Lots (77% for Intermediate C, 53% for Surface C, and 50% for Surface E) with a single test. These Lots do not add much to the analyses since it is not possible even to calculate a standard deviation when there is only 1 test in the Lot.

It is difficult to see how switching to defining a Lot by production quantity would help with this significant number of single test Lots. Depending upon the quantities selected for Lot or subLot sizes, the productions for multiple days probably would need to be added together. However, this can be, and often is, done with the current day's production definition for a Lot.

The current procedures call for combining tests from multiple Lots until at least 3 tests are available to determine PWL. It is not known why this was not done for the Lots for which there were only 1 or 2 tests, but if it was not done under the current Lot definition there is no reason to believe it would be more likely to be done if the Lot definition were based on quantity of production.

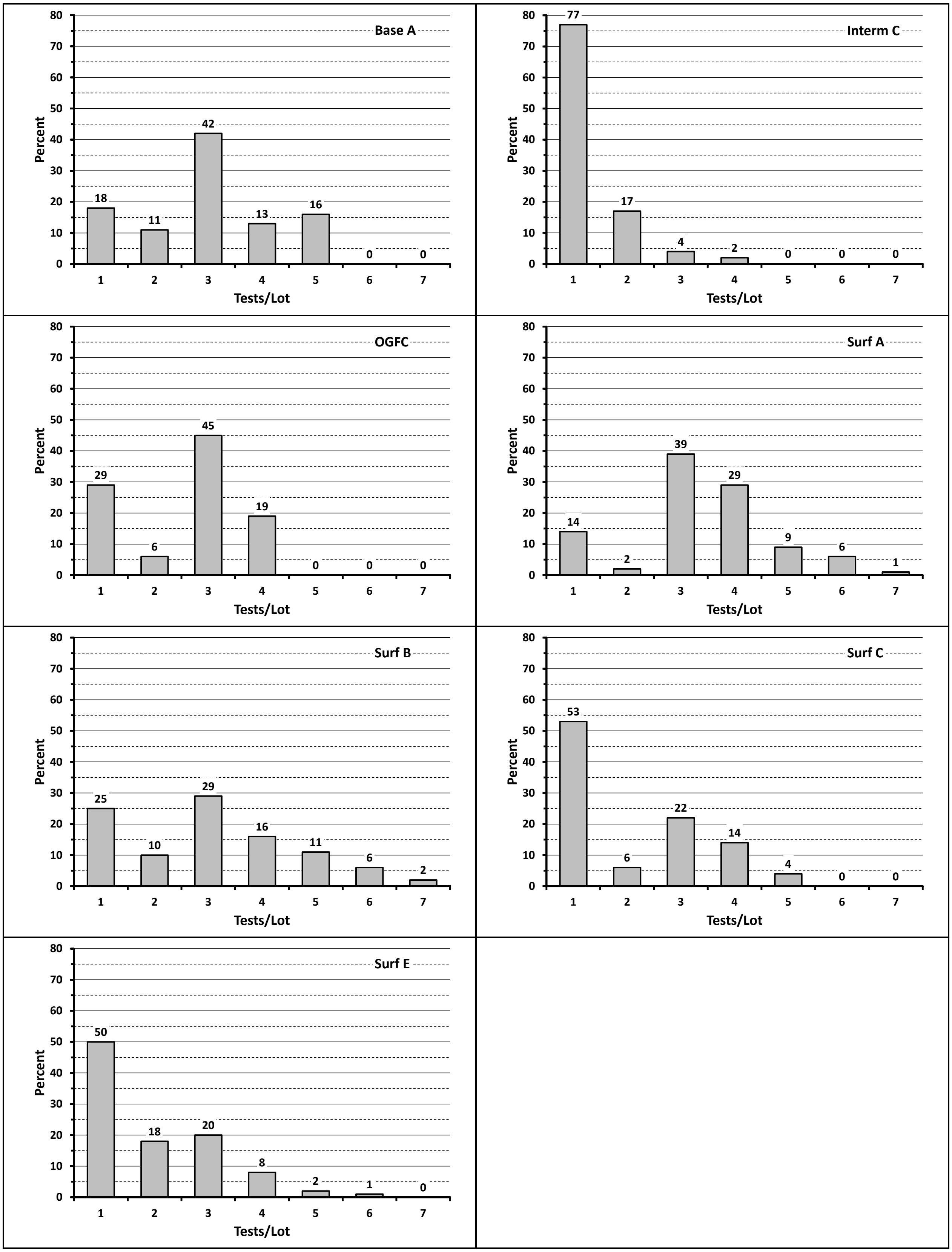


Figure 2.10. Distributions for the Number of Tests/Lot by Mix Type

Number of Lots by Contractor. Table 2.31 shows that there was a total of 971 Lots for which tests/Lot were available. Table 2.32 shows a breakdown of these Lots among the 7 Contractors from which data were received. It is a matter of concern whether these data are indicative of a "typical" contractor when 69% of them are from only 2 of the 7 Contractors that provided data.

Table 2.32. Number and Percent of Lots by Contractor

Contractor	No. of Lots	% of Total Lots	Combined %
C5	430	44.3%	**69%**
C2	242	24.9%	
C1	88	9.1%	**31%**
C6	66	6.8%	
C7	65	6.7%	
C3	55	5.7%	
C4	25	2.6%	
Total	971	100.1%	**100%**

Number of Days per Lot. As noted above, if there are fewer than 3 tests from a day's production then that day is combined with subsequent paving days until at least 3 test results are available and the combined days then become 1 Lot. To explore how often this happened on the projects from which data were supplied, Table 2.33 presents a breakdown of the number of paving days that were combined each for the Lots in the data set.

Table 2.33. Summary of the Number of Days/Lot by Mix Type

Mix Type	Days/Lot				
	1	**2**	**3**	**4**	**5**
Base A	37	17	1	0	0
Interm C	101	2	1	0	0
OGFC	16	9	6	0	0
Surface A	160	89	28	1	0
Surface B	196	62	15	1	1
Surface C	35	12	2	0	0
Surface E	160	19	0	0	0
Total	705	210	52	2	1
Percent	72.6%	21.7%	5.4%	0.2%	0.1%

The table shows that with rare exceptions all of the Lots had 3 or fewer paving days, with nearly three-fourths of them (72.6%) having a single day's production. However, this number is misleading due to the large number of Lots that had only 1 or 2 tests. It would not be possible to calculate a PWL value for these Lots.

Removing the 322 Lots that had only 1 test and the 95 Lots that had only 2 tests (see Table 2.31) leaves 288 PWL Lots that had all tests from a single day's production. After making these subtractions, Table 2.34 shows for the various numbers of days/Lot the number of Lots for which PWL values could be calculated. So, for Lots with 3 or more tests, approximately half (52%) consist of 1 paving day and approximately half (48%) consist of more than 1 paving day.

Table 2.34. Summary of the Number of Days/Lot by Mix Type for Lots with n ≥ 3

Mix Type	Days/Lot				
	1	2	3	4	5
Base A	21	17	1	0	0
Interm C	3	2	1	0	0
OGFC	5	9	6	0	0
Surface A	116	89	28	1	0
Surface B	100	62	15	1	1
Surface C	6	12	2	0	0
Surface E	37	19	0	0	0
Total	288	210	53	2	1
Percent	52.0%	37.9%	9.6%	0.4%	0.2%

Number of Tons per Day. To evaluate whether to switch to defining a Lot as a specified quantity of production it was necessary to look at the amount of tonnage that was placed each day on the projects in the data base. Daily tonnage information was available for 8 of the projects in the data base. For 7 of the projects the tonnage information was provided for each paving day. That is, if there were 3 paving days that comprised a Lot, then the tonnage was provided for each of the days.

However, on the remaining project tonnages were provided only for each Lot. On the project there were 6 Lots with 2 paving days and 3 Lots with 3 paving days. To be consistent, and to consider the tonnage placed per day, these 9 Lots were removed from the data set used for the analysis of tons placed per day. Table 2.35 shows a summary of the daily tonnage data for each Mix Type. Intermediate C was not included since it had only 2 total Lots.

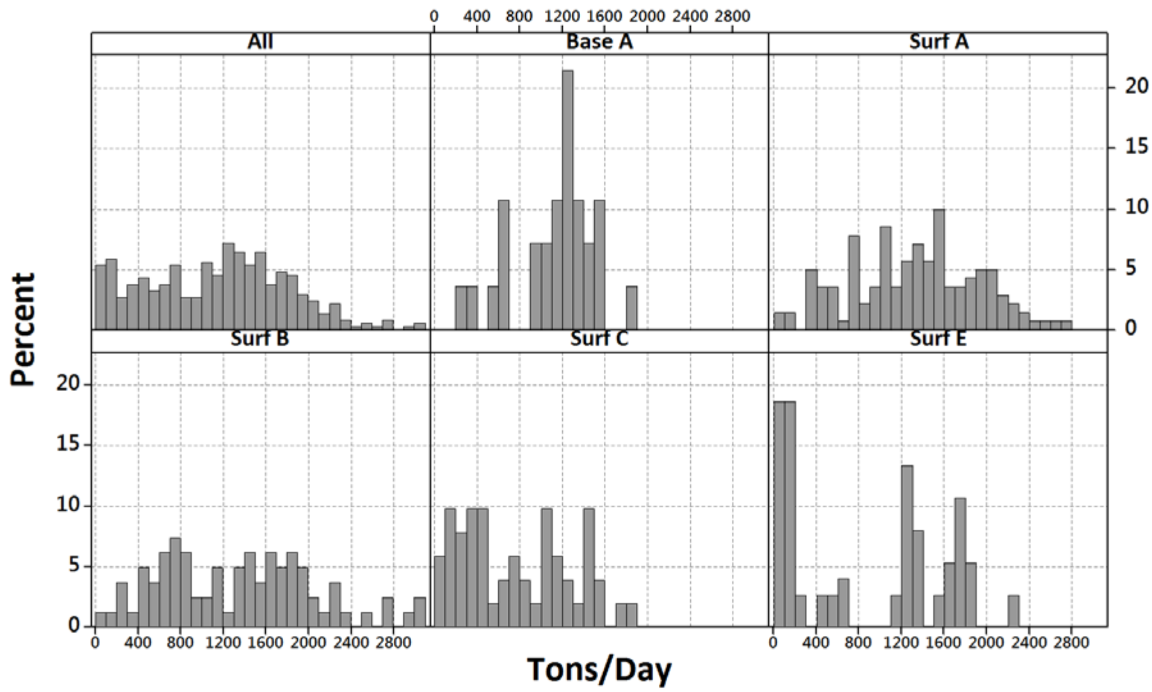
Table 2.35. Summary of Tonnage/Day by Mix Type

Mix Type	No. of Lots	Total Tonnage	Mean of Tons/Day	St Dev of Tons/Day	Minimum Tons/Day	Maximum Tons/Day
Base A	28	31,232	1,115	382	248	1,863
Surface A	141	185,584	1,316	602	38	2,744
Surface B	81	108,246	1,336	728	58	3,081
Surface C	51	38,403	753	511	58	1,838
Surface E	75	65,668	876	721	21	2,234
All Mixes	**376**	**429,133**	**1,141**	**671**	**21**	**3,081**

Several things are obvious from the table. Surface A and Surface B mixes account for the majority of the Lots and the majority of the tonnage. The average tonnage placed per day is quite a bit larger for Surface A and Surface B mixes than it is for Surface C and Surface E mixes. With the limited number of projects from which data were obtained there is no way to know if this is a consistent trend or if it is simply specific to these limited projects.

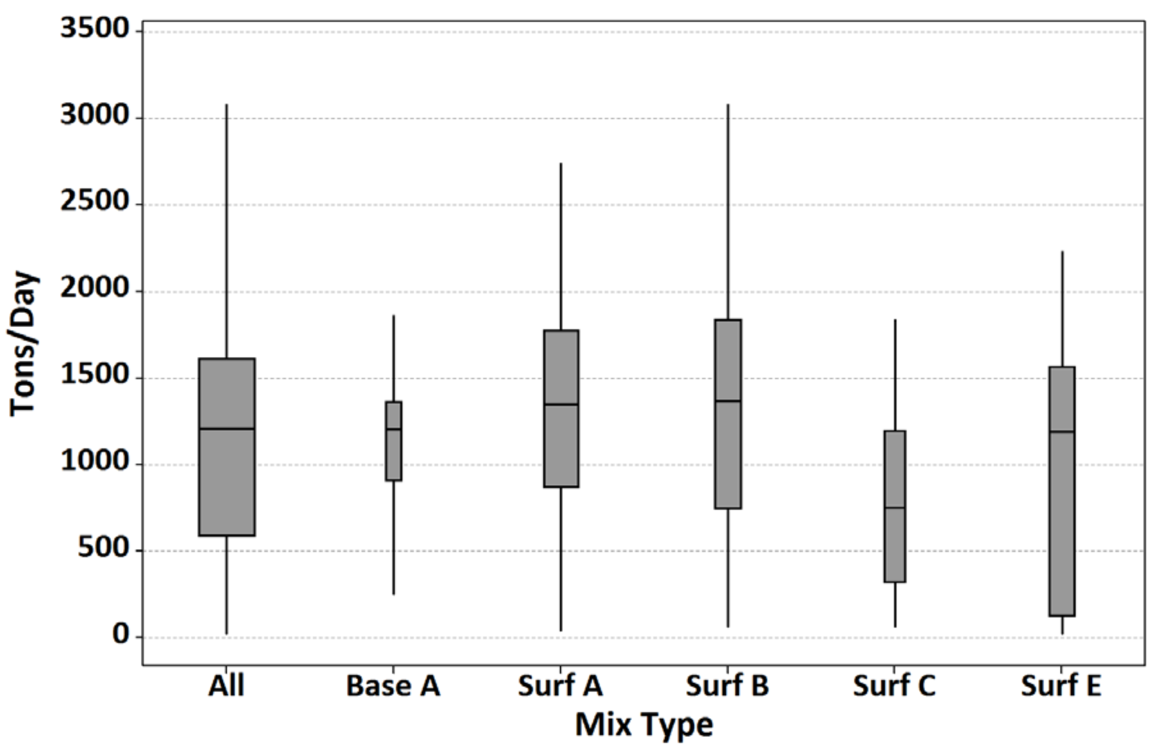
Figures 2.11 and 2.12 present 2 different graphical presentations of the daily tonnage data. Figure 2.11 presents histograms for each Mix Type as well as for the total data set (All Mixes). Figure 2.12 presents a similar breakdown, but in terms of BoxpLots. In Figure 2.12, the bottom of each box represents the 25th percentile, the top of each box represents the 75th percentile, and the horizontal line inside the box represents the median (50th percentile) of the data. The ends of the lines extending from the boxes represent the extent of the smallest and largest daily tonnage for each Mix Type.

Since each panel of Figure 2.11 has the same scale, both vertical and horizontal, the lower mean tonnages for Surface C and Surface E mixes are apparent from the upper end of the Surface C histogram being in the lower half of the horizontal scale and from the high percentage of Surface E results that are in the 0-100 and 100-200 tons/day ranges.



Panel variable: Mix Type

Figure 2.11. Histograms for the Number of Tons/Day by Mix Type



Note: Box width is proportional to sample size.

Figure 2.12. BoxpLots for the Number of Tons/Day by Mix Type

Table 2.36. Summary of Test Result Data for AC, AV, and VMA for all Projects

Course	Mix Types	Projects	JMFs	No. of Tests
AC				
Base	1	2	5	164
Intermediate	1	4	13	136
Surface	5	20	73	2489
AV				
Base	1	1	3	80
Intermediate	1	4	13	102
Surface	4	20	59	2052
VMA				
Base	1	1	3	80
Intermediate	1	4	13	102
Surface	4	20	59	2048

Issues and Concerns Regarding the Data that Were Provided

There are a number of issues with the data provided by SCDOT. The issue of most concern is the lack of data. As noted previously, the proposal for this project included the following statement:

> *To have a sufficient database from which to draw conclusions, it will be necessary to have data from at least 20, and preferably more, projects of relatively large size*. *The "large size" is necessary so the data are available from projects that had multiple verification data sets*.

As summarized in Table 2.36, there were very few projects that had data for Base and Intermediate courses for AC, AV, or VMA. It is obvious from Table 2.36 that there are not sufficient data for any meaningful analysis for Base and Intermediate courses. <u>Therefore, all further analyses of AC, AV, and VMA data were conducted solely on the Surface course data</u>.

While there are a large amount of test result data for Surface courses, there are still a number of issues with these data. Some of these issues were discussed previously in this chapter when discussing the total data set. These issues include for AC, for example, the following

- 6 of 20 projects accounted for 64.4% of the test results
- 11 of 20 projects were conducted by 2 of 7 Contractors
- 2 of 7 Contractors accounted of 68.8% of the test results
- C5 and C2 had 1209 tests and 709 tests, respectively, while C3 and C4 had 90 and 89, respectively.

There were other issues that required the elimination of some of the Surface course data. These issues are discussed in Chapter 3 where the final data set that was used for the data analyses is presented.

Finally, concerning whether SCDOT should consider switching to a specified quantity rather than a day's production as the definition of a Lot, there are two issues regarding any attempt to make a recommendation on this matter. The first and more important issue is the limited amount of data that were available for the project. Also, of the data available, nearly 70% of the data came from only 2 Contractors. This makes it highly questionable as to whether these data can be considered representative of "typical" contractors in the State.

Secondly, there is nothing in the limited data that were analyzed that indicates that switching to a specified quantity would improve the acceptance process over the current day's production definition.

CHAPTER 3 — PLANT DATA SET USED FOR THE ANALYSES

Background

This chapter discusses the modifications that were made to the original SCDOT plant data set (AC, AV, VMA) to obtain the "Analysis" data set on which analyses were performed.

The Abridged Data Set

As shown in Chapter 2, the original plant test data set consisted of 2,789 AC tests, 2,234 AV tests, and 2,230 VMA tests. These numbers included tests on Base, Intermediate, and Surface course mixes. Also as discussed in Chapter 2, there were not sufficient test results available to allow for analysis of Base and Intermediate courses.

Elimination of Selected Lots. One of the important objectives in analyzing an acceptance process is determining the typical within-Lot standard deviation to use when developing acceptance limits. Since it is not possible to determine a standard deviation when the sample size is 1, it was necessary to eliminate from the analyses any Lots for which there was only 1 test result available.

For example, Table 3.1 illustrates for Project P15 the process for eliminating Lots with sample sizes of n = 1. The table shows that the original data included a total of 107 tests from a total of 36 Lots. However, 9 of these Lots had only a single test. Therefore, the Abridged data set includes only 98 tests from 27 Lots.

Table 3.2 shows the comparison between sizes of the original and Abridged data sets for each project. For the original data set, 16 out of the 20 projects had at least 1 Lot with a sample size of n = 1. The number of Lots eliminated on each project ranged from 1 for Projects P08 and P14 to 90 on P12. Note that Project P07 is eliminated completely since all of its Lots had only a single sample.

The original data set had data from 1008 Lots. Of these, 314 had only a single test in each Lot, thereby leaving a total of 694 Lots in the Abridged data set. After eliminating single test Lots, the Abridged data set had 2,489 AC tests, 2,052 AV tests, and 2,048 VMA tests.

Elimination of Courses. As discussed in Chapter 2, there were insufficient data for Base and Intermediate courses to allow for meaningful analyses. Therefore, the Base and Intermediate course test results also were removed when arriving at the Abridged data set. This further reduced the sizes of the Abridged data to those shown in Table 3.3. The totals shown in the table include only the Surface course test data. After eliminating Base and Intermediate courses, the Abridged data set had 2,265 AC tests, 1,909 AV tests, and 1,905 VMA tests.

Table 3.1. Illustration, for Project P15, of How the Abridged Data Set Was Obtained

Original Data			Abridged Data		
JMF No.	**Lot No.**	**Lot Size**	**Lot No.**	**Lot Size, *n* > 1**	**Lot Size, *n* = 1**
J97	1	4	1	4	
J97	2	4	2	4	
J97	3	3	3	3	
J97	4	1	—	—	1
J97	5	1	—	—	1
J97	6	4	6	4	
J97	7	3	7	3	
J97	8	1	—	—	1
J97	9	4	9	4	
J97	10	6	10	6	
J97	11	5	11	5	
J97	12	3	12	3	
J97	13	3	13	3	
J97	14	3	14	3	
J97	16	1	—	—	1
J97	17	1	—	—	1
J97	18	3	18	3	
J97	19	1	—	—	1
J98	1	3	1	3	
J98	2	3	2	3	
J98	3	3	3	3	
J99	1	1	—	—	1
J99	2	2	2	2	
J100	20	3	20	3	
J100	21	4	21	4	
J100	22	3	22	3	
J100	23	3	23	3	
J100	24	8	24	8	
J100	25	5	25	5	
J100	26	3	26	3	
J100	27	3	27	3	
J100	28	3	28	3	
J100	29	1	—	—	1
J100	30	4	30	4	
J100	31	3	31	3	
J100	32	1	—	—	1
Totals	**36 Lots**	**107 Tests**	**27 Lots**	**98 Tests**	**9 Lots**

Table 3.2. Comparison of Number of Lots and Tests between the Original Data and the Abridged Data

Project No.	Original Data		Abridged Data	
	No. of Lots	No. of Tests	No. of Lots	No. of Tests
P01	61	78	15	32
P02	21	71	21	71
P03	24	81	22	79
P04	25	77	20	72
P05	55	90	25	60
P06	25	89	25	89
P07	18	18	0	0
P08	19	76	18	75
P09	16	64	16	64
P10	28	61	16	49
P11	85	238	61	214
P12	244	655	154	565
P13	174	460	112	398
P14	42	162	41	161
P15	36	107	27	98
P16	27	87	25	85
P17	19	50	13	44
P18	46	175	43	172
P19	24	89	24	89
P20	19	61	16	58
Total	**1008**	**2789**	**694**	**2475**

Table 3.3. Number of Surface Course Lots and Tests in the Abridged Data

Project No.	AC		AV		VMA	
	Lots	Tests	Lots	Tests	Lots	Tests
P01	15	32	15	32	15	32
P02	21	71	21	71	20	67
P03	22	79	22	79	22	79
P04	20	72	20	72	20	72
P05	21	51	17	43	17	43
P06	25	89	25	89	25	89
P07	0	0	0	0	0	0
P08	18	75	18	75	18	75
P09	16	64	16	64	16	64
P10	16	49	16	49	16	49
P11	61	214	42	157	42	157
P12	115	449	57	257	57	257
P13	110	394	77	295	76	295
P14	41	161	41	161	41	161
P15	27	98	27	98	27	98
P16	5	18	5	18	5	18
P17	13	44	13	44	13	44
P18	43	172	43	172	43	172
P19	20	75	20	75	20	75
P20	16	58	16	58	16	58
Total	**625**	**2265**	**510**	**1909**	**509**	**1905**

Data by Project. Table 3.4 shows for the Abridged data set the distribution of test data among the 20 projects. As with the original data set, a large amount of the data comes from a relatively small number of projects. Approximately 30% or more of the tests for AC (37.22%), AV (28.91%), and VMA (28.98%) are from only 2 of the 20 projects.

Figure 3.1 shows that the 5 largest projects (25% of the projects) account for approximately 55% or greater of the test result data. Specifically, these percentages are 61.4% for AC, 54.6% for AV, and 54.7% for VMA. This distribution of the data has the potential to bias the analyses in favor of these few larger projects that account for the majority of the data.

Data by Contractor. Table 3.5 shows for the Abridged data set the distribution of test data among the Contractors on the projects. A concern with the original test result data is the limited number of Contractors on the projects from which data were supplied. Only 7 different contractors were represented on these projects. Table 3.5 and Figure 3.2 show the breakdown of project data by Contractor. As can be seen, 60% or more of the tests for AC (66.71%), AV (60.92%), and VMA (60.84%) are from only 2 of the 7 Contractors.

The information presented in Table 3.5 and Figure 3.2 presents a limited and potentially skewed representation of the "typical" Contractor doing work for SCDOT.

Table 3.4. Number and Percentage Distribution of AC, AV, and VMA Tests by Project for the Abridged Data

AC			AV			VMA		
Proj.	Tests	Percent	Proj.	Tests	Percent	Proj.	Tests	Percent
P12	449	19.82	P13	295	15.45	P13	295	15.49
P13	394	17.40	P12	257	13.46	P12	257	13.49
P11	214	9.45	P18	172	9.01	P18	172	9.03
P18	172	7.59	P14	161	8.43	P14	161	8.45
P14	161	7.11	P11	157	8.22	P11	157	8.24
Top 5	**1390**	**61.4%**	**Top 5**	**1042**	**54.5%**	**Top 5**	**1042**	**54.7%**
P15	98	4.33	P15	98	5.13	P15	98	5.14
P06	89	3.93	P06	89	4.66	P06	89	4.67
P03	79	3.49	P03	79	4.14	P03	79	4.15
P08	75	3.31	P08	75	3.93	P08	75	3.94
P19	75	3.31	P19	75	3.93	P19	75	3.94
P04	72	3.18	P04	72	3.77	P04	72	3.78
P02	71	3.13	P02	71	3.72	P02	67	3.52
P09	64	2.83	P09	64	3.35	P09	64	3.36
P20	58	2.56	P20	58	3.04	P20	58	3.04
P05	51	2.25	P10	49	2.57	P10	49	2.57
P10	49	2.16	P17	44	2.30	P17	44	2.31
P17	44	1.94	P05	43	2.25	P05	43	2.26
P01	32	1.41	P01	32	1.68	P01	32	1.68
P16	18	0.79	P16	18	0.94	P16	18	0.94
P07	0	0.00	P07	0	0.00	P07	0	0.00
Next 15	**875**	**38.62**	**Next 15**	**867**	**45.41**	**Next 15**	**863**	**45.3**
TOTAL	**2265**	**99.99**	**TOTAL**	**1909**	**99.98**	**TOTAL**	**1905**	**100**

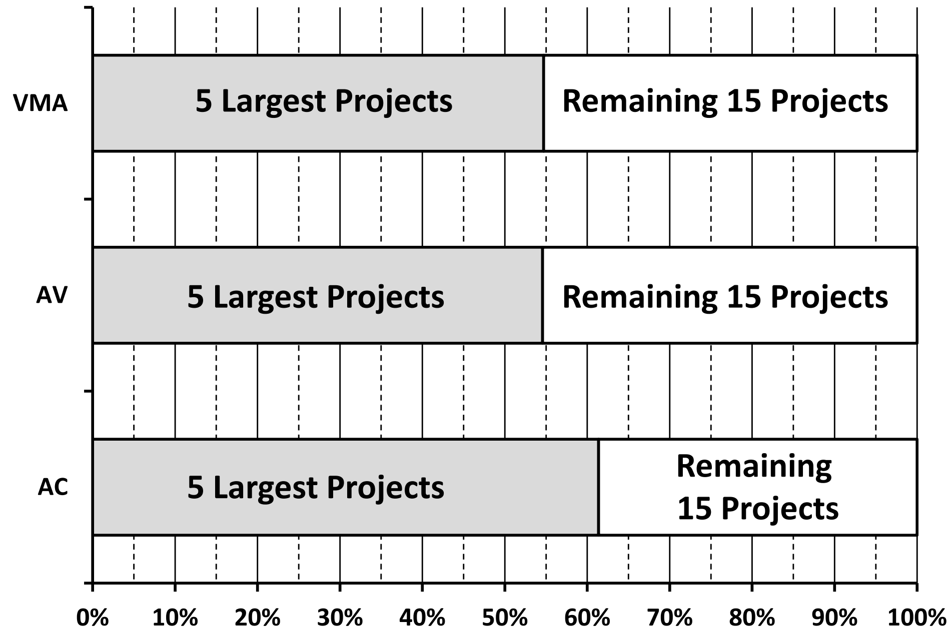


Figure 3.1. Abridged Data Set Percentage Distribution of Test Results by Project

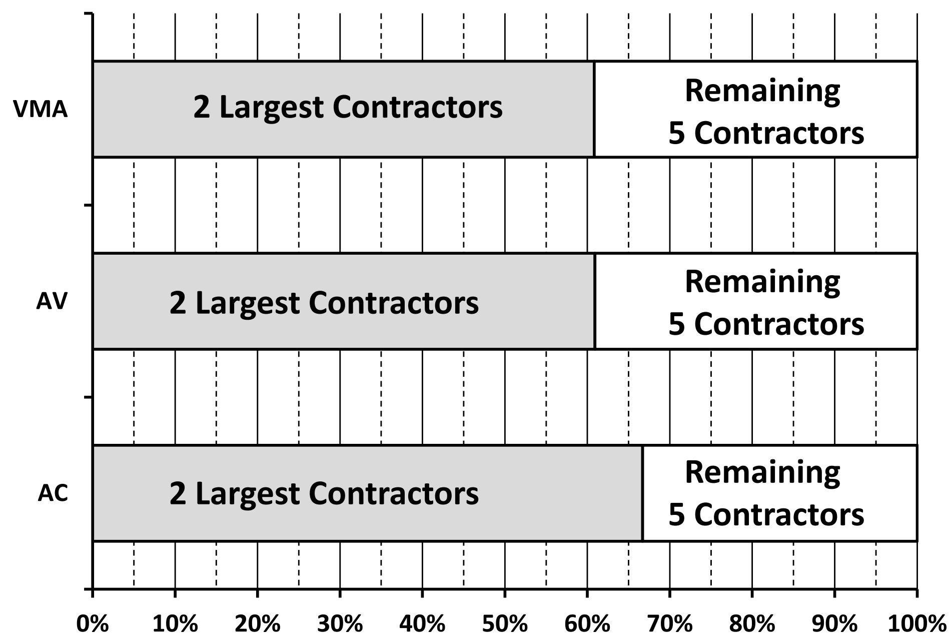


Figure 3.2. Abridged Data Set Percentage Distribution of Test Results by Contractor

Table 3.5. Summary of Amount of Data by Contractor for the Abridged Data

Contractor	No. of Tests	% of Total Tests	Combined %
AC Data			
C5	918	40.53%	66.71%
C2	593	26.18%	
C7	274	12.10%	33.29%
C6	236	10.42%	
C1	104	4.59%	
C4	89	3.93%	
C3	51	2.25%	
TOTAL	**2265**	**100.00%**	**100.00%**
AV Data			
C5	627	32.84%	60.92%
C2	536	28.08%	
C7	274	14.35%	39.07%
C6	236	12.36%	
C1	104	5.45%	
C4	89	4.66%	
C3	43	2.25%	
TOTAL	**1909**	**99.99%**	**99.99%**
VMA Data			
C5	627	32.91%	60.84%
C2	532	27.93%	
C7	274	14.38%	39.16%
C6	236	12.39%	
C1	104	5.46%	
C4	89	4.67%	
C3	43	2.26%	
TOTAL	**1905**	**100.00%**	**100.00%**

Preliminary Analysis of the Abridged Data Set for AC

While the Abridged data set includes only Surface course results, most of the projects combine the results for multiple JMFs. Macro-level analyses were conducted on the abridged data set to investigate potential differences among Mix Types, Projects, Contractors, and JMFs. Table 3.6 shows the AC test result data broken down by Mix Type, Project, and JMF.

Table 3.6. Summary of AC Data for the Abridged Data Set

Mix Type	Project	JMF	Lots in JMF	Tests in JMF	Lots on Proj.	Tests on Proj.
OGFC	P12	J90	24	85	24	85
	P13	J95	5	16	20	66
		J96	15	50		
Surf A	P02	J02	4	13	21	71
		J03	17	58		
	P03	J03	21	76	22	79
		J06	1	3		
	P06	J12	25	89	25	89
	P09	J16	11	44	16	64
		J17	5	20		
	P10	J18	8	24	8	24
	P11	J24	22	86	22	86
	P13	J13	11	41	42	166
		J14	12	43		
		J44	12	53		
		J45	5	22		
		J46	1	3		
		J48	1	4		
	P14	J62	15	58	41	161
		J63	26	103		
	P18	J85	23	86	23	86
Surf B	P01	J01	15	32	15	32
	P04	J01	20	72	20	72
	P05	J08	6	18	17	43
		J09	11	25		
	P08	J15	18	75	18	75
	P10	J19	1	2	7	23
		J20	2	6		
		J21	4	15		
	P11	J27	7	26	20	71
		J28	13	45		
	P12	J32	55	251	57	257
		J33	1	4		
		J34	1	2		
	P13	J49	9	37	34	129
		J50	4	12		
		J51	1	6		
		J52	4	19		
		J54	12	41		
		J55	1	3		
		J56	3	11		

Table 3.6. Summary of AC Data for the Abridged Data Set (*cont*)

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj.	Tests on Proj.
Surf B (*cont*)	P15	J97	12	45	27	98
		J98	3	9		
		J99	1	2		
		J100	11	42		
	P18	J84	20	86	20	86
	P19	J86	16	61	16	61
	P20	J91	16	58	16	58
Surf C	P10	J22	1	2	1	2
	P16	J79	1	4	5	18
		J80	4	14		
	P17	J81	2	6	13	44
		J82	11	38		
	P19	J87	4	14	4	14
Surf E	P05	J10	3	6	4	8
		J11	1	2		
	P11	J68	14	41	19	57
		J69	5	16		
	P12	J72	34	107	34	107
	P13	J74	6	13	13	33
		J75	6	16		
		J76	2	4		
TOTAL			**625**	**2265**	**625**	**2265**

Comparison among Surface Mix Types. The Abridged data set has sufficient data, 2,265 AC tests, to allow for comparison of the standard deviation values for the different Surface course Mix Types. The results for this analysis for AC are shown in Table 3.7 and Figure 3.3. Both Levene's test and Bartlett's test indicate a significant difference. The confidence intervals for the standard deviation values are shown in Figure 3.3.

Table 3.7. Summary of AC Comparisons among Surface Mixes for the Abridged Data Set

Mix Type	No. of Tests	St Dev	P-value*⁺ Bartlett's	P-value*⁺ Levene's
OGFC	151	0.227	**0.000**	**0.043**
Surface A	826	0.194		
Surface B	1005	0.189		
Surface C	78	0.153		
Surface E	205	0.166		
TOTAL	**2265**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

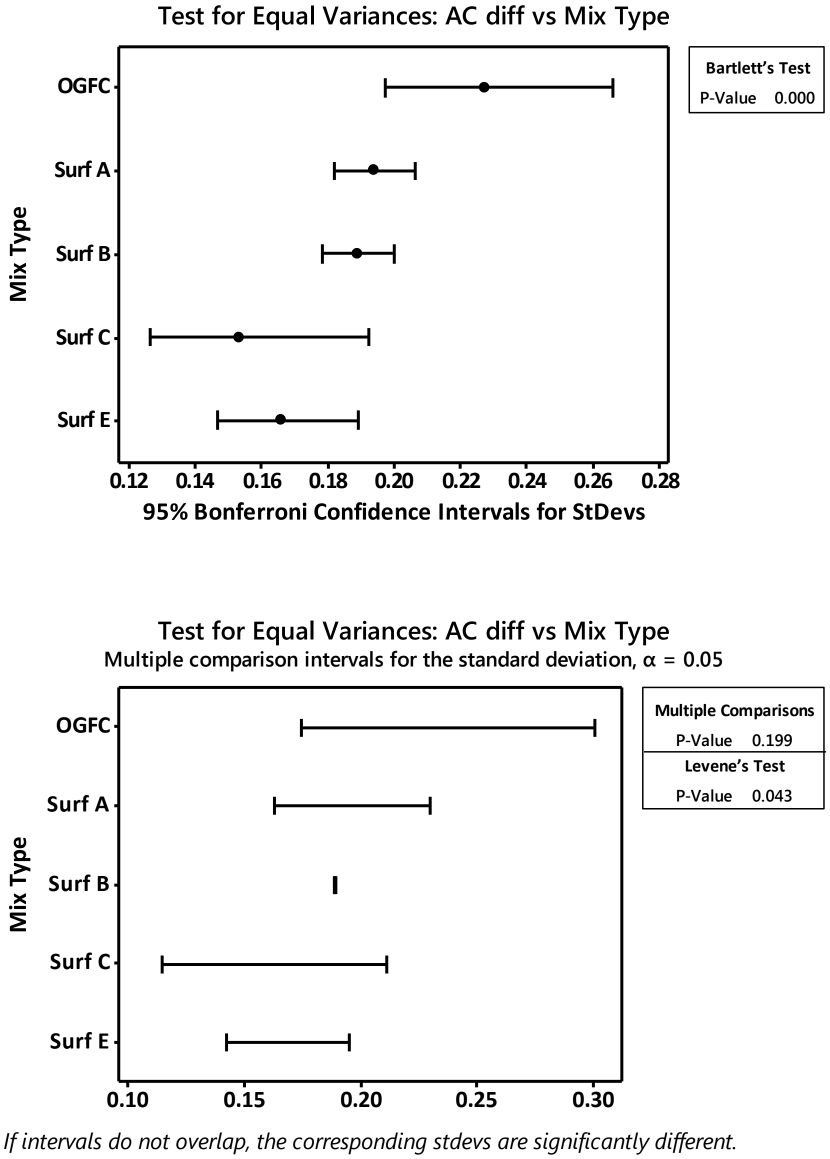


Figure 3.3. Confidence Intervals for AC Standard Deviations on Surface Course Mix Types for the Abridged Data Set

Possible reasons for the significant differences were considered. First, the tests may be influenced by the relatively small sample sizes for the Surface C (78 tests), OGFC (151 tests), and Surface E (205 tests) Mix Types compared with Surface A (826 tests) and Surface B (1,005 tests) Mix Types. Also note that it is likely that the OGFC and Surface E Mix Types are sufficiently different to not be considered with the other Surface mixes. For example, when OGFC and Surface E mixes were used, only AC tests were performed. Whereas, AC, AV, and VMA tests all were performed for Surface A, B, and C mixes.

To explore these possible issues, the analysis was run again using only Surface A, B, and C data and these results are shown in Table 3.8. Bartlett's test showed a significant difference while Levene's test did not show a significant difference in the standard deviation values. Inspection of the results in Table 3.8 indicates that it is likely that the Surface C standard deviation value is what caused the significant difference in Bartlett's test.

Table 3.8. Summary of AC Comparisons among Surface A, B, and C Mixes for Abridged Data

Mix Type	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
Surface A	826	0.194	**0.032**	0.195
Surface B	1005	0.189		
Surface C	78	0.153		
TOTAL	**1909**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

The analysis was run again using only Surface A and B data and these results are shown in Table 3.9. Neither test showed a significant difference in the standard deviation values. Note that when only 2 comparisons are made an F-test is used rather than Bartlett's test.

Table 3.9. Summary of AC Comparisons between Surface A and B Mixes for Abridged Data

Mix Type	No. of Tests	St Dev	P-value*+ F-test	P-value*+ Levene's
Surface A	826	0.194	0.462	0.800
Surface B	1005	0.189		
TOTAL	**1831**			

***** F-test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Comparison of Multiple Mix Types within a Project. Table 3.10 shows the results for standard deviation comparisons on the 7 Projects that had more than 1 Mix Type on the Project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The table shows that 6 of the 7 projects did not show significant differences in standard deviations for the multiple Mix Types. For P12 where there was a significant difference, it appears that the difference is caused by the Surface E mix that is different from the other 2 mixes. The analyses summarized in Table 3.10 included only Mix Types that had at least 5 test results.

Table 3.10. Projects with more than 1 Surface Mix Type (≥ 5 tests for each Mix) for AC for Abridged Data

Proj	Mix Type	No. of Tests	St Dev	Levene'sTest P-value+
P05	Surf B	43	0.202	0.740
	Surf E	6	0.180	
P10	Surf A	24	0.188	0.843
	Surf B	21	0.268	
P11	Surf A	86	0.168	0.397
	Surf B	71	0.178	
	Surf E	57	0.161	
P12	OGFC	85	0.224	**0.024**
	Surf B	251	0.213	
	Surf E	107	0.153	
P13	OGFC	66	0.229	0.165
	Surf A	166	0.165	
	Surf B	129	0.175	
	Surf E	33	0.185	
P18	Surf A	86	0.144	0.663
	Surf B	86	0.134	
P19	Surf B	61	0.171	0.785
	Surf C	14	0.140	

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Comparison of Multiple JMFs within a Project. Eleven of the projects had more than 1 JMF. The number of multiple JMFs on a project varied from 2 to 14. Table 3.11 shows the results for standard deviation comparisons for the 11 projects that had multiple JMFs. The Mix Type for each JMF is shown only for information purposes. The comparisons are made for all JMFs on each project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The analyses summarized in Table 3.11 included only JMFs that were used on at least 5 Lots on the given project.

In only 1 of 11 projects was a significant difference detected among the multiple JMFs. It should be noted that this is the same project that showed the only significant difference when comparing multiple Mix Types on projects (see Table 3.10). This lack of differences among JMFs on a project supports the combining of more than 1 JMF in the same Lot when the Contractor switches JMFs in the middle of a Lot.

Table 3.11. Projects with more than one JMF (≥ 5 tests for each JMF) for AC for Abridged Data

Proj	Mix Type	JMF	No. of Tests	St Dev	Levene'sTest P-value+
P02	Surf A	J02	13	0.178	0.155
		J03	58	0.341	
P09	Surf A	J16	44	0.176	0.161
		J17	20	0.115	
P10	Surf A	J18	24	0.188	0.360
	Surf B	J20	6	0.118	
		J21	15	0.299	
P11	Surf A	J24	86	0.168	0.253
	Surf B	J27	26	0.162	
		J28	45	0.178	
	Surf E	J68	41	0.179	
		J69	16	0.105	
P12	Surf B	J32	251	0.213	**0.024**
	Surf E	J72	107	0.153	
	OGFC	J90	85	0.224	
P13	Surf A	J13	41	0.171	0.190
		J14	43	0.183	
	Surf B	J44	53	0.161	
		J45	22	0.122	
		J49	37	0.191	
		J50	12	0.181	
		J51	6	0.128	
		J52	19	0.162	
		J54	41	0.151	
		J56	11	0.210	
	Surf E	J74	13	0.152	
		J75	16	0.115	
	OGFC	J95	16	0.276	
		J96	50	0.215	
P14	Surf A	J62	58	0.190	0.774
		J63	103	0.183	
P15	Surf B	J97	45	0.164	0.834
		J98	9	0.217	
		J100	42	0.164	
P17	Surf C	J81	6	0.206	0.062
		J82	38	0.117	
P18	Surf B	J84	86	0.134	0.663
		J85	86	0.144	
P19	Surf B	J86	61	0.171	0.785
		J87	14	0.140	

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Comparison among Contractors. The Abridged data set had sufficient data, 2,265 AC tests, to allow for comparison of the standard deviation values for the different Contractors. However, since 2 of the Contractors provided such a large portion of the total data set the distribution of the Contractors for the various Mix Types was explored before conducting any analysis. Table 3.12 shows the breakdown of Contractors and Mix Types.

Some potential problems for the analysis are apparent in the table. First, all of the OGFC data are from 1 Contractor. Only 3 Contractors each had test result data for Surface C and Surface E mixes. And, 1 Contractor had only 14 test results for Surface C and another had only 8 test results for Surface E.

Since Surface A had 5 Contractors and Surface B had 6 Contractors, it was decided that a Contractor comparison realistically could be made only using these 2 Mix Types. The results of this analysis are shown in Table 3.13. The results show clearly that there is a difference among Contractors when it comes to the variability of their Surface A and Surface B mixes.

Table 3.12. Summary of AC Tests by Mix Type and Contractor for Abridged Data

Mix Type	Contractor	No. of Tests	Standard Deviation
OGFC	C05	151	0.227
Surface A	C02	324	0.218
	C04	89	0.166
	C05	166	0.165
	C06	161	0.194
	C07	86	0.144
Surface B	C01	104	0.163
	C02	192	0.186
	C03	43	0.202
	C05	461	0.203
	C06	61	0.171
	C07	144	0.166
Surface C	C02	20	0.181
	C06	14	0.140
	C07	44	0.137
Surface E	C02	57	0.162
	C03	8	0.152
	C05	140	0.163
TOTAL		**2265**	

Table 3.13. Summary of AC Comparisons for Surface A and B Mixes among Contractors

Contractor	No. of Tests	St Dev	P-value*⁺ Bartlett's	P-value*⁺ Levene's
C01	104	0.163	**0.000**	**0.009**
C02	516	0.207		
C03	43	0.202		
C04	89	0.166		
C05	627	0.194		
C06	222	0.188		
C07	230	0.158		
TOTAL	**1831**			

***** Bartlett's test assume normal populations, while Levene's test does not require normal populations
⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Preliminary Analysis of the Abridged Data Set for AV

While the Abridged data set includes only Surface course results, many of the projects combine the results for multiple JMFs. Macro-level analyses were conducted on the abridged data set to investigate potential differences among Mix Types, Projects, Contractors, and JMFs. Table 3.14 shows the AV test result data broken down by Mix Type, Project, and JMF.

Comparison among Mix Types. The Abridged data set has sufficient data, 1,909 AV tests, to allow for comparison of the standard deviation values for the different Surface course Mix Types. The results for this analysis for AV are shown in Table 3.15. Both Levene's test and Bartlett's test indicate no significant difference.

Comparison of Multiple Mix Types within a Project. Table 3.16 shows the results for AV standard deviation comparisons on the 5 projects that had more than 1 Mix Type on the Project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The table shows that 4 of the 5 projects did not show significant differences in standard deviations for the multiple Mix Types. The analyses summarized in Table 3.16 included only Mix Types that had at least 5 test results.

Table 3.14. Summary of AV Data for the Abridged Data Set

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf A	P02	J02	4	13	21	71
		J03	17	58		
	P03	J03	21	76	22	79
		J06	1	3		
	P06	J12	25	89	25	89
	P09	J16	11	44	16	64
		J17	5	20		
	P10	J18	8	24	8	24
	P11	J24	22	86	22	86
	P13	J13	11	41	42	166
		J14	12	43		
		J44	12	53		
		J45	5	22		
		J46	1	3		
		J48	1	4		
	P14	J62	15	58	41	161
		J63	26	103		
	P18	J85	23	86	23	86
Surf B	P01	J01	15	32	15	32
	P04	J01	20	72	20	72
	P05	J08	6	18	17	43
		J09	11	25		
	P08	J15	18	75	18	75
	P10	J19	1	2	7	23
		J20	2	6		
		J21	4	15		
	P11	J27	7	26	20	71
		J28	13	45		
	P12	J32	55	251	57	257
		J33	1	4		
		J34	1	2		
	P13	J49	9	37	34	129
		J50	4	12		
		J51	1	6		
		J52	4	19		
		J54	12	41		
		J55	1	3		
		J56	3	11		

Table 3.14. Summary of AV Data for the Abridged Data Set (*cont*)

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf B (*cont*)	P15	J97	12	45	27	98
		J98	3	9		
		J99	1	2		
		J100	11	42		
	P18	J84	20	86	20	86
	P19	J86	16	61	16	61
	P20	J91	16	58	16	58
Surf C	P10	J22	1	2	1	2
	P16	J79	1	4	5	18
		J80	4	14		
	P17	J81	2	6	13	44
		J82	11	38		
	P19	J87	4	14	4	14
TOTAL			**510**	**1909**	**510**	**1909**

Table 3.15. Summary of AV Comparisons among Surface Mixes for the Abridged Data Set

Mix Type	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
Surface A	826	0.584	0.543	0.058
Surface B	1005	0.564		
Surface C	78	0.580		
TOTALS	**1909**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 3.16. Projects with more than one Surface Mix Type (≥ 5 tests for each Mix) for AV for Abridged Data

Proj	Mix Type	No. of Tests	St Dev	Levene's Test P-value+
P10	Surf A	24	0.421	0.088
	Surf B	23	0.819	
P11	Surf A	86	0.491	0.698
	Surf B	71	0.420	
P13	Surf A	166	0.473	**0.000**
	Surf B	129	0.611	
P18	Surf A	86	0.362	0.396
	Surf B	86	0.417	
P19	Surf B	61	0.534	0.198
	Surf C	14	0.361	

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Comparison of Multiple JMFs within a Project. Eleven of the projects had more than 1 JMF on the project. The number of multiple JMFs on a project varied from 2 to 10. Table 3.17 shows the results for standard deviation comparisons for the 11 projects that had multiple JMFs. The Mix Type for each JMF is shown only for information purposes. The comparisons are made for all JMFs on each project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The analyses summarized in Table 3.17 included only JMFs that at least 5 test results.

None of 11 projects showed a significant difference among the multiple JMFs. This lack of differences among JMFs on a project supports the combining of more than 1 JMF in the same Lot when the Contractor switches JMFs in the middle of a Lot.

Comparison among Contractors. The Abridged data set had sufficient data, 1,909 AC tests, to allow for comparison of the standard deviation values for the different Contractors. However, since 2 of the Contractors provided such a large portion of the total data set the distribution of the Contractors to the various Mix Types was explored before conducting any analysis. Table 3.18 shows the breakdown of Contractors and Mix Types.

Some potential problems for the analysis are apparent in the table. Only 3 Contractors each had test result data for Surface C mixes; and, 1 Contractor had only 14 test results and another had only 20.

Since Surface A had 5 Contractors and Surface B had 6 Contractors, it was decided that a Contractor comparison realistically could be made only using these 2 Mix Types. The results of this analysis are shown in Table 3.19. The results show clearly that there is a difference among Contractors when it comes to the variability of their Surface A and Surface B mixes.

Table 3.17. Projects with more than one JMF (≥ 5 tests for each JMF) for AV for Abridged Data

Proj	Mix	JMF	No. of Tests	St Dev	Levene'sTest P-value+
P02	Surf A	J02	13	0.378	0.103
		J03	58	0.664	
P05	Surf B	J08	18	0.430	0.521
		J09	25	0.494	
P09	Surf A	J16	44	0.533	0.188
		J17	20	0.391	
P10	Surf A	J18	24	0.421	0.203
	Surf B	J20	6	0.406	
		J21	15	0.909	
P11	Surf A	J24	86	0.491	0.192
	Surf B	J27	26	0.419	
		J28	45	0.577	
P13	Surf A	J13	41	0.376	0.108
		J14	43	0.459	
		J44	53	0.425	
		J45	22	0.314	
	Surf B	J49	37	0.540	
		J50	12	0.543	
		J51	6	0.553	
		J52	19	0.443	
		J54	41	0.460	
		J56	11	0.651	
P14	Surf A	J62	58	0.599	0.725
		J63	103	0.588	
P15	Surf B	J97	45	0.455	0.168
		J98	9	0.418	
		J100	42	0.302	
P17	Surf C	J81	6	0.226	0.094
		J82	38	0.588	
P18	Surf B	J84	86	0.417	0.396
	Surf A	J85	86	0.362	
P19	Surf B	J86	61	0.534	0.198
	Surf C	J87	14	0.361	

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 3.18. Summary of AV Tests by Mix Type and Contractor for Abridged Data

Mix Type	Contractor	No. of Tests	Standard Deviation
Surface A	C02	324	0.634
	C04	89	0.549
	C05	166	0.473
	C06	161	0.625
	C07	86	0.362
Surface B	C01	104	0.538
	C02	192	0.574
	C03	43	0.465
	C05	461	0.608
	C06	61	0.534
	C07	144	0.441
Surface C	C02	20	0.526
	C06	14	0.361
	C07	44	0.551
TOTAL		**1909**	

Table 3.19. Summary of AV Comparisons for Surface A and B Mixes among Contractors

Contractor	No. of Tests	St Dev	P-value*⁺ Bartlett's	P-value*⁺ Levene's
C01	104	0.538	**0.000**	**0.000**
C02	516	0.612		
C03	43	0.465		
C04	89	0.549		
C05	627	0.577		
C06	222	0.615		
C07	230	0.420		
TOTAL	**1831**			

***** Bartlett's test assume normal populations, while Levene's test does not require normal populations

⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Preliminary Analysis of the Abridged Data Set for VMA

While the Abridged data set includes only Surface course results, many of the projects combine the results for multiple JMFs. Macro-level analyses were conducted on the abridged data set to investigate potential differences among Mix Types, Projects, Contractors, and JMFs. Table 3.20 shows the VMA test results broken down by Mix Type, Project, and JMF.

Comparison among Mix Types. The Abridged data set has sufficient data, 1,905 AV tests, to allow for comparison of the standard deviation values for the different Surface course Mix Types. The results for this analysis for VMA are shown in Table 3.21 and Figure 3.4. Both Levene's test and Bartlett's test show significant differences. From Figure 3.4 it appears likely that the difference results from the difference in the Surface A and Surface B mixes.

Comparison of Multiple Mix Types within a Project. Table 3.22 shows the results for VMA standard deviation comparisons on the 5 projects that had more than 1 Mix Type on the Project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The table shows that 4 of the 5 projects did not show significant differences in standard deviations for the multiple Mix Types. The analyses summarized in Table 3.22 included only Mix Types that had at least 5 test results.

Table 3.20. Summary of VMA Data for the Abridged Data Set

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf A	P02	J02	3	9	20	67
		J03	17	58		
	P03	J03	21	76	22	79
		J06	1	3		
	P06	J12	25	89	25	89
	P09	J16	11	44	16	64
		J17	5	20		
	P10	J18	8	24	8	24
	P11	J24	22	86	22	86
	P13	J13	11	41	42	166
		J14	12	43		
		J44	12	53		
		J45	5	22		
		J46	1	3		
		J48	1	4		
	P14	J62	15	58	41	161
		J63	26	103		
	P18	J85	23	86	23	86
Surf B	P01	J01	15	32	15	32
	P04	J01	20	72	20	72
	P05	J08	6	18	17	43
		J09	11	25		
	P08	J15	18	75	18	75
	P10	J19	1	2	7	23
		J20	2	6		
		J21	4	15		
	P11	J27	7	26	20	71
		J28	13	45		
	P12	J32	55	251	57	257
		J33	1	4		
		J34	1	2		
	P13	J49	9	37	34	129
		J50	4	12		
		J51	1	6		
		J52	4	19		
		J54	12	41		
		J55	1	3		
		J56	3	11		

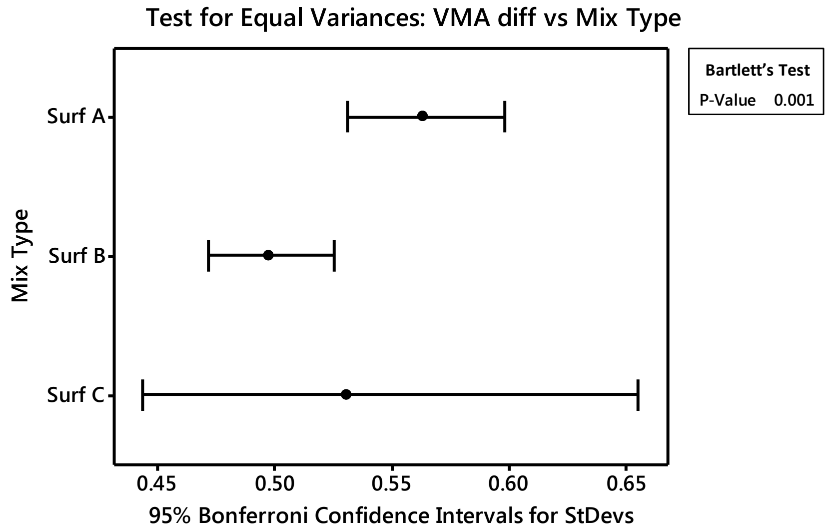
Table 3.20. Summary of VMA Data for the Abridged Data Set (*cont*)

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf B (*cont*)	P15	J97	12	45	27	98
		J98	3	9		
		J99	1	2		
		J100	11	42		
	P18	J84	20	86	20	86
	P19	J86	16	61	16	61
	P20	J91	16	58	16	58
Surf C	P10	J22	1	2	1	2
	P16	J79	1	4	5	18
		J80	4	14		
	P17	J81	2	6	13	44
		J82	11	38		
	P19	J87	4	14	4	14
TOTAL			**509**	**1905**	**509**	**1909**

Table 3.21. Summary of VMA Comparisons among Surface Mixes for the Abridged Data Set

Mix Type	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
Surface A	822	0.563	**0.001**	**0.002**
Surface B	1005	0.498		
Surface C	78	0.530		
TOTALS	**1905**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the α = 0.05 level.



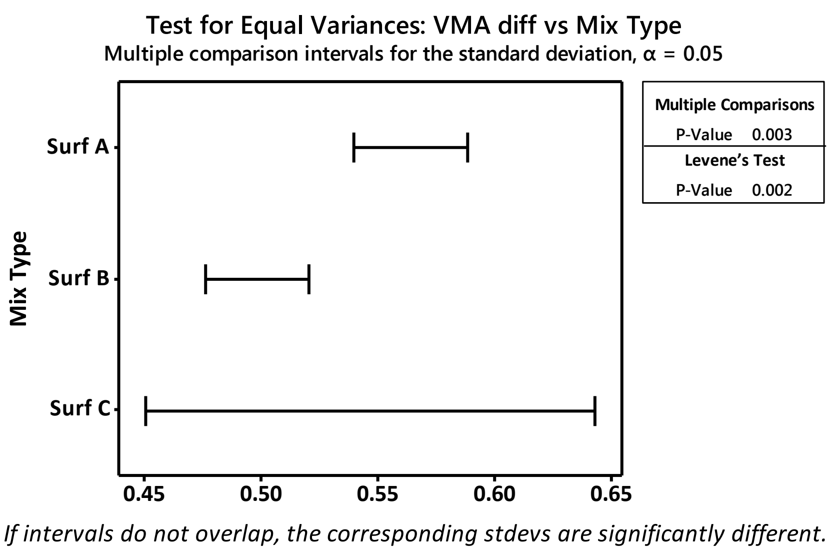


Figure 3.4. Confidence Intervals for VMA Standard Deviations on Surface Course Mix Types for the Abridged Data Set

Table 3.22. Projects with more than one Surface Mix Type (≥ 5 tests for each Mix) for VMA for Abridged Data

Proj	Mix Type	No. of Tests	St Dev	Levene's Test P-value[+]
P10	Surf A	24	0.549	0.459
	Surf B	23	0.564	
P11	Surf A	86	0.471	0.258
	Surf B	71	0.551	
P13	Surf A	166	0.426	**0.005**
	Surf B	129	0.525	
P18	Surf A	86	0.425	0.279
	Surf B	86	0.358	
P19	Surf B	61	0.411	0.561
	Surf C	14	0.422	

[+] Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Comparison of Multiple JMFs within a Project. Eleven of the projects had more than 1 JMF on the project. The number of multiple JMFs on a project varied from 2 to 6. Table 3.23 shows the results for standard deviation comparisons for the 11 projects that had multiple JMFs. The Mix Type for each JMF is shown only for information purposes. The comparisons are made for all JMFs on each project. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The analyses summarized in Table 3.23 included only JMFs that at least 5 test results.

None of 11 projects showed a significant difference among the multiple JMFs. This lack of differences among JMFs on a project supports the combining of more than 1 JMF in the same Lot when the Contractor switches JMFs in the middle of a Lot.

Comparison among Contractors. The abridged data set had sufficient data, 1,909 AC tests, to allow for comparison of the standard deviation values for the different Contractors. However, since 2 of the Contractors provided such a large portion of the total data set the distribution of the Contractors for the various Mix Types was explored before conducting any analysis. Table 3.24 shows the breakdown of Contractors and Mix Types.

Some potential problems for the analysis are apparent in the table. Only 3 Contractors had test result data for Surface C mixes. One Contractor had 14 test results, 1 had 20 test results, and 1 had 44 test results.

Since Surface A had 5 Contractors and Surface B had 6 Contractors, it was decided that realistically a Contractor comparison only could be made using these 2 Mix Types. The results of this analysis are shown in Table 3.25. The results show clearly that there is a difference among Contractors when it comes to the variability of their Surface A and Surface B mixes.

Table 3.23. Projects with more than one JMF (≥ 5 tests for each JMF) for VMA for Abridged Data

Proj	Mix	JMF	No. of Tests	St Dev	Levene'sTest P-value
P02	Surf A	J02	9	0.337	0.115
		J03	58	0.687	
P05	Surf B	J08	18	0.461	0.296
		J09	25	0.517	
P09	Surf A	J16	44	0.396	0.842
		J17	20	0.365	
P10	Surf A	J18	24	0.548	0.421
	Surf B	J20	6	0.371	
		J21	15	0.587	
P11	Surf A	J24	86	0.471	0.240
	Surf B	J27	26	0.407	
		J28	45	0.579	
P13	Surf A	J13	41	0.317	0.444
		J14	43	0.350	
		J44	53	0.417	
		J45	22	0.374	
	Surf B	J49	37	0.446	
		J50	12	0.459	
		J51	6	0.361	
		J52	19	0.392	
		J54	41	0.373	
		J56	11	0.473	
P14	Surf A	J62	58	0.559	0.920
		J63	103	0.534	
P15	Surf B	J97	45	0.446	0.323
		J98	9	0.526	
		J100	42	0.357	
P17	Surf C	J81	6	0.448	0.963
		J82	38	0.502	
P18	Surf B	J84	86	0.358	0.279
	Surf A	J85	86	0.425	
P19	Surf B	J86	61	0.411	0.561
	Surf C	J87	14	0.422	

[+] Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 3.24. Summary of VMA Tests by Mix Type and Contractor for Abridged Data

Mix Type	Contractor	No. of Tests	Standard Deviation
Surface A	C02	324	0.634
	C04	89	0.549
	C05	166	0.473
	C06	161	0.625
	C07	86	0.362
Surface B	C01	104	0.538
	C02	192	0.574
	C03	43	0.465
	C05	461	0.608
	C06	61	0.534
	C07	144	0.441
Surface C	C02	20	0.526
	C06	14	0.361
	C07	44	0.551
TOTAL		**1909**	

Table 3.25. Summary of VMA Comparisons for Surface A and B Mixes among Contractors

Contractor	No. of Tests	St Dev	P-value*⁺ Bartlett's	P-value*⁺ Levene's
C01	104	0.538	**0.000**	**0.000**
C02	516	0.612		
C03	43	0.465		
C04	89	0.549		
C05	627	0.577		
C06	222	0.615		
C07	230	0.420		
TOTALS	**1831**			

***** Bartlett's test assume normal populations, while Levene's test does not require normal populations

⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

The Final Analysis Data Set

The original plant test data provided by SCDOT consisted of 2,789 AC tests, 2,234 AV tests, and 2,230 VMA tests. However, as discussed previously in this chapter, after eliminating Lots for which there was only 1 test result available, and after eliminating Base and Intermediate courses due to insufficient data, the Abridged data set had 2,265 AC tests, 1,909 AV tests, and 1,905 VMA tests from the various Surface mixes (see Table 3.26).

Table 3.26. Summary of Test Results for Surface Mix types for the Abridged Data Set

Mix Type	AC		AV		VMA	
	Projects	Tests	Projects	Tests	Projects	Tests
OGFC	2	151	0	0	0	0
Surface A	9	826	9	826	9	822
Surface B	12	1005	12	1005	12	1005
Surface C	4	78	4	78	4	78
Surface E	4	205	0	0	0	0
TOTALS		**2265**		**1909**		**1905**

Table 3.26 shows the limited amount of data available for the OGFC (2 projects, 151 tests), Surface C (4 projects, 78 tests), and Surface E (4 projects, 205 tests) Mix Types compared with Surface A (9 projects, 826 tests) and Surface B (12 projects, 1,005 tests) Mix Types. Also note that for the OGFC and Surface E Mix Types only AC tests were performed.

None of the Surface Mix Types meet the following requirement that was stated in the proposal for this project:

> *To have a sufficient database from which to draw conclusions, it will be necessary to have data from at least 20, and preferably more, projects of relatively large size.*

While it is somewhat of a stretch using 9 and 12 projects, using data from 4 or fewer projects with 205 or fewer test results is not sufficient for a valid analysis. Therefore, the final Analysis data set was comprised only of the test results for Surface A and Surface B Mix Types. The composition of the Analysis data set is shown in Table 3.27.

Table 3.27. Summary of Data for the Analysis Data Set

Mix Type	Proj	JMFs	Lots	Tests
Surf A	P02	2	21*	71*
	P03	2	22	79
	P06	1	25	89
	P09	2	16	64
	P10	1	8	24
	P11	1	22	86
	P13	6	42	166
	P14	2	41	161
	P18	1	23	86
Surf B	P01	1	15	32
	P04	1	20	72
	P05	2	17	43
	P08	1	18	75
	P10	3	7	23
	P11	2	20	71
	P12	3	57	257
	P13	7	34	129
	P15	4	27	98
	P18	1	20	86
	P19	1	16	61
	P20	1	16	58
Total			**487**	**1831**

* Only 20 Lots and 67 Tests for VMA

Observations, Issues and Concerns

During the course of this chapter a number of data evaluations are presented and various observations are made concerning the data set. Some of these are summarized below.

- While limited data were obtained for 1 Base Mix Type, 1 Intermediate Mix Type, and 3 additional Surface Mix Types, there only were sufficient data to allow for analyses of Surface A and Surface B mixes. This obviously limits any potential conclusions to these 2 Mix Types.
- There is concern that there are not more projects from which data are included in the Analysis data set. While data were obtained from 20 different projects, the final analyses were made using data from only 9 Projects for Surface A mixes and 12 Projects for Surface B mixes. These are not sufficient for drawing meaningful conclusions regarding all potential paving projects in the State.

- There is concern over the fact that a relatively large amount of the data are from a relatively small number of Projects. The distribution of data among Projects is shown in Figure 3.5. For example, the 5 largest Projects account for 56.9% of the data. This leaves only 43.1% for the 15 remaining projects. This heavy weighting of the data towards a limited number of Projects may limit the breadth of any conclusions that may be reached.
- There is concern over the fact that a relatively large amount of the data are from a relatively small number of Contractors. The distribution of data among Contractors is summarized in Table 3.28 and illustrated in Figure 3.6. This heavy weighting of the data towards a limited number of Contractors may limit the applicability to the "typical" Contractor of possible conclusions drawn from the data.
- The analyses in this chapter did not identify any differences between the variability of Surface A and Surface B mixes for AC or AV, but did identify a difference for VMA.
- The analyses in this chapter did not identify any differences between the variability of the various JMFs when multiple JMFs were used on the same project. It therefore was decided not to consider any effects of multiple JMFs on a project when performing subsequent analyses. This lack of differences among JMFs on a project supports the combining of more than 1 JMF in the same Lot when the Contractor switches JMFs in the middle of a Lot.

Table 3.28. Summary of Data for the Analysis Data Set by Contractor

Contractor	Projects	JMFs	Lots	Tests
C1	2	1	35	104
C2	6	16	143*	516*
C3	1	11	17	43
C4	1	1	25	89
C5	3	17	151	627
C6	2	3	57	222
C7	2	3	59	230
Total	17		**487**	**1831**

* Only 142 Lots and 512 Tests for VMA

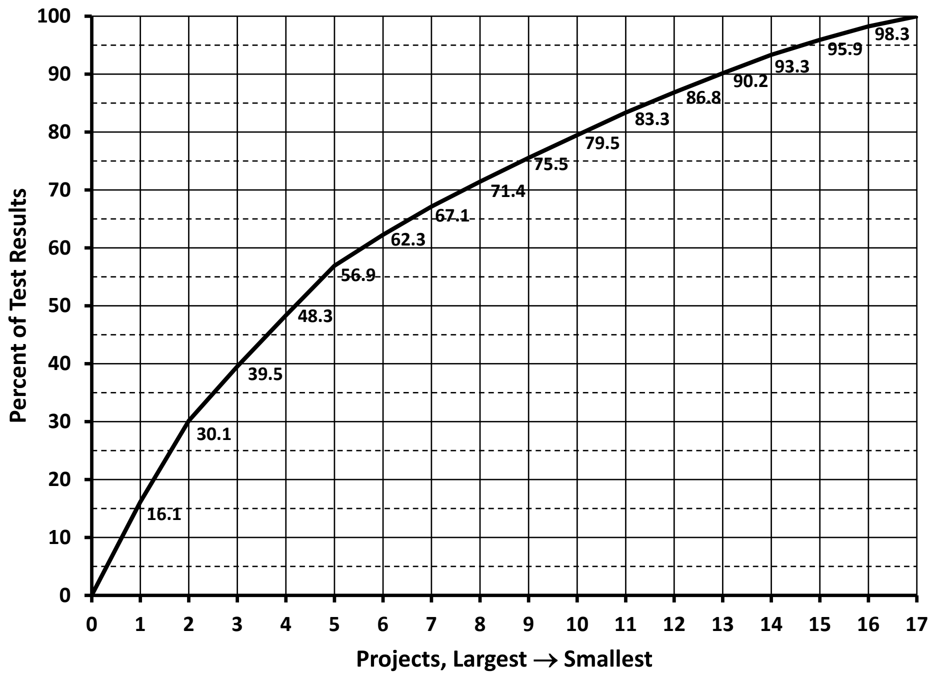


Figure 3.5. PLot Showing the Percent of Test Results vs. Number of Projects for the Analysis Data Set

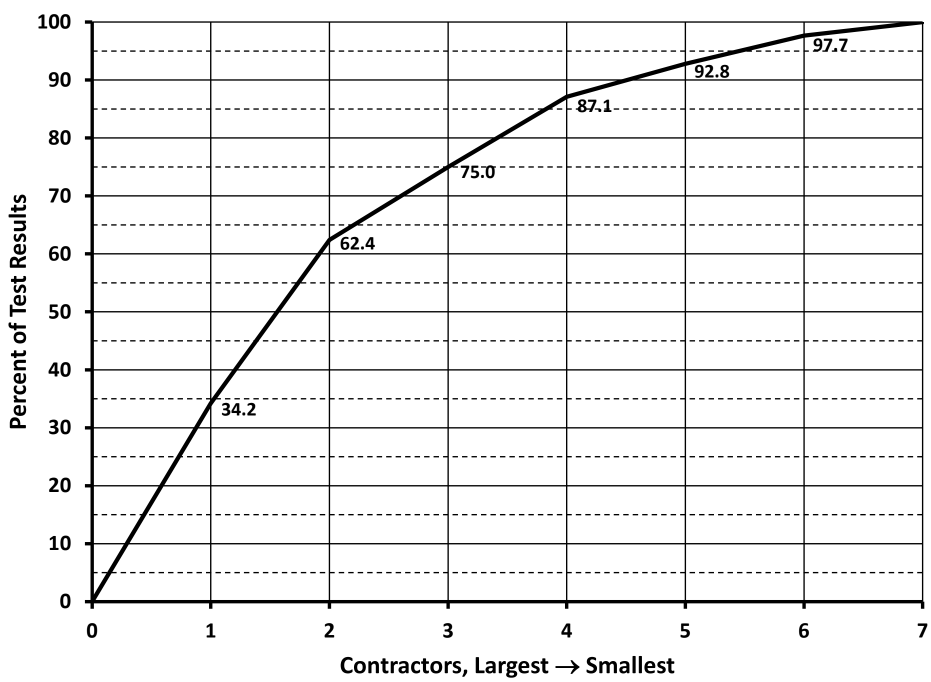


Figure 3.6. PLot Showing the Percent of Test Results vs. Number of Contractors for the Analysis Data Set

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CHAPTER 4 — ANALYSIS OF FINAL PLANT ACCEPTANCE TEST DATA SET

Background

This chapter summarizes and discusses the results of analyses to determine appropriate standard deviation values to represent the variability of AC, AV, and VMA. These variabilities are necessary to evaluate the appropriateness of the existing specification limits.

Final Analysis Data Set

The final Analysis data set consisted of 1,831 AC and AV tests, and 1,827 VMA tests. All of the data are from Surface A and Surface B mix types. The numbers of tests for the various projects and JMF mix designs are presented in Table 4.1.

Table 4.1. Summary of Data for the Analysis Data Set

Mix Type	Proj	JMFs	Lots	Tests
Surf A	P02	2	21*	71*
	P03	2	22	79
	P06	1	25	89
	P09	2	16	64
	P10	1	8	24
	P11	1	22	86
	P13	6	42	166
	P14	2	41	161
	P18	1	23	86
Surf B	P01	1	15	32
	P04	1	20	72
	P05	2	17	43
	P08	1	18	75
	P10	3	7	23
	P11	2	20	71
	P12	3	57	257
	P13	7	34	129
	P15	4	27	98
	P18	1	20	86
	P19	1	16	61
	P20	1	16	58
Total			**487**	**1831**

* Only 20 Lots and 67 Tests for VMA

Asphalt Content Analysis

Comparing Surface Mix Types. The first question to consider is whether it is appropriate to use the same specification tolerances for both Surface A and Surface B Mix Types. When establishing the allowable tolerances it is the standard deviation that is most important.

Table 4.2 shows the results of comparisons between the AC variabilities for the 2 types of Surface mixes. The results show that there is no significant difference between the standard deviations of Surface A and Surface B mixes. Therefore, there is no indication that it is necessary to have different acceptance limits for AC for the different Mix Types.

Table 4.2. Summary of AC Comparisons of Surface Course Mix Types

Mix Type	No. of Tests	St Dev	P-value*+ F-test	P-value*+ Levene's
Surface A	826	0.194	0.462	0.800
Surface B	1005	0.189		
TOTAL	**1831**			

***** Bartlett's test assume normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Caveat. The standard deviation values shown in Table 4.2 are not the appropriate standard deviation to use to represent the process standard deviation for AC. The calculations summarized in Table 4.2 were done simply for exploratory purposes. Aggregating the data as is done in this table is not appropriate for establishing specification limits since the specification limits are based on Lot-by-Lot acceptance, or at least on acceptance of a Project.

Projects with Multiple Mix Types. Before considering the within-Lot and Project variabilities, a decision had to be made regarding how to deal with Projects on which more than 1 Mix Type (i.e., Surface A and Surface B) was used. Should each Mix Type be treated as a separate Project, or should the multiple Mix Type results be combined together as 1 Project? To help make this decision, the Projects with multiple Mix Types were examined.

Table 4.3 shows the Projects (extracted from Table 4.1) that had both Surface A and Surface B Mix Types. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The table shows that none of the 4 Projects had significant differences in standard deviations for the 2 Mix Types. This result supports not separating the results for different Mix Types when determining the within-Lot standard deviation value for a Project.

Table 4.3. Projects with more than one Surface Mix Type (≥ 5 tests for each Mix) for AC for the Analysis Data Set

Project	Mix Type	No. of Tests	St Dev	Levene's Test P-value⁺
P10	Surf A	24	0.188	0.873
	Surf B	23	0.260	
P11	Surf A	86	0.168	0.421
	Surf B	71	0.578	
P13	Surf A	166	0.165	0.779
	Surf B	129	0.175	
P18	Surf A	86	0.144	0.663
	Surf B	86	0.134	

⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Projects with Multiple JMFs. Before considering the within-Lot and project variabilities, a decision also had to be made regarding how to deal with Projects on which more than 1 JMF was used. Should each JMF be treated as a separate Project, or should the multiple JMF results be combined together as 1 Project? To help make this decision, the projects with multiple JMFs were examined. Table 4.4 shows the projects (extracted from Table 4.1) that had multiple JMFs.

None of the multiple JMF Projects showed a difference in variability for AC. This argues against the need of treating the JMFs as separate projects when determining the within-Lot standard deviations.

Table 4.4. Projects with more than one JMF (≥ 5 tests for each JMF) for AC for Analysis Data Set

Project	Mix	JMF	No. of Tests	St Dev	Levene'sTest P-value
P02	Surf A	J02	13	0.178	0.155
		J03	58	0.341	
P05	Surf B	J08	18	0.198	0.364
		J09	25	0.165	
P09	Surf A	J16	44	0.176	0.161
		J17	20	0.115	
P10	Surf A	J18	24	0.188	0.360
	Surf B	J20	6	0.118	
		J21	15	0.299	
P11	Surf A	J24	86	0.168	0.592
	Surf B	J27	26	0.162	
		J28	45	0.178	
P13	Surf A	J13	41	0.171	0.595
		J14	43	0.183	
		J44	53	0.161	
		J45	22	0.122	
	Surf B	J49	37	0.191	
		J50	12	0.181	
		J51	6	0.128	
		J52	19	0.162	
		J54	41	0.151	
		J56	11	0.210	
P14	Surf A	J62	58	0.190	0.774
		J63	103	0.183	
P15	Surf B	J97	45	0.164	0.834
		J98	9	0.217	
		J100	42	0.164	
P18	Surf B	J84	86	0.134	0.663
	Surf A	J85	86	0.144	

⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Typical Variability Values for AC. Since the SCDOT specification is based on Lot-by-Lot acceptance, the AC variability that is used to evaluate the specification limits must be that which is appropriate for a typical Lot. To determine this, the unbiased standard deviation values for each Lot were calculated and then these Lot standard deviations were averaged to get the "within-Lot" standard deviation for each project. This calculation process is illustrated in Exhibit 4.1 for 1 of the projects for which data were obtained.

The data in Exhibit 4.1 are for Surface A using JMF J02 on project P02. There were 4 Lots with differing sample sizes of 3, 3, 4, and 3. The mean and standard deviation are shown for each Lot. Then, each Lot standard deviation is divided by the c_4 factor (see Table 4.3) corresponding to the Lot sample size to get the unbiased estimate. Finally, the 4 unbiased Lot standard deviations are averaged to arrive at the within-Lot standard deviation for the Project. This within-Lot standard deviation does not take into consideration any target miss variability that may be present.

Lot No.	Lot Size	Lot Mean	Lot St Dev*	c_4**	Unbiased Lot St Dev***
1	3	-0.010	0.157	0.8862	0.177
2	3	-0.057	0.078	0.8862	0.088
3	4	0.028	0.238	0.9213	0.258
4	3	0.007	0.007	0.8862	0.008
	Average	**-0.008**			**0.133********

* calculated from $s = \sqrt{\dfrac{\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2}{n-1}}$

** obtained from Table 4.3 for the sample size, *n*

*** calculated as $\dfrac{s}{c_4}$

**** calculated as $\dfrac{\dfrac{s_1}{c_{4_1}} + \dfrac{s_2}{c_{4_2}} + \dfrac{s_3}{c_{4_3}} + \dfrac{s_4}{c_{4_4}}}{4}$

Exhibit 4.1. Example of Calculating Unbiased St Dev for Project P02, JMF J02

Table 4.3. c_4 Factors for Various Sample Sizes, *n*

Sample Size, *n*	c_4
2	0.7979
3	0.8862
4	0.9213
5	0.9400
6	0.9515
7	0.9594
8	0.9650
9	0.9693
10	0.9727
11	0.9754
12	0.9776
13	0.9794
14	0.9810
15	0.9823
16	0.9835
17	0.9845
18	0.9854
19	0.9862
20	0.9869
21	0.9876
22	0.9882
23	0.9887
24	0.9892
25	0.9896
Over 25	*a*

[a] $(4n-4)/(4n-3)$

Table 4.4 presents the results broken down by Project. Typically, SCDOT has begun a new Lot each time a new JMF is implemented. Under these circumstances it probably is appropriate to determine typical standard deviation values on a JMF basis rather than a Project basis. Therefore, Table 4.4 presents the within-Lot standard deviations based on each JMF for each Project.

However, since no differences were identified among the standard deviations when there was more than 1 JMF on a Project, Table 4.4 also presents the within-Lot standard deviations calculated for each Project. These standard deviation values would be more appropriate if SCDOT decides that it is not necessary to begin a new Lot for each new JMF.

Table 4.4. Summary of AC Within-Lot Standard Deviations for the Analysis Data Set, by JMF (≥ 5 tests for each JMF) and by Project

Project	JMF	All JMF Lots*				All Project Lots**			
		No. of Tests	No. of Lots	Mean Lot Mean	Mean Lot SD	No. of Tests	No. of Lots	Mean Lot Mean	Mean Lot SD
P01	J01	32	15	0.001	0.124	32	15	0.001	0.124
P02	J02	13	4	-0.008	0.205	71	21	-0.000	0.302
	J03	58	17	0.002	0.325				
P03	J03	76	21	0.014	0.206	76	21	0.013	0.206
P04	J01	72	20	0.051	0.127	72	20	0.051	0.127
P05	J08	18	6	-0.101	0.322	43	17	0.019	0.185
	J09	25	11	0.085	0.111				
P06	J12	89	25	-0.043	0.150	89	25	-0.043	0.150
P08	J15	75	18	-0.082	0.164	75	18	-0.082	0.164
P09	J16	44	11	-0.107	0.139	64	16	-0.102	0.135
	J17	20	5	-0.091	0.128				
P10	J18	24	8	-0.058	0.150	45	14	-0.017	0.175
	J20	6	2	0.153	0.082				
	J21	15	4	-0.020	0.272				
P11	J24	86	22	-0.025	0.167	157	42	-0.006	0.170
	J27	26	7	0.079	0.186				
	J28	45	13	-0.019	0.167				
P12	J32	251	55	0.068	0.183	251	55	0.068	0.183
P13	J13	41	11	-0.027	0.173	285	73	-0.010	0.158
	J14	43	12	0.004	0.131				
	J44	53	12	-0.004	0.160				
	J45	22	5	-0.091	0.123				
	J49	37	9	0.048	0.186				
	J50	12	4	-0.103	0.138				
	J51	6	1	0.068	0.135				
	J52	19	4	-0.108	0.158				
	J54	41	12	0.017	0.162				
	J56	11	3	0.040	0.194				
P14	J62	58	15	0.123	0.191	161	41	0.041	0.176
	J63	103	26	-0.006	0.167				
P15	J97	45	12	-0.007	0.137	96	26	0.004	0.156
	J98	9	3	0.007	0.208				
	J100	42	11	-0.013	0.163				
P18	J84	86	20	0.085	0.119	172	43	0.056	0.130
	J85	86	23	0.032	0.140				
P19	J86	61	16	0.003	0.170	61	16	0.003	0.170
P20	J91	58	16	0.012	0.154	58	16	0.012	0.154
Total/Average		**1808**	**479**	**-0.001**	**0.168**	**1808**	**479**	**0.000**	**0.169**

* **All JMF Lots:** Means of — (1) all the individual Lot means and (2) all the individual Lot unbiased standard deviations — for all Lots for each JMF on the Project.

** **All Project Lots:** Means of — (1) all the individual Lot means and (2) all the individual Lot unbiased standard deviations — for all Lots on the Project.

To address the option of using the total Project as the payment Lot, the total Project standard deviation also was calculated for each Project. This was done by calculating a single unbiased standard deviation using all of the test results on the Project. This "Project" standard deviation could also be used as 1 way of trying to incorporate any target miss variability that might be present in the Contractor's process. These values are shown in Table 4.5.

The percentile values for the empirical cumulative distribution functions (CDF) for the standard deviations shown in Tables 4.4 and 4.5 are shown in Table 4.6. SCDOT can use Tables 4.4-4.6 to assist in selecting the "typical" variability to use to establish specification limits. There is no single "correct" way to establish this value. A subjective decision must be made regarding the standard deviation to select. To get a "picture" of the results in Tables 4.4-4.6, Figures 4.1-4.3 show the CDFs for the within-Lot standard deviation based on JMFs, the within-Lot standard deviation based on Projects, and the overall Project standard deviation values. These tables and figures should assist SCDOT in making the subjective decision regarding the "typical" standard deviation to use.

Review of Table 4.6 and Figures 4.1 and 4.2 shows that there is not much difference between the within-Lot standard deviations when using the JMF or the Project. This would support a decision not to begin a new Lot when a new JMF is implemented. The results of different JMFs could be combined as long as the difference from the target value is used as the measure rather than the actual AC value.

Table 4.6 and Figure 4.3 show that a larger "typical" standard deviation would be required if the total project is used as the Lot for acceptance decisions. For comparison purposes, the 70th percentile is 0.175 for both JMF and Project within-Lot standard deviation, whereas it is 0.198 for total Project standard deviation. For comparison, the analysis of the Phase I data yielded a recommended typical Lot standard deviation between 0.195% and 0.215%. The Phase II analysis yielded considerably lower within-Lot standard deviation values. In fact, the Phase II total Project standard deviation value was consistent with the Phase I within-Lot values.

Note that in the above paragraph, the 70th percentile was chosen strictly for purposes of illustration. SCDOT must make whatever subjective decision they feel is appropriate based on the percentiles in Table 4.6 and the CDFs in Figures 4.1-4.3.

Table 4.5. Summary of AC Within-Project Standard Deviations for the Analysis Data Set

Project	All Project Tests*				
	No. of JMFs	No. of Lots	No. of Tests	Mean of All Tests	Project SD
P01	1	15	32	-0.009	0.192
P02	2	21	71	-0.004	0.316
P03	1	21	79	0.008	0.201
P04	1	20	72	0.045	0.147
P05	2	17	43	0.013	0.202
P06	1	25	89	-0.041	0.166
P08	1	18	75	-0.079	0.172
P09	2	16	64	-0.098	0.159
P10	3	14	47	-0.017	0.227
P11	3	42	157	-0.008	0.173
P12	1	55	257	0.061	0.213
P13	10	73	295	0.000	0.170
P14	2	41	161	0.042	0.194
P15	3	26	98	-0.004	0.172
P18	2	43	172	0.053	0.141
P19	1	16	61	-0.000	0.171
P20	1	16	58	0.004	0.197
Total		**479**	**1831**		
	Average			**-0.002**	**0.189**

* **All Project Tests:** Mean and unbiased standard deviation for all individual test results on project.

Table 4.6. Percentile Ranking of AC Standard Deviations for the Analysis Data Set

Percentile	Within-Lot St Dev, by JMF	Within-Lot St Dev, by Project	Overall Total Project St Dev
50%	0.162	0.164	0.173
60%	0.167	0.170	0.193
70%	0.175	0.175	0.198
75%	0.186	0.176	0.201
80%	0.190	0.182	0.202
90%	0.207	0.193	0.219

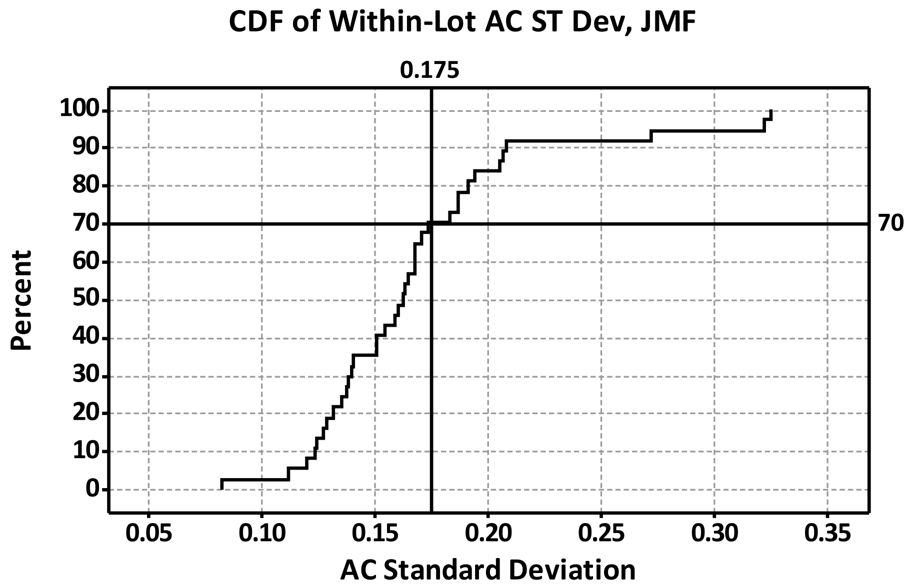


Figure 4.1. CDF for Within-Lot AC Standard Deviation Based on Each JMF

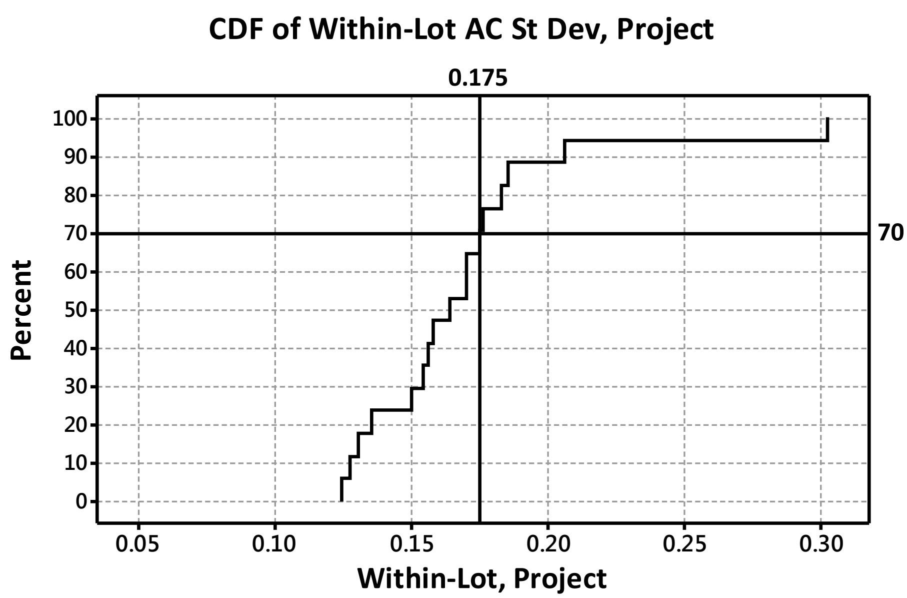


Figure 4.2. CDF for Within-Lot AC Standard Deviation Based on Each Project

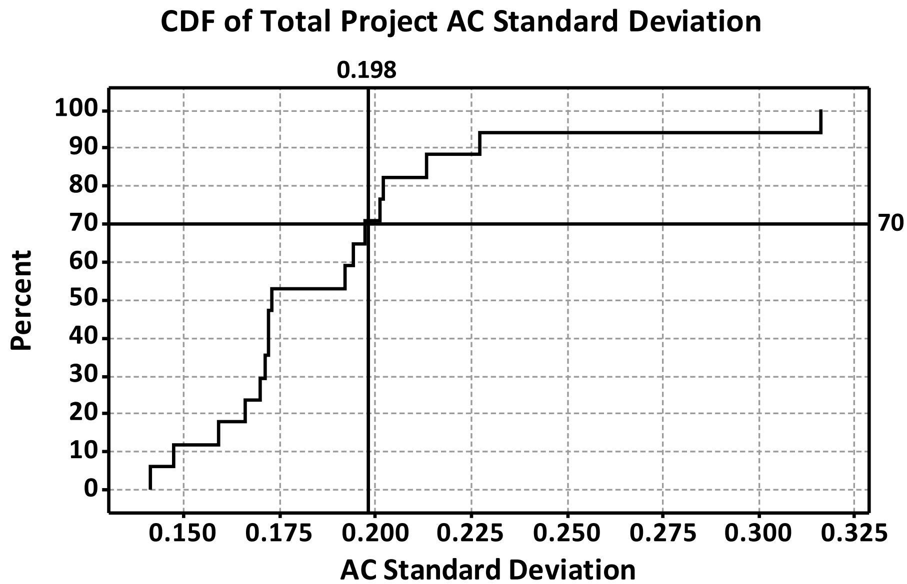


Figure 4.3. CDF for Total AC Standard Deviation Based on Each Project

Air Voids Analysis

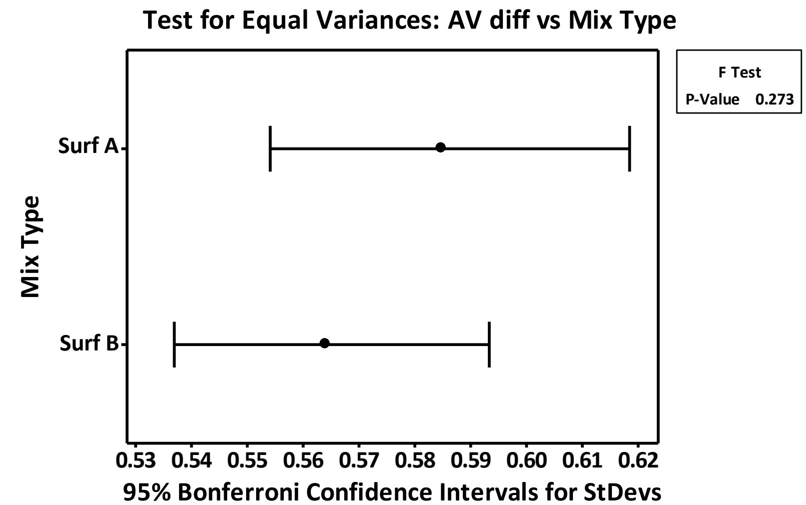
Comparing Surface Mix Types. The first question to consider is whether it is appropriate to use the same specification tolerances for both Surface A and Surface B Mix Types. When establishing the allowable tolerances it is the standard deviation that is most important.

Table 4.7 shows the results of comparisons between the AV variabilities for the 2 types of Surface mixes. The results show that there is no significant difference between the standard deviations of Surface A and Surface B mixes for the F-test, but that there is a significant difference for Levene's test. Figure 4.3 shows the confidence intervals for the F-test and the comparison intervals for the standard deviations. These comparison intervals do not show a significant difference. With the F-test results and the obvious overlap of the comparison intervals, it may be reasonable to assume that it is not necessary to have different acceptance limits for the different Mix Types. However, this is a subjective decision that ultimately must be made by SCDOT.

Table 4.7. Summary of AV Comparisons of Surface Course Mix Types

Mix Type	No. of Tests	St Dev	P-value*⁺ F-test	P-value*⁺ Levene's
Surface A	826	0.584	0.273	**0.018**
Surface B	1005	0.564		
TOTAL	**1831**			

***** Bartlett's test assume normal populations, while Levene's test does not require normal populations
⁺ Values in **bold** are statistically significantly different at the α = 0.05 level.



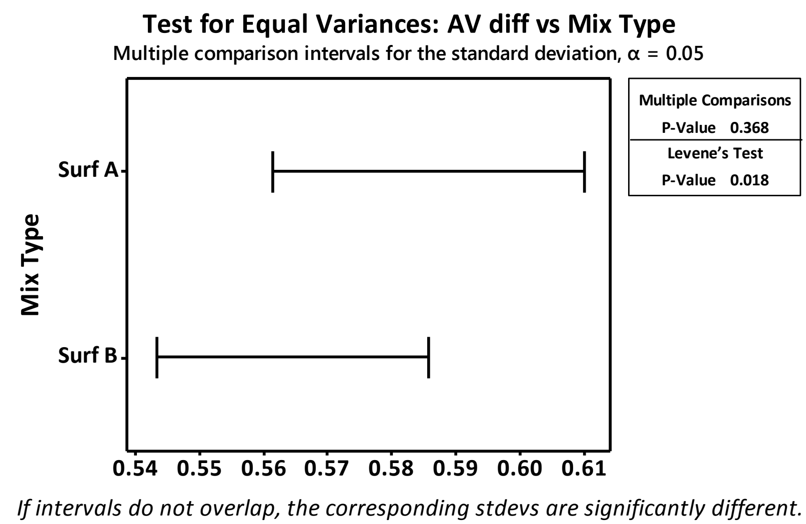


Figure 4.4. Confidence Intervals for AV Standard Deviations for the Analysis Data Set

Caveat. The standard deviation values shown in Table 4.7 are not the appropriate standard deviation to use to represent the process standard deviation for AV. These calculations were done simply for exploratory purposes. Aggregating the data as is done in these tables is not appropriate for establishing specification limits since the specification limits are based on Lot-by-Lot acceptance, or at least on acceptance of a Project.

Projects with Multiple Mix Types. Before considering the within-Lot and Project variabilities, a decision had to be made regarding how to deal with Projects on which more than 1 Mix Type (i.e., Surface A and Surface B) was used. Should each Mix Type be treated as a separate Project, or should the multiple Mix Type results be combined together as 1 Project? To help make this decision, the Projects with multiple Mix Types were examined.

Table 4.8 shows the Projects (extracted from Table 4.1) that had both Surface A and Surface B Mix Types. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The table shows that 3 of the 4 Projects had no significant differences in standard deviations for the 2 Mix Types. It was decided not to separate Mix Types for any of the additional analyses on the current project. However, SCDOT will need to decide whether these results support not separating the results for different Mix Types when determining the within-Lot standard deviation value for a Project.

Table 4.8. Projects with more than one Surface Mix Type (≥ 5 tests for each Mix) for AV for the Analysis Data Set

Proj	Mix Type	No. of Tests	St Dev	Levene's Test P-value+
P10	Surf A	24	0.421	0.088
	Surf B	23	0.819	
P11	Surf A	86	0.491	0.698
	Surf B	71	0.530	
P13	Surf A	166	0.473	**0.000**
	Surf B	129	0.611	
P18	Surf A	86	0.362	0.396
	Surf B	86	0.417	

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Projects with Multiple JMFs. Before considering the within-Lot and Project variabilities, a decision also had to be made regarding how to deal with Projects on which more than 1 JMF was used. Should each JMF be treated as a separate Project, or should the multiple JMF results be combined together as 1 Project? To help make this decision, the Projects with multiple JMFs were examined. Table 4.9 shows the Projects (extracted from Table 4.1) that had multiple JMFs.

None of the multiple JMF Projects showed a difference in variability for AV. This argues against the need to treat JMFs as separate Projects when determining the within-Lot standard deviations.

Table 4.9. Projects with more than one JMF (≥ 5 tests for each JMF) for AV for Analysis Data Set

Proj	Mix	JMF	No. of Tests	St Dev	Levene'sTest P-value
P02	Surf A	J02	13	0.378	0.103
		J03	58	0.664	
P05	Surf B	J08	18	0.430	0.521
		J09	25	0.494	
P09	Surf A	J16	44	0.533	0.188
		J17	20	0.391	
P10	Surf A	J18	24	0.421	0.203
	Surf B	J20	6	0.406	
		J21	15	0.909	
P11	Surf A	J24	86	0.491	0.192
	Surf B	J27	26	0.419	
		J28	45	0.577	
P13	Surf A	J13	41	0.376	0.108
		J14	43	0.459	
		J44	53	0.425	
		J45	22	0.314	
	Surf B	J49	37	0.540	
		J50	12	0.543	
		J51	6	0.553	
		J52	19	0.443	
		J54	41	0.460	
		J56	11	0.651	
P14	Surf A	J62	58	0.599	0.725
		J63	103	0.588	
P15	Surf B	J97	45	0.418	0.168
		J98	9	0.302	
		J100	42	0.455	
P18	Surf B	J84	86	0.417	0.396
	Surf A	J85	86	0.362	

[+] Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Typical Variability Values for AV. Since the SCDOT specification is based on Lot-by-Lot acceptance, the AV variability that is used to evaluate the specification limits must be that which is appropriate for a typical Lot. To determine this, the unbiased standard deviation values for each Lot were calculated and then these Lot standard deviations were averaged to get the "within-Lot" standard deviation for each Project. The calculation process that was used is same one that is illustrated in Exhibit 4.1.

Table 4.10 presents the results broken down by Project. Typically, SCDOT has begun a new Lot each time a new JMF is implemented. Under these circumstances it probably is appropriate to determine typical standard deviation values on a JMF basis rather than a Project basis. Therefore, Table 4.10 presents the within-Lot standard deviations based on each JMF for each Project.

However, since no differences were identified among the standard deviations when there was more than 1 JMF on a Project, Table 4.10 also presents the within-Lot standard deviations calculated for each Project. These standard deviation values would be more appropriate if SCDOT decides that it is not necessary to begin a new Lot for each new JMF.

To address the option of using the total Project as the payment Lot, the total Project standard deviation also was calculated for each Project. This was done by calculating a single unbiased standard deviation using all of the test results on the Project. This “Project” standard deviation could also be used as one way of trying to incorporate any target miss variability that might be present in the Contractor’s process. These values are shown in Table 4.11.

The percentile values for the empirical CDF for the standard deviations shown in Tables 4.10 and 4.11 are shown in Table 4.12. SCDOT can use Tables 4.10-4.12 to assist in selecting the “typical” variability to use to establish specification limits. There is no single “correct” way to establish this value. A subjective decision must be made regarding the standard deviation to select. To get a “picture” of the results in Tables 4.10-4.12, Figures 4.5-4.7 show the CDFs for the within-Lot standard deviation based on JMFs, the within-Lot standard deviation based on Projects, and the overall Project standard deviation values. These tables and figures should assist SCDOT in making the subjective decision regarding the “typical” standard deviation to use.

Review of Table 4.12 and Figures 4.5 and 4.6 shows that there is not much difference between the within-Lot standard deviations when using the JMF or the Project. This would support a decision not to begin a new Lot when a new JMF is implemented. The results of different JMFs could be combined as long as the difference from the target value is used as the measure rather than the actual AV value.

Table 4.12 and Figure 4.7 show that a larger “typical” standard deviation would be required if the total project is used as the Lot for acceptance decisions. For comparison purposes, the 70th percentile is 0.441 for JMF within-Lot standard deviation and 0.451 for Project within-Lot standard deviation, whereas it is 0.579 for total Project standard deviation. For comparison, the analysis of the Phase I data yielded a recommended typical Lot standard deviation between 0.525% and 0.59%. The Phase II analysis yielded considerably lower within-Lot standard deviation values, as well as a slightly lower total Project standard deviation value.

Note that in the above paragraph, the 70th percentile was chosen strictly for purposes of illustration. SCDOT must make whatever subjective decision they feel is appropriate based on the percentiles in Table 4.12 and the CDFs in Figures 4.5-4.7.

Table 4.10. Summary of AV Within-Lot Standard Deviations for the Analysis Data Set, by JMF (≥ 5 tests for each JMF) and by Project

Project	JMF	All JMF Lots*				All Project Lots**			
		No. of Tests	No. of Lots	Mean Lot Mean	Mean Lot SD	No. of Tests	No. of Lots	Mean Lot Mean	Mean Lot SD
P01	J01	32	15	-0.241	0.257	32	15	-0.241	0.257
P02	J02	13	4	-0.166	0.331	71	21	0.160	0.611
	J03	58	17	0.237	0.677				
P03	J03	76	21	0.106	0.473	76	21	0.106	0.473
P04	J01	72	20	-0.139	0.412	72	20	-0.139	0.412
P05	J08	18	6	-0.042	0.358	43	17	0.037	0.396
	J09	25	11	0.080	0.417				
P06	J12	89	25	0.005	0.437	89	25	0.005	0.437
P08	J15	75	18	-0.057	0.441	75	18	-0.057	0.441
P09	J16	44	11	-0.700	0.468	64	16	-0.657	0.446
	J17	20	5	-0.564	0.396				
P10	J18	24	8	-0.252	0.440	45	14	-0.005	0.556
	J20	6	2	-0.120	0.385				
	J21	15	4	0.548	0.872				
P11	J24	86	22	-0.340	0.415	157	42	-0.315	0.444
	J27	26	7	-0.418	0.403				
	J28	45	13	-0.218	0.515				
P12	J32	251	55	-0.281	0.416	251	55	-0.281	0.416
P13	J13	41	11	-0.288	0.293	285	73	-0.004	0.403
	J14	43	12	-0.247	0.372				
	J44	53	12	0.274	0.367				
	J45	22	5	0.232	0.352				
	J49	37	9	0.288	0.499				
	J50	12	4	0.408	0.414				
	J51	6	1	0.655	0.581				
	J52	19	4	0.287	0.355				
	J54	41	12	-0.358	0.441				
	J56	11	3	-0.115	0.710				
P14	J62	58	15	-0.217	0.586	161	41	0.071	0.494
	J63	103	26	0.238	0.442				
P15	J97	45	12	-0.243	0.274	96	26	-0.227	0.329
	J98	9	3	0.300	0.386				
	J100	42	11	-0.354	0.301				
P18	J84	86	20	-0.194	0.387	172	43	-0.292	0.363
	J85	86	23	-0.378	0.342				
P19	J86	61	16	-0.247	0.492	61	16	-0.247	0.492
P20	J91	58	16	-0.270	0.235	58	16	-0.270	0.235
Total/Average		**1808**	**479**	**-0.075**	**0.431**	**1808**	**479**	**-0.139**	**0.424**

* **All JMF Lots:** Means of — (1) all the individual Lot means and (2) all the individual Lot unbiased standard deviations — for all Lots for each JMF on the Project.

** **All Project Lots:** Means of — (1) all the individual Lot means and (2) all the individual Lot unbiased standard deviations — for all Lots on the Project.

Table 4.11. Summary of AV Within-Project Standard Deviations for the Analysis Data Set

Project	All Project Tests*				
	No. of JMFs	No. of Lots	No. of Tests	Mean of All Tests	Project SD
P01	1	15	32	-0.222	0.470
P02	2	21	71	0.177	0.641
P03	1	21	79	0.097	0.639
P04	1	20	72	-0.122	0.569
P05	2	17	43	-0.013	0.467
P06	1	25	89	-0.014	0.551
P08	1	18	75	-0.076	0.494
P09	2	16	64	-0.625	0.494
P10	3	14	47	0.054	0.710
P11	3	42	157	-0.317	0.508
P12	1	55	257	-0.235	0.617
P13	10	73	295	0.013	0.538
P14	2	41	161	0.078	0.626
P15	3	26	98	-0.237	0.461
P18	2	43	172	-0.283	0.401
P19	1	16	61	-0.230	0.536
P20	1	16	58	-0.252	0.477
Total		**479**	**1831**		
	Average			**-0.130**	**0.541**

* **All Project Tests:** Mean and unbiased standard deviation for all individual test results on project.

Table 4.12. Percentile Ranking of AV Standard Deviations for the Analysis Data Set

Percentile	Within-Lot St Dev, by JMF	Within-Lot St Dev, by Project	Overall Total Project St Dev
50%	0.414	0.437	0.536
60%	0.429	0.443	0.546
70%	0.441	0.451	0.579
75%	0.468	0.473	0.617
80%	0.488	0.488	0.624
90%	0.583	0.519	0.640

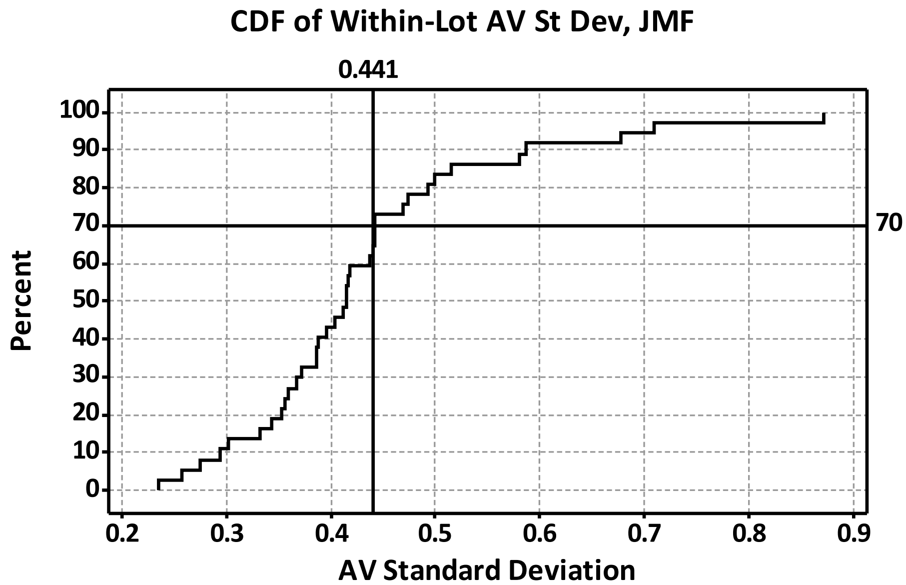


Figure 4.5. CDF for Within-Lot AV Standard Deviation Based on Each JMF

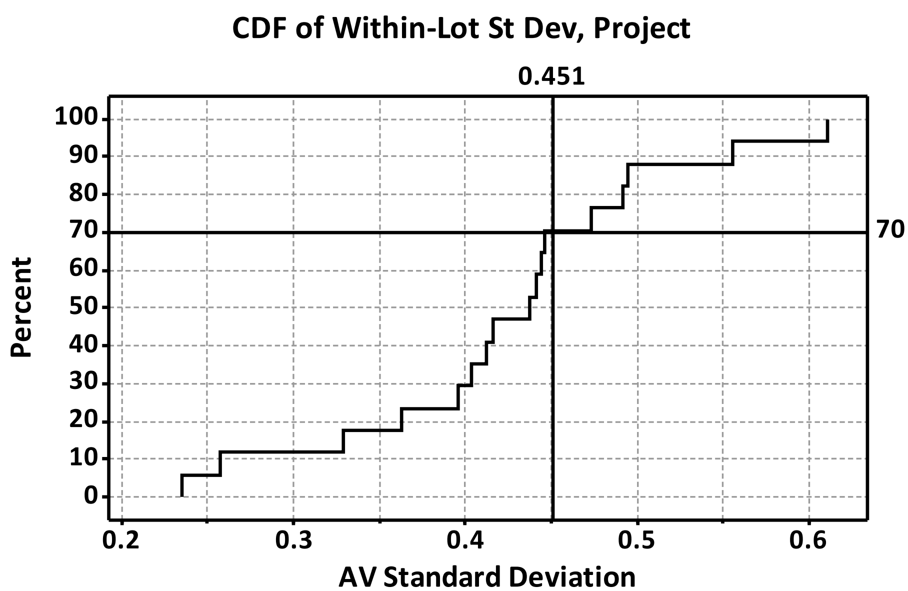


Figure 4.6. CDF for Within-Lot AV Standard Deviation Based on Each Project

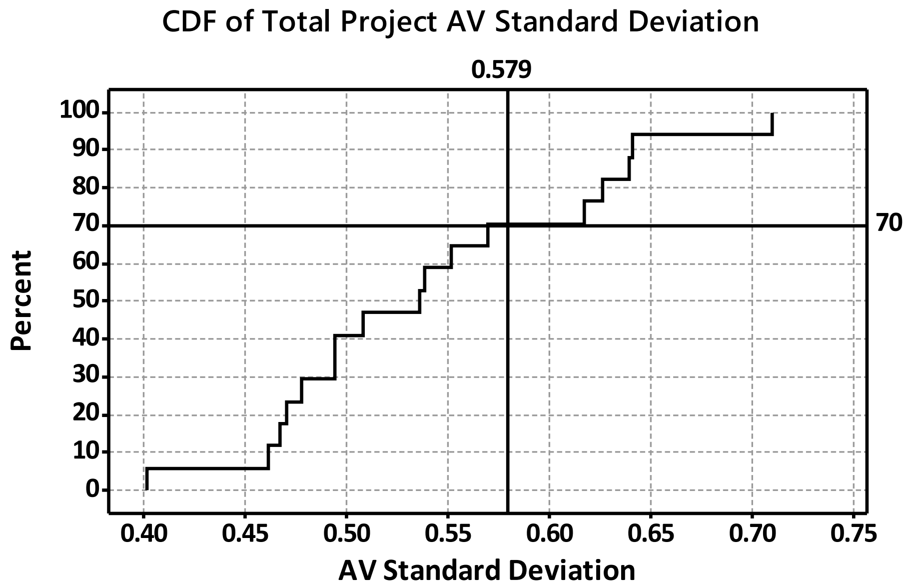


Figure 4.7. CDF for Total AC Standard Deviation Based on Each Project

VMA Analysis

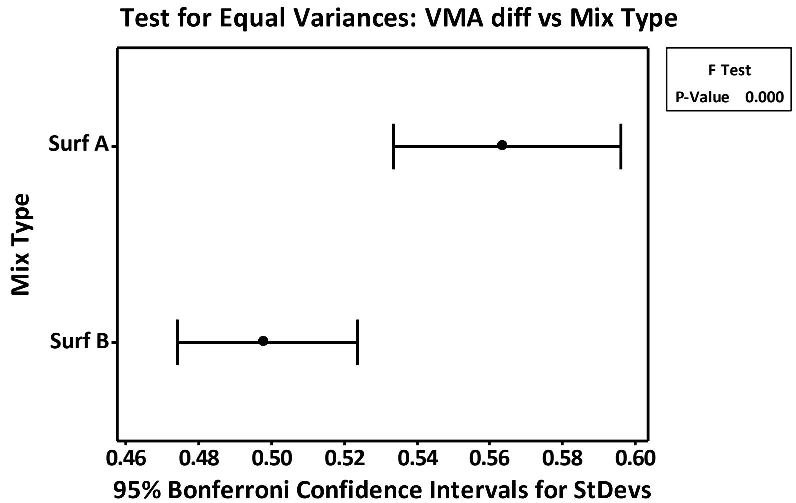
Comparing Surface Mix Types. The first question to consider is whether it is appropriate to use the same specification tolerances for both Surface A and Surface B Mix Types. When establishing the allowable tolerances it is the standard deviation that is most important.

Table 4.13 shows the results of comparisons between the VMA variabilities for the 2 types of Surface mixes. The results show that there is a pronounced significant difference between the standard deviations of Surface A and Surface B mixes both for the F-test and for Levene's test. Figure 4.8 shows the confidence intervals for the F-test and the comparison intervals for the standard deviations. SCDOT will have to make a subjective decision regarding whether it is necessary to have different acceptance limits for the different Mix Types. Another option might be to use for both Mix Types the larger of the standard deviation values.

Table 4.13. Summary of VMA Comparisons of Surface Course Mix Types

Mix Type	No. of Tests	St Dev	P-value*⁺ F-test	P-value*⁺ Levene's
Surface A	822	0.563	**0.000**	**0.000**
Surface B	1005	0.498		
TOTAL	**1827**			

***** Bartlett's test assume normal populations, while Levene's test does not require normal populations
⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.



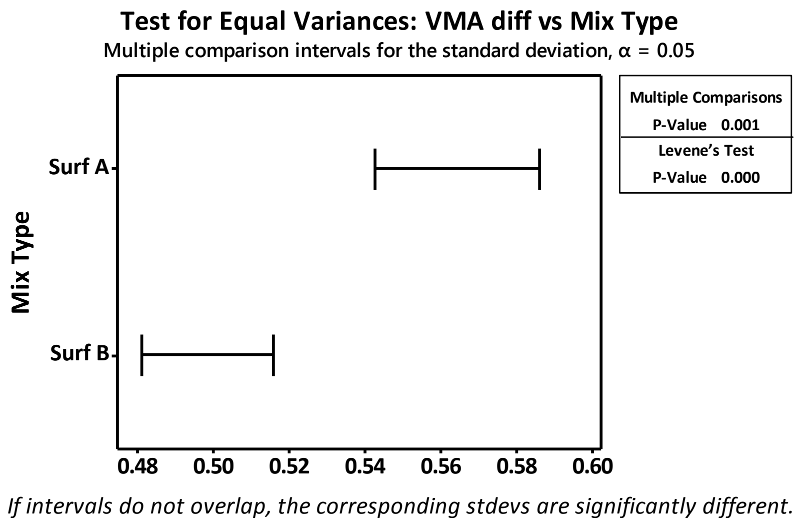


Figure 4.8. Confidence Intervals for VMA Standard Deviations for the Analysis Data Set

Caveat. The standard deviation values shown in Table 4.13 are not the appropriate standard deviation to use to represent the process standard deviation for VMA. These calculations were done simply for exploratory purposes. Aggregating the data as is done in these tables is not appropriate for establishing specification limits since the specification limits are based on Lot-by-Lot acceptance, or at least on acceptance of a Project.

Projects with Multiple Mix Types. Before considering the within-Lot and Project variabilities, a decision had to be made regarding how to deal with Projects on which more than 1 Mix Type (i.e., Surface A and Surface B) was used. Should each Mix Type be treated as a separate Project, or should the multiple Mix Type results be combined together as 1 Project? To help make this decision, the Projects with multiple Mix Types were examined.

Table 4.14 shows the Projects (extracted from Table 4.1) that had both Surface A and Surface B Mix Types. The comparisons are based on Levene's test as it is more general since it does not require a normality assumption. The table shows that 3 of the 4 Projects had no significant differences in standard deviations for the 2 Mix Types. It was decided not to separate Mix Types for any of the additional analyses on the current project. However, SCDOT will need to decide whether Table 4.14 supports not separating the results for different Mix Types when determining the within-Lot standard deviation value for a Project.

Table 4.14. Projects with more than one Surface Mix Type (≥ 5 tests for each Mix) for VMA for the Analysis Data Set

Proj	Mix Type	No. of Tests	St Dev	Levene's Test P-value+
P10	Surf A	24	0.548	0.459
	Surf B	23	0.564	
P11	Surf A	86	0.471	0.258
	Surf B	71	0.551	
P13	Surf A	166	0.426	**0.005**
	Surf B	129	0.525	
P18	Surf A	86	0.425	0.279
	Surf B	86	0.258	

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Projects with Multiple JMFs. Before considering the within-Lot and Project variabilities, a decision also had to be made regarding how to deal with Projects on which more than 1 JMF was used. Should each JMF be treated as a separate Project, or should the multiple JMF results be combined together as 1 Project? To help make this decision, the projects with multiple JMFs were examined. Table 4.15 shows the Projects (extracted from Table 4.1) that had multiple JMFs.

None of the multiple JMF Projects showed a difference in variability for VMA. This argues against the need to treat the JMFs as separate Projects when determining the within-Lot standard deviations.

Table 4.15. Projects with more than one JMF (≥ 5 tests for each JMF) for VMA for Analysis Data Set

Proj	Mix	JMF	No. of Tests	St Dev	Levene'sTest P-value
P02	Surf A	J02	9	0.337	0.115
		J03	58	0.687	
P05	Surf B	J08	18	0.461	0.296
		J09	25	0.517	
P09	Surf A	J16	44	0.396	0.842
		J17	20	0.365	
P10	Surf A	J18	24	0.548	0.421
	Surf B	J20	6	0.371	
		J21	15	0.587	
P11	Surf A	J24	86	0.471	0.240
	Surf B	J27	26	0.407	
		J28	45	0.579	
P13	Surf A	J13	41	0.317	0.444
		J14	43	0.350	
		J44	53	0.417	
		J45	22	0.374	
	Surf B	J49	37	0.446	
		J50	12	0.459	
		J51	6	0.361	
		J52	19	0.392	
		J54	41	0.373	
		J56	11	0.473	
P14	Surf A	J62	58	0.559	0.920
		J63	103	0.534	
P15	Surf B	J97	45	0.446	0.323
		J98	9	0.526	
		J100	42	0.357	
P18	Surf B	J84	86	0.358	0.279
	Surf A	J85	86	0.425	

[+] Values in **bold** are statistically significantly different at the α = 0.05 level.

Typical Variability Values for VMA. Since the SCDOT specification is based on Lot-by-Lot acceptance, the VMA variability that is used to evaluate the specification limits must be that which is appropriate for a typical Lot. To determine this, the unbiased standard deviation values for each Lot were calculated and then these Lot standard deviations were averaged to get the "within-Lot" standard deviation for each Project. The calculation process that was used is same one that is illustrated in Exhibit 4.1.

Table 4.16 presents the results broken down by Project. Typically, SCDOT has begun a new Lot each time a new JMF is implemented. Under these circumstances it probably is appropriate to determine typical standard deviation values on a JMF basis rather than a Project basis. Therefore, Table 4.16 presents the within-Lot standard deviations based on each JMF for each Project.

However, since no differences were identified among the standard deviations when there was more than 1 JMF on a Project, Table 4.16 also presents the within-Lot standard deviations calculated for each Project. These standard deviation values would be more appropriate if SCDOT decides that it is not necessary to begin a new Lot for each new JMF.

To address the option of using the total Project as the payment Lot, the total Project standard deviation also was calculated for each Project. This was done by calculating a single unbiased standard deviation using all of the test results on the Project. This “Project” standard deviation also could be used as one way of trying to incorporate any target miss variability that might be present in the Contractor’s process. These values are shown in Table 4.17.

The percentile values for the empirical CDF for the standard deviations shown in Tables 4.16 and 4.17 are shown in Table 4.18. SCDOT can use Tables 4.16-4.18 to assist in selecting the “typical” variability to use to establish specification limits. There is no single “correct” way to establish this value. A subjective decision must be made regarding the standard deviation to select. To get a “picture” of the results in Tables 4.16-4.18, Figures 4.9-4.11 show the CDFs for the within-Lot standard deviation based on JMFs, the within-Lot standard deviation based on Projects, and the overall Project standard deviation values, respectively. These tables and figures should assist SCDOT in making the subjective decision regarding the “typical” standard deviation to use.

Review of Table 4.16 and Figures 4.9 and 4.10 shows that there is not much difference between the within-Lot standard deviations when using the JMF or the Project. This would support a decision not to begin a new Lot when a new JMF is implemented. The results of different JMFs could be combined as long as the difference from the target value is used as the measure rather than the actual VMA value.

Table 4.18 and Figure 4.11 show that a larger “typical” standard deviation would be required if the total project is used as the Lot for acceptance decisions. For comparison purposes, the 70th percentile is 0.433 for JMF within-Lot standard deviation and 0.439 for Project within-Lot standard deviation, whereas it is 0.562 for total Project standard deviation. For comparison, the analysis of the Phase I data yielded a recommended typical Lot standard deviation between 0.55% and 0.63%. The Phase II analysis yielded considerably lower within-Lot standard deviation values, as well as a lower total Project standard deviation value.

Note that in the above paragraph, the 70th percentile was chosen strictly for purposes of illustration. SCDOT must make whatever subjective decision they feel is appropriate based on the percentiles in Table 4.18 and the CDFs in Figures 4.9-4.11.

Table 4.16. Summary of VMA Within-Lot Standard Deviations for the Analysis Data Set, by JMF (≥ 5 tests for each JMF) and by Project

Project	JMF	All JMF Lots*				All Project Lots**			
		No. of Tests	No. of Lots	Mean Lot Mean	Mean Lot SD	No. of Tests	No. of Lots	Mean Lot Mean	Mean Lot SD
P01	J01	32	15	-0.189	0.380	32	15	-0.189	0.380
P02	J02	9	3	-0.022	0.406	71	20	0.149	0.661
	J03	58	17	0.180	0.706				
P03	J03	76	21	0.168	0.512	76	21	0.168	0.512
P04	J01	72	20	0.022	0.461	72	20	0.022	0.461
P05	J08	18	6	-0.246	0.436	43	17	0.059	0.396
	J09	25	11	0.225	0.374				
P06	J12	89	25	-0.214	0.390	89	25	-0.214	0.390
P08	J15	75	18	-0.269	0.380	75	18	-0.269	0.380
P09	J16	44	11	-0.851	0.354	64	16	-0.794	0.345
	J17	20	5	-0.670	0.326				
P10	J18	24	8	-0.325	0.536	45	14	-0.042	0.510
	J20	6	2	0.082	0.379				
	J21	15	4	0.461	0.524				
P11	J24	86	22	-0.350	0.442	157	42	-0.218	0.433
	J27	26	7	-0.322	0.406				
	J28	45	13	0.061	0.432				
P12	J32	251	55	-0.062	0.390	251	55	-0.062	0.390
P13	J13	41	11	-0.347	0.343	285	73	-0.039	0.362
	J14	43	12	-0.217	0.313				
	J44	53	12	0.194	0.450				
	J45	22	5	-0.051	0.421				
	J49	37	9	0.394	0.413				
	J50	12	4	0.044	0.286				
	J51	6	1	0.710	0.379				
	J52	19	4	0.253	0.339				
	J54	41	12	-0.316	0.266				
	J56	11	3	-0.053	0.531				
P14	J62	58	15	-0.191	0.536	161	41	0.060	0.487
	J63	103	26	0.205	0.459				
P15	J97	45	12	-0.226	0.420	96	26	-0.185	0.355
	J98	9	3	0.618	0.286				
	J100	42	11	-0.360	0.303				
P18	J84	86	20	0.115	0.367	172	43	-0.080	0.374
	J85	86	23	-0.250	0.380				
P19	J86	61	16	-0.309	0.376	61	16	-0.309	0.376
P20	J91	58	16	-0.153	0.375	58	16	-0.153	0.375
Total/Average		**1804**	**478**	**-0.061**	**0.407**	**1808**	**479**	**-0.123**	**0.423**

* **All JMF Lots:** Means of — (1) all the individual Lot means and (2) all the individual Lot unbiased standard deviations — for all Lots for each JMF on the Project.

** **All Project Lots:** Means of — (1) all the individual Lot means and (2) all the individual Lot unbiased standard deviations — for all Lots on the Project.

Table 4.17. Summary of VMA Within-Project Standard Deviations for the Analysis Data Set

Project	All Project Tests*				
	No. of JMFs	No. of Lots	No. of Tests	Mean of All Tests	Project SD
P01	1	15	32	-0.195	0.505
P02	2	20	67	0.163	0.656
P03	1	21	79	0.152	0.581
P04	1	20	72	0.026	0.559
P05	2	17	43	0.005	0.540
P06	1	25	89	-0.224	0.509
P08	1	18	75	-0.281	0.376
P09	2	16	64	-0.754	0.390
P10	3	14	47	0.008	0.642
P11	3	42	157	-0.230	0.523
P12	1	55	257	-0.031	0.432
P13	10	73	295	-0.014	0.477
P14	2	41	161	0.069	0.572
P15	3	26	98	-0.209	0.505
P18	2	43	172	-0.076	0.432
P19	1	16	61	-0.308	0.413
P20	1	16	58	-0.151	0.588
Total		**478**	**1827**		
	Average			**-0.121**	**0.512**

* **All Project Tests:** Mean and unbiased standard deviation for all individual test results on project.

Table 4.18. Percentile Ranking of VMA Standard Deviations for the Analysis Data Set

Percentile	Within-Lot St Dev, by JMF	Within-Lot St Dev, by Project	Overall Total Project St Dev
50%	0.390	0.390	0.509
60%	0.410	0.394	0.533
70%	0.433	0.439	0.562
75%	0.442	0.461	0.572
80%	0.457	0.482	0.579
90%	0.527	0.511	0.610

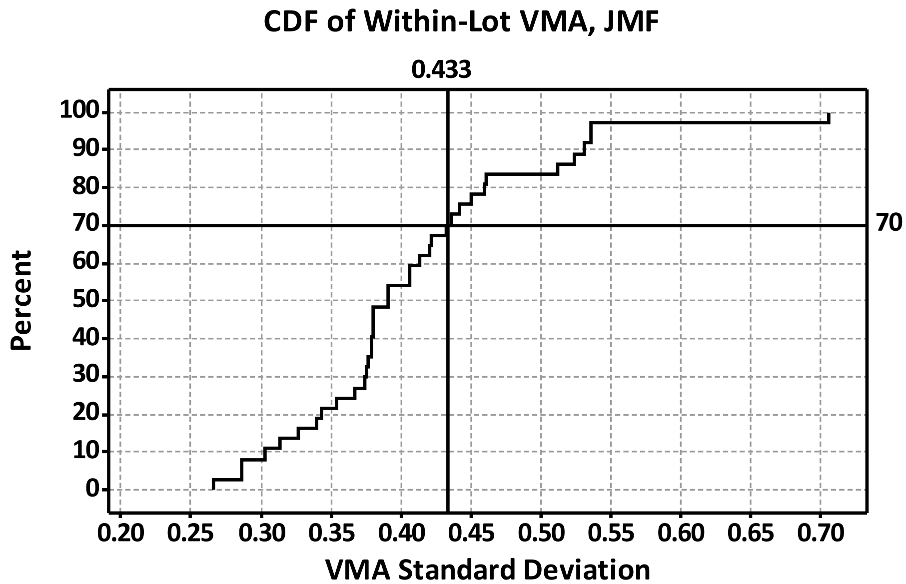


Figure 4.9. CDF for Within-Lot VMA Standard Deviation Based on Each JMF

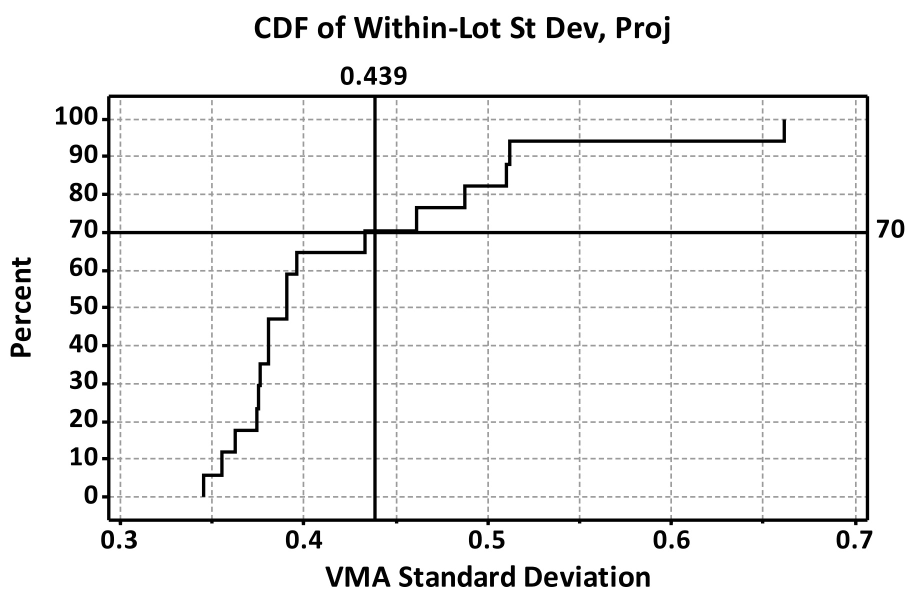


Figure 4.10. CDF for Within-Lot VMA Standard Deviation Based on Each Project

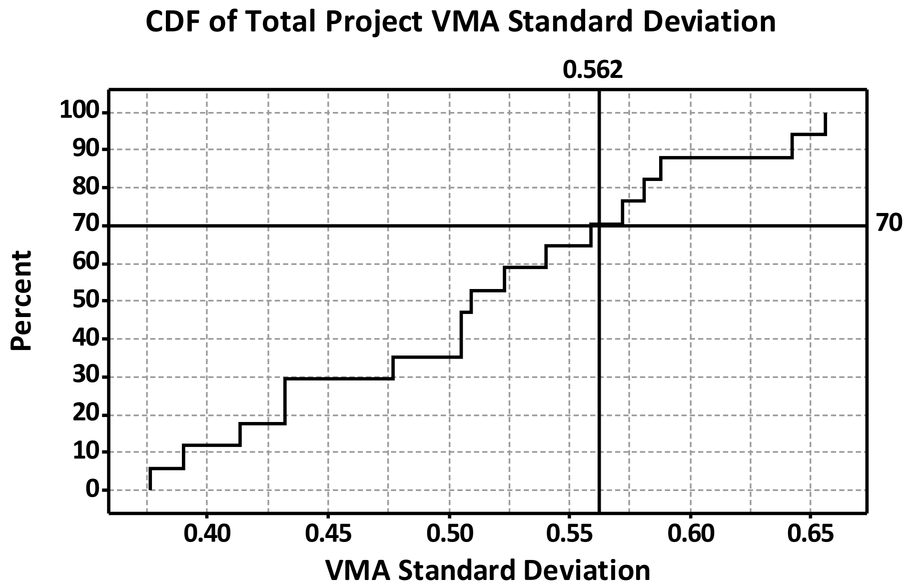


Figure 4.11. CDF for Total VMA Standard Deviation Based on Each Project

Observations, Issues and Concerns

During the course of this chapter a number of data evaluations are presented and various observations are made concerning the data set. Some of these are summarized below.

Analysis Data Set. For reasons discussed in previous chapters, the final Analysis data set consisted only of Surface Type A and Surface Type B Mix Types. The Analysis data set included 479 Lots and 1,831 tests results for AC and AV, and 478 Lots and 1,827 test results for VMA.

Typical Standard Deviations. One of the primary goals of the analyses was to determine values to use to represent the typical variability for each of these characteristics. This is a subjective decision that ultimately must be made by SCDOT. The values for typical standard deviations that SCDOT might consider to represent the typical within-Lot variability used to evaluate existing specification limits are shown in Table 4.19.

Table 4.19. Comparison of Potential "Typical" Within-Lot Standard Deviation Values

Characteristic	Phase I Value, %	Within-Lot by JMF, %*	Within-Lot by Project, %*	All Project Tests, %*
AC	0.195 – 0.215	0.175	0.175	0.198
AV	0.525 – 0.590	0.441	0.451	0.579
VMA	0.550 – 0.630	0.433	0.439	0.562

* These numbers are for illustration only. SCDOT must make a subjective decision concerning the appropriate values to use.

Comparing Mix Types. The Surface A and Surface B mixes did not show a significant difference between their respective standard deviation values for AC. Therefore, there is no indication that it is necessary to have different AC acceptance limits for the different Mix Types.

For AV there was no significant difference between the standard deviations of Surface A and Surface B mixes for the F-test, but there was a significant difference for Levene's test. With the F-test results and the obvious overlap of the comparison intervals (see Figure 4.4), it may be reasonable to assume that it is not necessary to have different AV acceptance limits for the different Mix Types. However, this is a subjective decision that ultimately must be made by SCDOT.

However, for VMA the results showed that there was a pronounced significant difference between the standard deviations of Surface A and Surface B mixes both for the F-test and for Levene's test. SCDOT will have to make a subjective decision regarding whether it is necessary to have different VMA acceptance limits for the different Mix Types. Another option might be to use for both Mix Types the larger of the standard deviation values.

Comparing Mix Types within a Project. There were 4 Projects that used both Surface Type A and Surface Type B mixes. Comparisons did not show a significant difference between the Type A and Type B AC standard deviation values for any of the 4 Projects. This result supports not separating the results for different Mix Types when determining the within-Lot standard deviation value for a Project.

For AV and VMA, 3 of the 4 Projects had no significant differences in standard deviations for the 2 Mix Types. It was the same Project that had significant differences for both AV and VMA. SCDOT will need to decide whether this result supports not separating the results for different Mix Types when determining the within-Lot standard deviation value for a Project.

Comparing JMFs. There were 9 Projects that had more than 1 JMF. For AC, AV, and VMA, comparisons did not show a significant difference among the JMF standard deviation values for any of the 9 Projects. This would support a decision not to begin a new Lot when a new JMF is implemented. The results of different JMFs could be combined as long as the difference from the target value is used as the measure rather than the actual AC value.

CHAPTER 5 — ANALYSIS OF DENSITY DATA

Background

This chapter discusses the Density data that were provided by SCDOT along with the data collection procedures. As with the plant data, there were significant problems encountered during the Density data collection process. Some of these have serious ramifications concerning the potential validity of the data analyses as well as conclusions and recommendations based on the data analyses results.

Discussion of Data that Were Provided

All of the Density acceptance test data that were provided are included in Appendix B. Table 5.1 presents a summary of all Density test results data provided by SCDOT. The values in the table include all Courses and Mix Types for each project. Each Project in the table is identified with a unique number ranging from D01 to D19. The "D" identifies the data as being from the Density data set. Each of the numbers corresponds with a unique SCDOT project file number. The numeric portions are assigned in the same fashion as were the numbers for the Plant data. In other words, Projects P01 and D01 are the same project with P representing the Plant test results and D representing the Density test results.

Table 5.1. Original Density Data Set Total Number of Test Results by Project

Proj. No.	No. of Lots	No. of Tests	Tests/Lot	No. of JMFs
D02	14	73	5.62	2*
D03	22	110	5.00	1*
D04	21	106	5.05	1
D05	9	39	4.33	2
D06	25	138	5.52	1
D07	12	12	1.00	1
D08	18	115	6.39	1
D09	16	107	6.69	3
D10	16	91	5.69	4
D11	48	316	6.58	5
D14	34	218	6.41	2
D16	26	263	10.12	4
D17	7	36	5.14	2
D18	40	265	6.63	2
D19	20	121	6.05	2
TOTAL **Average**	**328**	**2010**	 **5.75**	 **32***

* 1 JMF is used on both Project D02 and D03

A total of 2,010 Density test results representing 328 Lots from 15 Projects were provided by SCDOT. Table 5.1 is limited in its usefulness since each project could include some combination of Base, Intermediate, and Surface courses. In addition, a majority of the projects contain more than a single JMF. While the table shows that a large number of test results were obtained, it also shows a number of issues and potential problems with the collected data.

For example, Project D07 had 12 tests from 12 Lots because there was only a single test each day. Since it is not possible to calculate a standard deviation from 1 tet, this project had to be eliminated. Similarly, while they were not eliminated, Projects D05 and D17 had relatively small numbers of test results that call into question the validity of the data for these Projects.

Data by Project. Table 5.1 shows the distribution of test data among the 15 Projects from which data were obtained. Specifically, a large amount of the data comes from a relatively small number of Projects. Figure 5.1 shows for each Project the number and the percentage of the total number of tests ranked from highest to lowest. As can be seen in Figure 5.1, over half of the Density tests are from only 4 of the 15 Projects. This distribution of the data has the potential to bias the analyses in favor of these few larger Projects that account for most of the data.

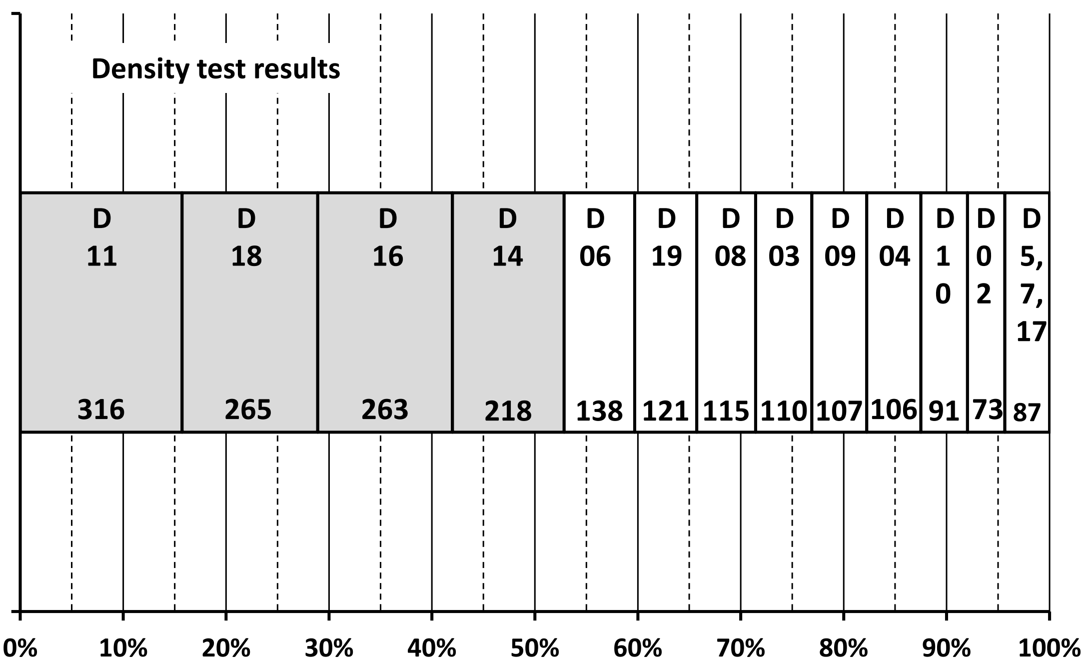


Figure 5.1. Original Data Set Percentage Distribution of Density Test Results by Project

Data by Contractor. Another concern with the provided test result data is the limited number of Contractors on the Projects from which data were supplied. While Density data were obtained from 15 Projects, only 7 different contractors were represented on these projects. Table 5.2 and Figure 5.2 show the breakdown of project data by Contractor. Note that 1 of the 7 Contractors accounted for nearly half (47.8%) of the data provided.

The distribution of test result data by Contractor is even more biased than were the data by Project. As shown in Figure 5.2, 3 of the 7 Contractors accounted for nearly 80% of the data provided.

The information presented in Figure 5.2 casts serious doubts regarding how representative the data are for the "typical" Contractor that does work for SCDOT.

Table 5.2. Original Density Data Set Total Number of Test Results by Contractor

Contractor	No. of Lots	No. of Tests	No. of JMFs
C1	21	106	1
C2	142	960	18*
C3	9	39	2
C4	25	138	1
C5	30	127	2
C6	54	339	4
C7	47	301	4
TOTAL	**328**	**2010**	**32**

* 1 JMF is used on both Project D02 and D03

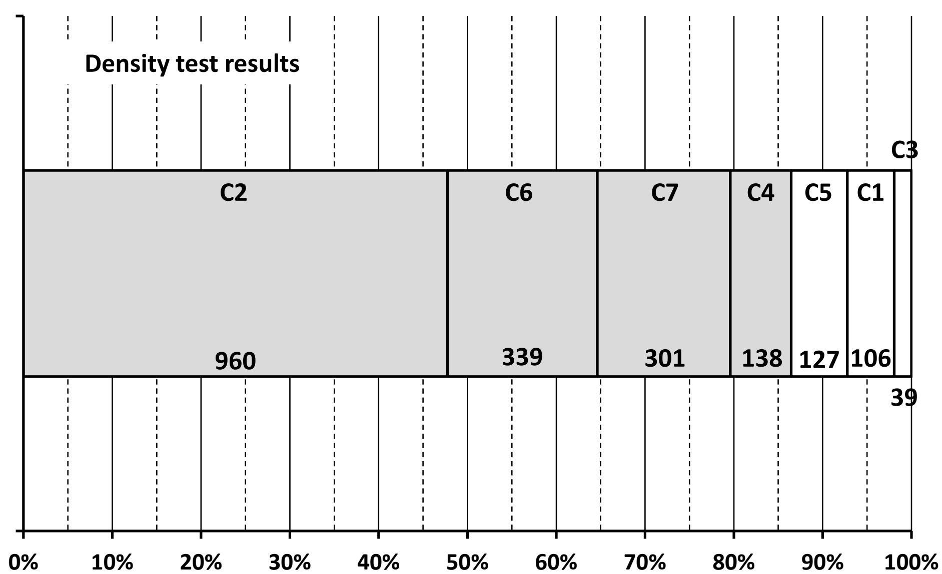


Figure 5.2. Original Data Set Distribution of Density Test Results by Contractor

Macro Analysis of the Total Data Set for Density

As noted above, the data summaries shown in Tables 5.1-5.2 and in Figures 5.1-5.2 for some of the projects combine the results for multiple courses and some Projects combine the results for multiple JMFs. In addition, the Density test results included values obtained both from cores and from nuclear gages.

Table 5.3 shows the distribution of test results among the Projects sorted by Course and also by Core or Nuclear Gage. Since some Projects had more than 1 JMF, Table 5.4 shows the breakdown of the Density data by Mix Type, Project, and JMF.

The first thing that stands out in these tables is the small number of test results data that were obtained for Base (1 Project, 201 Tests, 10%) and Intermediate (2 Projects, 39 Tests, 1.94%) Courses. The relatively small number of Nuclear Gage test results (2 Projects, 343 Tests, 17.06%) is also apparent. This also means that the Surface Mix data, which are from 14 of the 15 Projects, are 88.06% of the total data set (81.00% from Cores, 7.06% from Nuclear Gages).

Realistically, there are not sufficient Density test results data for Nuclear Gages or for Base or Intermediate Mix Types to consider valid any analyses of these data. Additionally, only 1 Contractor had data for Base course and only 2 had data for Intermediate course. These data simply are not sufficient for evaluating the performance of a “typical” Contractor in SC. However, some macro-level analyses were conducted for informational purposes, with no intent of drawing conclusions from the results of the analyses.

Table 5.3. Original Density Data Set Sorted by Mix Type and Project

Mix Type	Project	No. of Tests	% of Total Tests
Cores			
Intermediate	P05	11	0.55%
	P19	28	1.39%
All Intermediate		**39**	**1.94%**
Surface A	P02	73	3.63%
	P03	110	5.47%
	P06	138	6.87%
	P07	12	0.60%
	P09	107	5.32%
	P10	47	2.34%
	P11	148	7.36%
	P14	218	10.85%
	P18	134	6.67%
All Surface A		**987**	**49.10%**
Surface B	P04	106	5.27%
	P05	28	1.39%
	P08	115	5.72%
	P10	44	2.19%
	P11	88	4.38%
	P18	131	6.52%
	P19	93	4.63%
All Surface B		**605**	**30.10%**
Surface C	P17	**36**	**1.79%**
All Surface Mixes		**1628**	**81.00%**
All Cores		**1667**	**82.94%**
Nuclear Gages			
Base A	P16	**201**	**10.00%**
Surface B	P11	**80**	**3.98%**
Surface C	P16	**62**	**3.08%**
All Nuclear Gage		**343**	**17.06%**
All Tests		**2010**	**100.00%**

Table 5.4. Summary of Density Data for the Original Data Set

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Cores						
Interm C	D05	J07	3	11	3	11
	D19	J88	4	28	4	28
Intermediate Subtotal			**7**	**39**	**7**	**39**
Surf A	D02	J02	4	27	14	73
		J03	10	46		
	D03	J03	22	110	22	110
	D06	J12	25	138	25	138
	D07	J14	12	12	12	12
	D09	J16	2	11	16	107
		J17	5	37		
		J89	9	59		
	D10	J18	8	47	8	47
	D11	J23	1	3	23	148
		J24	22	145		
	D14	J62	9	62	34	218
		J63	25	156		
	D18	J85	23	134	23	134
Surf B	D04	J01	21	106	21	106
	D05	J08	6	28	6	28
	D08	J15	18	115	18	115
	D10	J19	1	4	8	44
		J20	3	10		
		J21	4	30		
	D11	J26	1	2	17	88
		J27	7	43		
		J28	9	43		
	D18	J84	17	131	17	131
	D19	J86	16	93	16	93
Surf C	D17	J81	5	26	7	36
		J82	2	10		
Surface Subtotal			**287**	**1628**	**287**	**1628**
Core Subtotal			**294**	**1667**	**294**	**1667**
Nuclear Gages						
Base A	D16	J77	17	172	20	201
		J78	3	29		
Surf B	D11	J27	1	10	8	80
		J28	7	70		
Surf C	D16	J79	2	21	6	62
		J80	4	41		
Nuclear Gage Subtotal			**34**	**343**	**45**	**369**
All Tests			**328**	**2010**	**328**	**2010**

Comparisons among Courses. Even though there were insufficient data for valid analysis, for informational purposes only, Bartlett's test and Levene's test were conducted on the Abridged data set to see if statistically significant differences existed among the Density standard deviation values for the various courses. Bartlett's test assumes normal populations, while Levene's test does not require normal populations. The results of these tests are shown in Table 5.5.

Table 5.5. Summary of Density Comparisons among Courses

Course	No. of Tests	St Dev	P-value* Bartlett's	P-value* Levene's
Base	201	2.019	**0.000**+	0.087
Intermediate	39	1.129		
Surface	1770	2.010		
TOTAL	**2010**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

The results from Table 5.5 show that Levene's test did not show a significant difference and that Bartlett's test showed a significant difference in the standard deviation values among Base, Intermediate, and Surface courses. The reason that Levene's test did not identify a difference, even though there is an apparent difference in the Intermediate standard deviation, is almost certainly due to the very small sample size for Intermediate. However, any "conclusions" must be viewed with skepticism due to the extremely small sample size for Intermediate and the relatively small sample size for Base.

Determining the Final Density Data Set for Analysis

As noted above, there clearly were not sufficient data to allow for any meaningful analyses of the Intermediate or Base mixes. Nor were there sufficient Nuclear Gage results to allow for valid analyses. This, therefore, limited the analyses to Surface mix test results obtained from Cores.

Table 5.4 shows that there were a total of 1,628 Core results for Surface mixes. However, Project D07 had 12 Lots with 12 total tests. A single test was taken for each Lot. Since it is not possible to determine a Lot standard deviation when there is only 1 test, Project D07 was eliminated from analyses. In addition, 3 JMFs that each had fewer than 5 tests were eliminated. Finally, 1 of the Lots from Project D03 had only 1 test and was therefore eliminated. Eliminating these data resulted in the "Analysis" data set shown in Table 5.6. This is the data set that was used for subsequent analyses of the Density data.

Table 5.6. Summary of Density Data for the Analysis Data Set

Mix Type	Proj	JMF	Lots in JMF	Tests in JMF	Lots on Proj	Tests on Proj
Surf A	D02	J02	4	27	14	73
		J03	10	46		
	D03	J03	21	109	21	109
	D06	J12	25	138	25	138
	D09	J16	2	11	16	107
		J17	5	37		
		J89	9	59		
	D10	J18	8	47	8	47
	D11	J24	22	145	22	145
	D14	J62	9	62	34	218
		J63	25	156		
	D18	J85	23	134	23	134
Surf B	D04	J01	21	106	21	106
	D05	J08	6	28	6	28
	D08	J15	18	115	18	115
	D10	J20	3	10	7	40
		J21	4	30		
	D11	J27	7	43	16	86
		J28	9	43		
	D18	J84	17	131	17	131
	D19	J86	16	93	16	93
Surf C	D17	J81	5	26	7	36
		J82	2	10		
TOTAL			**271**	**1606**	**271**	**1606**

Comparison among Mix Types. A comparison was made of the standard deviation values for the different Surface course Mix Types that comprised the Analysis data set. The results for this analysis are shown in Table 5.7.

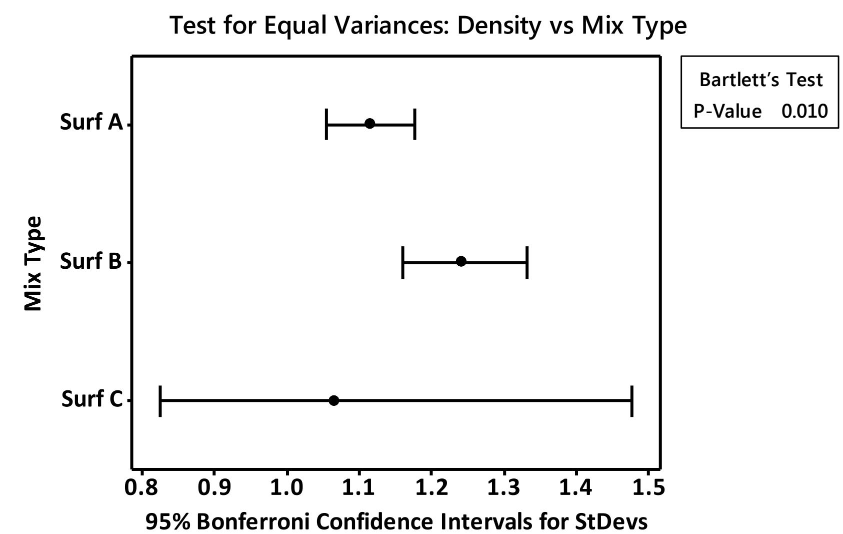
Table 5.7. Summary of AC Comparisons among Surface Mixes

Mix Type	No. of Tests	St Dev	P-value*+ Bartlett’s	P-value*+ Levene’s
Surface A	971	1.113	**0.010**	0.069
Surface B	599	1.241		
Surface C	36	1.064		
TOTAL	**1606**			

***** Bartlett’s test assumes normal populations, while Levene’s test does not require normal populations

+ Values in **bold** are statistically significantly different at the α = 0.05 level.

Levene's test does not show a significant difference in standard deviations for the 3 Surface course Mix Types, while Bartlett's test does indicate a significant difference. The confidence intervals for the standard deviation values are shown in Figure 5.3.



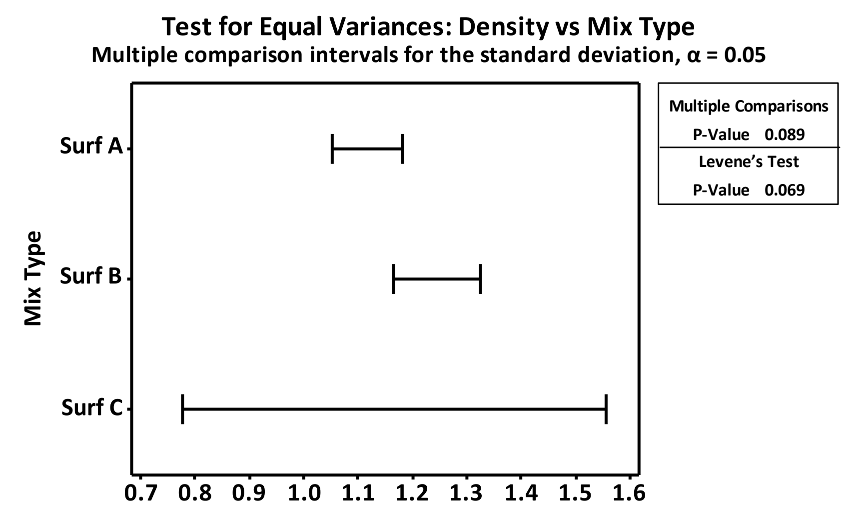


Figure 5.3. Confidence Intervals for Density Standard Deviations on Surface Mix Types

Review of Table 5.7 quickly identifies the extremely small sample size, both absolute size and size relative to the other Surface mixes, for the Surface C mix. Therefore, it was decided that it was not valid to consider the Surface C mix in the analysis of Surface mixes. The analysis was run again without the Surface C data and these results are shown in Table 5.8.

Table 5.8. Summary of Density Comparisons among Surface Mixes without Surface C

Mix Type	No. of Tests	St Dev	P-value* Bartlett's	P-value* Levene's
Surface A	971	1.113	**0.003**+	**0.027**+
Surface B	599	1.241		
TOTAL	**1570**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in bold are statistically significantly different at the α = 0.05 level.

Both Bartlett's and Levene's tests showed a significant difference between the standard deviation values for the Surface A and Surface B mixes. This raises doubts concerning whether or not it is appropriate to use the same acceptance limits for different Surface Mix Types.

Comparison among Projects. For the Surface course data there were 8 Projects on which Surface A mixes were used and 7 Projects on which Surface B mixes were used. This allows for a comparison of the standard deviation values among the various Projects using each Mix Type. The results for these analyses are shown in Table 5.9 for Surface A mixes and Table 5.10 for Surface B mixes.

Table 5.9. Summary of Density Comparisons among Projects with Surface A Mixes

Project	No. of Tests	St Dev	Bartlett's-Test P-value*+	Levene's Test P-value*+
P02	73	0.925	**0.001**	**0.000**
P03	109	1.178		
P06	138	0.959		
P09	107	0.776		
P10	47	1.422		
P11	145	0.965		
P14	218	1.157		
P18	134	1.029		
TOTAL	**971**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
+ Values in **bold** are statistically significantly different at the α = 0.05 level.

Table 5.10. Summary of Density Comparisons among Projects with Surface B Mixes

Project	No. of Tests	St Dev	Bartlett's-Test P-value*⁺	Levene's Test P-value*⁺
P04	106	0.793	**0.000**	**0.000**
P05	28	1.193		
P08	115	1.382		
P10	40	1.738		
P11	86	1.249		
P18	131	1.027		
P19	93	1.142		
TOTAL	**599**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations
⁺ Values in **bold** are statistically significantly different at the α = 0.05 level.

There is a significant difference among project standard deviations for both Surface A and Surface B mixes. This is not unexpected since there is no expectation that every project will have the same amount of variability. The fact that the various projects had different Contractors and different Mix Types among them, obviously contributed to these identified differences.

Comparison of Multiple JMFs within a Project. As shown in Table 5.6, a number of Projects had more than 1 JMF. Table 5.11 shows the results for standard deviation comparisons when there were multiple JMFs for a Mix Type on a Project. The comparisons were made on the final Analysis data set and are based on Levene's test as it is more general since it does not require a normality assumption. There really are too few cases of multiple JMFs to draw valid conclusions. Disregarding the limited number of cases, the results are still inconclusive with 4 of the 7 Projects showing no significant differences among their multiple JMFs, and 3 of the 7 Projects showing significant differences.

Table 5.11. Comparison of Density Test Results for Projects with Multiple JMFs for the Analysis Data Set

Project	Mix Type	JMF	No. of Tests	St Dev	Levene'sTest P-value+
D02	Surf A	J02	27	0.922	0.860
	Surf A	J03	46	0.937	
D09	Surf A	J16	11	0.901	0.273
	Surf A	J17	37	0.699	
	Surf A	J89	59	0.774	
D10	Surf A	J18	47	1.422	**0.016**
	Surf B	J20	10	2.329	
	Surf B	J21	30	1.222	
D11	Surf A	J24	145	0.965	**0.002**
	Surf B	J27	43	1.432	
	Surf B	J28	43	0.948	
D14	Surf A	J62	62	0.855	**0.006**
	Surf A	J63	156	1.252	
D17	Surf C	J81	26	0.776	0.133
	Surf C	J82	10	1.648	
D18	Surf B	J84	131	1.027	0.773
	Surf A	J85	134	1.029	
			1017		

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Comparison among Contractors. For the Surface course data there are sufficient data to allow for comparison of the standard deviation values for the different. Also, all 7 of the Contractors placed some Surface course mixes. The results for this analysis are shown in Table 5.12. The results show clearly that there is a difference among Contractors when it comes to the variability of their Surface course mixes. Some of this difference can be attributed to the different Mix Types as well as to the different Contractors on the Projects.

Table 5.12. Summary of Density Comparisons for Surface Course among Contractors for the Analysis Data Set

Contractor	No. of Tests	St Dev	P-value*+ Bartlett's	P-value*+ Levene's
C01	106	0.793	**0.000**	**0.000**
C02	607	1.251		
C03	28	1.193		
C04	138	0.959		
C05	115	1.382		
C06	311	1.168		
C07	265	1.026		
TOTALS	**1570**			

***** Bartlett's test assumes normal populations, while Levene's test does not require normal populations

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Typical Variability Values for Density

Since there are no Verification data associated with Density, the only analysis that could be conducted on the Density data set was to determine whether or not the Density "typical" variability had shown any signs of a change since the Phase I study was conducted.

None of the standard deviation values shown in the previous tables in this chapter are the appropriate standard deviation to use to represent the process standard deviation for Density. These calculations were done simply for exploratory purposes. Aggregating the data as in these tables is not appropriate for establishing specification limits since the specification limits are based on Lot-by-Lot acceptance, or at least on acceptance of a project.

Therefore, the variability that is used to evaluate the specification limits must be that which is appropriate for a typical Lot. To determine this, the individual unbiased standard deviation values for each Lot were calculated and then these Lot standard deviations were averaged to get the "within Lot" standard deviation for each project. This calculation process is illustrated in Exhibit 5.1 for 1 of the projects for which data were obtained.

Lot No.	Lot Size	Lot Mean	Lot St Dev*	c_4**	Unbiased Lot St Dev***
1	8	93.78	1.123	0.9650	1.164
2	4	93.86	1.335	0.9213	1.449
3	7	93.54	0.860	0.9594	0.896
4	8	93.85	0.659	0.9650	0.683
	Average	**93.76**	**0.601**		**1.048**

* calculated from $s = \sqrt{\dfrac{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2}{n-1}}$

** obtained from Table 4.13 for the sample size, *n*

*** calculated as $\dfrac{s}{c_4}$

**** calculated as $\dfrac{\dfrac{s_1}{c_{4_1}} + \dfrac{s_3}{c_{4_3}} + \dfrac{s_4}{c_{4_4}} + \dfrac{s_5}{c_{4_5}}}{4}$

Exhibit 5.1. Example of Calculating Unbiased St Dev for Project D02, JMF J02

The data in Exhibit 5.1 are for Surface A using JMF J02 on project D02. There were 4 Lots with differing sample sizes of 8, 4, 7, and 8. The mean and standard deviation are shown for each Lot. Then, each Lot standard deviation is divided by the c_4 factor (see Table 5.13) corresponding to the Lot sample size to get the unbiased estimate. Finally, the 4 unbiased Lot standard deviations are averaged to arrive at the within-Lot standard deviation for the Project. This within-Lot standard deviation does not take into consideration any target miss variability that may be present.

To address the option of using the total Project as the payment Lot, the total Project standard deviation was also calculated for each Project. This was done by calculating a single standard deviation using all of the test results on the Project. This “Project” standard deviation could also be used as one way of trying to incorporate any target miss variability that might be present in the Contractor’s process.

Table 5.14 shows the standard deviation results for Density for all Projects in the Analysis data set. The within-Project data are sorted by JMF. The “Mean Lot SD” is the average of the unbiased standard deviation estimates for each Lot on the project. The “Project SD” is the standard deviation of all the individual test results for the total Project. The table also shows the total number of Lots and Tests for each Project, the mean for all Tests on the Project, and the mean of the individual Project Lot means.

Table 5.13. c_4 Factors for Various Sample Sizes, n

Sample Size, n	c_4
2	0.7979
3	0.8862
4	0.9213
5	0.9400
6	0.9515
7	0.9594
8	0.9650
9	0.9693
10	0.9727
11	0.9754
12	0.9776
13	0.9794
14	0.9810
15	0.9823
16	0.9835
17	0.9845
18	0.9854
19	0.9862
20	0.9869
21	0.9876
22	0.9882
23	0.9887
24	0.9892
25	0.9896
Over 25	*a*

[a] $(4n-4)/(4n-3)$

Table 5.14 presents the results broken down by each JMF on a Project. Typically, SCDOT begins a new Lot each time a new JMF is implemented. Under these circumstances it probably is appropriate to determine typical standard deviation values on a JMF basis rather than a Project basis.

SCDOT can use Table 5.14 to assist in selecting the "typical" variability to use to establish specification limits. There is no single "correct" way to establish this value. A subjective decision must be made regarding the standard deviation to select. The percentile values shown in the table should assist in making the decision. To get a "picture" of the results in Table 5.14, Figure 5.4 shows the empirical CDF for the Lot standard deviation and Project standard deviation values.

Table 5.14. Summary of Density Test Results for Each JMF for the Abridged Data Set, by JMF

Project	JMF	All JMF Tests*			All JMF Lots**			Mix Type
		Tests	Mean All Tests	Project SD	No. of Lots	Mean of Lot Means	Mean Lot SD	
P02	J02	27	93.75	0.931	4	93.76	1.048	Surf A
	J03	46	93.72	0.942	10	93.79	0.874	Surf A
P03	J03	109	93.95	1.181	21	93.98	1.026	Surf A
P04	J01	106	93.49	0.795	21	93.48	0.778	Surf B
P05	J08	28	92.98	1.204	6	93.09	1.169	Surf B
P06	J12	138	93.28	0.961	25	93.33	0.745	Surf A
P08	J15	115	93.01	1.385	18	92.99	1.240	Surf B
P09	J16	11	94.16	0.924	2	94.16	0.971	Surf A
	J17	37	93.90	0.704	5	94.00	0.546	Surf A
	J89	59	93.63	0.777	9	93.68	0.687	Surf A
P10	J18	47	93.41	1.430	8	93.56	1.121	Surf A
	J20	10	90.55	2.395	3	90.93	1.585	Surf B
	J21	30	92.40	1.232	4	92.44	1.268	Surf B
P11	J24	145	94.34	0.967	22	94.37	0.846	Surf A
	J27	43	93.20	1.440	7	93.21	1.453	Surf B
	J28	43	93.84	0.953	9	93.92	0.622	Surf B
P14	J62	62	93.68	0.858	9	93.68	0.787	Surf A
	J63	156	93.92	1.254	25	93.84	0.977	Surf A
P18	J84	131	93.20	1.029	17	93.20	0.886	Surf B
	J85	134	93.13	1.031	23	93.16	0.990	Surf A
P19	J86	93	93.41	1.145	16	93.41	1.085	Surf B
Total/Average		**1570**	**93.38**	**1.121**	**264**	**93.43**	**0.986**	
Percentile		**50%**		**1.029**			**0.977**	
		60%		**1.145**			**1.026**	
		70%		**1.204**			**1.085**	
		75%		**1.232**			**1.121**	
		80%		**1.254**			**1.169**	
		90%		**1.430**			**1.268**	

* **All Project Tests:** Mean and unbiased standard deviation for all individual test results on project.

** **All Project Lots:** Means of — (1) all the individual Lot means on the project and (2) all the individual Lot unbiased standard deviations — for all Lots on the project.

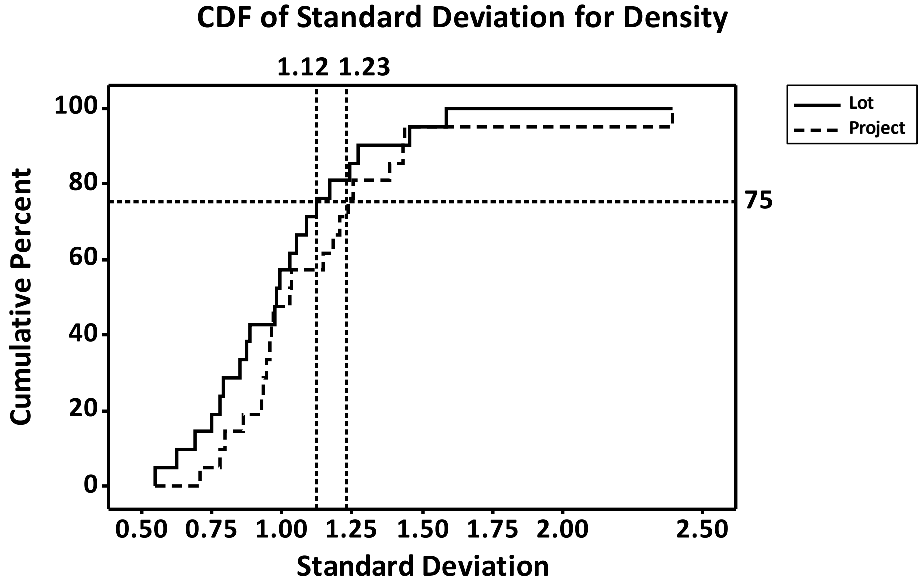


Figure 5.4. CDFs for Density Standard Deviations for Abridged Data Set, by JMF

While the selection of the typical variability to use to develop acceptance limits is a subjective one, the reference lines in Figure 5.4 appear to be potential reasonable choices for typical Lot standard deviation (1.12%) and Project standard deviation (1.23%). For comparison, the analysis of the Phase I data yielded a recommended typical Lot standard deviation between 1.16% and 1.26%.

Since Table 5.8 indicated that there was a difference between the variability of Surface A and Surface B mixes, Tables 5.15 and 5.16 present the information from Table 5.14 sorted by Mix Type. Figures 5.5 and 5.6 show comparisons of the CDF for Surface A and Surface B for the Lot standard deviations and Project standard deviations, respectively.

The figures show clearly that the Project standard deviations are larger than the Lot standard deviations. Also, the standard deviations for Surface B are noticeably larger than those for Surface A.

Table 5.15. Summary of Density Test Results for Each JMF for Each Project for Surface A, by JMF

Project	JMF	All JMF Tests*			All JMF Lots**			Mix Type
		Tests	Mean All Tests	Project SD	No. of Lots	Mean of Lot Means	Mean Lot SD	
P02	J02	27	93.75	0.931	4	93.76	1.048	Surf A
	J03	46	93.72	0.942	10	93.79	0.874	Surf A
P03	J03	109	93.95	1.181	21	93.98	1.026	Surf A
P06	J12	138	93.28	0.961	25	93.33	0.745	Surf A
P09	J16	11	94.16	0.924	2	94.16	0.971	Surf A
	J17	37	93.90	0.704	5	94.00	0.546	Surf A
	J89	59	93.63	0.777	9	93.68	0.687	Surf A
P10	J18	47	93.41	1.430	8	93.56	1.121	Surf A
P11	J24	145	94.34	0.967	22	94.37	0.846	Surf A
P14	J62	62	93.68	0.858	9	93.68	0.787	Surf A
	J63	156	93.92	1.254	25	93.84	0.977	Surf A
P18	J85	134	93.13	1.031	23	93.16	0.990	Surf A
Total/Average		**971**	**93.74**	**0.997**	**264**	**93.78**	**0.885**	
Percentile		**50%**		**0.952**			**0.923**	
		60%		**0.965**			**0.975**	
		70%		**1.012**			**0.986**	
		75%		**1.069**			**0.999**	
		80%		**1.151**			**1.019**	
		90%		**1.247**			**1.046**	

* **All Project Tests:** Mean and unbiased standard deviation for all individual test results on project.

** **All Project Lots:** Means of — (1) all the individual Lot means on the project and (2) all the individual Lot unbiased standard deviations — for all Lots on the project.

Table 5.16. Summary of Density Test Results for Each JMF for Each Project for Surface B, by JMF

Project	JMF	All JMF Tests*			All JMF Lots**			Mix Type
		Tests	Mean All Tests	Project SD	No. of Lots	Mean of Lot Means	Mean Lot SD	
P04	J01	106	93.49	0.795	21	93.48	0.778	Surf B
P05	J08	28	92.98	1.204	6	93.09	1.169	Surf B
P08	J15	115	93.01	1.385	18	92.99	1.240	Surf B
P10	J20	10	90.55	2.395	3	90.93	1.585	Surf B
	J21	30	92.40	1.232	4	92.44	1.268	Surf B
P11	J27	43	93.20	1.440	7	93.21	1.453	Surf B
	J28	43	93.84	0.953	9	93.92	0.622	Surf B
P18	J84	131	93.20	1.029	17	93.20	0.886	Surf B
P19	J86	93	93.41	1.145	16	93.41	1.085	Surf B
Total/Average		**971**	**93.74**	**0.997**	**264**	**93.78**	**0.885**	
Percentile		**50%**		**1.204**			**1.169**	
		60%		**1.226**			**1.226**	
		70%		**1.324**			**1.257**	
		75%		**1.385**			**1.268**	
		80%		**1.407**			**1.342**	
		90%		**1.631**			**1.479**	

* **All Project Tests:** Mean and unbiased standard deviation for all individual test results on project.

** **All Project Lots:** Means of — (1) all the individual Lot means on the project and (2) all the individual Lot unbiased standard deviations — for all Lots on the project.

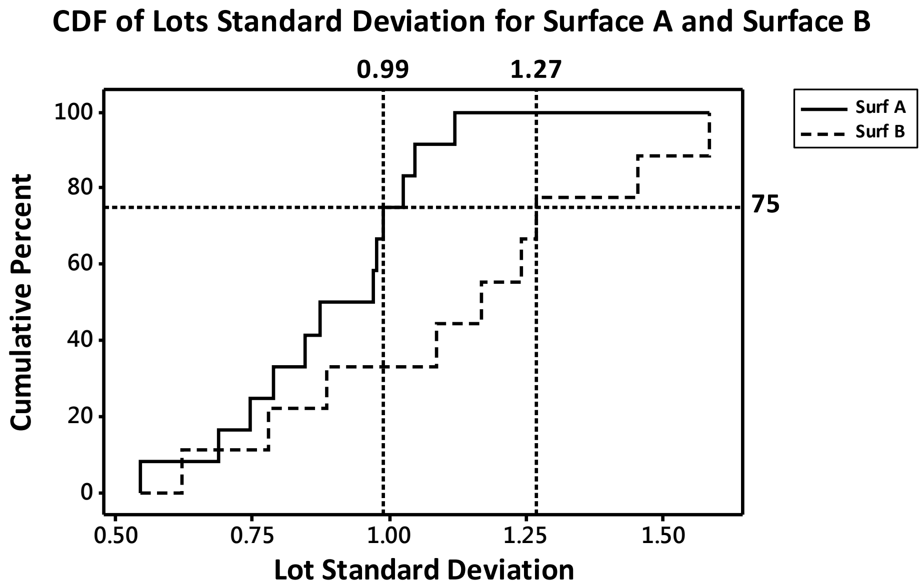


Figure 5.5. CDFs for Density Lot Standard Deviations for Surface A vs Surface B, by JMF

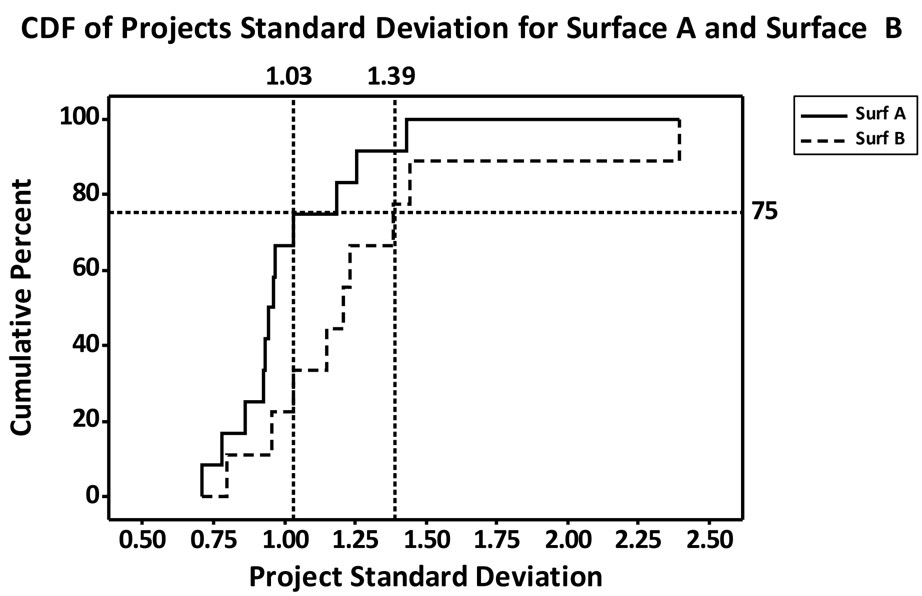


Figure 5.6. CDFs for Density Project Standard Deviations for Surface A vs Surface B, by JMF

In the event that SCDOT decides not to begin a new Lot each time a new JMF is implemented, then the typical standard deviation probably should be based on the Lot standard deviation on a Project basis rather than a JMF basis. Table 5.17 and Figure 5.7 present the results of determining the typical Lot standard deviation using all Lots on the Project, rather than on each JMF. That means that if there is more than 1 JMF on the Project a new Lot is not initiated when the Contractor changes JMFs.

Table 5.17. Summary of Density Surface Course Test Results for Each Project for the Abridged Data Set, by Project

	All Project Tests*			All Project Lots**		
Project	**No.**	**Mean**	**St Dev**	**No.**	**Mean**	**St Dev**
P02	73	93.73	0.928	14	93.78	0.924
P03	109	93.95	1.181	21	93.98	1.026
P04	106	93.49	0.795	21	93.48	0.778
P05	28	92.98	1.204	6	93.09	1.169
P06	138	93.28	0.961	25	93.33	0.745
P08	115	93.01	1.385	18	92.99	1.240
P09	107	93.78	0.778	16	93.84	0.678
P10	87	92.74	1.736	15	92.73	1.253
P11	231	94.04	1.149	38	94.05	0.905
P14	218	93.85	1.158	34	93.80	0.926
P17	36	91.79	1.071	7	91.92	0.887
P18	265	93.16	1.027	40	93.17	0.946
P19	93	93.41	1.145	16	93.41	1.085
Total/Average	**1606**	**93.32**	**1.117**	**271**	**93.35**	**0.966**
Percentile	**50%**		**1.145**			**0.926**
	60%		**1.151**			**0.962**
	70%		**1.167**			**1.050**
	75%		**1.181**			**1.085**
	80%		**1.195**			**1.135**
	90%		**1.349**			**1.226**

* **All Project Tests:** Mean and unbiased standard deviation for all individual test results on project.

** **All Project Lots:** Means of — (1) all the individual Lot means on the project and (2) all the individual Lot unbiased standard deviations — for all Lots on the project.

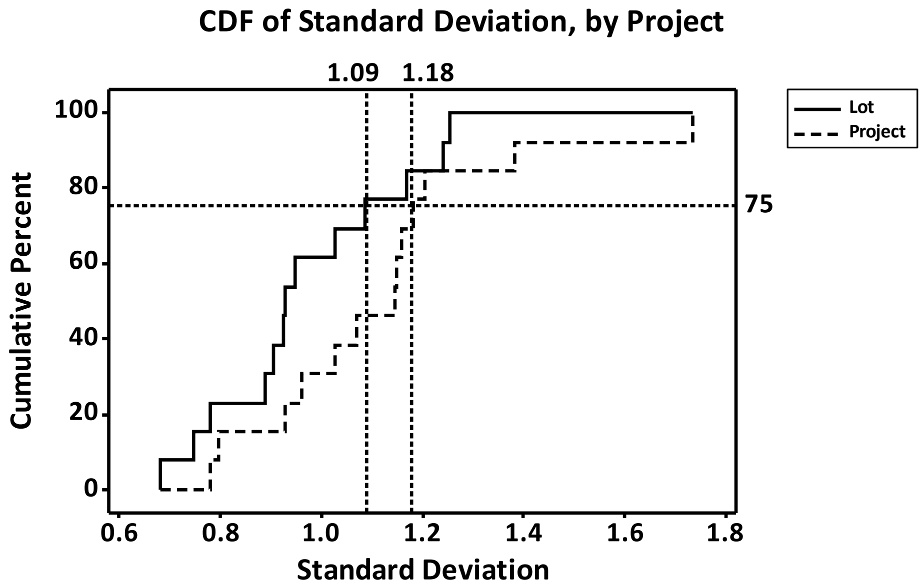


Figure 5.7. CDFs for Density Standard Deviations for Abridged Data Set, by Project

Observations from the Analyses of Density Test Results

A total of 2010 Density test results were provided by SCDOT. The breakdown of these tests results by Course, Mix Type, JMFs, and Cores vs. Nuclear Gages is presented in Table 5.18.

Table 5.18. Breakdown of Density Test Results Provided by SCDOT

Course	Mix	Projects	Contr	JMFs	Lots	Tests	Cores	Gage
Base	Base A	1	1	2	17	201	0	201
Interm	Interm C	2	2	2	7	39	39	0
Surface	Surf A	9	5	13	161	987	987	0
	Surf B	7	6	11	105	685	605	80
	Surf C	2	2	4	11	98	36	62
Surface Subtotal					277	1770	1628	142
TOTAL					**301**	**2010**	**1667**	**343**

The following observations can be made from the information in Table 5.18 and from the analyses reported in this chapter.

- With Base course results from only 1 Project and totaling only 201 Nuclear Gage results, it was not possible to perform meaningful analyses on the Base course data.
- With Intermediate course results from only 2 Projects and totaling only 39 Core results, it was not possible to perform meaningful analyses on the Intermediate course data.
- Analyses, therefore, were limited to the Surface course data. However, with Surface C Mix Type results from only 2 Projects and totaling only 36 Core results and 62 Nuclear Gage results, it was not possible to perform meaningful analyses on the Surface C Mix Type data.
- With a total of only 80 test results for Surface B mixes and 0 test results for Surface A mixes, the Nuclear Gage results for Surface mixes were not included in the Analysis data set.
- The final Analysis data set consisted of 1,672 Core Density test results, with 987 from Surface Type A mixes and 685 from Surface Type B mixes.
- Table 5.8 shows a significant difference between the standard deviation values for the Surface A and Surface B mixes. This raises doubts concerning whether or not it is appropriate to use the same acceptance limits for different Surface Mix Types.
- Table 5.11 shows that when there were multiple JMFs for a Mix Type on a Project 4 of the 7 Projects show no significant differences among their multiple JMFs, and 3 of the 7 Projects show significant differences. These results are inconclusive regarding whether or not it is appropriate to combine multiple JMFs into one common population when making calculations for acceptance decisions. No significant differences were found in a small majority (4/7 = 57%) of the projects, and this is supportive of combining the test results of various JMFs of the same Mix Type when making acceptance decisions.
- Table 5.18 shows a comparison of potential "typical" Density standard deviation values for both Within-Lot and Total Project variabilities. The standard deviations are presented for the total data set as well as for Surface A and Surface B Mix Types. Also included is the typical standard deviation values obtained from the Phase I study. Note that the values in Table 5.19 are for illustration. The subjective decision regarding which values to use for "typical" standard deviations ultimately must be made by SCDOT.

Table 5.19. Summary of "Typical" Density Standard Deviation Values

Source	Mix Type	Within-Lot St Dev	Project St Dev	Comments
Phase II	Surf A & B	1.12	1.23	Typical within-Lot Values based on each JMF
	Surf A	0.99	1.03	
	Surf B	1.27	1.39	
	Surf A & B	1.09	1.18	Typical within-Lot Values based on each Project
Phase I	Surface	1.16-1.26		

CHAPTER 6 — PROCESS VARIABILITIES

Background

In Chapter 4, potential within-Lot standard deviation values were calculated for AC, AV, and VMA. In this chapter, the potential variability of the population mean about the target value is considered in addition to the within-Lot standard deviation values to develop an “overall process” standard deviation for AC, AV, and VMA. These standard deviation values are compared with the current SCDOT specification limits to investigate whether or not these limits are still appropriate.

Variability of the Process Mean

The typical within-Lot standard deviation serves as a measure of variability within each Lot for a typical Contractor on a typical Project. This standard deviation can be used to help decide upon specification limits for the acceptance characteristic. However, another factor that may need to be considered in addition to the within–Lot variability is the capability of contractors to center their processes on the target value.

AC, AV, and VMA all have target values about which 2-sided specification limits are established. The typical within-Lot standard deviation can be used to establish these specification limits. SCDOT, however, must decide whether or not a typical Contractor always can be expected to be able to center its process exactly on the target value. If SCDOT believes this to be possible, then the typical process standard deviation that was developed from the individual project values can be used when setting the specification limits. If, on the other hand, SCDOT believes that a typical Contractor’s process mean may vary about the target value, then it may be necessary to consider this fact when developing specification limits.

One approach might be to combine the “process center” variability and the “within-Lot” variability by adding their associated variances (not their standard deviations). This assumes that the amount of within-Lot variability is independent of where the process is centered; an assumption that seems reasonable, particularly as long as the target miss is not very large.

If SCDOT does not believe that the Contractor’s process is constant throughout the life of a project, as would typically be the case with Lot-by-Lot acceptance, then there is no way to know how much of the Lot-to-Lot variation in sample means is from the natural variation of the sampling process and how much is due to misses, changes, or adjustments in the Contractor’s target mean during the project.

Therefore, a second approach might be to calculate a standard deviation based on combining all of the project data into 1 data set. While this is not a good way to establish a typical within-Lot standard deviation, this approach will provide a larger standard deviation value that includes the Lot-to-Lot variation among the individual Lot means. A decision to use this approach assumes that any process center variation within the Project will be accounted for when all the test results are combined. The various project standard deviations could then be used to arrive at a typical process standard deviation that attempts to include both the within-Lot and the process center variability.

Asphalt Content

As noted in Chapter 4, the AC test data had specific target values. It was not possible to compare directly the actual test results since each Project and each JMF had its own set of target values. It was possible, however, to normalize the data by considering the AC as differences from their target values. This made it possible to make comparisons among the various Lots, JMFs, Projects, Mix Types, and Courses that could not be done on the actual test values.

Selecting the Project Variability. With a target value, if SCDOT thought it necessary, it could combine any potential “process target” variability with the selected “within-Lot” variability to determine the overall typical process variability for AC. One approach to do this would be to add the “process center” variance and the “within-Lot” variance. Another approach, as discussed above, would be to use the “Project” standard deviation values to select the typical process standard deviation.

Table 6.1 shows the AC results for the Analysis data set. The table shows the average and unbiased standard deviation for the average project Lot means, as well as percentiles based on ranked order for both the Project and Lot standard deviation values. The data shown for overall Project mean AC and average Lot standard deviation are taken from Table 4.5.

In Chapter 4, the typical Surface course within-Lot standard deviation was found to be in the 0.175 range. In Table 6.1, the standard deviation of the project Lot means might be used as an estimate for the process target standard deviation. From Table 6.1, the mean of the Mean of the Project Lot Means is essentially 0 (to 3 decimal places), while the unbiased standard deviation of the Mean of the Project Lot Means is 0.0455.

Equation 6.1 can be used to combine the target miss standard deviation and the within-Lot standard deviation into a single typical process standard deviation.

$$\sqrt{(0.175)^2 + (0.0455)^2} = 0.181 \qquad \textbf{(6.1)}$$

Figure 6.1 (which is the same as Figure 4.3) shows the empirical CDF for the Project (i.e., All Tests) standard deviation values in Table 6.1. As the reference lines show, there is very little difference in the standard deviation values for the 70^{th} and 82^{nd} percentiles. In this range the Project standard deviation is approximately 0.20. This is larger than the value calculated using Equation 6.1 and the within-Lot and process target variabilities. However, if the 82^{nd} percentile had been used when selecting the within-Lot standard deviation (see Figure 4.1), a value of 0.183, rather than 0.175, would have been obtained. Using this value in Equation 6.1 would result in a standard deviation value of 0.189, which is closer to, but still less than, the value of 0.20.

Table 6.1. Summary of AC Test Results for the Analysis Data Set

Project	No. of Tests	Mean of All Tests*	Std Deviation All Tests+	No. of Lots	Mean of Lot Means^
P01	32	-0.009	0.192	15	0.001
P02	71	-0.004	0.316	21	0.000
P03	79	0.008	0.201	21	0.013
P04	72	0.045	0.147	20	0.051
P05	43	0.013	0.202	17	0.019
P06	89	-0.041	0.166	25	-0.043
P08	75	-0.079	0.172	18	-0.082
P09	64	-0.098	0.159	16	-0.102
P10	47	-0.017	0.227	14	-0.017
P11	157	-0.008	0.173	42	-0.006
P12	257	0.061	0.213	55	0.068
P13	295	0.000	0.170	73	-0.010
P14	161	0.042	0.194	41	0.041
P15	98	-0.004	0.172	26	0.004
P18	172	0.053	0.141	43	0.056
P19	61	-0.000	0.171	16	0.003
P20	58	0.004	0.197	16	0.012
Average		**-0.002**	**0.189**	**Average**	**0.00045**
				Std Dev	**0.04483**
				Unbiased SD	**0.04549**
	Percentile	**50%**	**0.173**		
		60%	**0.193**		
		70%	**0.198**		
		75%	**0.201**		
		80%	**0.202**		
		90%	**0.219**		

***** the mean of all individual test results on the project

+ the standard deviation of all individual test results on the project

^ the mean of all the individual Lot means on the project

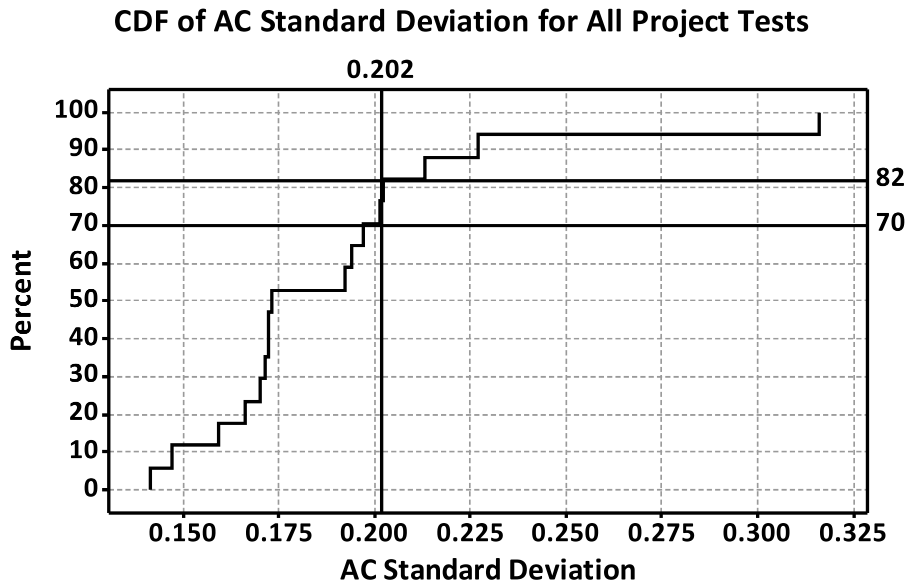


Figure 6.1. CDF for the Standard Deviations of All Project Tests for AC

Air Voids

As noted in Chapter 4, the AV test data had specific target values. It was not possible to compare directly the actual test results since each Project and each JMF had its own set of target values. It was possible, however, to normalize the data by considering the AV results as differences from their target values. This made it possible to make comparisons among the various Lots, JMFs, Projects, Mix Types, and Courses that could not be done on the actual test values.

Selecting the Project Variability. With a target value, if SCDOT thought it necessary, it could combine any potential "process target" variability with the selected "within-Lot" variability to determine the overall typical process variability for AC. One approach to do this would be to add the "process center" variance and the "within–Lot" variance. Another approach, as discussed above, would be to use the "Project" standard deviation values to select the typical process standard deviation.

Table 6.2 shows the AC results for the Analysis data set. The table shows the average and unbiased standard deviation for the average project Lot means, as well as percentiles based on ranked order for both the Project and Lot standard deviation values. The data shown for overall Project mean AC and average Lot standard deviation are taken from Table 4.11.

In Chapter 4, the typical within-Lot standard deviation was found to be in the 0.44-0.45 range. For illustration, a value of 0.45 is used. In Table 6.2, the standard deviation of the project Lot means, 0.209, might be used as an estimate for the process target standard deviation. Equation 6.2 can be used to combine these into a single typical process standard deviation.

Table 6.2. Summary of AV Test Results for the Analysis Data Set

Project	No. of Tests	Mean of All Tests*	Std Deviation All Tests+	No. of Lots	Mean of Lot Means^
P01	32	-0.222	0.470	15	-0.241
P02	71	0.177	0.641	21	0.160
P03	79	0.097	0.639	21	0.106
P04	72	-0.122	0.569	20	-0.139
P05	43	-0.013	0.467	17	0.037
P06	89	-0.014	0.551	25	0.005
P08	75	-0.076	0.494	18	-0.057
P09	64	-0.625	0.494	16	-0.657
P10	47	0.054	0.710	14	-0.005
P11	157	-0.317	0.508	42	-0.315
P12	257	-0.235	0.617	55	-0.281
P13	295	0.013	0.538	73	-0.004
P14	161	0.078	0.626	41	0.071
P15	98	-0.237	0.461	26	-0.227
P18	172	-0.283	0.401	43	-0.292
P19	61	-0.230	0.536	16	-0.247
P20	58	-0.252	0.477	16	-0.270
Average		**-0.130**	**0.541**	**Average**	**-0.139**
				Std Dev	**0.206**
				Unbiased SD	**0.209**
	Percentile	**50%**	**0.536**		
		60%	**0.546**		
		70%	**0.579**		
		75%	**0.617**		
		80%	**0.624**		
		90%	**0.640**		

* the mean of all individual test results on the project

\+ the standard deviation of all individual test results on the project

^ the mean of all the individual Lot means on the project

Equation 6.2 can be used to combine the target miss standard deviation and the within-Lot standard deviation into a single typical process standard deviation.

$$\sqrt{(0.45)^2 + (0.209)^2} = 0.496 \quad \textbf{(6.2)}$$

Figure 6.2 (which is the same as Figure 4.7) shows the empirical CDF for the Project (i.e., All Tests) standard deviation values in Table 6.2. As the reference lines show, unlike with AC, there is quite a difference in the standard deviation values for the 70th (0.579) and 82nd (0.626) percentiles. This range is larger than the value calculated using Equation 6.2 and the within-Lot and process target variabilities. However, if the 82nd percentile had been used when selecting the within-Lot standard deviation (see Figure 4.7), a value of 0.492, rather than 0.45, would have been obtained. Using this value in Equation 6.2 would result in a standard deviation value of 0.535, which is closer to, but still less than the All Project Test value of 0.579 to 0.626.

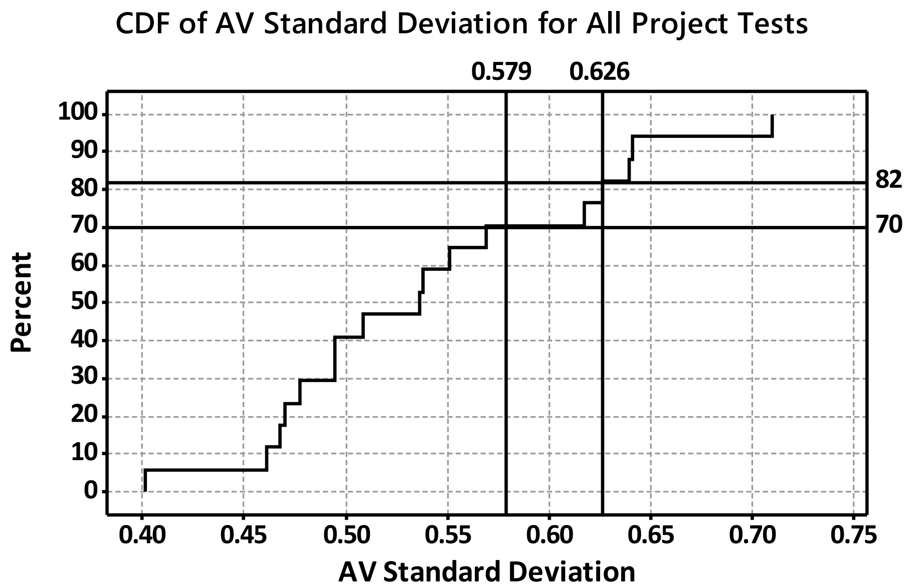


Figure 6.2. CDF for the Standard Deviations of All Project Tests for AV

VMA

As noted in Chapter 4, the VMA test data had specific target values. It was not possible to compare directly the actual test results since each Project and each JMF had its own set of target values. It was possible, however, to normalize the data by considering the VMA results as differences from their target values. This made it possible to make comparisons among the various Lots, JMFs, Projects, Mix Types, and Courses that could not be done on the actual test values.

Selecting the Project Variability. With a target value, if SCDOT thought it necessary, it could combine any potential "process target" variability with the selected "within-Lot" variability to determine the overall typical process variability for VMA. One approach to do this would be to add the "process center" variance and the "within–Lot" variance. Another approach, as discussed above, would be to use the "Project" standard deviation values to select the typical process standard deviation.

Table 6.3 shows the VMA results for the analysis data set. The table shows the average and unbiased standard deviation for the average Project Lot means, as well as percentiles based on ranked order for both the Project and Lot standard deviation values. The data shown for overall Project mean AC and average Lot standard deviation are taken from Table 4.17.

In Chapter 4, the typical within-Lot standard deviation was found to be in the 0.433-0.439 range. For illustration, a value of 0.439 is used. In Table 6.3, the standard deviation of the project Lot means, 0.227, might be used as an estimate for the process target standard deviation.

Equation 6.3 can be used to combine the target miss standard deviation and the within-Lot standard deviation into a single typical process standard deviation.

$$\sqrt{(0.439)^2 + (0.227)^2} = 0.494 \qquad \textbf{(6.3)}$$

Figure 6.3 (which is the same as Figure 4.11) shows the empirical CDF for the Project (i.e., All Tests) standard deviation values in Table 6.3. The reference lines show a small difference in the standard deviation values for the 70^{th} (0.562) and 82^{nd} (0.581) percentiles. This range is quite a bit larger than the value calculated using Equation 6.3 and the within-Lot and process target variabilities. However, if the 82^{nd} percentile had been used when selecting the within-Lot standard deviation (see Figure 4.11), a value of 0.487, rather than 0.439, would have been obtained. Using this value in Equation 6.3 would result in a standard deviation value of 0.537, which is closer to, but still less than the All Project Test value.

Summary

The potential variability of the population mean about the target value was considered in addition to the within-Lot standard deviation values to develop an overall "process standard deviation" for each of the acceptance characteristics. These standard deviation values can be compared with similar values obtained during the Phase I study to see if there were any obvious differences.

Typical Process Standard Deviations. One of the primary goals of the analyses was to determine values to use to represent the typical process variability for AC, AV, and VMA. This is a subjective decision that ultimately must be made by SCDOT. The values for typical standard deviations that SCDOT might consider to represent the typical process variability used to evaluate existing specification limits are shown in Table 6.4.

Table 6.3. Summary of VMA Test Results for the Analysis Data Set

Project	No. of Tests	Mean of All Tests*	Std Deviation All Tests+	No. of Lots	Mean of Lot Means^
P01	32	-0.195	0.505	15	-0.189
P02	71	0.163	0.656	21	0.149
P03	79	0.152	0.581	21	0.168
P04	72	0.026	0.559	20	0.022
P05	43	0.005	0.540	17	0.059
P06	89	-0.224	0.509	25	-0.214
P08	75	-0.281	0.376	18	-0.269
P09	64	-0.754	0.390	16	-0.794
P10	47	0.008	0.642	14	-0.042
P11	157	-0.230	0.523	42	-0.218
P12	257	-0.031	0.432	55	-0.062
P13	295	-0.014	0.477	73	-0.039
P14	161	0.069	0.572	41	0.060
P15	98	-0.209	0.505	26	-0.185
P18	172	-0.076	0.432	43	-0.080
P19	61	-0.308	0.413	16	-0.309
P20	58	-0.151	0.588	16	-0.153
Average		**-0.1210**	**0.512**	**Average**	**-0.123**
				Std Dev	**0.223**
				Unbiased SD	**0.227**
	Percentile	**50%**	**0.509**		
		60%	**0.533**		
		70%	**0.562**		
		75%	**0.572**		
		80%	**0.579**		
		90%	**0.610**		

* the mean of all individual test results on the project

+ the standard deviation of all individual test results on the project

^ the mean of all the individual Lot means on the project

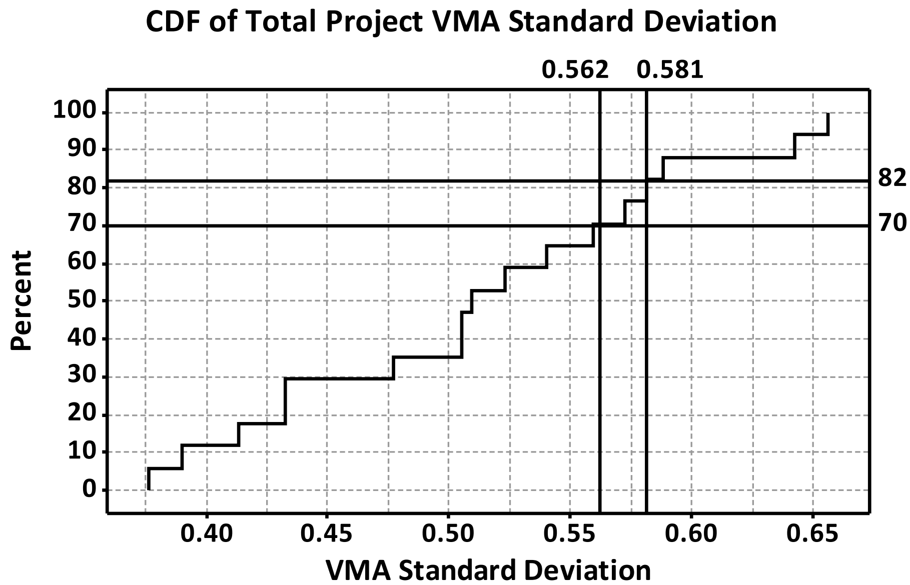


Figure 6.3. CDF for the Standard Deviations of All Project Tests for VMA

Table 6.4. Comparison of Potential Typical "Process" Standard Deviation Values

Characteristic	Phase I Value, %	Using Within-Lot and Target Miss St Dev's*	All Project Tests, %*
AC	0.21 – 0.23	0.181 – 0.189	0.202
AV	0.63 – 0.69	0.496 – 0.535	0.579 – 0.626
VMA	0.64 – 0.71	0.494 – 0.537	0.562 – 0.581

* These numbers are for illustration only. SCDOT must make a subjective decision concerning the appropriate values to use.

The values for typical process standard deviations are all lower than the corresponding values from the Phase I study. SCDOT will have to consider whether or not, given the data set concerns expressed in this report, they have sufficient confidence in the Phase II data to use these data to evaluate their existing specification limits.

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CHAPTER 7 — VERIFICATION TESTING PROCEDURES

Background

The SCDOT has adopted the use of Contractor tests in the acceptance decision for HMA paving materials. SCDOT developed and implemented verification testing procedures that were in effect for the Projects for which data were obtained for the current study. The verification testing procedures are conducted in accordance with SC-T-97 (07/12), Verification of Contractor HMA Acceptance Test Results. The verification test results were compared with the Contractor's acceptance tests to verify the Contractor tests before they were used in the acceptance decision.

Verification Sampling and Testing Procedures

In general, SCDOT personnel direct the Contractor to obtain and split the verification sample into 3 portions:

- 1 split for the SCDOT verification test
- 1 split for the Contractor
- 1 split for potential dispute resolution testing.

The Contractor is required to test their portion of each day's first verification test sample, and the verification split sample cannot be used as an acceptance sample. The Contractor has the option to test their split portion from the other verification samples. The Contractor is required to send their split sample results to SCDOT within 48 hours from the time the sample was taken.

The Contractor and SCDOT split sample results must compare within the allowable tolerances shown in Table 7.1. If the results do not compare, the Contractor can request that the dispute resolution sample be tested. This testing will be performed at the SCDOT Central Laboratory and this result will be used in lieu of the initial SCDOT verification test result.

Table 7.1. Allowable Tolerances for Verification Split Sample Test Results

Characteristic	Tolerance		
	Surface	Intermediate	Base
AC, %	0.36	0.43	0.50
AV, %	1.15		—
VMA, %	1.15		—

Verification Comparison Procedures

The SCDOT verification data set is compared with the Contractor's acceptance test results once there are 7 or more verification test results available. The verification tests are compared with the acceptance test results from Lot 1 through the end of the Lot from which the 7th verification test was obtained.

The next verification data set is comprised of the Lot following the 1st data set continuing through the completion of the Lot from which the 7th verification test is obtained. This process continues until production is completed. SC-T-97 states the following: *If the last data set is fewer than the minimum of 7 verification tests, then go back to the previous LOTS far enough to yield the number of test needed in the data set*.

The verification test results were compared with the Contractor acceptance test results using the *F*-test to compare the variances of the 2 samples and the 2-sample *t*-test to compare the means of the 2 samples. If neither of these tests declared a significant difference at the 0.01 level, then the Contractor acceptance tests were used to determine the payment factors. If 1 or both of the tests concluded that the 2 samples were different, then the SCDOT verification tests were used to determine the payment factors.

When the SCDOT verification tests are used, the modified allowable tolerances shown in Table 7.2 are used to determine the percent within limits (PWL) for those characteristics that did not compare statistically, and this PWL is used in the Lot payment factor determination. These modified allowable tolerances are larger to account for the fact that the verification data set has test results from multiple Lots and therefore there may be greater variability than for the case where acceptance is based on a single Lot.

Table 7.2. Allowable Tolerances When Verification Test Results Are Used for Acceptance

Characteristic	Tolerance		
	Surface	Intermediate	Base
AC, %	0.43	0.50	0.55
AV, %	1.32		—
VMA, %	1.32		—

Discussion of Verification Test Data

All of the Verification test data that were provided are included in Appendix C. Table 7.3 presents a summary of all verification test results data provided by SCDOT for AC, AV, and VMA. The values in the table include all Courses and Mix Types for each project. In the table each Project is identified with a unique number, ranging from V01 to V19. The "V" identifies the data as being from the Verification data set. Each of the numbers corresponds with a unique SCDOT project file number. The numeric portions are assigned in the same fashion as were the numbers for the Plant data. In other words, Projects P01 and V01 are the same project with P representing the Plant test results and V representing the Verification test results.

Table 7.3. Summary of All Verification Test Results by Project – Original Data Set

Project	AC Verif	AC Contr	AV Verif	AV Contr	VMA Verif	VMA Contr
V01	30	29	30	29	30	29
V02	31	30	31	30	31	30
V03	29	29	29	29	29	29
V04	25	23	25	23	25	23
V05	47	2	34	0	34	0
V06	40	23	40	23	40	23
V07	9	0	9	0	9	0
V08	18	14	18	14	18	14
V09	15	15	15	15	15	15
V10	20	20	20	20	20	20
V11	31	34	31	34	31	34
V14	64	64	64	64	64	64
V16	28	28	6	6	6	6
V17	13	13	13	13	13	13
V18	62	62	62	62	62	62
V19	25	25	25	25	25	25
	487	**411**	**452**	**387**	**452**	**387**

Table 7.3 is limited in its usefulness since each of the 16 Projects could include some combination of Base, Intermediate, and Surface courses. In addition, many of the projects contain more than a single JMF. The table shows a number of issues and potential problems with the collected data.

Data by Mix Type. Table 7.4 shows the distribution of test data among the 6 Mix Types for which data were obtained. A review of the table identifies a number of issues. First, there are only 15 Verification and no Contractor test results for the Intermediate C mixes, and there are only 13 Verification and only 2 Contractor test results (and only for AC) for the Surface E mixes. Also, for Base A mixes there were only 22 Verification and 22 Contractor tests results and these were only for AC, with no test results for AV or VMA. As a result, Base A, Intermediate C, and Surface E mixes were not considered for any analyses.

Table 7.4. Summary of Verification Test Results by Mix Type – Original Data Set

Mix Type	AC Verif	AC Contr	AV Verif	AV Contr	VMA Verif	VMA Contr
Base A	22	22	0	0	0	0
Interm C	15	0	15	0	15	0
Surf A	259	235	259	235	259	235
Surf B	155	129	155	129	155	129
Surf C	23	23	23	23	23	23
Surf E	13	2	0	0		
	487	**411**	**452**	**387**	**452**	**387**

While some preliminary analyses were conducted using Surface A, B, and C mixes, there was concern over the small number of Surface C results, 23 test results, and Surface C ultimately was eliminated from the final analyses. The tables below show the results of preliminary analyses using all 3 Surface Mix Types.

Table 7.5-7.7 shows the results of comparing the AC standard deviation values of the 3 surface Mix Types. Table 7.5 shows that there is no significant difference among the surface Mix Types for AC standard deviations for the SCDOT verification tests (AC-Verif). Table 7.6 shows similar results for the Contractors' verification splits (AC-Contr). Finally, Table 7.7 shows that there are no significant differences between the AC means for the SCDOT and Contractor split verification samples for any of the 3 surface Mix Types. These tables show that there is no reason to believe that either the means or variabilities of the AC-Verif and AC-Contr test results differ among the 3 Surface Mix Types.

Table 7.5. Comparison of Verification Test Results St Dev for AC-Verif Tests for Surface A, B, & C Mix Types – Original Data Set

<table>
<tr><th>Mix Type</th><th>No. of Tests</th><th>St Dev</th><th>P-value+ Bartlett's</th><th>P-value+ Levene's</th></tr>
<tr><td>Surf A</td><td>259</td><td>0.270</td><td rowspan="3">0.475</td><td rowspan="3">0.332</td></tr>
<tr><td>Surf B</td><td>155</td><td>0.294</td></tr>
<tr><td>Surf C</td><td>23</td><td>0.270</td></tr>
<tr><td>Total</td><td>437</td><td></td><td></td><td></td></tr>
</table>

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 7.6. Comparison of Verification Test Results St Dev for AC-Contr Tests for Surface A, B, & C Mix Types – Original Data Set

Mix Type	No. of Tests	St Dev	P-value⁺ Bartlett's	P-value⁺ Levene's
Surf A	235	0.252	0.221	0.864
Surf B	129	0.256		
Surf C	23	0.325		
Total	**387**			

⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 7.7. t-Test Comparison of Verification Test Results for AC-Verif vs. AC-Contr for Surface A, B, & C Mix Types – Original Data Set

Mix Type	Test Type	No. of Tests	Mean	St Dev	P-value⁺
Surf A	AC-Verif	259	5.026	0.270	0.500
	AC-Contr	235	5.042	0.252	
Surf B	AC-Verif	155	5.089	0.294	0.830
	AC-Contr	129	5.082	0.256	
Surf C	AC-Verif	23	5.423	0.270	0.845
	AC-Contr	23	5.441	0.325	

⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 7.8-7.10 show the results of comparing the AV standard deviation values of the 3 Surface Mix Types. Table 7.8 shows that there is no significant difference among the Surface Mix Types for AV standard deviations for the SCDOT verification tests (AV-Verif). Table 7.9 shows that there is a significant difference among the 3 surface Mix Types in the Contractors' verification splits (AV-Contr). Finally, Table 7.10 shows that there is a significant difference between the means of the AV-Verif and AV-Contr tests for Surf A, but not for Surf B or Surf C.

Table 7.8. Comparison of Verification Test Results St Dev for AV-Verif Tests for Surface A, B, & C Mix Types – Original Data Set

Mix Type	No. of Tests	St Dev	P-value⁺ Bartlett's	P-value⁺ Levene's
Surf A	259	0.977	0.153	0.117
Surf B	155	0.900		
Surf C	23	0.724		
Total	**437**			

⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 7.9. Comparison of Verification Test Results St Dev for AV-Contr Tests for Surface A, B, & C Mix Types – Original Data Set

Mix Type	No. of Tests	St Dev	P-value+ Bartlett's	P-value+ Levene's
Surf A	235	0.730	**0.002**	**0.014**
Surf B	129	0.700		
Surf C	23	0.379		
Total	**387**			

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 7.10. t-Test Comparison of Verification Test Results for AV-Verif vs. AV-Contr for Surface A, B, & C Mix Types – Original Data Set

Mix Type	Test Type	No. of Tests	Mean	St Dev	P-value+
Surf A	AV-Verif	259	3.536	0.977	**0.039**
	AV-Contr	235	3.376	0.730	
Surf B	AV-Verif	155	3.333	0.900	0.495
	AV-Contr	129	3.398	0.700	
Surf C	AV-Verif	23	4.030	0.724	0.555
	AV-Contr	23	3.928	0.379	

+ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 7.11-7.13 shows the results of comparing the VMA standard deviation values of the 3 surface Mix Types. Table 7.11 shows that there is no significant difference among the surface Mix Types for VMA standard deviations for the SCDOT verification tests (VMA-Verif). Table 7.12 shows similar results for the Contractors' verification splits (VMA-Contr). Finally, Table 7.13 shows that there are no significant differences between the VMA means for the SCODT and Contractor split verification samples for any of the 3 surface Mix Types. These tables show that there is no reason to believe that either the means or variabilities of the VMA-Verif and VMA-Contr test results differ among the 3 Surface Mix Types.

Data by Project. Tables 7.14-7.16 show for AC, AV, and VMA, respectively, the distribution of test data among the 16 projects and their corresponding JMFs for which verification data were obtained.

A large amount of the data comes from a relatively small number of projects. As an example, Figure 7.1 shows the number of SCDOT AC verification tests on each project ranked from highest to lowest. This same information also is plotted as a CDf on a percentage basis in Figure 7.2. As can be seen in Figure 7.2, half of the SCDOT AC verification tests are from 5 of the 16 projects.

Table 7.11. Comparison of Verification Test Results St Dev for VMA-Verif Tests for Surface A, B, & C Mix Types – Original Data Set

Mix Type	No. of Tests	St Dev	P-value⁺ Bartlett's	P-value⁺ Levene's
Surf A	259	0.833	0.178	0.171
Surf B	155	0.750		
Surf C	23	0.662		
Total	**437**			

⁺ Values in **bold** are statistically significantly different at the $\alpha = 0.05$ level.

Table 7.12. Comparison of Verification Test Results St Dev for VMA-Contr Tests for Surface A, B, & C Mix Types – Original Data Set

Mix Type	No. of Tests	St Dev	P-value⁺ Bartlett's	P-value⁺ Levene's
Surf A	235	0.830	0.888	0.900
Surf B	129	0.802		
Surf C	23	0.794		
Total	**387**			

⁺ Values in **bold** are statistically significantly different at the α= 0.05 level.

Table 7.13. t-Test Comparison of Verification Test Results for VMA-Verif vs. VMA-Contr for Surface A, B, & C Mix Types – Original Data Set

Mix Type	Test Type	No. of Tests	Mean	St Dev	P-value⁺
Surf A	VMA-Verif	259	15.106	0.833	0.059
	VMA-Contr	235	14.965	0.830	
Surf B	VMA-Verif	155	15.064	0.750	0.833
	VMA-Contr	129	15.084	0.802	
Surf C	VMA-Verif	23	16.467	0.662	0.625
	VMA-Contr	23	16.360	0.794	

⁺ Values in **bold** are statistically significantly different at the α= 0.05 level.

Table 7.14. Summary of All Verification Test Results for AC by Project and JMF – Original Data Set

Proj	JMF	Verif Tests	Contr Tests	Verif Tests on Proj	Contr Tests on Proj	Mix Type
V01	J01	30	29	30	29	Surf B
V02	J02	8	8	31	30	Surf A
	J03	23	22			Surf A
V03	J03	29	29	29	29	Surf A
V04	J01	25	23	25	23	Surf B
V05	J07	15	0	47	2	Interm C
	J08	9	0			Surf B
	J09	10	0			Surf B
	J10	9	0			Surf E
	J11	4	2			Surf E
V06	J12	40	23	40	23	Surf A
V07	J14	9	0	9	0	Surf A
V08	J15	18	14	18	14	Surf B
V09	J16	11	11	15	15	Surf A
	J17	4	4			Surf A
V10	J18	10	10	20	20	Surf A
	J20	2	2			Surf B
	J21	4	4			Surf B
	J22	4	4			Surf C
V11	J24	31	34	31	34	Surf A
V14	J62	20	20	64	64	Surf A
	J63	44	44			Surf A
V16	J77	20	20	28	28	Base A
	J78	2	2			Base A
	J79	3	3			Surf C
	J80	3	3			Surf C
V17	J81	2	2	13	13	Surf C
	J82	11	11			Surf C
V18	J84	32	32	62	62	Surf B
	J85	30	30			Surf A
V19	J86	25	25	25	25	Surf B
Total		**487**	**411**	**487**	**411**	

Table 7.15. Summary of All Verification Test Results for AV by Project and JMF – Original Data Set

Proj	JMF	Verif Tests	Contr Tests	Verif Tests on Proj	Contr Tests on Proj	Mix Type
V01	J01	30	29	30	29	Surf B
V02	J02	8	8	31	30	Surf A
	J03	23	22			Surf A
V03	J03	29	29	29	29	Surf A
V04	J01	25	23	25	23	Surf B
V05	J07	15	0	34	0	Interm C
	J08	9	0			Surf B
	J09	10	0			Surf B
	J10	0	0			Surf E
	J11	0	0			Surf E
V06	J12	40	23	40	23	Surf A
V07	J14	9	0	9	0	Surf A
V08	J15	18	14	18	14	Surf B
V09	J16	11	11	15	15	Surf A
	J17	4	4			Surf A
V10	J18	10	10	20	20	Surf A
	J20	2	2			Surf B
	J21	4	4			Surf B
	J22	4	4			Surf C
V11	J24	31	34	31	34	Surf A
V14	J62	20	20	64	64	Surf A
	J63	44	44			Surf A
V16	J77	0	0	6	6	Base A
	J78	0	0			Base A
	J79	3	3			Surf C
	J80	3	3			Surf C
V17	J81	2	2	13	13	Surf C
	J82	11	11			Surf C
V18	J84	32	32	62	62	Surf B
	J85	30	30			Surf A
V19	J86	25	25	25	25	Surf B
Total		**452**	**387**	**452**	**387**	

Table 7.16. Summary of All Verification Test Results for VMA by Project and JMF – Original Data Set

Proj	JMF	Verif Tests	Contr Tests	Verif Tests on Proj	Contr Tests on Proj	Mix Type
V01	J01	30	29	30	29	Surf B
V02	J02	8	8	31	30	Surf A
	J03	23	22			Surf A
V03	J03	29	29	29	29	Surf A
V04	J01	25	23	25	23	Surf B
V05	J07	15	0	34	0	Interm C
	J08	9	0			Surf B
	J09	10	0			Surf B
	J10	0	0			Surf E
	J11	0	0			Surf E
V06	J12	40	23	40	23	Surf A
V07	J14	9	0	9	0	Surf A
V08	J15	18	14	18	14	Surf B
V09	J16	11	11	15	15	Surf A
	J17	4	4			Surf A
V10	J18	10	10	20	20	Surf A
	J20	2	2			Surf B
	J21	4	4			Surf B
	J22	4	4			Surf C
V11	J24	31	34	31	34	Surf A
V14	J62	20	20	64	64	Surf A
	J63	44	44			Surf A
V16	J77	0	0	6	6	Base A
	J78	0	0			Base A
	J79	3	3			Surf C
	J80	3	3			Surf C
V17	J81	2	2	13	13	Surf C
	J82	11	11			Surf C
V18	J84	32	32	62	62	Surf B
	J85	30	30			Surf A
V19	J86	25	25	25	25	Surf B
Total		**452**	**387**	**452**	**387**	

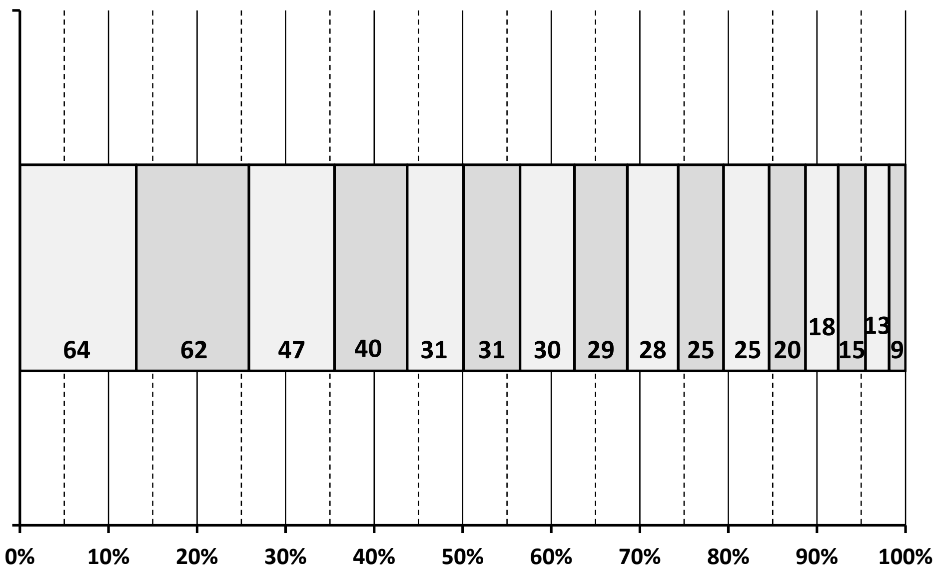

Figure 7.1. SCDOT AC Verification Test Results by Project – Original Data Set

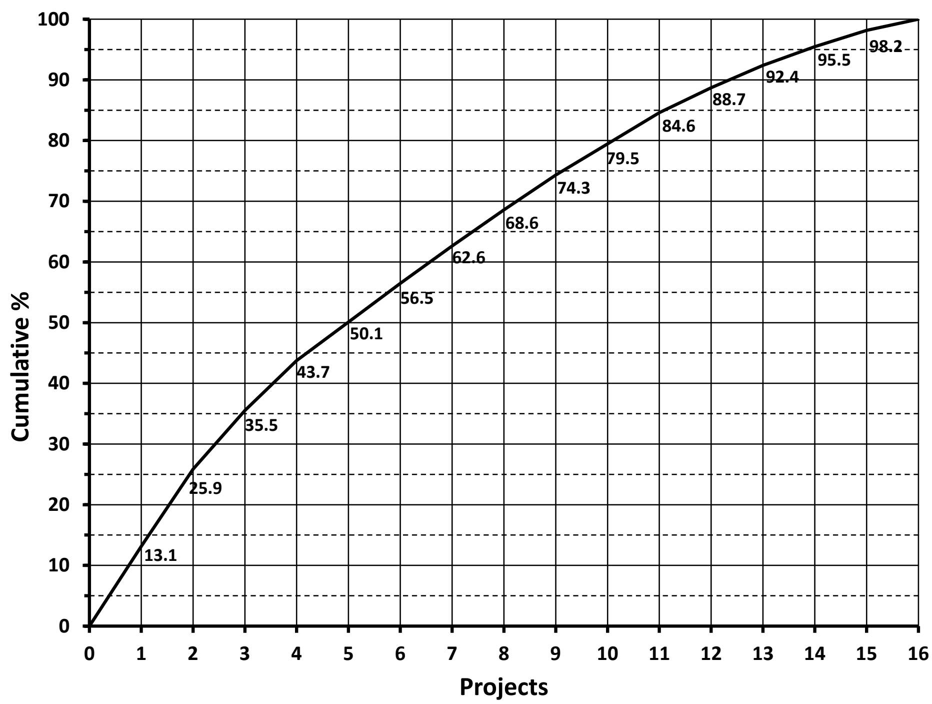

Figure 7.2. CDF of SCDOT AC Verification Test Results by Project – Original Data Set

Data by Contractor. Another concern with the provided verification test result data is the limited number of Contractors on the projects from which data were supplied. While at least some data were obtained from 16 projects, only 7 different contractors were represented on these projects. Figure 7.3 shows the breakdown of project data by Contractor. One of the 7 Contractors performed 6 (37.5%) of the projects for which data were obtained.

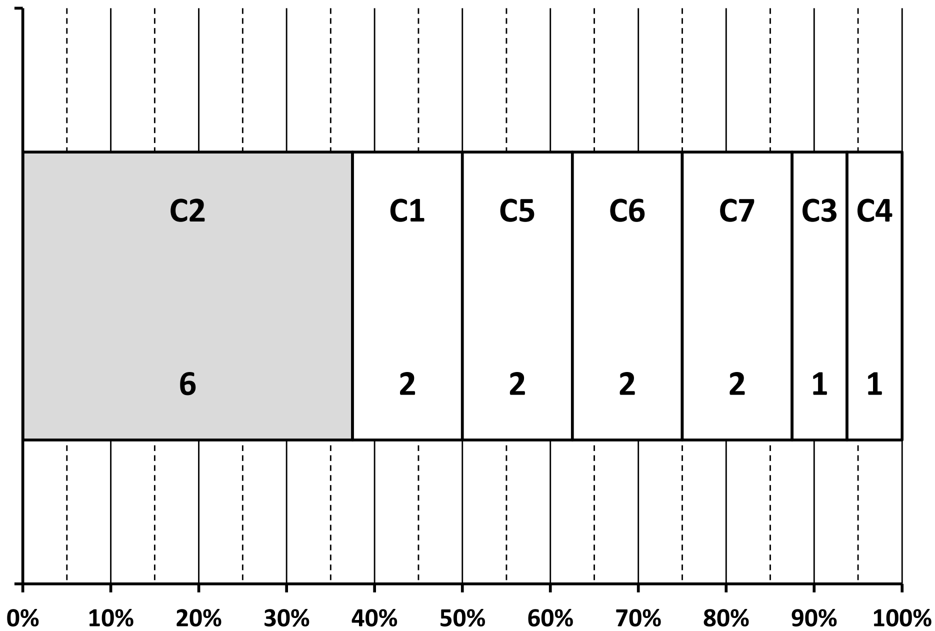

Figure 7.3. SCDOT AC Verification Test Results by Contractor – Original Data Set

Final Verification Analysis Data Set

As shown in Table 7.4, and for convenience repeated here as Table 7.17, there were not sufficient Base and Intermediate course data to allow for any meaningful analyses. For similar reasons the Surface E Mix Type was eliminated from further analyses. While there were 23 SCDOT verification tests for the Surface C Mix Type, there was concern that this number was not sufficient, and it was decided to consider only Surface A and Surface B mixes in the final Analysis data set.

Table 7.17. Summary of Verification Test Results by Mix Type – Original Data Set

Project	AC Verif	AC Contr	AV Verif	AV Contr	VMA Verif	VMA Contr
Base A	22	22	0	0	0	0
Interm C	15	0	15	0	15	0
Surf A	259	235	259	235	259	235
Surf B	155	129	155	129	155	129
Surf C	23	23	23	23	23	23
Surf E	13	2	0	0		
	487	**411**	**452**	**387**	**452**	**387**

Note: this is the same table as Table 7.4.

Verification Test Data

As noted above, SCDOT provided verification test results for 16 of the 20 Projects. However, after some Mix Types were eliminated from analysis due to small data sets, the final Analysis data set included SCDOT and Contractor verification data from 12 Projects.

Table 7.18 presents a summary of the verification data sets for AC. A total of 55 different data sets were compared, with the number of Lots in the verification data set varying from 3 to 7, with 5 being the most common.

In the table, the Lots with the X **+** Y format indicate cases where the final comparison data set had fewer than 7 tests (the number before the **+** sign) to which a number of Lots (the number after the **+** sign) that had been used in previous comparisons were added to make a total of at least 7 tests.

The number of contractor tests in the comparisons varied from as few as 12 to as many as 41. The X **+** Y format is again used to indicate the number of new Lots/tests and previously used Lots/tests in the comparison.

Since there is no way of knowing whether or not the SCDOT and Contractor verification split samples actually were equivalent or different, the primary use for Table 7.18 is to determine a distribution for how many verification data sets were on each Project, as well as how many Lots, SCDOT tests, and Contractor tests were used in each comparison. This distribution information is presented in Figures 7.4-7.6.

Figure 7.4 shows that 9 of the 12 Projects had 4 or more verification data sets on the Project. Figure 7.5 shows that 40 of 55 Projects had 4 or 5 Lots in their verification data sets. Since 7 was the minimum number allowed, all of the verification data sets had at least 7 SCDOT tests. The breakdown shows that 34 times there were 7 tests and 18 times there were 8 tests in the verification data sets. All but 6 of the data sets had 25 or fewer Contractor tests. While the numbers of tests were not identical for AC, AV, and VMA, the AC numbers are representative of the typical values.

Table 7.18. Summary of the Verification Comparison Data Set Sizes for AC

Project No.	Mix Type	No. of Verification Data Sets+	No. of Lots	No. of SCDOT Tests	No. of Contractor Tests
V01	Surf B	**5**	6	7	15
			7	7	12
			6	7	15
			7	7	19
			2 + 5*	2 + 5*	3 + 11*
V02	Surf A	4	3	8	13
			4	8	16
			4	8	13
			5	7	23
V03	Surf A	4	5	7	17
			5	7	22
			5	7	19
			5	8	15
V04	Surf B	**4**	5	7	16
			4	7	19
			5	7	24
			4 + 3*	4 + 4*	14 + 9*
V06	Surf A	**6**	5	7	18
			4	7	14
			5	8	17
			4	7	14
			5	8	21
			2 + 2*	3 + 4*	5 + 9*
V08	Surf A	**3**	5	7	40
			4	8	17
			4 + 1*	5 + 2*	19 + 6*
V09	Surf A	2	5	7	18
			7	8	41
V10	Surf A	1	5	7	18
V11	Surf A	**5**	4	7	19
			5	7	15
			4	7	26
			4	8	16
			2 + 3*	2 + 6*	15 + 12*

Table is continued on the next page.

Table 7.18. Summary of the Verification Comparison Data Set Sizes for AC (*cont*)

Project No.	Mix Type	No. of Verification Data Sets[+]	No. of Lots	No. of SCDOT Tests	No. of Contractor Tests
V14	Surf A	**9**	5	8	20
			4	7	25
			5	7	19
			3	7	13
			3	8	14
			4	7	15
			4	7	22
			3	7	14
			4 + 1*	6 + 4*	19 + 6*
V18	Surf B	4	6	8	24
			4	8	21
			4	7	19
			6	9	25
	Surf A	4	4	8	14
			5	7	24
			5	7	20
			6	8	28
V19	Surf B	**4**	5	7	26
			5	9	14
			5	7	17
			2 + 4*	2 + 6*	4 + 14*
Total		**55**			

[+] For numbers in bold, the final verification data set included test results from the previous verification data set so as to have at least 7 verification test results in the comparison.

* the second number refers to Lots/tests from the previous verification data set that were repeated in the current data set so as to have at least 7 verification test results in the comparison.

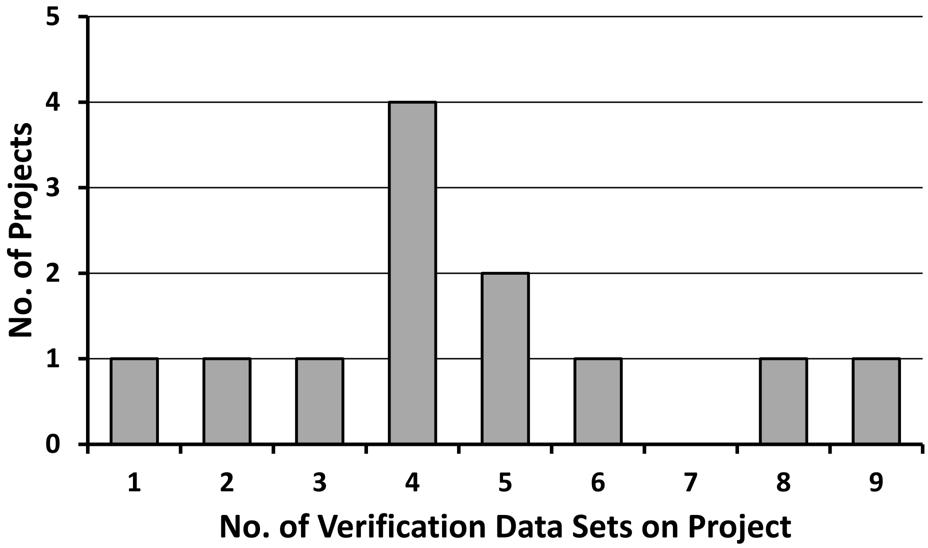

Figure 7.4. Number of Projects with Various Numbers of Verification Data Sets

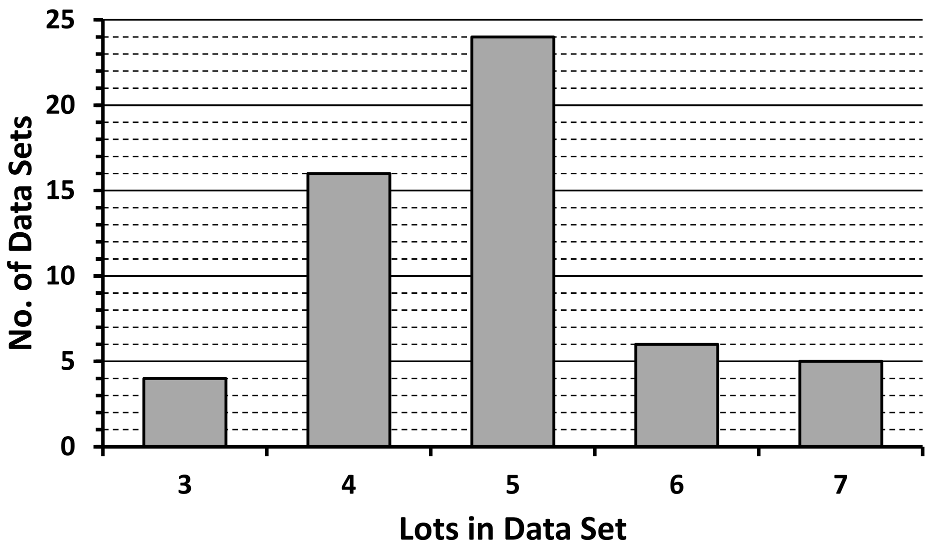

Figure 7.5. Number of Verification Data Sets with Various Numbers of Lots

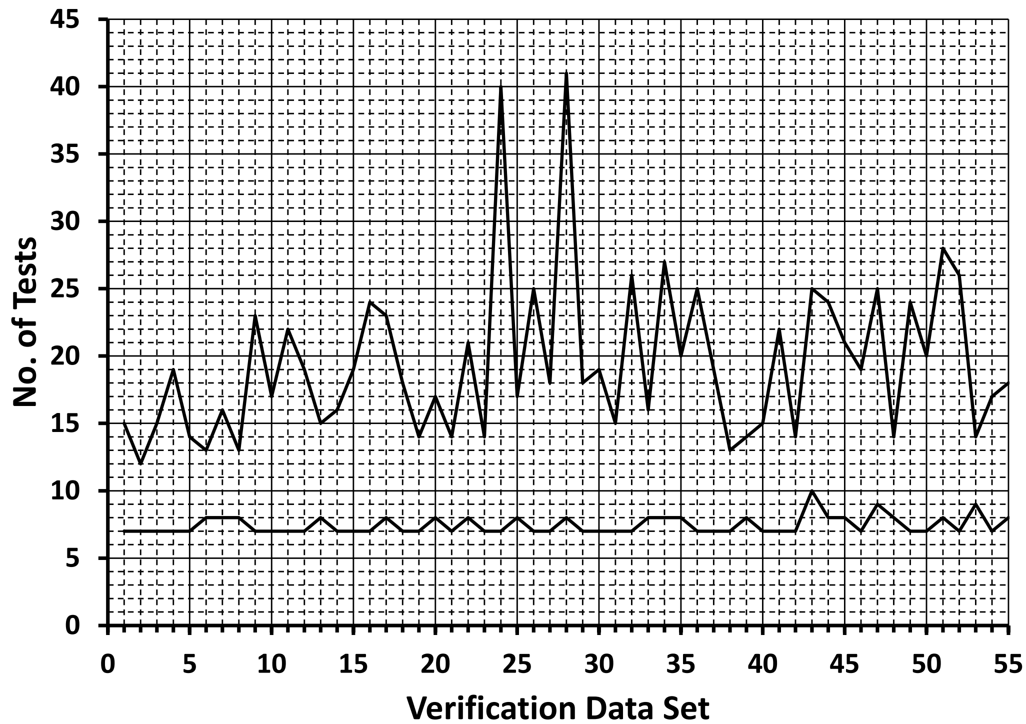

Figure 7.6. Number of SCDOT and Contractor Tests for Each Verification Data Set

Power of the Verification Comparisons for Differences in Standard Deviation

As noted above, SC-T-97 (07/12) requires the use of the F-test to compare the variances and the t-test to compare the means of the SCDOT verification tests and the Contractor acceptance tests. Statistically, the F-test is used to assess the size of the ratio of the variances and the t-test is used to assess the degree of difference in the means. A question that needs to be addressed is what power do these tests have, when used with small to moderate sized samples, to declare various differences in means and variances to be statistically significant differences. Power curves can be used to answer this question.

Power Curves for the F-test. In conducting an F-test it is necessary to select a level of significance, α, for the tests. For example, selecting $\alpha = 0.05$ means we are allowing up to a 5% chance of incorrectly deciding the variances are different when they really are the same. In SC-T-97 SCDOT uses $\alpha = 0.01$ as the level of significance. This makes it unlikely to incorrectly declare a difference when there is none, but it also makes it more difficult to declare a difference when one actually exists.

A statistical program called Piface (8) was used to develop the F-test power curves for various sample sizes that are consistent with those identified in Figure 7.6 for SCDOT Projects.

Selection of α Value. The first item to consider is the selection of the level of significance, α. SCDOT uses α = 0.01. This is beneficial for the Contractor since it limits to 0.01 (or 1%) the Contractor's risk of incorrectly having the variances declared different when in fact they are equal. However, the smaller the α value, the more difficult it is to declare the variances different when they are actually different.

This fact is illustrated in the power curves in Figure 7.7 for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$. In the figure, the horizontal axis is the ratio of the standard deviation values for the 2 populations. In this case, s_V is the standard deviation for the SCDOT verification tests (i.e., the smaller sample size n_V = 7) and s_C is the standard deviation for the Contractor acceptance tests (i.e., the larger sample size n_C = 20). The vertical axis represents the power (i.e., the probability of deciding that the variances are different).

When the standard deviations are actually equal (i.e., s_V / s_C = 1.0) the probability of declaring them different equals the level of significance, α. As the ratio of the standard deviations increases or decreases from 1.0, the probability of detecting the difference increases as the ratio increases or decreases. This leads to the shape of the curves shown in the Figure 7.7.

In the figure, the solid line is the power curve for α = 0.01 and the dashed line is the power curve for α = 0.05. As can be seen, the power for any given s_V / s_C ratio is much higher for the α = 0.05 curve than for the α = 0.01 curve. SCDOT currently uses α = 0.01 for the F-test. This means that there is less and a 0.4 (or 40%) chance of detecting the difference when the SCDOT standard deviation is twice as large as the Contractor's standard deviation. If the test were conducted at the α = 0.05 level, there would be nearly a 0.6 (or 60%) chance of detecting the same difference.

The situation is even worse if the SCDOT standard deviation is half as large as the Contractor's standard deviation. At the α = 0.01 level there is less and a 0.15 (or 15%) chance of detecting the difference, whereas the power increases to 0.4 (or 40%) for α = 0.05.

Figure 7.7 is a little more difficult to read accurately when the s_V / s_C ratio is less than 1 since the power values must all fit between ratios of 0 and 1. To make the power curves easier to read accurately, the range for s_V / s_C between 0 and 1 can be pLotted on a separate graph using the ratio s_C / s_V instead. In this way Figure 7.7 could be replaced by Figure 7.8(a) and 7.8(b). This avoids the problem of squeezing the power curve between 0 and 1.

For example, in Figure 7.7 when the Contractor's standard deviation is half as large as the SCDOT standard deviation, in Figure 7.8(b) this would correspond to an s_C / s_V ratio of 2.0. Figure 7.8(b) yields the same power for s_C / s_V = 2.0 as Figure 7.7 does for s_V / s_C = 0.5.

SCDOT should review the power curves in Figures 7.7 and 7.8 to determine whether they wish to consider switching to a value of α = 0.05 for their F-test comparison.

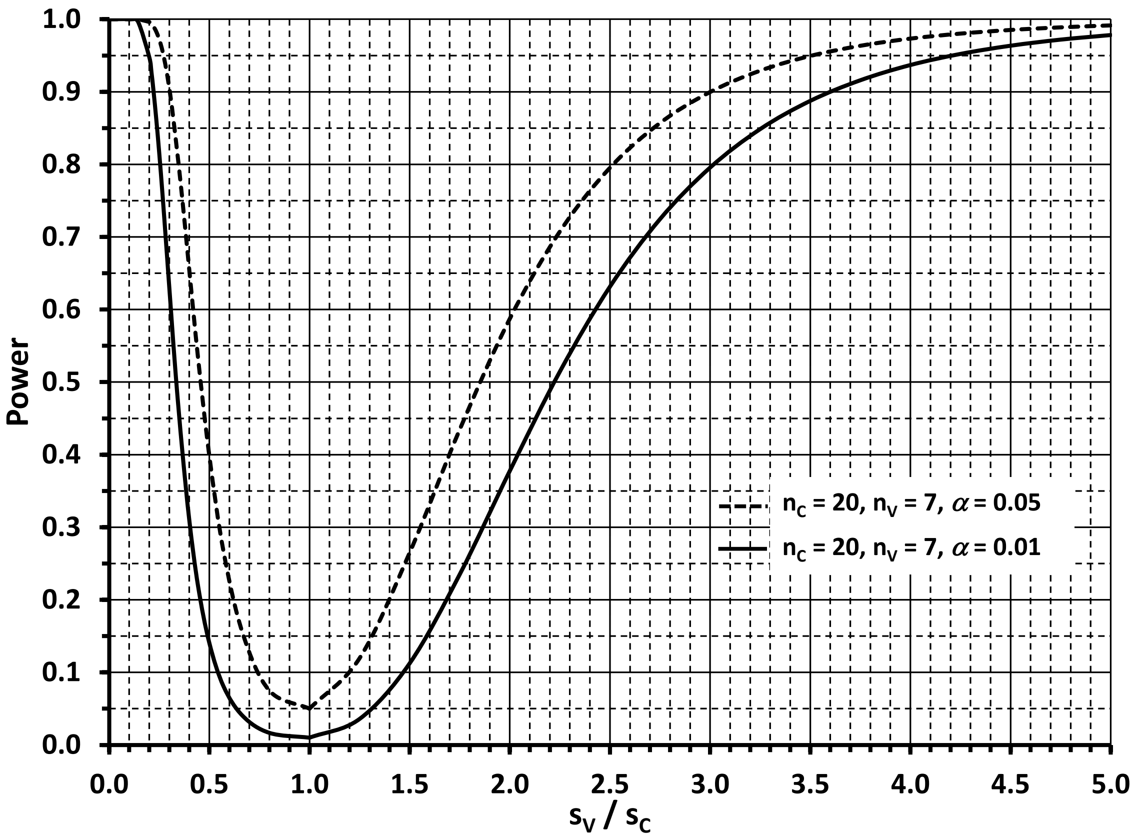

Figure 7.7. Power Curves for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$ for the F-test.

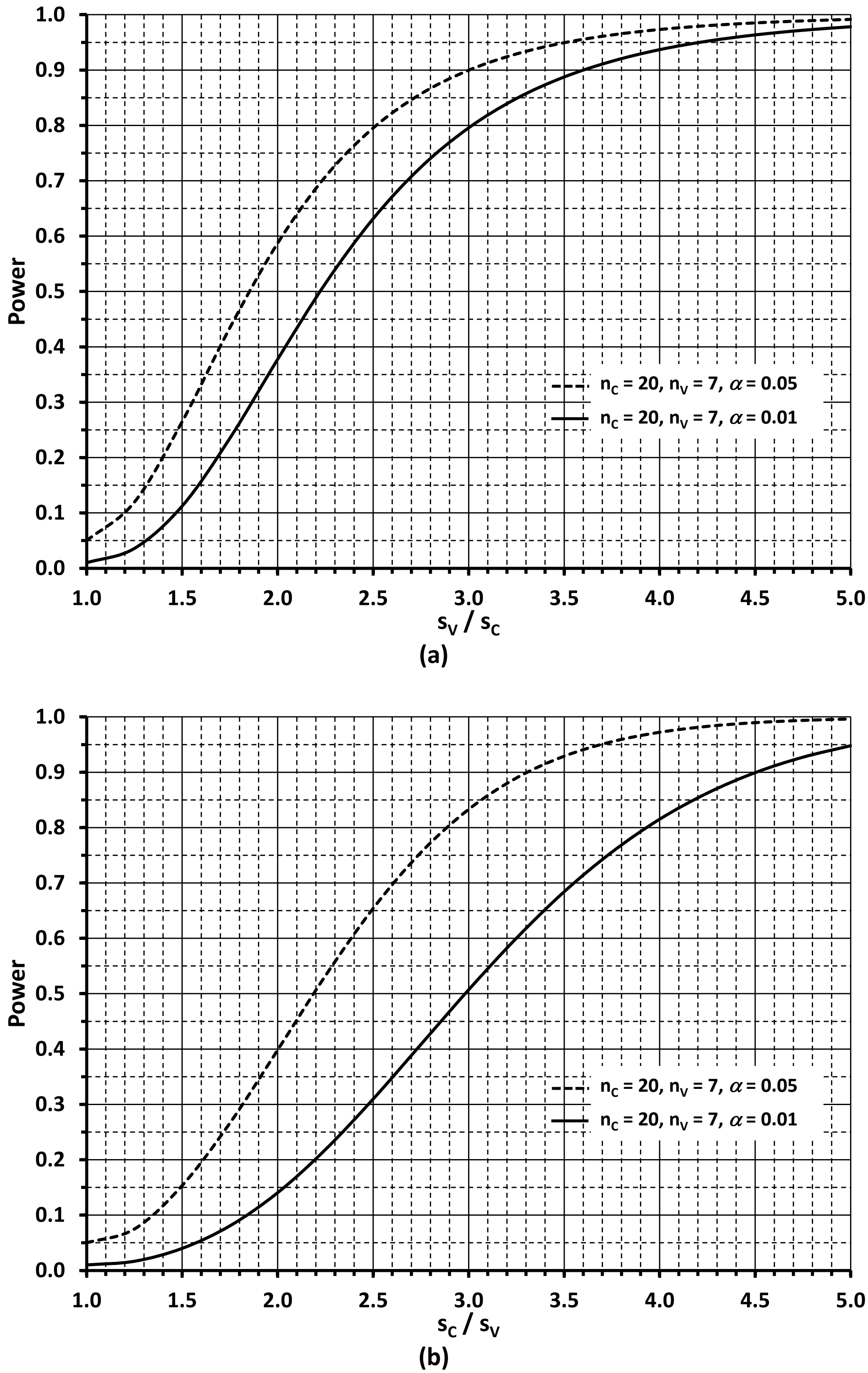

Figure 7.8. Power Curves for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$ for the F-test, s_V/s_C and s_C/s_V

Sample Sizes. Another item to consider is the effect of various sample sizes on the power of the F-test. Current SCDOT procedures provide for a minimum of 7 SCDOT verification tests before the F-test is conducted. Figure 7.6 shows that this number very often was 8 and that one time it was as high as 10. The smallest number of Contractor acceptance tests in the comparison was 12 and the largest was 41. All but 4 times the number of Contractor tests was below 25, with an average of 19.4.

To compare the impact of sample size, power curves for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$ were developed for Contractor sample sizes of n_C = 20, 25, and 30, and SCDOT sample sizes of n_V = 7, 8, and 10. These power curves are shown in Figures 7.9-7.11.

A comparison of these figures shows clearly that it is the smaller sample size (i.e., the SCDOT verification tests) that has the larger influence on the power of the F-test. For example, in Figure 7.9 there is a noticeable difference among the power curves as the verification sample size is increased from 7 to 8 to 10.

In Figures 7.10 and 7.11 there is not as big a difference in the power curves as the Contractor's acceptance sample is increased from 20 to 25 to 30. And, when the population of the verification tests has a smaller standard deviation than the population of the Contractor acceptance tests (i.e., $[s_V / s_C] < 1.0$) there is essentially no difference in power as n_c increases.

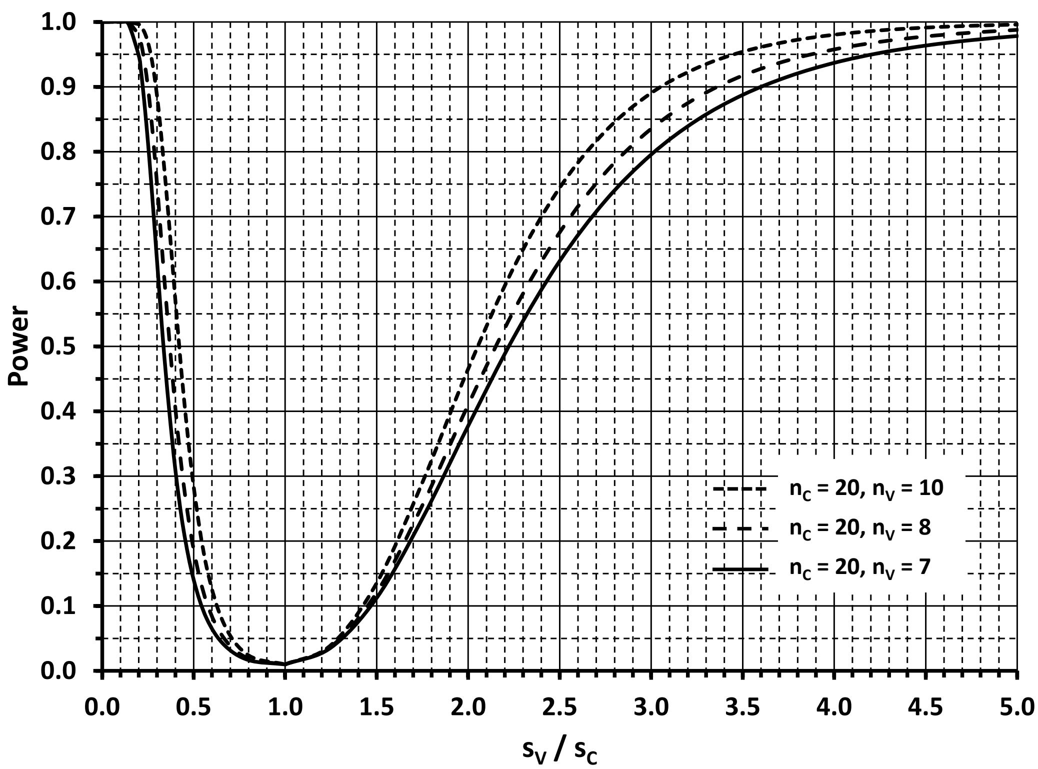

Figure 7.9. Power Curves for the F-test with n_c = 20 and n_v = 7, 8, & 10 for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$, α = 0.01

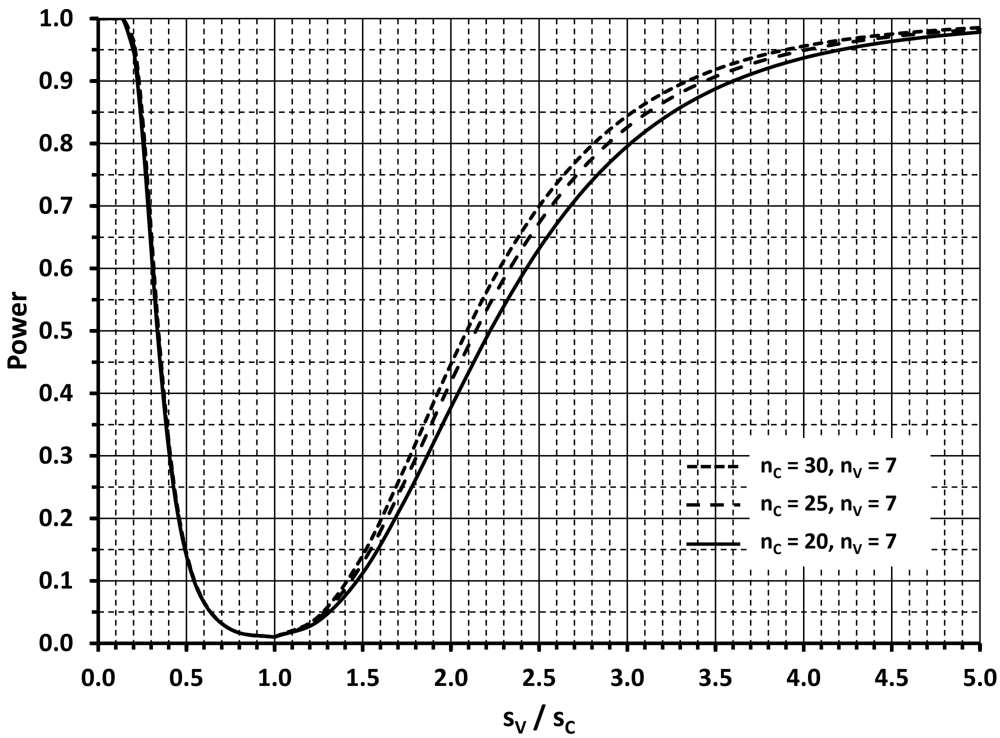

Figure 7.10. Power Curves for the F-test with n_v = 7 and n_C = 20, 25, & 30 for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$, $\alpha = 0.01$

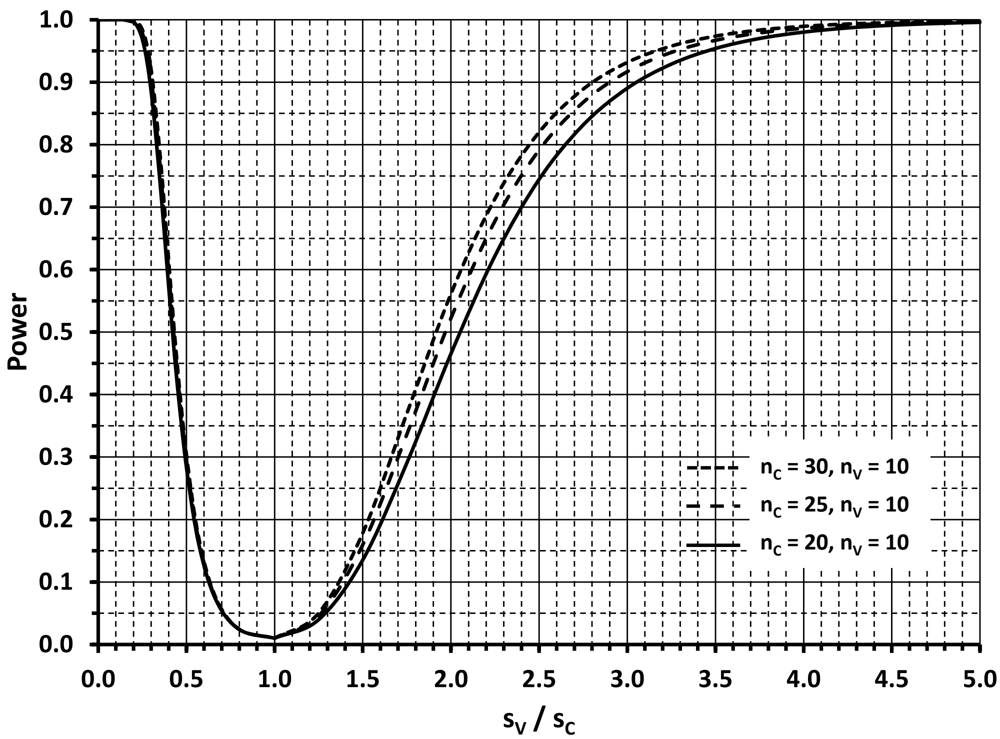

Figure 7.11. Power Curves for the F-test with n_v = 10 and n_C = 20, 25, & 30 for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$, $\alpha = 0.01$

For example, for n_C = 20 and s_V / s_C = 0.5 there is an increase in power of ±0.14 as n_V increases from 7 to 10. For n_V = 7 and s_V / s_C = 0.5 there is essentially no change in power as n_V increases from 20 to 30.

To investigate the effect of the level of significance used for the F-test, Figures 7-12-7.14 are the same as Figures 7.9-7.11 with the exception that α = 0.05 is used rather than α = 0.01. Comparing the figures shows clearly that there is a greater chance (0.05 or 5% when α = 0.05 vs. 0.01 or 1% when α = 0.01) of detecting a difference in variances when they actually are equal (i.e., when s_V / s_C = 1.0). This places more risk on the Contractor. However, the figures also show that when α = 0.05 the chances are much greater of detecting actual differences in variances than they are when α = 0.01. SCDOT should compare these figures and determine subjectively which level of significance they believe provides the best balance of risks to the Contractor and SCDOT.

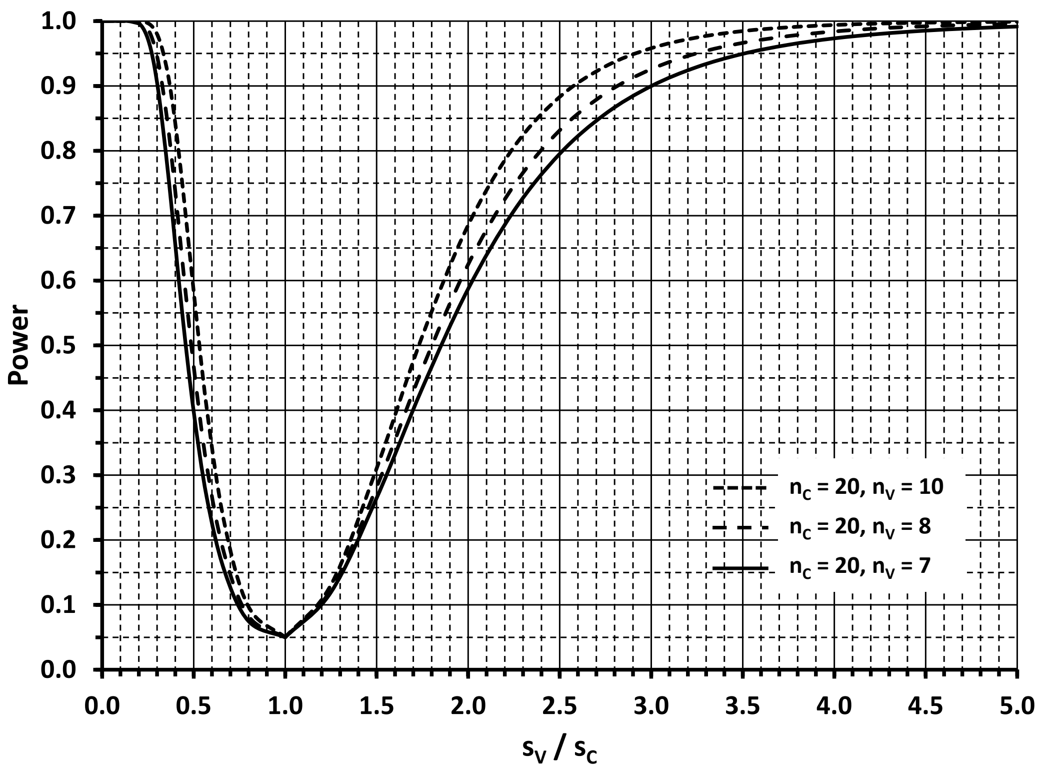

Figure 7.12. Power Curves for the F-test with n_c = 20 and n_v = 7, 8, & 10 for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$, α = 0.05

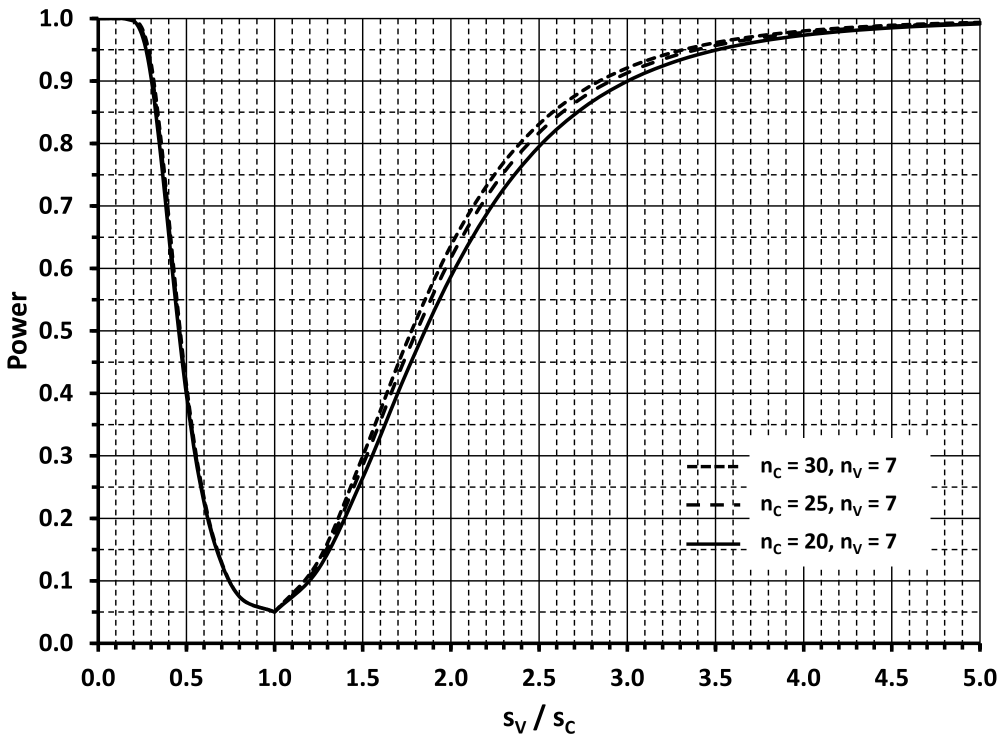

Figure 7.13. Power Curves for the F-test with n_v = 7 and n_C = 20, 25, & 30 for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$, $\alpha = 0.05$

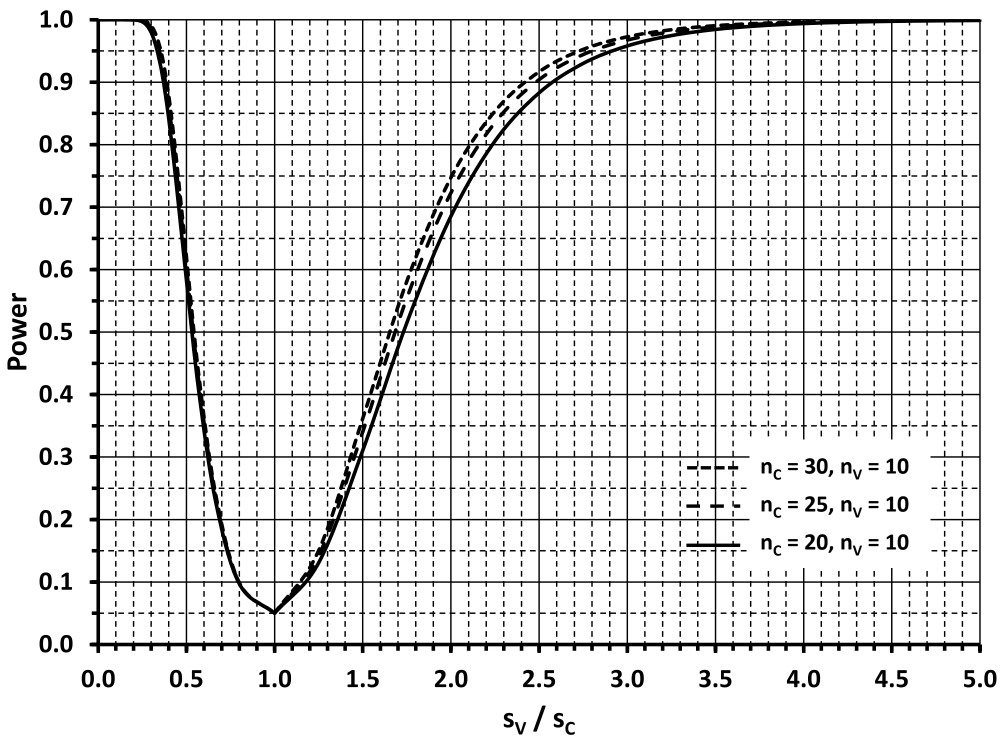

Figure 7.14. Power Curves for the F-test with n_v = 10 and n_C = 20, 25, & 30 for H_0: $s_c^2 = s_v^2$ and H_a: $s_c^2 \neq s_v^2$, $\alpha = 0.05$

Power of the Verification Comparisons for Differences in Mean

As noted above, SC-T-97 (07/12) requires the use of the F-test to compare the variances and the t-test to compare the means of the SCDOT verification tests and the Contractor acceptance tests. Statistically, the t-test is used to assess the degree of difference in the means. How the t-test is conducted depends upon what assumption is made concerning the variances of the populations that are being assessed. As stated in SC-T-97:

> *Two approaches for the t-test are necessary. If the sample variances are found to be equal from the F- Test, then the t-test is conducted based on the two samples using a pooled estimate for the variance and the pooled degrees of freedom. If the sample variances are found to be different from the F-Test, then the t-test is conducted using the individual sample variances, the individual sample sizes, and the effective degrees of freedom.*

Step-by-step procedures for performing the appropriate t-tests are provided in SC-T-97 and are not repeated here. However, a question that needs to be addressed is what power these tests have, with small to moderate sized samples, to declare various differences in means to be statistically significant differences. Power curves can be used to answer this question.

Power Curves for the t-Test. A statistical program called Piface (8) was used to develop the t-test power curves for various sample sizes that are consistent with those identified in Figure 7.6 for SCDOT Projects.

Selection of α Value. The first item to consider is the selection of the level of significance, α. SCDOT uses $\alpha = 0.01$ (see SC-T-97). This is beneficial for the Contractor since it limits to 0.01 the Contractor's risk of incorrectly having the means declared different when in fact they are equal. However, the smaller the α value, the more difficult it is to declare the means different when they are actually different.

This fact is illustrated in the power curves in Figure 7.15 for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$. The power curves are for the situation when the population standard deviations are unknown, but equal (i.e., $\sigma_C / \sigma_V = 1.0$). Figure 7.15 is based on using the t-test that assumes equal variances. In this figure the horizontal axis is the actual difference, measured in standard deviation units, between the means for the 2 populations. In this case, μ_V is the mean for the SCDOT verification tests (i.e., the smaller sample size, $n_V = 7$) and μ_C is the mean for the Contractor acceptance tests (i.e., the larger sample size, $n_C = 20$). The vertical axis represents the power (i.e., the probability of deciding that the means are different).

When the means are actually equal, i.e., $\mu_V - \mu_C = 0$, the probability of declaring them different equals the level of significance, α. As the difference between means increases from 0, the probability of detecting the difference increases. This leads to the shape of the curves shown in Figure 7.15.

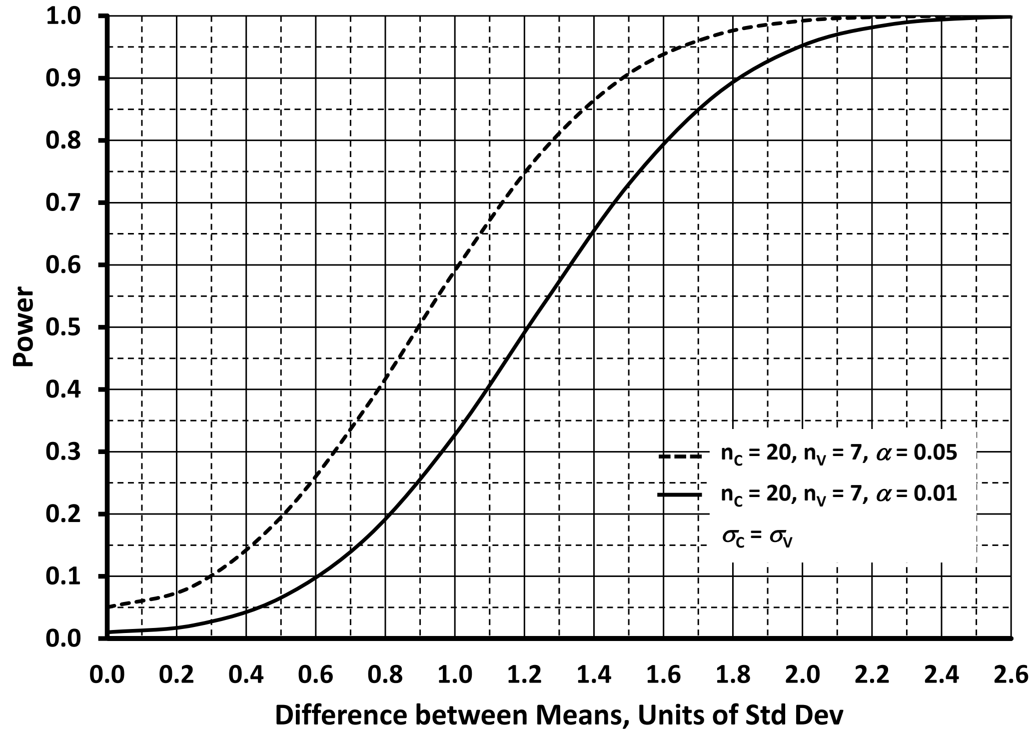

Figure 7.15. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for the t-Test Assuming Equal Variances, $\sigma_C = \sigma_V$

In the figure, the solid line is the power curve for α = 0.01 and the dashed line is the power curve for α = 0.05. As can be seen, the power for any given difference in means is much higher for the α = 0.05 curve than for the α = 0.01 curve. SCDOT currently uses α = 0.01 for the t-test. This means that there is less and a 0.35 (or 35%) chance of detecting the difference when the means are 1 standard deviation apart. If the test were conducted at the α = 0.05 level, there would be nearly a 0.6 (or 60%) chance of detecting the same difference.

In SC-T-97, if the F-test determined a difference, then the t-test for unequal variances is used. In this case the power curves will differ depending upon the ratio of the 2 standard deviations (i.e., σ_C / σ_V). Figure 7.16 shows power curves α = 0.05 and for various σ_C / σ_V ratios. The horizontal axis is the same as in Figure 7.15, except that the units are in terms of the Contractor's standard deviation. Figure 7.17 presents similar power curves for α = 0.01.

Figure 7.18 plots similar information as Figures 7.16 and 7.17. The curves are for n_C = 20 and n_V = 7. They also are for σ_C / σ_V = 2.0 and σ_C / σ_V = 0.5. In this way it is easy to compare directly the differences in the α = 0.01 and α = 0.05 power curves.

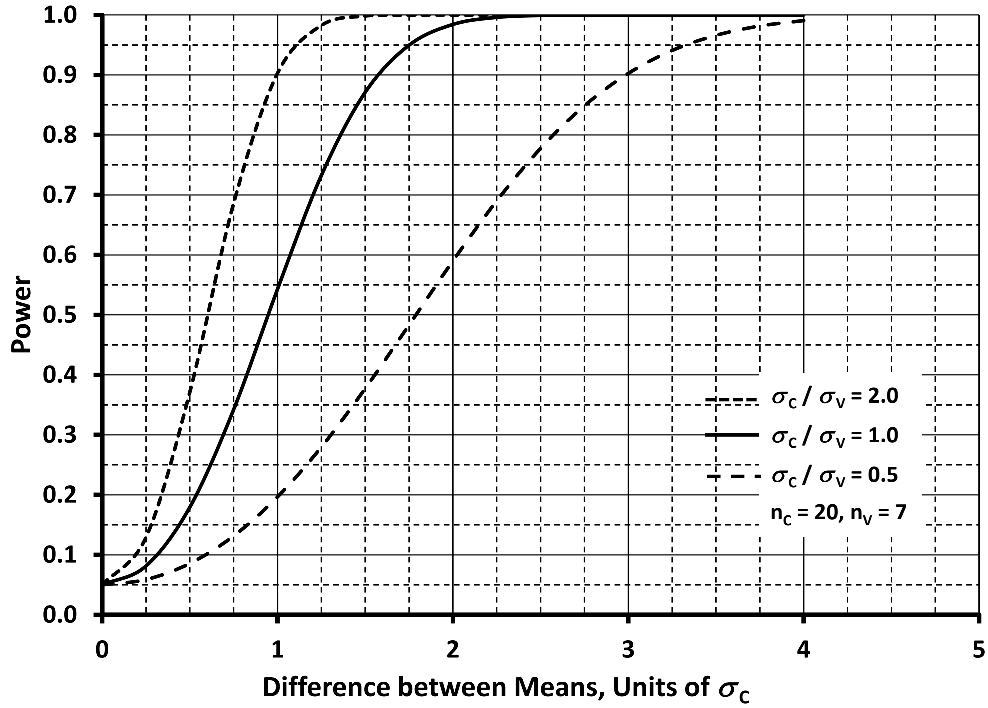

Figure 7.16. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for the t-Test Assuming Unequal Variances, $n_C = 20$, $n_V = 7$, $\alpha = 0.05$.

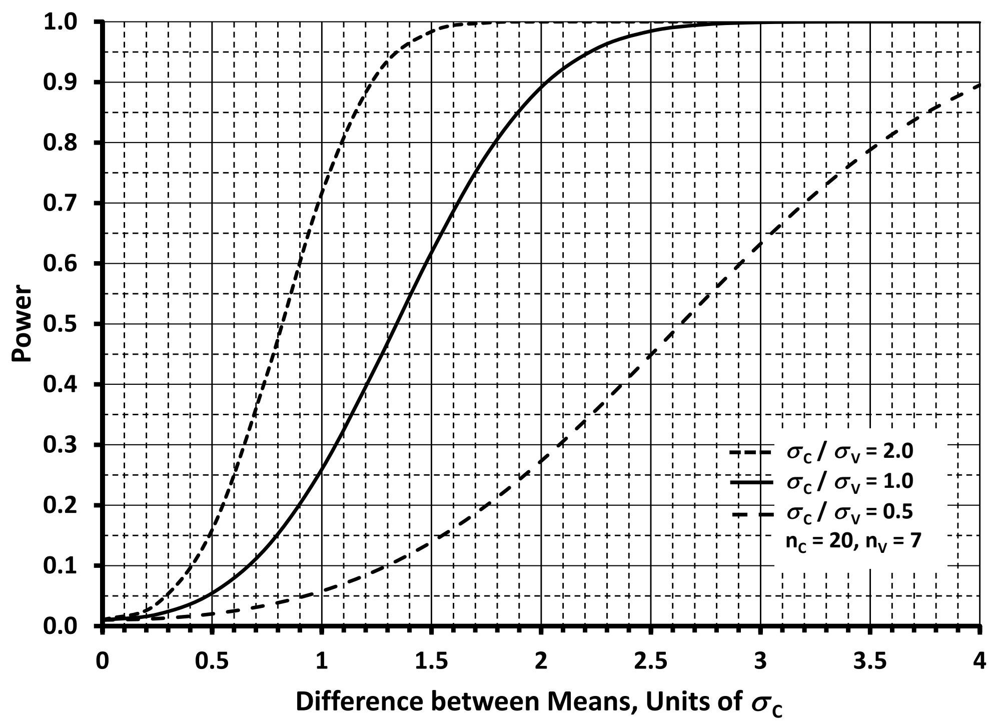

Figure 7.17. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for the t-Test Assuming Unequal Variances, $n_C = 20$, $n_V = 7$, $\alpha = 0.01$

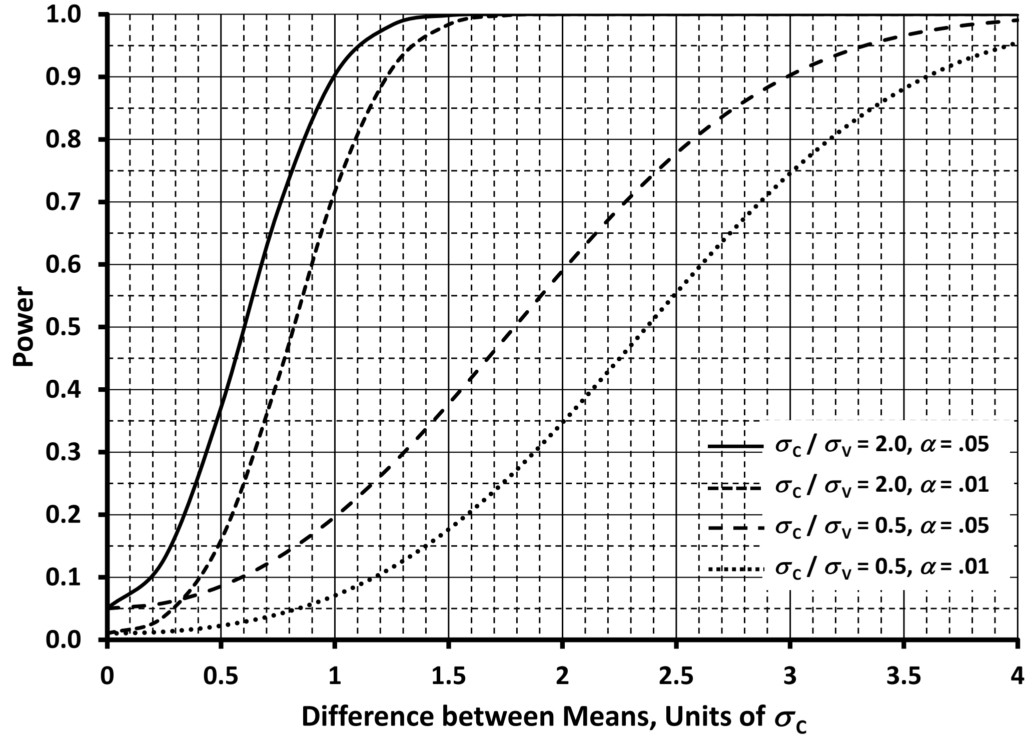

Figure 7.18. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for the t-Test Assuming Unequal Variances, $n_C = 20$, $n_V = 7$.

Revised Procedure for SC-T-97. Figures 7.7-7.13 demonstrate the relatively low power to detect differences in variances that the F-test has for the sample sizes typically encountered by SCDOT. This means that there may be many times that the F-test will not detect actual differences that exist between the variances of the Contractor's acceptance tests and the SCDOT verification tests.

In any F-test, if the variances are not declared different this does not mean that the 2 variances actually are equal. It simply means that the F-test did not detect a difference. As such, it is optimistic to use the t-test for equal variances simply because the F-test did not declare the variances to be different.

It is recommended that SCDOT consider using the t-test for unequal variances (often referred to as Welch's test) regardless of the outcome of the F-test. Ruxton (9) states the case for this approach:

> *If you want to compare the central tendency of 2 populations based on samples of unrelated data, then the unequal variance t-test should always be used in preference to the Student's t-test or Mann–Whitney U test.*

This approach would simplify the SC-T-97 comparison procedures and would not have a major difference on the power to detect differences between population means. Figure 7.19 shows the power curves for the equal variance test and the unequal variance test for n_C = 20, n_V = 7 and for n_C = 20, n_V = 10. The curves in this figure are for the case where $\sigma_C = \sigma_V$.

As the figure shows, there is not a major difference in power between the equal variance t-test and the unequal variance t-test when n_C = 20, n_V = 7. The maximum difference has the power of the unequal variance test about .05 (or 5%) lower than the equal variance test. For the case of n_C = 20, n_V = 10 essentially there is no difference in the power of the 2 test methods.

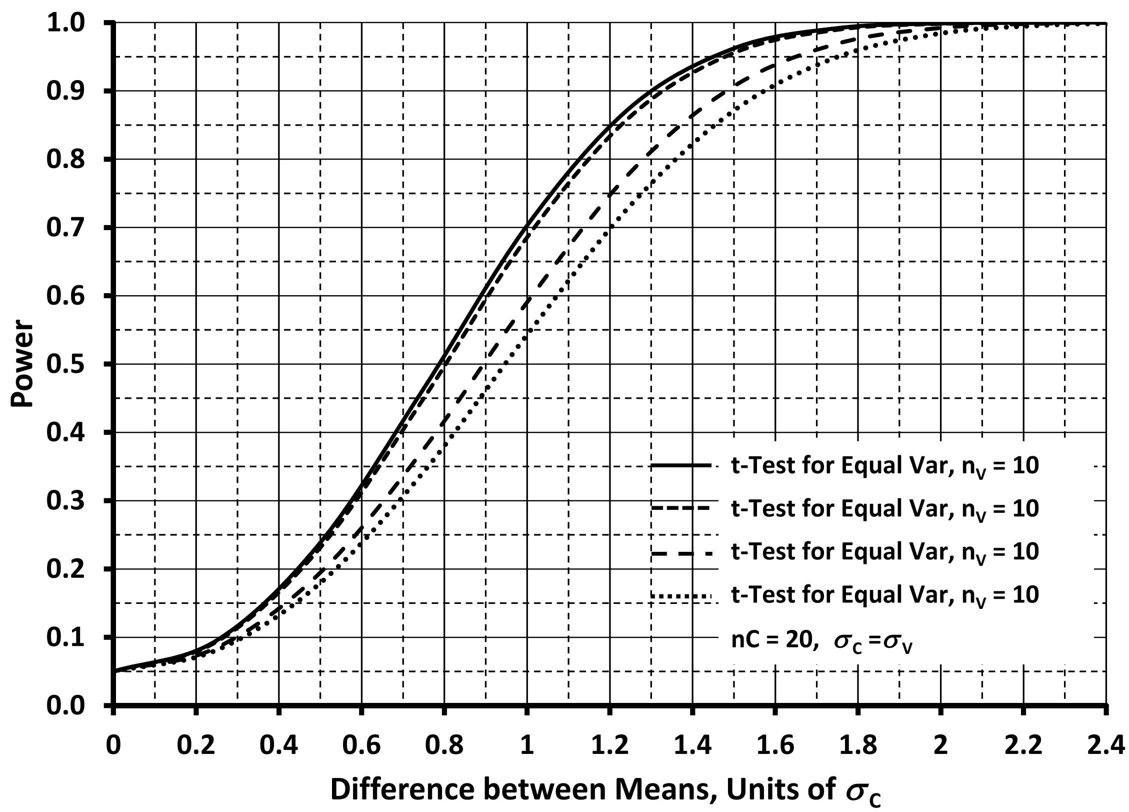

Figure 7.19. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for t-Tests Assuming Unequal Variances and Equal Variances, n_C = 20, $\sigma_C = \sigma_V$.

Power of the t-test for Unequal Variances. As illustrated in Figures 7.16-7.18, the power of the t-test for unequal variances is dependent upon the ratio of the standard deviations of the 2 populations whose means are being compared. It is clear in each of these figures that the power curves are dramatically different when the Contractor's (i.e., the larger sample size, n_C = 20) standard deviation is twice as large as the verification (i.e., the smaller sample size, n_V = 7) standard deviation than they are when the Contractor's standard deviation is half as large as the verification standard deviation.

Figures 7.20-7.22 help to demonstrate more thoroughly these differences in power. The figures represent the range from worst-case to best-case scenarios given the sample sizes that were typically found in the analysis data set. Each of the figures shows unequal variance t-test power curves for various standard deviation ratios. Figure 7.20 is for n_C = 20, n_V = 7; Figure 7.21 is for n_C = 25, n_V = 8, and Figure 7.22 is for n_C = 30, n_V = 10.

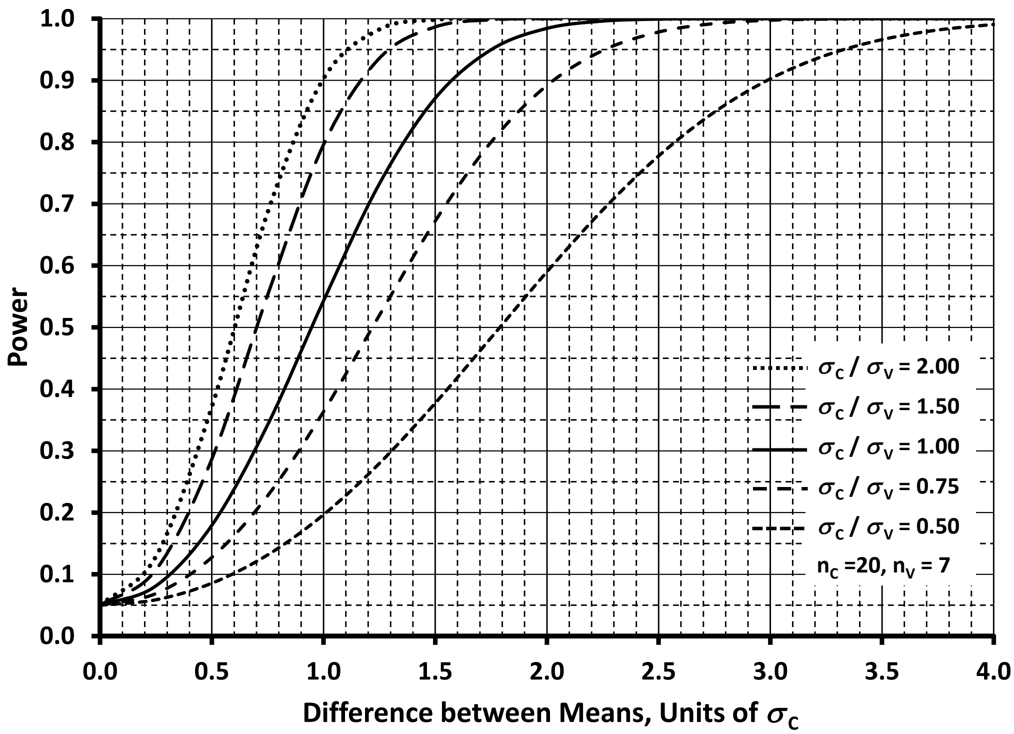

Figure 7.20. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for t-Tests Assuming Unequal Variances for Various σ_C / σ_V Ratios, n_C = 20, n_V = 7.

A review of Figures 7.20-7.22 clearly shows the large differences in power to detect differences in means as the relationship between the standard deviation of the Contractor's tests and that for the verification tests varies. For example, when n_C = 20 and n_V = 7 (see Figure 7.20) there is essentially a 1.0 (100%) chance of detecting a difference of $2\sigma_C$ units between population means when the Contractor's standard deviation is twice as large as the verification standard deviation. However, when the situation is reversed (i.e., the verification standard deviation is twice the Contractor's standard deviation) the power drops to less than 0.6 (60%).

For the case where n_C = 30 and n_V = 10 (see Figure 7.22), there is approximately a 0.96 (96%) chance of detecting a difference of $1\sigma_C$ unit between population means when the Contractor's standard deviation is twice as large as the verification standard deviation. When the situation is reversed, i.e., the verification standard deviation is twice the Contractor's standard deviation, the power drops to less than 0.3 (30%).

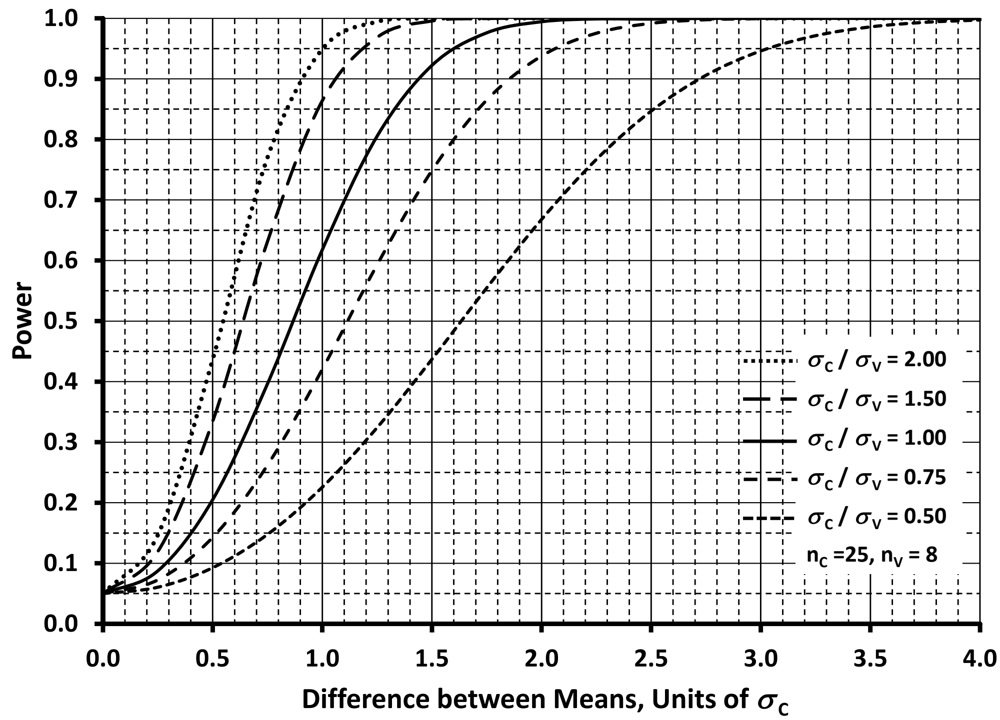

Figure 7.21. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for t-Tests Assuming Unequal Variances and for Various $\sigma_C = \sigma_V$ Ratios, n_C = 25, n_V = 8.

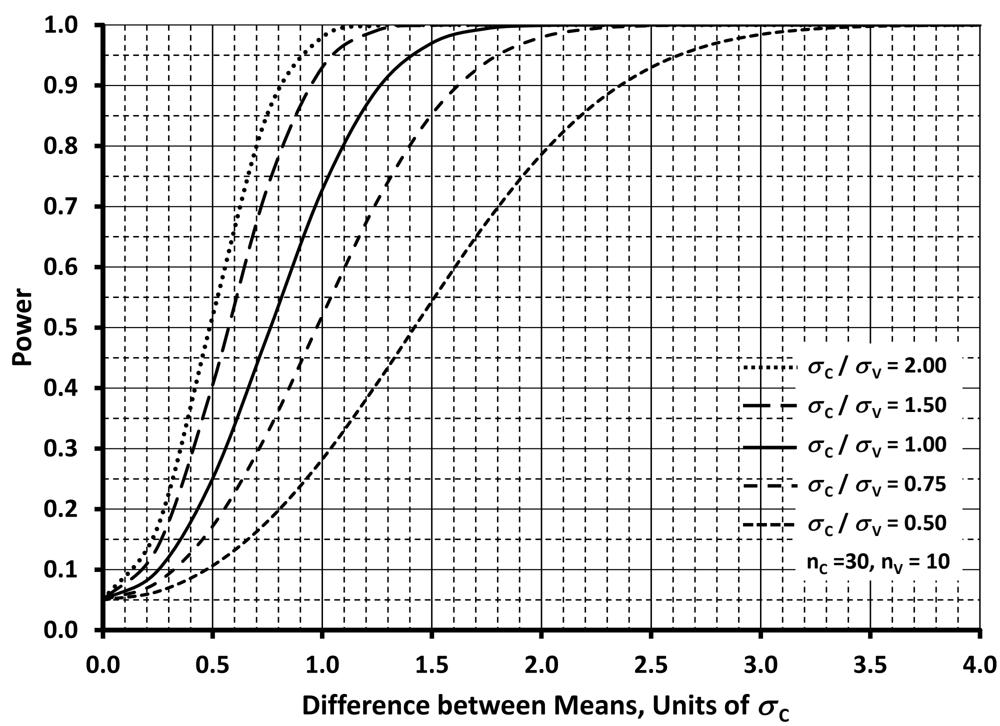

Figure 7.22. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for t-Tests Assuming Unequal Variances and for Various $\sigma_C = \sigma_V$ Ratios, n_C = 30, n_V = 10.

Sample Sizes. As shown above for the F-test, it is important to consider the effect of various sample sizes on the power of the t-test. All of the discussion and analyses regarding sample sizes for the t-test are based on the t-Test for unequal variances since that is the approach that is recommended in this report.

Current SCDOT procedures provide for a minimum of 7 SCDOT verification tests before the t-test is conducted. Figure 7.6 shows that this number very often was 8 and that one time it was a high as 10. The smallest number of Contractor acceptance tests in the comparison was 12 and the largest was 41. All but 4 times the number of Contractor tests was below 25, with an average of 19.4.

To compare the impact of sample size, power curves for $H_0 : \mu_C = \mu_V$ and $H_a : \mu_C \neq \mu_V$ were developed for Contractor sample sizes of n_C = 20, 25, and 30, and SCDOT sample sizes of n_V = 7, 8, and 10. Power curves were developed for σ_C / σ_V ratios of 0.5, 1.0, and 2.0.

Figure 7.23 shows for σ_C / σ_V = 1.0 power curves for n_C = 20 and n_V = 7, 8, and 10. The curves are shown for α = 0.01 and α = 0.05. There is a noticeable difference among the power curves as the verification sample size is increased from 7 to 8 to 10. The difference is greater for the α = 0.01 curves than for the α = 0.05 curves.

Figure 7.24 and 7.25 show results similar to Figure 7.23, but for σ_C / σ_V = 2.0 and σ_C / σ_V = 0.5, respectively. While the same trends are present, when σ_C / σ_V = 2.0 (see Figure 7.24) all the power curves are noticeably higher and also there is not as much difference in power as n_V varies from 7 to 8 to 10 when α = 0.01. When σ_C / σ_V = 0.5 (see Figure 7.25) all the power curves are considerably lower and there is more difference in power as n_V varies from 7 to 8 to 10 for both α = 0.01 and α = 0.05.

Of particular note for SCDOT, given that their current procedures use α = 0.01, is the fact that when α = 0.01 there is quite a bit less power than when α = 0.05. In fact, when α = 0.01 there is less power when n_V = 10 than there is when α = 0.05 and n_V = 7. For this reason, all subsequent pLots are based only on α = 0.05.

The issue of sample size is more involved for the t-test for unequal variances than it was for the F-test since the power curves vary so dramatically depending upon the σ_C / σ_V ratio. SCDOT will need to consider this fact when making the subjective decision concerning the balance between risks and sample size.

To compare the impact of sample size, power curves for $H_0 : \mu_C = \mu_V$ and $H_a : \mu_C \neq \mu_V$ were developed for Contractor sample sizes of n_C = 20, 25, and 30, and SCDOT verification sample size of n_V = 7 in Figure 7.26. Similarly, Figure 7.27 shows power curves for Contractor sample size n_C = 30 and for SCDOT verification sample sizes of n_V = 7, 8, and 10.

A comparison of these figures clearly shows that it is the smaller sample size, n_V, that has the larger influence on the power of the t-test for unequal variances. In Figure 7.26, when σ_C / σ_V = 0.5 or 1.0 there essentially is no difference in power as n_C is increased from 20 to 25 to 30, and there is very little difference for σ_C / σ_V = 2.0.

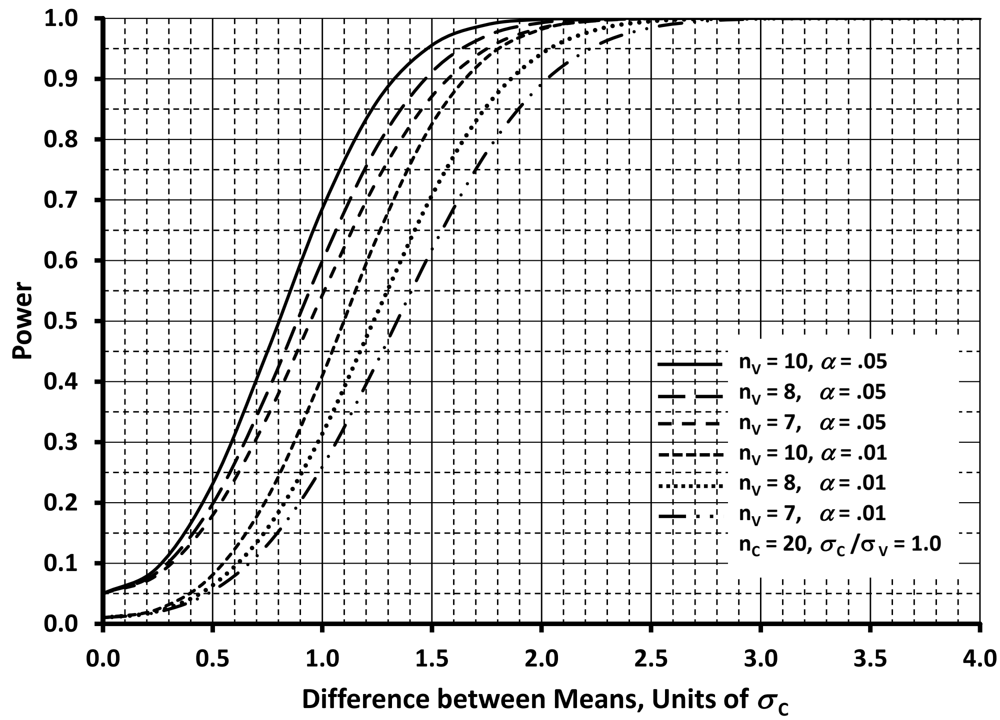

Figure 7.23. Power Curves for t-Tests Assuming for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ Assuming Unequal Variances and for σ_C / σ_V = 1.0, n_C = 20, n_V = 7, 8, 10.

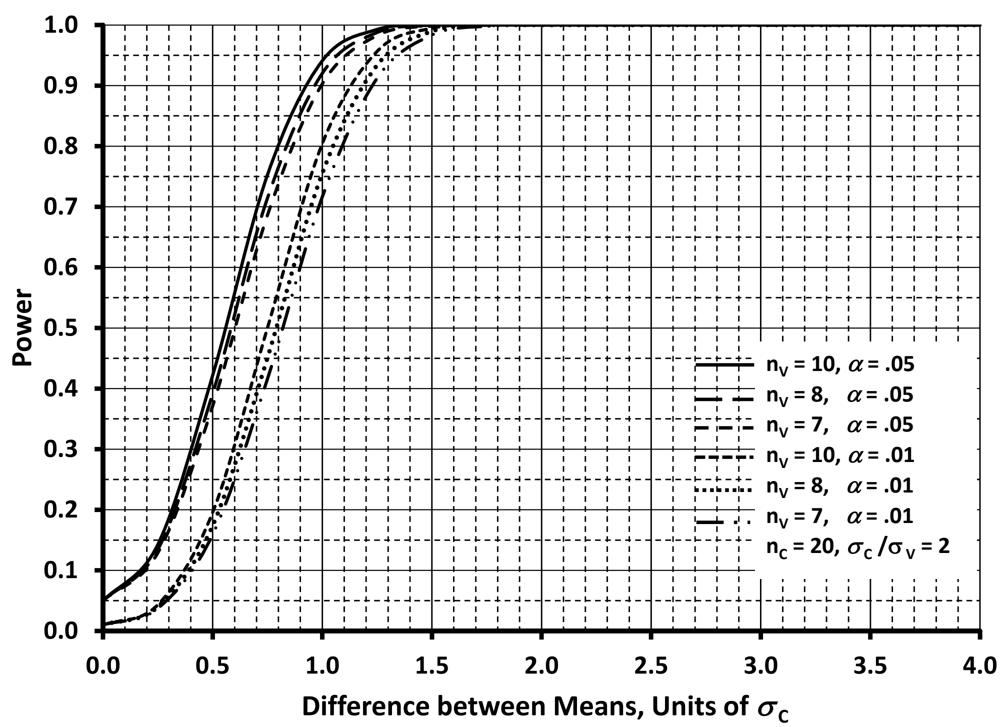

Figure 7.24. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for t-Tests Assuming Unequal Variances and for σ_C / σ_V = 2.0, n_C = 20, n_V = 7, 8, 10.

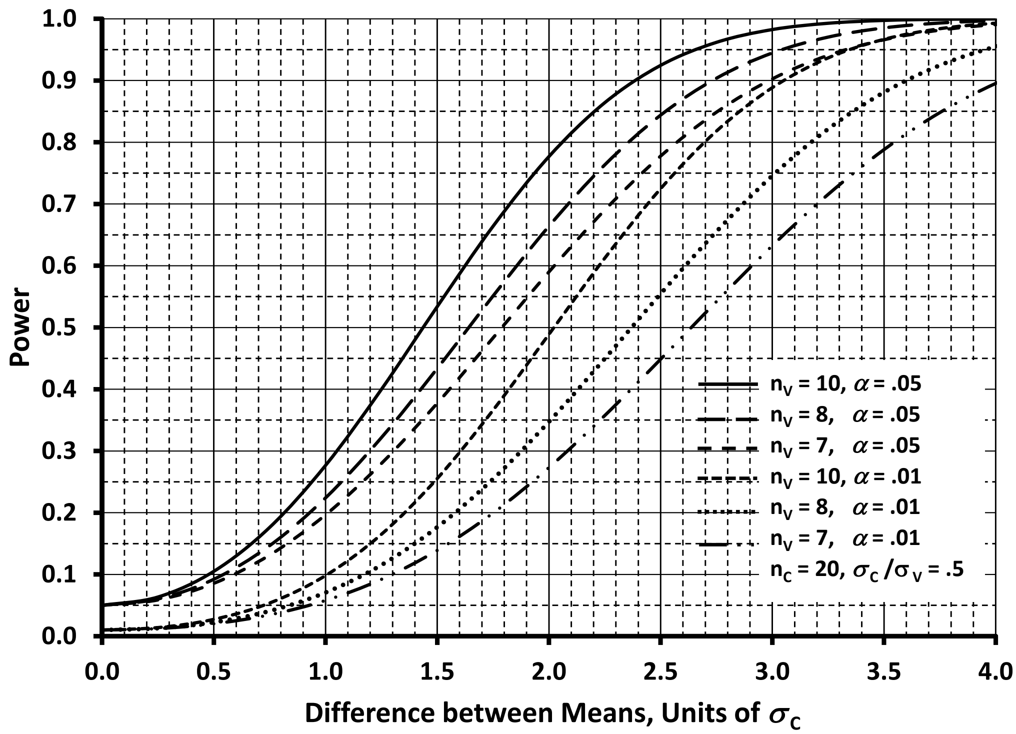

Figure 7.25. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for t-Tests Assuming Unequal Variances and for σ_C / σ_V = 0.5, n_C = 20, n_V = 7, 8, 10.

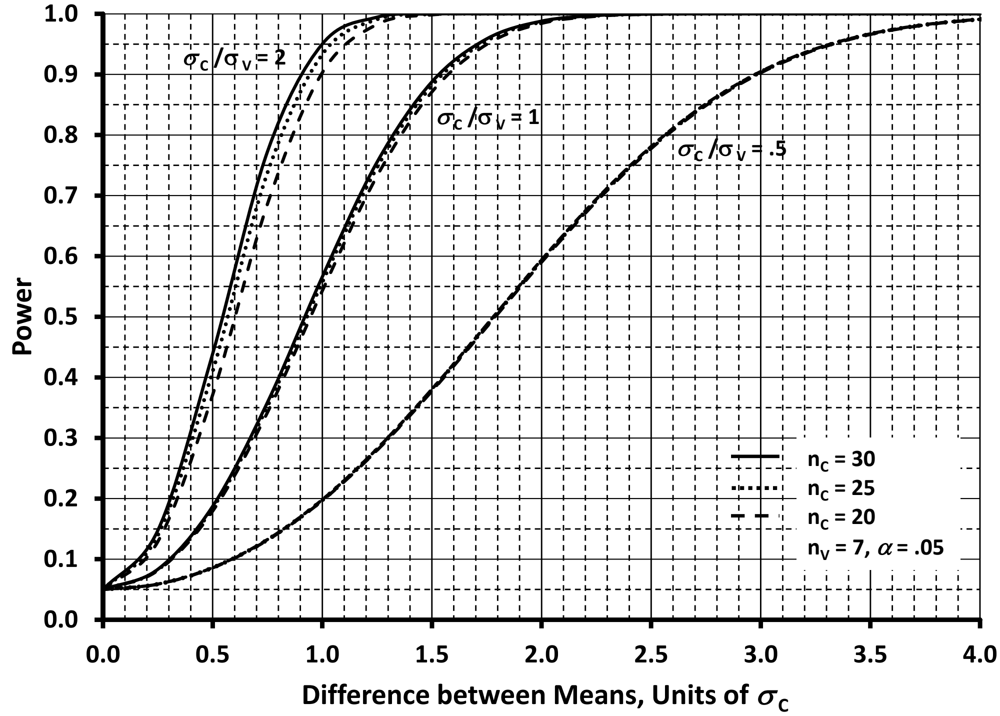

Figure 7.26. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for t-Tests Assuming Unequal Variances and for σ_C / σ_V = 0.5, 1.0, 2.0 and n_V = 7, n_C = 20, 25, 30.

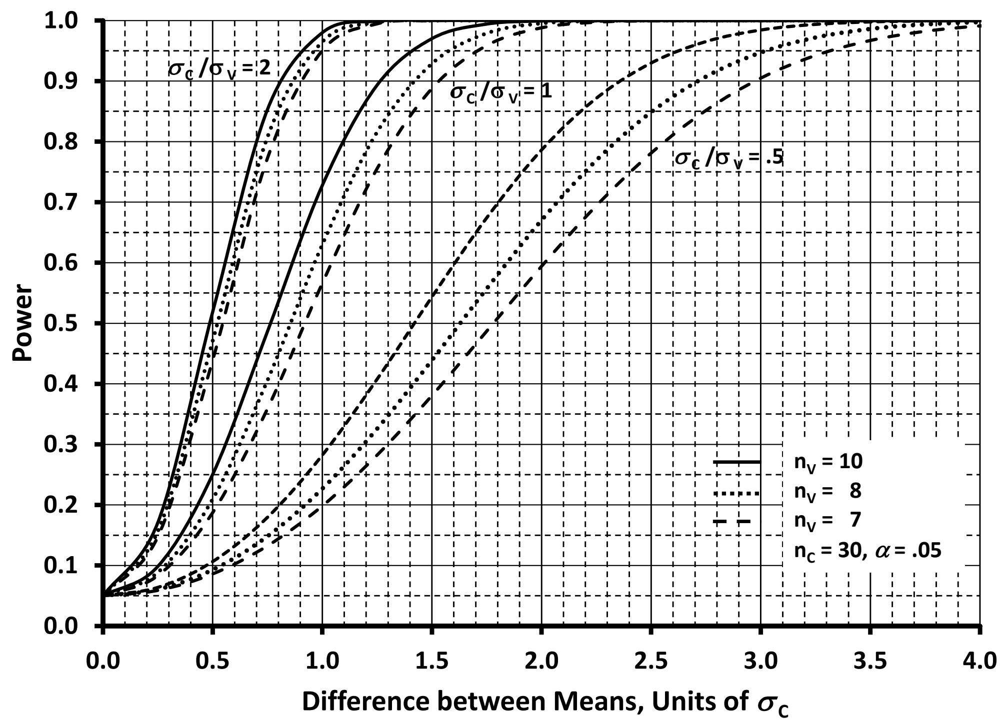

Figure 7.27. Power Curves for H_0: $\mu_C = \mu_V$ and H_a: $\mu_C \neq \mu_V$ for t-Tests Assuming Unequal Variances and for σ_C / σ_V = 0.5, 1.0, 2.0 and n_C = 30, n_V = 7, 8, 10.

Verification Comparison Results and Specification Limits

It is important that the selected typical variability is consistent with the way in which a Lot is defined under the acceptance plan. Since the SCDOT specification is based on Lot-by-Lot acceptance, the variability used to establish the specification limits must be that which is appropriate for a typical Lot. To determine this, the unbiased individual standard deviation values for each Lot were calculated and then these Lot standard deviations were averaged to get a typical "within-Lot" standard deviation.

If it is decided to consider potential variability in the of the various Lot population means, then the "within-Lot" standard deviation can be considered along with the standard deviation for the Lot means to establish a typical "process" variability to use in developing specification limits.

The decision regarding the standard deviation value to use to establish the specification limits must be made subjectively by the SCDOT. The verification procedure used by SCDOT includes comparing the acceptance and verification tests once at least 7 verification tests are completed. If the values compare, then there is no issue since the Contractor acceptance tests for each Lot are then used to determine an individual payment factor for each Lot. This is the way that the specification was intended to operate, and the specification limits have been established for this Lot-by-Lot acceptance approach.

Tolerances If Verification Tests Are Used for Acceptance. An issue arises if the acceptance and verification tests do not compare. In this instance, SCDOT uses the verification test results to establish a single payment factor for all of the Lots from which the verification tests were obtained. This is not the way in which the specification originally was intended to operate, and this approach is not necessarily consistent with the specification limits that were developed for Lot-by-Lot acceptance. That is, the within-Lot variability, which does not include potential Lot-to-Lot variability of the process, may not be the same as the variability associated with the 3 to 7 Lots (see Figure 7.5) from which the verification tests were obtained.

This means that the specification limits that SCDOT selected for Lot-by-Lot acceptance may be too narrow to use when basing the acceptance decision on tests obtained from 3 to 7 different Lots. SC-T-97 addresses this issue by modifying the acceptance limits (called "allowable tolerances" in SC-T-97) when the SCDOT verification tests are used for the acceptance decision. These increased tolerances are shown in Table 7.19.

Since SCDOT uses 90 percent within limits (PWL) as the requirement for full payment, and since in such case the allowable tolerances typically are set at $\pm 1.645\sigma$ from the target, it is possible to estimate the typical standard deviation values that were used by SCDOT. The calculations for the standard deviation values are shown in Table 7.20.

Table 7.19. Allowable Tolerances When Contractor Acceptance Test Results and When SCDOT Verification Test Results Are Used for Acceptance

Characteristic	Contractor Acceptance Tests	SCDOT Verification Tests	Ratio: $Contr_{Acc}/SC_{Verif}$
AC, %			
Surface	0.36	0.43	1.194
Intermediate	0.43	0.50	1.163
Base	0.50	0.55	1.100
AV, %	1.15	1.32	1.148
VMA, %	1.15	1.32	1.148

Table 7.20. Calculation of the Likely Typical Standard Deviation Values Used by SCDOT

Characteristic	σ for Contractor Acceptance Tests	σ for SCDOT Verification Tests
AC, %		
Surface	0.36/1.645 = 0.219	0.43/1.645 = 0.261
Intermediate	0.43/1.645 = 0.261	0.50/1.645 = 0.304
Base	0.50/1.645 = 0.304	0.55/1.645 = 0.334
AV, %	1.15/1.645 = 0.699	1.32/1.645 = 0.802
VMA, %	1.15/1.645 = 0.699	1.32/1.645 = 0.802

The typical standard deviation values when Contractor acceptance tests are used are within the ranges that were recommended in the Phase I study. It therefore is likely that it was the source of the allowable tolerances for Contractor acceptance tests.

It is not certain how the revised tolerances were determined, but there was not a consistent increase in the tolerances from Table 7.19 to Table 7.20. The amount that the tolerances increase when verification tests are used for acceptance varies from 10.0% (AC, Base) to 19.4% (AC, Surface). The revised tolerances should be based on the anticipated standard deviation for acceptance when multiple Lots are evaluated for payment.

To investigate how the "typical" standard deviation varied with the number of Lots that were included in the evaluation, the projects in the analysis data set were divided into 3-, 5-, and 7-Lot Group data sets. Only complete Groups were included. For example, when dividing the analysis data set into Groups of 3, if there were 2 Lots after the last 3-Lot Group the 2 Lots were not included in the analysis. When assigning Groups, neither a different JMF nor a different Mix Type triggered the start of a new Group.

The standard deviations for AC for all of the test results in each Group were then calculated to see how the standard deviations behaved as the Group size increased. The results of this analysis are shown in Table 7.21. Figure 7.28 clearly shows that the typical standard deviations increase with the number of Lots in the Group.

The results in Table 7.21 and Figure 7.28 clearly show that the allowable tolerances should be greater when the SCDOT verification tests are used for the acceptance decision since the results span multiple Lots. Similar results for AV and VMA are shown in Table 7.22 and Figure 7.29, and Table 7.23 and Figure 7.30, respectively.

Since the magnitudes of the standard deviations differ for AC, AV, and VMA, to allow for more direct comparison, Figures 7.31 and 7.32 present the mean and 75th percentile standard deviation values from Figures 7.28-7.30 in terms of the ratio of the given standard deviation to the 1-Lot standard deviation values. In this way the trends for AC, AV and VMA can all be pLotted on the same graph.

Table 7.21. AC Standard Deviation Values for Various Group Sizes

Project	Within-Lot		3-Lot Groups		5-Lot Groups		7-Lot Groups		Total Project	
	No. of Lots	Mean Unb SD	No. of Group	Mean Unb SD	No. of Group	Mean Unb SD	No. of Groups	Mean Unb SD	No. of Tests	Unb SD
P01	15	0.124	5	0.136	3	0.189	2	0.201	32	0.192
P02	21	0.302	6	0.317	4	0.318	2	0.356	71	0.316
P03	21	0.206	7	0.201	4	0.206	3	0.197	79	0.201
P04	20	0.127	6	0.139	4	0.142	2	0.135	72	0.147
P05	17	0.185	5	0.157	3	0.177	2	0.178	43	0.202
P06	25	0.150	8	0.162	5	0.167	3	0.156	89	0.166
P08	18	0.164	6	0.174	3	0.165	2	0.178	75	0.172
P09	16	0.135	5	0.154	3	0.159	2	0.156	64	0.159
P10	14	0.175	4	0.163	2	0.181	2	0.225	47	0.227
P11	42	0.170	14	0.175	8	0.174	6	0.174	157	0.173
P12	55	0.183	19	0.198	11	0.205	8	0.207	257	0.213
P13	73	0.158	25	0.161	15	0.164	10	0.158	295	0.170
P14	41	0.176	13	0.179	8	0.180	5	0.190	161	0.194
P15	26	0.156	9	0.172	5	0.175	3	0.172	98	0.172
P18	43	0.130	14	0.132	8	0.134	6	0.137	172	0.141
P19	16	0.170	5	0.181	3	0.177	2	0.178	61	0.171
P20	16	0.154	5	0.174	3	0.190	2	0.182	58	0.197
Total	**479**		**156**		**92**		**62**		**1831**	
Average		**0.169**		**0.175**		**0.183**		**0.187**		**0.189**
	50%	0.164		0.172		0.177		0.178		0.173
	60%	0.170		0.174		0.179		0.180		0.193
	70%	0.175		0.176		0.183		0.191		0.198
	75%	0.176		0.179		0.189		0.197		0.201
	80%	0.182		0.181		0.190		0.200		0.202
	90%	0.193		0.199		0.205		0.214		0.219

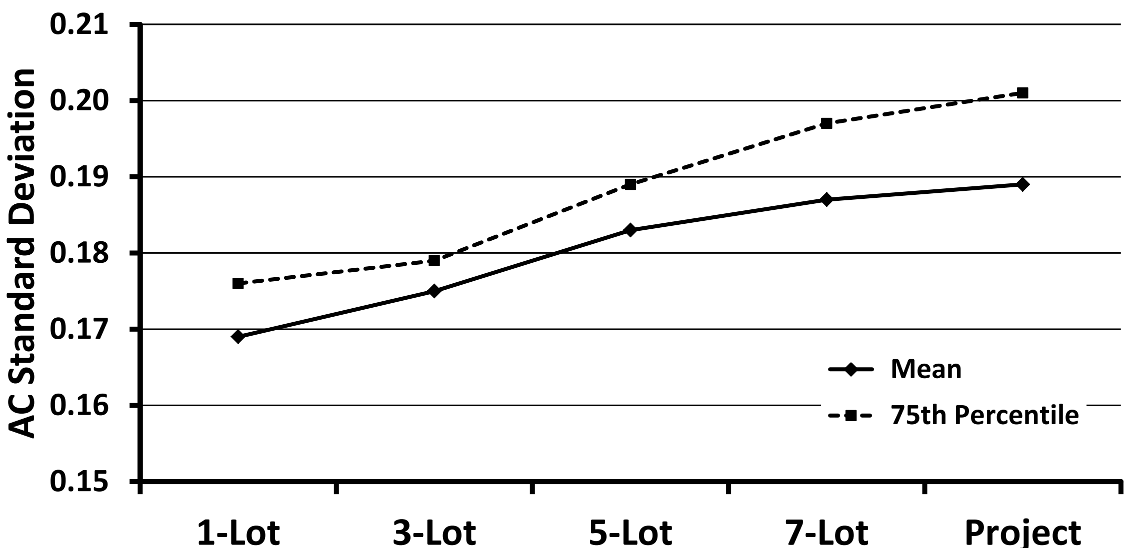

Figure 7.28. AC Standard Deviation Values for Various Group Sizes

Table 7.22. AV Standard Deviation Values for Various Group Sizes

Project	Within-Lot		3-Lot Groups		5-Lot Groups		7-Lot Groups		Total Project	
	No. of Lots	Mean Unb SD	No. of Groups	Mean Unb SD	No. of Groups	Mean Unb SD	No. of Groups	Mean Unb SD	No. of Tests	Unb SD
P01	15	0.257	5	0.466	3	0.433	2	0.486	32	0.470
P02	21	0.611	6	0.637	4	0.651	2	0.610	71	0.641
P03	21	0.473	7	0.454	4	0.533	3	0.552	79	0.639
P04	20	0.412	6	0.523	4	0.555	2	0.541	72	0.569
P05	17	0.396	5	0.486	3	0.481	2	0.486	43	0.467
P06	25	0.437	8	0.520	5	0.513	3	0.485	89	0.551
P08	18	0.441	6	0.459	3	0.426	2	0.509	75	0.494
P09	16	0.446	5	0.448	3	0.499	2	0.514	64	0.494
P10	14	0.556	4	0.498	2	0.416	2	0.625	47	0.710
P11	42	0.444	14	0.458	8	0.469	6	0.494	157	0.508
P12	55	0.416	19	0.515	11	0.545	8	0.555	257	0.617
P13	73	0.403	25	0.451	15	0.477	10	0.465	295	0.538
P14	41	0.494	13	0.544	8	0.553	5	0.566	161	0.626
P15	26	0.329	9	0.448	5	0.454	3	0.466	98	0.461
P18	43	0.36	14	0.363	8	0.378	6	0.383	172	0.401
P19	16	0.492	5	0.564	3	0.547	2	0.580	61	0.536
P20	16	0.235	5	0.331	3	0.314	2	0.391	58	0.477
Total Average	**479**	**0.424**	**156**	**0.480**	**92**	**0.485**	**62**	**0.512**	**1831**	**0.541**
	50%	0.437		0.466		0.481		0.509		0.536
	60%	0.443		0.493		0.507		0.530		0.546
	70%	0.451		0.516		0.535		0.553		0.579
	75%	0.473		0.520		0.545		0.555		0.617
	80%	0.488		0.522		0.547		0.564		0.624
	90%	0.519		0.552		0.554		0.592		0.640

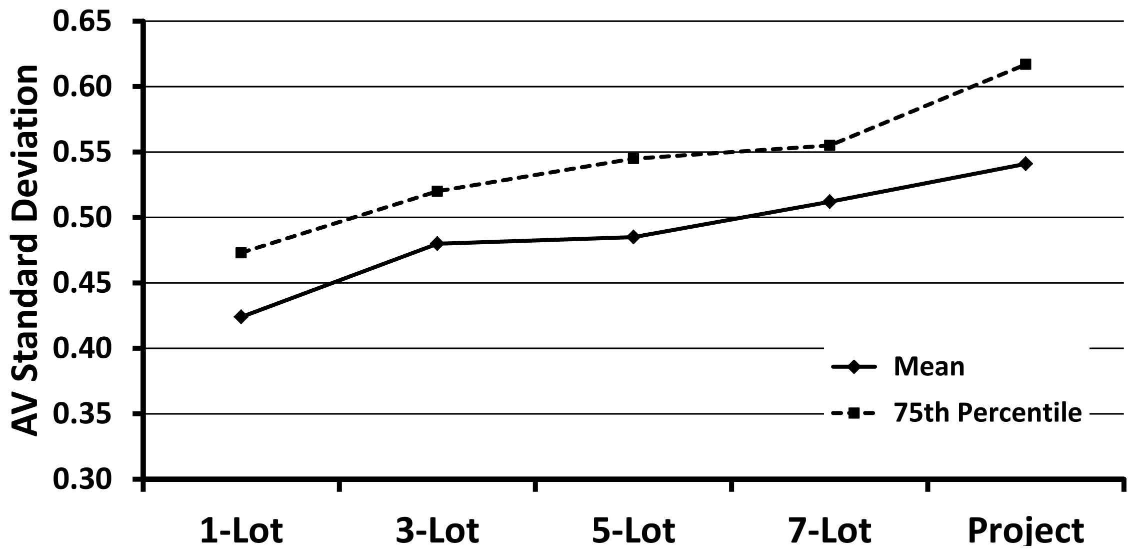

Figure 7.29. AV Standard Deviation Values for Various Group Sizes

Table 7.23. VMA Standard Deviation Values for Various Group Sizes

Project	Within-Lot		3-Lot Groups		5-Lot Groups		7-Lot Groups		Total Projext	
	No. of Lots	Mean Unb SD	No. of Group	Mean Unb SD	No. of Group	Mean Unb SD	No. of Groups	Mean Unb SD	No. of Tests	Unb SD
P01	15	0.380	5	0.487	3	0.491	2	0.522	32	0.505
P02	21	0.661	6	0.647	4	0.677	2	0.613	67	0.656
P03	21	0.512	7	0.504	4	0.510	3	0.526	79	0.581
P04	20	0.461	6	0.497	4	0.540	2	0.529	72	0.559
P05	17	0.396	5	0.473	3	0.511	2	0.504	43	0.540
P06	25	0.390	8	0.446	5	0.469	3	0.410	89	0.509
P08	18	0.380	6	0.358	3	0.350	2	0.361	75	0.376
P09	16	0.345	5	0.370	3	0.377	2	0.410	64	0.390
P10	14	0.510	4	0.552	2	0.545	2	0.596	47	0.642
P11	42	0.433	14	0.421	8	0.461	6	0.492	157	0.523
P12	55	0.390	19	0.417	11	0.400	8	0.397	257	0.432
P13	73	0.362	25	0.394	15	0.408	10	0.394	295	0.477
P14	41	0.487	13	0.512	8	0.520	5	0.530	161	0.572
P15	26	0.355	9	0.479	5	0.481	3	0.515	98	0.505
P18	43	0.374	14	0.360	8	0.366	6	0.376	172	0.432
P19	16	0.376	5	0.412	3	0.399	2	0.428	61	0.413
P20	16	0.375	5	0.431	3	0.514	2	0.545	58	0.588
Total	**479**		**156**		**92**		**62**		**1827**	
Average		**0.423**		**0.456**		**0.472**		**0.479**		**0.512**
	50%	0.390		0.446		0.481		0.504		0.509
	60%	0.394		0.477		0.502		0.519		0.533
	70%	0.439		0.489		0.512		0.527		0.562
	75%	0.461		0.497		0.514		0.529		0.572
	80%	0.482		0.503		0.519		0.530		0.579
	90%	0.511		0.528		0.542		0.565		0.610

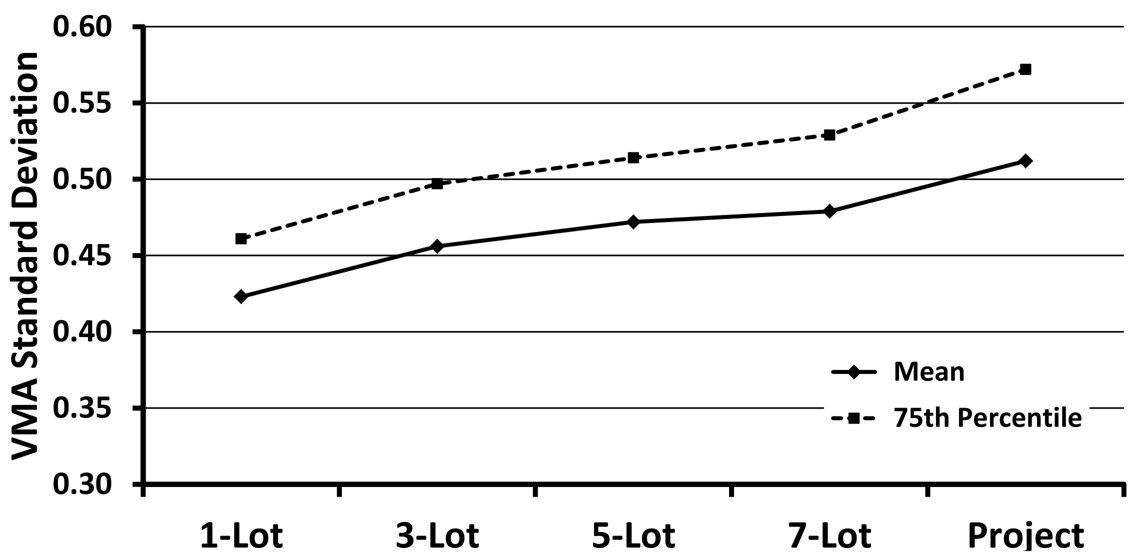

Figure 7.30. VMA Standard Deviation Values for Various Group Sizes

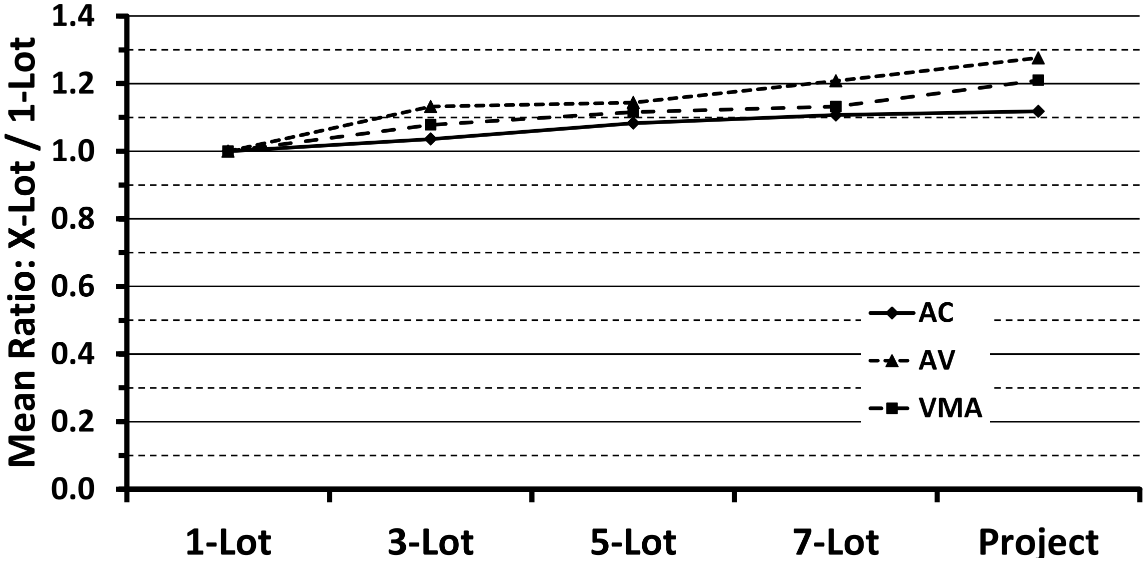

Figure 7.31. Ratio of the Mean Standard Deviations to the 1-Lot Standard Deviations

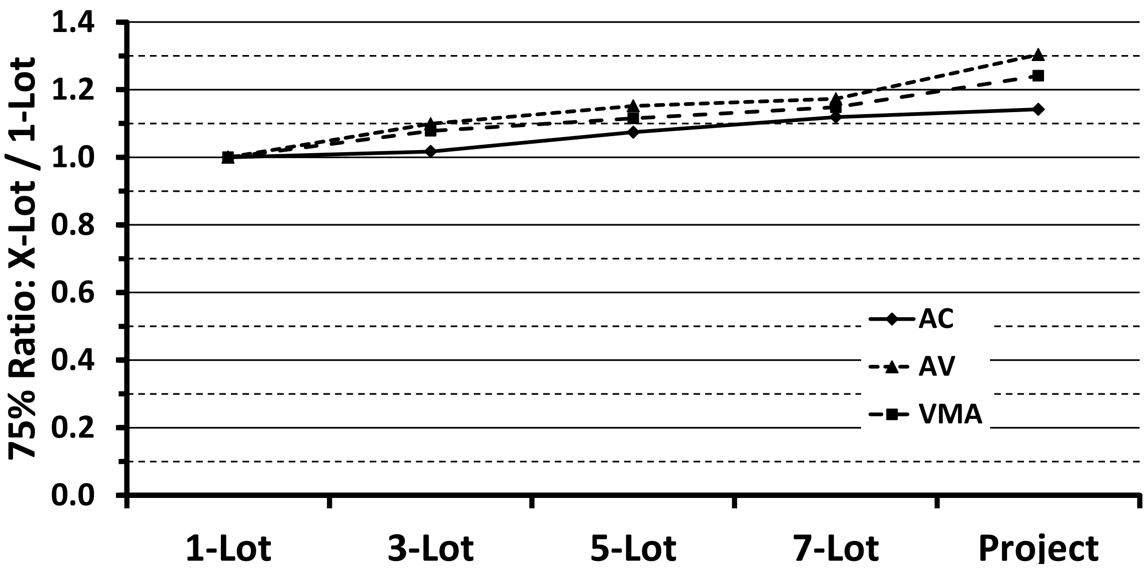

Figure 7.32. Ratio of 75th Percentile Standard Deviations to the 1-Lot Standard Deviations

Process Standard Deviations for Various Group Sizes. The previous section addressed the standard deviations within each of the Group sizes. As is the case for process standard deviation, there also could be variability associated with the ability of the Group means to be equal to the target value. To consider this “target miss” variability the standard deviations for the Group means were calculated.

However, since for the larger Group sizes there were only a few Groups for each Project the Group target miss and standard deviation values were based on all of the Groups and not on a Project-by-Project basis. The results of these calculations are presented in Table 7.24.

Table 7.24. Summary of Means and Standard Deviations for Various Group Sizes

Characteristic	Group Size	No. of Groups	Mean of Groups	St Dev of Group Means
AC	3-Lots	156	0.011	0.083
	5-Lots	92	0.009	0.065
	7-Lots	62	0.009	0.061
AV	3-Lots	156	-0.131	0.331
	5-Lots	92	-0.132	0.289
	7-Lots	62	-0.121	0.276
VMA	3-Lots	156	-0.093	0.316
	5-Lots	92	-0.100	0.280
	7-Lots	62	-0.085	0.275

Table 7.24 shows that there is little difference in the mean of the Groups, which can be defined as the “target miss,” as the number of Lots per Group varies. There is a little more variability, as measured by the standard deviation of the various Group means, as eh number of Lots per Group varies.

As was done previously for determining a within-Lot (i.e., 1-Lot Group) “process standard deviation,” we can use the within-Group standard deviations from Tables 7.21-7.23 along with the standard deviation values in Table 7.24 to calculate “process standard deviations” for the various Group sizes. The 1-Lot and Total Project values are obtained from Chapter 4.

For example, using the 7-Lot average standard deviation (0.187) for AC from Table 7.21, and the corresponding value (0.061) from Table 7.24, the overall process standard deviation can be calculated using Equation 7.1.

$$\sqrt{0.187^2 + 0.061^2} = 0.197 \qquad \textbf{(7.1)}$$

The overall process standard deviations for the various Group sizes are shown in Table 7.25.

Table 7.25. Summary of Mean Overall Process Standard Deviations for Various Group Sizes

Group Size	Within-Group St Dev	Target Miss St Dev	Overall Process St Dev
AC			
1-Lot	0.169	0.046	0.175
3-Lot	0.175	0.083	0.194
5-Lot	0.183	0.065	0.194
7-Lot	0.187	0.061	0.197
Total Project	—	—	0.189
AV			
1-Lot	0.424	0.209	0.473
3-Lot	0.480	0.331	0.583
5-Lot	0.485	0.289	0.565
7-Lot	0.512	0.276	0.582
Total Project	—	—	0.541
VMA			
1-Lot	0.423	0.227	0.480
3-Lot	0.456	0.316	0.555
5-Lot	0.472	0.280	0.549
7-Lot	0.479	0.275	0.552
Total Project	—	—	0.512

Table 7.26. Summary of 75th Percentile Overall Process Standard Deviations for Various Group Sizes

Group Size	Within-Group St Dev	Target Miss St Dev	Overall Process St Dev
AC			
1-Lot	0.176	0.046	0.182
3-Lot	0.179	0.083	0.197
5-Lot	0.189	0.065	0.200
7-Lot	0.197	0.061	0.206
Total Project	—	—	0.201
AV			
1-Lot	0.424	0.209	0.473
3-Lot	0.480	0.331	0.583
5-Lot	0.485	0.289	0.565
7-Lot	0.512	0.276	0.582
Total Project	—	—	0.541
VMA			
1-Lot	0.461	0.227	0.514
3-Lot	0.497	0.316	0.589
5-Lot	0.514	0.280	0.585
7-Lot	0.529	0.275	0.596
Total Project	—	—	0.572

Sample Size, Lot Size, and Payment Risks. The quality index approach to estimating PWL provides an unbiased estimate for the population PWL. As a result, as long as there is a sufficient bonus provision, the expected payment that a Contractor would receive in the long run for a given quality of material will be equal to the payment that the Contractor would receive if the population were known with certainty. However, while the average payment in the long run will be correct, due to sampling variability there is a high degree of variability in the individual Lot payment factors that will be calculated for the given population. That is, sometimes a sample will give results that over-estimate the quality and thus the payment, while other times the sample will under-estimate the payment for a given population. However, over a large number of Lots, the high and low estimates for Lot PWL will tend to balance out to give the correct average payment factor.

If there are only a small number of Lots on a project, then it will be possible that a significantly low estimated PWL value could negatively impact the payment that the Contractor should have received. Similarly, larger PWL estimates could be obtained that would provide a larger payment than is deserved. Given the payment equation used by SCDOT (i.e., $PF = 55 + 0.5PWL$), for material that should receive 100% payment the under-payment error for an individual Lot has the potential to be much greater than the over-payment error, which is limited to the maximum bonus of 5%.

Also, the variability associated with the estimate of the Lot PWL can be reduced by increasing the sample size obtained from each Lot. Therefore, the risks to both parties of the total project payment being in error can be reduced by having a larger number of smaller Lots and/or by having a larger sample size for each Lot. In the event that the SCDOT verification tests are used to determine the payment factor the number of Lots on the project can be considerably reduced. Not only is the number of Lots reduced, but the amount of material at risk is also greatly increased for each payment factor determination.

When the verification tests are used for payment determination instead of the larger number of acceptance tests, the risks to both SCDOT and the Contractor will increase due to the greater amount of material that is being evaluated with typically much fewer tests. Rather than having each Lot evaluated on the basis of 3-5 tests, 3-7 Lots may be evaluated on the basis of 7-8 tests. In this scenario, based on the preceding discussions, the Contractor would seem to be exposed to a greater payment risk than would the SCDOT.

CHAPTER 8 — ANALYSIS OF VERIFICATION TEST DATA

Background

SCDOT's verification testing procedures are conducted in accordance with SC-T-97 (07/12). The verification procedure is 2-fold. First, split samples are tested and compared. Second, SCDOT verification test results are compared with the independently obtained Contractor acceptance test results.

At the direction of SCDOT personnel the Contractors obtains a verification sample that is split into 3 portions: 1 for SCDOT verification testing, 1 for the Contractor, and 1 for potential dispute resolution. If the Contractor and verification tests results do not compare closely enough the dispute resolution sample is tested and used in further calculations.

The SCDOT verification test results are compared with the Contractor acceptance test results using the F-Test and the t-Test. If the verification and Contractor tests are not declared different, the Contractor tests are used for the acceptance and payment decision. If the tests are declared different, the verification tests are used for the acceptance and payment decision. In this report, the 2 comparison approaches are referred to as the Split Sample comparison and the Independent Sample comparison.

Independent Sample Data Analysis

The verification data that were supplied by SCDOT are discussed in Chapter 7. For the reasons discussed there, the final Analysis data set consisted only of the test results for Surface A and Surface B mixes. Table 8.1 shows the breakdown of the initial verification data set as well as the final Analysis data set.

Table 8.1. Number of Verification Tests in the Initial and Analysis Data Sets

Mix Type	AC Verif	AC Contr	AV Verif	AV Contr	VMA Verif	VMA Contr
Initial Data Set						
Base A	22	22	0	0	0	0
Interm C	15	0	15	0	15	0
Surf A	259	235	259	235	259	235
Surf B	155	129	155	129	155	129
Surf C	23	23	23	23	23	23
Surf E	13	2	0	0		
Total	**487**	**411**	**452**	**387**	**452**	**387**
Analysis Data Set						
Surf A	259	235	259	235	259	235
Surf B	155	129	155	129	155	129
Total	**414**	**364**	**414**	**364**	**414**	**364**

Concern Regarding Verification Data Set. In comparing the verification test results with the Contractor acceptance test results, a potential problem was identified on several of the projects. The concern relates to a number of cases in which the Contractors' split sample test results were identical to the Contractors' acceptance test result for the same Lot and same day. The results were identical for all 3 characteristics: AC, AV, and VMA. It seems extremely unlikely that these identical results could have happened by random chance.

It could not be verified since the data were obtained after-the-fact, but it seems likely that on these days the Contractor did not test their verification split sample and SCDOT recorded the closest acceptance test results as the Contractor verification tests.

If this is indeed the case, then it not only potentially biases the data, it indicates that the proper SC-T-97 procedures were not followed all of the time on all of the projects from which data were obtained. Table 8.2 provides a summary of the number of Contractor verification tests that were identical to the acceptance test results. Due the relatively small number of verification tests that were provided, when conducting analyses these questionable tests were treated as if they actually were verification split sample results. The project that is of the most concern obviously is V11 where 21 of 34 Contractor split sample test results appeared to be questionable.

Table 8.2. Summary of Contractor Verification Test Results that Exactly Matched Contractor Acceptance Test Results

Project	No. of Verification Splits		No. of Identical Acc/Verif Tests
	SCDOT	Contractor	
V01	30	29	5
V02	31	30	2
V03	29	29	6
V04	25	23	1
V05	34 (+13 AC)	0 (+2 AC)	0
V06	40	23	0
V07	9	0	0
V08	18	14	0
V09	15	15	0
V10	20	20	0
V11	31	34	21
V14	64	64	0
V16	6 (+22 AC)	6 (+22 AC)	0
V17	13	13	0
V18	62	62	0
V19	25	25	0
Total	**452 (+35 AC)**	**387 (+24 AC)**	**35**

Comparing SCDOT Verification and Contractor Acceptance Tests. Once the results of 7 SCDOT verification tests were available, they were compared with the Contractor's acceptance tests from the same Lots covered by the verification tests. In some cases there were 1, 2, or even 3 verification tests taken from the last Lot in the verification data set. In such cases, all of the verification tests from the last Lot were included in the verification data set. Therefore, in a number of cases there were more than 7 verification tests in the comparison with the Contractor acceptance tests.

Since there is no way to know whether or not the SCDOT verification tests and Contractor acceptance tests were from similar populations (i.e., whether the population means and standard deviations were equal), there is no way to evaluate how well the verification procedure performed.

For information purposes, the results from the analysis data set were compared using the procedures from SC-T-97. The results are shown in Tables 8.3, 8.4, and 8.5 for AC, AV, and VMA, respectively. First, the verification data sets were determined for each project. Then, the F-test was used to compare the variances of the SCDOT verification tests with those of the Contractor acceptance tests. Then, the t-test was used to similarly compare the associated means.

Following SC-T-97 procedures, if the F-test did not declare a difference in variances, the t-test for equal variances was used. If the F-test declared the means to be different, the t-test for unequal variances was used. However, since earlier in this report it is recommended that SCDOT consider whether they wish to modify their procedure and always use the t-test for unequal variances, this test also was run in cases where the F-test did not declare a difference in variances. This was done to determine if this approach would yield different results concerning the population means.

Just because the F-test did not identify a difference in variances, particularly when using $\alpha = 0.01$, does not prove that the variances actually are equal. As noted in Minitab 17, the computer software used for all F-tests and t-tests in this report, "*The two-sample t-test with a pooled variance is slightly more powerful than the two-sample t-test with unequal variances, but serious error can result if the variances are not equal*." The slightly less power associated with using the t-test with unequal variances probably is more than offset by the recommendation that SCDOT switch to a level of significance of $\alpha = 0.05$.

In Tables 8.3-8.5, if the F-test was significantly different at $\alpha = 0.01$, the P-Value was shown in **bold**. This case would have been identified as being different under current SCDOT procedures. In this case, only the t-test for unequal variances was performed since that is what would have been done by SCDOT. If the F-test was significantly different at $\alpha = 0.05$ but not at $\alpha = 0.01$, the P-Value was shown in ***bold italics***. In this case, both the t-test for equal variances and the t-test for unequal variances were performed since SCDOT would not have declared the variances to be different.

The arrows in the tables indicate whether the Contractor's mean or variance was greater than (↑) or less than (↓) the SCDOT verification mean or variance.

Table 8.3. Summary of F-Test and t-Test Results Comparing SCDOT Verification Tests with Contractor Acceptance Tests for AC

Project	Mix	Set ID	Verif. Tests	Accept. Tests	F-Test P-Value*	t-Test Equal Var. P-Value*	t-Test Unequal Var P-Value*
V01	Surf B	A	7	15	**0.001** ↓	—	0.388
		B	7	12	0.287	0.461	0.510
		C	7	15	0.329	0.781	0.807
		D	7	19	0.653	0.584	0.553
V02	Surf A	A	8	13	0.201	0.783	0.806
		B	8	16	0.140	0.545	0.471
		C	8	13	0.054	0.651	0.699
		D	7	23	0.439	0.194	0.138
V03	Surf A	A	7	17	0.215	0.960	0.967
		B	7	22	***0.030*** ↓	0.186	0.353
		C	7	19	0.063	**0.001** ↑	***0.018*** ↑
		D	8	15	0.363	0.242	0.196
V04	Surf B	A	7	16	**0.001** ↓	—	0.743
		B	7	19	0.351	0.198	0.277
		C	7	24	0.380	0.808	0.835
V06	Surf A	A	7	18	***0.034*** ↑	0.537	0.390
		B	7	14	0.059	0.459	0.555
		C	8	17	***0.020*** ↓	0.841	0.876
		D	7	14	0.628	0.746	0.761
		E	8	21	0.484	0.565	0.604
V08	Surf B	A	7	40	0.967	0.929	0.929
		B	8	17	0.792	0.558	0.571
V09	Surf A	A	7	18	0.284	0.996	0.995
		B	8	41	0.558	0.490	0.435
V10	Surf A	A	7	18	0.555	0.344	0.298
V11	Surf A	A	7	19	0.576	0.127	0.101
		B	7	15	***0.038*** ↓	0.097	0.209
		C	7	26	0.839	0.120	0.119
		D	8	16	0.162	0.703	0.653
V14	Surf A	A	8	20	0.317	0.101	0.163
		B	7	25	0.914	0.292	0.310
		C	7	19	0.445	0.225	0.290
		D	7	13	0.550	0.752	0.769
		E	8	14	0.156	0.484	0.422
		F	7	15	0.545	0.707	0.729
		G	7	22	0.093	0.150	0.286
		H	7	14	**0.007** ↓	—	0.287

Table continued on next page.

Table 8.3. Summary of F-Test and t-Test Results Comparing SCDOT Verification Tests with Contractor Acceptance Tests for AC (*continued*)

Project	Mix	Set ID	Verif. Tests	Accept. Tests	F-Test P-Value*	t-Test Equal Var. P-Value*	t-Test Unequal Var P-Value*
V18	Surf B	A	8	24	0.174	0.844	0.872
		B	8	21	**0.005** ↑	—	**0.006** ↑
		C	7	19	0.290	0.538	0.458
		D	9	25	0.434	0.871	0.884
	Surf A	A	8	14	0.391	0.149	0.191
		B	7	24	0.088	0.122	0.259
		C	7	20	0.722	0.720	0.736
		D	8	28	0.055	0.463	0.589
V19	Surf B	A	7	26	0.901	0.209	0.231
		B	9	14	0.614	0.761	0.752
		C	7	17	0.458	0.934	0.941

* Values in **bold** indicate significantly different at the α = 0.01 level.
Values in ***bold italics*** indicate significantly different at the α = 0.05 level.
↓ Contractor's mean or variance < than SCDOT verification mean or variance.
↑ Contractor's mean or variance > SCDOT verification mean or variance.

There are 48 AC verification comparison data sets in Table 8.3. In 4 cases, the variances were declared different at the α = 0.01 level. Of these, 1 also declared the means different. Another 4 comparisons would have declared the variances different at the α = 0.05 level. In none of these 4 were the means also declared different. In only 1 case did the t-test for equal variances and the t-test for unequal variances provide conflicting results, but they were quite close. The P-value for the equal variance test was 0.001, while it was 0.018 for the unequal variance test. Both would have been declared different at the α = 0.05 level, but only the equal variance test would have been declared different at the α = 0.01.

The results in Table 8.3 may be of some concern to SCDOT. Of the 48 F-test comparisons, 4 were significantly different at α = 0.01 and an additional 4 were significantly different at α = 0.05. If all of the comparison sets had equal variances, then it would be expected that about 1% would incorrectly be declared different at the α = 0.01 level, whereas 8% (i.e., 4/48) were declared different. Similarly, if all of the comparison sets had equal variances, then it would be expected that about 5% would incorrectly be declared different at the α = 0.05 level, whereas nearly 17% (i.e., 8/48) were declared different. Whether these results are of concern must be decided by SCDOT.

Table 8.4. Summary of F-Test and t-Test Results Comparing SCDOT Verification Tests with Contractor Acceptance Tests for AV

Project	Mix	Set ID	Verif. Tests	Accept. Tests	F-Test P-Value*	t-Test Equal Var. P-Value*	t-Test Unequal Var P-Value*
V01	Surf B	A	7	15	**0.006** ↓	—	0.361
		B	7	12	0.078	0.095	0.168
		C	7	15	0.878	0.109	0.125
		D	7	19	0.784	0.185	0.171
V02	Surf A	A	8	13	***0.046*** ↓	***0.018*** ↓	0.053
		B	8	16	0.615	0.118	0.146
		C	8	13	***0.016*** ↓	0.538	0.611
		D	7	23	0.879	***0.041*** ↑	0.062
V03	Surf A	A	7	17	0.763	0.307	0.334
		B	7	22	0.081	0.133	0.270
		C	7	19	0.321	0.435	0.508
		D	8	15	0.204	0.057	***0.031*** ↑
V04	Surf B	A	7	16	***0.011*** ↓	0.089	0.222
		B	7	19	0.218	**0.004** ↑	***0.028*** ↑
		C	7	24	**0.005** ↓	—	0.722
V06	Surf A	A	7	18	0.762	0.121	0.111
		B	7	14	**0.005** ↓	—	0.475
		C	8	17	**0.000** ↓	—	0.217
		D	7	14	***0.040*** ↓	0.625	0.700
		E	8	21	0.335	0.995	0.995
V08	Surf B	A	7	40	0.467	0.454	0.526
		B	8	17	***0.027*** ↓	0.537	0.630
V09	Surf A	A	7	18	0.136	***0.037*** ↑	**0.010** ↑
		B	8	41	0.480	**0.000** ↑	**0.001** ↑
V10	Surf A	A	7	18	0.768	***0.011*** ↑	***0.023*** ↑
V11	Surf A	A	7	19	**0.000** ↓	—	0.182
		B	7	15	**0.001** ↓	—	0.157
		C	7	26	**0.004** ↓	—	0.153
		D	8	16	0.158	0.119	0.190
V14	Surf A	A	8	20	0.762	0.938	0.940
		B	7	25	0.759	0.785	0.796
		C	7	19	0.850	0.439	0.425
		D	7	13	0.871	0.826	0.822
		E	8	14	0.080	0.570	0.630
		F	7	15	0.696	0.961	0.963
		G	7	22	**0.003** ↓	—	0.585
		H	7	14	0.059	0.400	0.502

Table continued on next page.

Table 8.4. Summary of F-Test and t-Test Results Comparing SCDOT Verification Tests with Contractor Acceptance Tests for AV (*continued*)

Project	Mix	Set ID	Verif. Tests	Accept. Tests	F-Test P-Value*	t-Test Equal Var. P-Value*	t-Test Unequal Var P-Value*
V18	Surf B	A	8	24	0.669	0.958	0.954
		B	8	21	***0.011*** ↓	**0.002** ↓	***0.036*** ↓
		C	7	19	***0.038*** ↓	0.120	0.260
		D	9	25	**0.001** ↓	***0.023*** ↓	0.129
	Surf A	A	8	14	0.617	**0.000** ↓	**0.000** ↓
		B	7	24	***0.042*** ↓	**0.000** ↓	***0.014*** ↓
		C	7	20	**0.002** ↓	0.988	0.992
		D	8	28	0.817	**0.004** ↓	***0.011*** ↓
V19	Surf B	A	7	26	0.147	0.082	0.197
		B	9	14	0.116	0.210	0.268
		C	7	17	0.542	0.563	0.599

* Values in **bold** indicate significantly different at the α = 0.01 level.
Values in ***bold italics*** indicate significantly different at the α = 0.05 level.
↓ Contractor's mean or variance **<** than SCDOT verification mean or variance.
↑ Contractor's mean or variance **>** SCDOT verification mean or variance.

There are 48 AV verification comparison data sets in Table 8.4. In 10 cases, the variances were declared different at the α = 0.01 level. Another 8 comparisons would have declared the variances different at the α = 0.05 level. The equal variance t-test declared 6 means different at the α = 0.01 level, and another 4 would have been declared different at the α = 0.05 level. The unequal variance t-test declared 9 means different at the α = 0.05 level, 3 of which were also different at the α = 0.01 level.

The results in Table 8.4 should be of more concern to SCDOT than those in Table 8.3. Of the 48 F-test comparisons, 10 were significantly different at α = 0.01 and an additional 8 were significantly different at α = 0.05. If all of the comparison sets had equal variances, then it would be expected that about 1% or 5% would incorrectly be declared different depending upon the α level; whereas nearly 21% (i.e., 10/48) were declared different at α = 0.01 and over 37% (18/48) were different at α = 0.05.

Similarly, the equal variance t-test declared over 12% (6/48) different at α = 0.01 and nearly 21% (10/48) different at α = 0.05. The unequal variance t-test declared only 6% (3/48) different at α = 0.01, but nearly 19% (9/48) different at α = 0.05

These results appear to indicate that there may be a systemic cause leading to a difference between the Contractor acceptance test process and the SCDOT verification test process. It seems likely that the differences are due to the verification process rather than to differences in materials themselves. Whether these results are of concern must be decided by SCDOT.

Table 8.5. Summary of F-Test and t-Test Results Comparing SCDOT Verification Tests with Contractor Acceptance Tests for VMA

Project	Mix	Set ID	Verif. Tests	Accept. Tests	F-Test P-Value*	t-Test Equal Var. P-Value*	t-Test Unequal Var P-Value*
V01	Surf B	A	7	15	***0.042*** ↓	**0.010**↑	0.058
		B	7	12	***0.017*** ↓	0.272	0.381
		C	7	15	0.203	0.104	0.180
		D	7	19	0.266	0.068	***0.032*** ↑
V02	Surf A	A	8	13	0.104	0.101	0.123
		B	8	16	0.840	0.169	0.184
		C	8	13	0.913	0.116	0.123
		D	7	23	0.984	0.266	0.274
V03	Surf A	A	7	17	0.066	0.461	0.569
		B	7	22	0.767	0.814	0.803
		C	7	19	0.527	**0.009** ↑	**0.006** ↑
		D	8	15	0.867	0.468	0.460
V04	Surf B	A	7	16	0.456	***0.011*** ↑	**0.007** ↑
		B	7	19	0.171	**0.001** ↑	***0.013*** ↑
		C	7	24	**0.004** ↓	—	0.863
V06	Surf A	A	7	18	0.545	***0.029*** ↓	0.059
		B	7	14	0.172	0.487	0.558
		C	8	17	***0.016*** ↓	0.055	0.150
		D	7	14	0.839	0.481	0.469
		E	8	21	0.177	0.459	0.542
V08	Surf B	A	7	40	***0.038*** ↓	0.584	0.717
		B	8	17	***0.040*** ↓	0.903	0.923
V09	Surf A	A	7	18	0.112	**0.002** ↑	**0.000** ↑
		B	8	41	0.295	**0.001** ↑	***0.015*** ↑
V10	Surf A	A	7	18	0.680	0.317	0.352
V11	Surf A	A	7	19	**0.002** ↓	—	0.374
		B	7	15	0.984	0.157	0.161
		C	7	26	**0.002** ↓	—	0.061
		D	8	16	0.077	***0.035*** ↓	0.091
V14	Surf A	A	8	20	0.313	0.475	0.536
		B	7	25	0.750	0.299	0.335
		C	7	19	0.517	0.759	0.729
		D	7	13	0.079	0.227	0.145
		E	8	14	0.723	0.692	0.680
		F	7	15	0.481	0.481	0.524
		G	7	22	0.265	**0.008** ↓	***0.041*** ↓
		H	7	14	***0.014*** ↓	0.989	0.992

Table continued on next page.

Table 8.5. Summary of F-Test and t-Test Results Comparing SCDOT Verification Tests with Contractor Acceptance Tests for VMA (*continued*)

Project	Mix	Set ID	Verif. Tests	Accept. Tests	F-Test P-Value*	t-Test Equal Var. P-Value*	t-Test Unequal Var P-Value*
V18	Surf B	A	8	24	0.697	0.825	0.835
		B	8	21	0.064	0.068	0.169
		C	7	19	***0.048*** ↓	0.215	0.360
		D	9	25	**0.001** ↓	—	0.067
	Surf A	A	8	14	***0.040*** ↓	**0.000** ↓	**0.002** ↓
		B	7	24	0.278	**0.002** ↓	**0.001** ↓
		C	7	20	***0.019*** ↓	0.816	0.868
		D	8	28	0.158	***0.022*** ↓	**0.005** ↓
V19	Surf B	A	7	26	0.329	**0.005** ↓	***0.031*** ↓
		B	9	14	***0.011*** ↓	0.134	0.212
		C	7	17	0.307	0.793	0.756

* Values in **bold** indicate significantly different at the α = 0.01 level.
Values in ***bold italics*** indicate significantly different at the α = 0.05 level.
↓ Contractor's mean or variance **<** than SCDOT verification mean or variance.
↑ Contractor's mean or variance **>** SCDOT verification mean or variance.

There are 48 VMA verification comparison data sets in Table 8.5. In 4 cases, the variances were declared different at the α = 0.01 level. Another 10 comparisons would have declared the variances different at the α = 0.05 level. The equal variance t-test declared 9 means different at the α = 0.01 level, and another 4 would have been declared different at the α = 0.05 level. The unequal variance t-test declared 11 means different at the α = 0.05 level, 6 of which were also different at the α = 0.01 level.

The results in Table 8.5 should be of concern to SCDOT. Of the 48 F-test comparisons, 4 were significantly different at α = 0.01 and an additional 10 were significantly different at α = 0.05. If all of the comparison sets had equal variances, then it would be expected that about 1% or 5% would incorrectly be declared different depending upon the α level; whereas over 8% (i.e., 4/48) were declared different at α = 0.01 and over 29% (14/48) were different at α = 0.05.

Similarly, the equal variance t-test declared nearly 19% (9/48) different at α = 0.01 and 27% (13/48) different at α = 0.05. The unequal variance t-test declared over 12% (6/48) different at α = 0.01 and nearly 23% (11/48) different at α = 0.05.

These results appear to indicate that there may be a systemic cause leading to a difference between the Contractor acceptance test process and the SCDOT verification test process. It seems likely that the differences are due to the verification process rather than to differences in materials themselves. Whether these results are of concern must be decided by SCDOT.

Table 8.6 presents a summary of all of the verification data sets that showed any significant differences in Tables 8.3-8.5. In the table, a shaded cell represents a comparison with a significantly different result. The thicker arrows (🡅 or 🡇) show a significant difference at α = 0.01, and indicate whether the Contractor's variance or mean was greater (🡅) than or less than (🡇) the SCDOT verification variance or mean. The narrower arrows (↑ or ↓) show a difference that is significant at α = 0.05 but not at α = 0.01. The direction of the arrow indicates whether the Contractor's variance or mean was greater (↑) than or less than (↓) the SCDOT verification variance or mean.

To assist in evaluating the results presented in Table 8.6, Table 8.7 shows a breakdown of the number of significant differences for each type of comparison test as well as the number of times the Contractor value was greater than or less than the verification value. For example, for the F-test there were 8 significant differences for AC (4 each for α = 0.01 and α = 0.05). AV, on the other hand, had 18 significant differences (10 for α = 0.01 and an additional 8 for α = 0.05). VMA was between these 2 with 14 significant differences (only 4 for α = 0.01 and an additional 10 for α = 0.05).

A total of 144 F-test comparisons and 288 t-test comparisons (144 for equal variances and 144 for unequal variances) between Contractor acceptance tests and SCDOT verification tests were made. Of the 144 F-tests, 18 (12.5%) were significantly different at the α = 0.01 level and a total of 40 (27.5%) were significantly different at the α = 0.05 level.

These are fairly large percentages of significantly different tests, particularly when compared with the power curves shown in Chapter 7. Table 8.8 summarizes the information shown in Table 8.7.

The differences were not as great for the t-test comparisons. For the equal variance t-test, a total of 16 (11.1%) showed differences at the α = 0.01 level and a total of 25 (17.4%) were significantly different at the α = 0.05 level. For the unequal variance t-test, a total of 9 (6.3%) showed differences at the α = 0.01 level and a total of 22 (15.3%) were significantly different at the α = 0.05 level.

Some obvious differences in the AC, AV, and VMA results are apparent in the table. For example, for AC only 1 of the t-tests for equal variances and only 2 of the t-tests for unequal variances showed significant differences. These numbers were 11 and 9 for AV and 13 and 11 for VMA. So, only 3 combined AC comparisons were different while there were a combined 20 and 24 differences for AV and VMA.

Similarly, for the F-tests there were 8 AC differences, but 18 AV differences and 14 VMA differences. What really "jumps out" about the AV and VMA differences is that <u>the Contractor variance was less than the SCDOT verification variance for all 32 of them</u>. For AC, the SCDOT variance was greater for 6 of the 8 differences. This indicates clearly that some systemic difference is involved. If the differences had been the result of a random process, all of them would not have been less for the Contractor's tests.

Table 8.6. Acceptance Test with Verification Test Comparisons with Significant Differences

Project	Mix	F-Test*			t-Test, Equal Variance*			t-Test, Unequal Variance*		
		AC	AV	VMA	AC	AV	VMA	AC	AV	VMA
V01	Surf B	⬇	⬇	↓			⬆			
				↓						
										↑
V02	Surf A		↓			↓				
			↓							
						↑				
V03	Surf A	↓								
					⬆		⬆	↑		⬆
									↑	
V04	Surf B	⬇	↓				↑			⬆
						⬆	⬆		↑	↑
			⬇	⬇						
V06	Surf A	↑					↓			
		↓	⬇	↓						
			⬇							
			↓							
V08	Surf B			↓						
			↓	↓						
V09	Surf A					↑	⬆		⬆	⬆
						⬆	⬆		⬆	↑
V10	Surf A					↑			↑	
V11	Surf A		⬇	⬇						
		↓	⬇							
			⬇	⬇						
							↓			
V14	Surf A		⬇				⬇			↓
		⬇		↓						
V18	Surf B									
		⬆	↓			⬇		⬆	↓	
			↓	↓						
			⬇	⬇		↓				
	Surf A			↓		⬇	⬇		⬇	⬇
			↓			⬇	⬇		↓	⬇
			⬇	↓						
						⬇	↓		↓	⬇
V19	Surf B						⬇			↓
				↓						

* Significantly different at $\alpha = 0.01$ (⬇ or ⬆); significantly different at $\alpha = 0.05$ (↓ or ↑)
Contractor mean or variance **<** (⬇ or ↓) or **>** (⬆ or ↑) SCDOT verification mean or variance.

Table 8.7. Summary of Significant Differences in the Acceptance Test with Verification Test Comparisons

	F-Test	t-Test, Equal Variances	t-Test, Unequal Variances
Asphalt Content (AC)			
No. of Sig. Diff.			
α = 0.01	4	1	1
α = 0.05	4	0	1
Total	8	1	2
No. of 🡇 or ↓	6	0	0
No. of 🡅 or ↑	2	1	2
Air Voids (AV)			
No. of Sig. Diff.			
α = 0.01	10	6	3
α = 0.05	8	5	6
Total	18	11	9
No. of 🡇 or ↓	18	6	4
No. of 🡅 or ↑	0	5	5
VMA			
No. of Sig. Diff.			
α = 0.01	4	9	6
α = 0.05	10	4	5
Total	14	13	11
No. of 🡇 or ↓	14	6	6
No. of 🡅 or ↑	0	7	5

* Contractor mean or variance **< (**🡇 or ↓**)** or **> (**🡅 or ↑**)** SCDOT verification mean or variance.

These data cannot identify the cause of the systematic difference. We can only speculate as to the cause. One likely cause is the fact that the Contractor acceptance tests likely did not require reheating before preparing and testing specimens as was likely necessary for all of the verification test samples. This is a consistent occurrence and is an issue that SCDOT needs to consider. Even when the F-test did not identify significant differences, the majority of the time the Contractor variances were less than the SCDOT verification variances.

Split Sample Data Analysis

SCDOT's verification procedure is 2-fold. First, split samples are tested and compared. Second, SCDOT verification test results are compared with the independently obtained Contractor acceptance test results. The previous sections of this report cover the independently obtained samples. This section addresses the split samples.

The verification data that were supplied by SCDOT are discussed in Chapter 7. For the reasons discussed, there the final Analysis data set consisted only of the test results for Surface A and Surface B mixes. While Table 8.1 showed that the total number of SCDOT verification split samples was 414 and that there were 364 Contractor split samples, there were a few cases where there were not results available for both split sample tests. The split sample analysis data set therefore had 232 sets of split samples for Surface A mixes and 127 sets for Surface B mixes. The breakdown by project of the split samples is shown in Table 8.8. The table shows that 4.5% to 5.0% of the split samples required that the dispute resolution sample be tested.

Table 8.8. Number of Split Sample Pairs by Project

Project	No. of Split Sample Pairs			Dispute Resolution Splits Tested	
	AC	AV	VMA	Number	Percent
V01	29	29	29	3	10.3%
V02	30	30	30	1	3.3%
V03	29	29	29	0	0%
V04	23	23	23	1 AV, 2 VMA	1.3% 8.7%
V06	23	23	23	0	0%
V08	14	14	14	1	7.1%
V09	15	15	15	0	0%
V10	14	14	14	0	0%
V11	31	31	31	0	0%
V14	64	64	64	2	3.1%
V18	62	62	62	9	14.5%
V19	25	25	25	0	0%
Total	**359**	**359**	**359**	**16 AC 17 AV 18 VMA**	**4.5% AC 4.7% AV 5.0% VMA**

Since there is no way to know whether or not the Contractor and SCDOT split samples were or were not equal for any of the tests, there is no way to evaluate whether or the SC-T-97 procedure worked as desired.

For information purposes, t-tests for paired values were performed on the split sample analysis data set. The tests were conducted on a Project basis and they were broken down by Mix Type if there was both Surface A and Surface B mixes on a particular Project. The t-test results provided the mean and standard deviation of the split sample differences as well as a determination of whether the mean difference was different than 0. The results are shown in Tables 8.9, 8.10, and 8.11 for AC, AV, and VMA, respectively.

For AC, only 3 of 14 t-tests showed significant differences at $\alpha = 0.05$ and none of these differences were significant at $\alpha = 0.01$. Also, 2 of them were from the same project. For AV, 9 of the 14 t-tests showed significant differences at $\alpha = 0.01$. For VMA, 6 of the 14 t-tests showed significant differences at $\alpha = 0.01$ and an additional 2 were different at $\alpha = 0.05$.

While none of the above numbers relates to allowable limits for individual split samples, they do indicate that the Contractor and SCDOT portions will likely come from different populations with respect to AV and VMA in particular. These results are similar to those from the analysis of the independent samples.

Table 8.9. Results of t-Test for Paired Values for Each Project for AC

Project	Contractor	Mix Type	No. of Splits	Mean Diff.	St Dev of Diff.	t-Test* P-Value+
V01	C1	Surf B	29	-0.006	0.173	0.848
V02	C2	Surf A	30	-0.026	0.287	0.620
V03	C2	Surf A	29	-0.051	0.380	0.475
V04	C1	Surf B	23	0.036	0.149	0.263
V06	C4	Surf A	23	0.067	0.212	0.144
V08	C5	Surf B	14	0.056	0.140	0.161
V09	C2	Surf A	15	0.021	0.120	0.502
V10	C2	Surf A	10	-0.112	0.211	0.127
		Surf B	4	-0.090	0.100	0.171
V11	C2	Surf A	31	0.010	0.263	0.829
V14	C6	Surf A	64	-0.053	0.202	***0.040***
V18	C7	Surf B	32	-0.074	0.159	***0.013***
		Surf A	30	0.062	0.166	***0.048***
V19	C6	Surf B	25	0.013	0.151	0.676

* Values in **bold** indicate significantly different at the $\alpha = 0.01$ level.
Values in ***bold italics*** indicate significantly different at the $\alpha = 0.05$ level.

Table 8.10. Results of t-Test for Paired Values for Each Project for AV

Project	Contractor	Mix Type	No. of Splits	Mean Diff.	St Dev of Diff.	t-Test* P-Value+
V01	C1	Surf B	29	-0.662	0.335	**0.000**
V02	C2	Surf A	30	0.011	0.651	0.929
V03	C2	Surf A	29	0.431	0.693	**0.002**
V04	C1	Surf B	23	-0.604	0.399	**0.000**
V06	C4	Surf A	23	0.155	0.617	0.242
V08	C5	Surf B	14	-0.071	0.664	0.697
V09	C2	Surf A	15	-0.634	0.459	**0.000**
V10	C2	Surf A	10	-0.398	0.384	**0.010**
		Surf B	4	0.047	0.921	0.924
V11	C2	Surf A	31	0.403	0.779	**0.007**
V14	C6	Surf A	64	0.070	0.554	0.317
V18	C7	Surf B	32	.409	.442	**0.000**
		Surf A	30	0.514	0.524	**0.000**
V19	C6	Surf B	25	0.441	0.484	**0.000**

* Values in **bold** indicate significantly different at the $\alpha = 0.01$ level.
Values in ***bold italics*** indicate significantly different at the $\alpha = 0.05$ level.

Table 8.11. Results of t-Test for Paired Values for Each Project for VMA

Project	Contractor	Mix Type	No. of Splits	Mean Diff.	St Dev of Diff.	t-Test* P-Value+
V01	C1	Surf B	29	-0.628	0.505	**0.000**
V02	C2	Surf A	30	-0.062	0.635	0.595
V03	C2	Surf A	29	0.279	0.853	0.089
V04	C1	Surf B	23	-0.397	0.616	**0.005**
V06	C4	Surf A	23	0.290	0.503	***0.011***
V08	C5	Surf B	14	0.124	0.769	0.206
V09	C2	Surf A	15	-0.520	0.524	**0.002**
V10	C2	Surf A	10	-0.597	0.713	***0.027***
		Surf B	4	-0.143	0.837	0.756
V11	C2	Surf A	31	0.427	0.640	**0.001**
V14	C6	Surf A	64	0.059	0.565	00409
V18	C7	Surf B	32	0.210	0.605	0.059
		Surf A	30	0.597	0.571	**0.000**
V19	C6	Surf B	25	0.435	0.551	**0.001**

* Values in **bold** indicate significantly different at the $\alpha = 0.01$ level.
Values in ***bold italics*** indicate significantly different at the $\alpha = 0.05$ level.

Effect of Mix Type. Since the split sample analysis data set consisted of test results for Surface A and Surface B mixes, it was decided to explore whether there was a difference between the results for the 2 Mix Types. To do this, the differences between the pairs of split samples were used in the analysis. That is, the 232 differences for Surface A mixes were compared with the 127 differences for Surface B mixes using the F-test and Levene's Test to compare variances, and using the t-test for unequal variances to compare means. The results are shown in Tables 8.12 and 8.13.

Table 8.12. Results of Tests Comparing Variances for Surface A vs. Surface B Mixes

Characteristic	Mix Type	No. of Tests	St Dev	P-value+ F-Test	P-value+ Levene's
AC	Surf A	232	0.247	**0.000**	**0.000**
	Surf B	127	0.160		
AV	Surf A	232	0.675	0.990	0.330
	Surf B	127	0.674		
VMA	Surf A	232	0.695	0.671	0.938
	Surf B	127	0.717		

+ Values in **bold** are statistically significantly different at the $\alpha = 0.01$ level.

Table 8.13. Results of Two Sample t-Test for Unequal Variances for Surface A vs. Surface B Mixes

Characteristic	Mix Type	No. of Tests	Mean	St Dev	P-value+
AC	Surf A	232	-0.012	0.247	0.857
	Surf B	127	-0.008	0.160	
AV	Surf A	232	0.152	0.675	**0.002**
	Surf B	127	-0.077	0.674	
VMA	Surf A	232	0.147	0.695	**0.007**
	Surf B	127	-0.068	0.717	

+ Values in bold are statistically significantly different at the $\alpha = 0.01$ level.

The results in Table 8.12 indicate that there is no reason to believe that the AV and VMA variances of the split sample differences differ between Surface A and Surface B mixes. There is, however, a difference in the variances of the split sample differences for AC. Note that this does not indicate that the variability for Surface A and Surface B mixes is different. It means that the difference between the Contractor and SCDOT AC split samples has greater variability for Surface A mixes than for Surface B mixes.

Similarly, Table 8.13 shows that the mean difference between the Contractor and SCDOT AV and VMA split samples is greater for Surface A mixes than for Surface B mixes. There was no difference identified for AC.

Typical Variability for Establishing Split Sample Allowable Tolerances. To establish allowable tolerances for the difference between the Contractor and SCDOT split sample result, it is necessary to decide on a population for the differences. That is, it is necessary to determine the mean and standard deviation for the population of split sample differences.

Since Tables 8.12 and 8.13 showed potential differences between the results for Surface A and Surface B mixes, population means and standard deviations are developed both for the case of developing separate limits for Surface A and Surface B mixes and for the case of combining the 2 Mix Types and developing a single set of limits.

Asphalt Content. Tables 8.14 and 8.15 show for AC the unbiased standard deviations for the differences between split samples for each project for Surface A mixes and Surface B mixes, respectively. Table 8.16 shows similar values for each project without separating the project standard deviations by Mix Type.

Table 8.14. Results of t-Test for Paired Values for Surface A Mixes for Each Project for AC

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V02	C2	30	-0.026	0.287	0.289
V03	C2	29	-0.051	0.380	0.383
V06	C4	23	0.067	0.212	0.214
V09	C2	15	0.021	0.120	0.122
V10	C2	10	-0.112	0.211	0.217
V11	C2	31	0.010	0.263	0.265
V14	C6	64	-0.053	0.202	0.203
V18	C7	30	0.062	0.166	0.167
Total		**232**			
Average			**-0.010**	**0.230**	**0.233**

Table 8.15. Results of t-Test for Paired Values for Surface B Mixes for Each Project for AC

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V01	C1	29	-0.006	0.173	0.175
V04	C1	23	0.036	0.149	0.151
V08	C5	14	0.056	0.140	0.143
V10	C2	4	-0.090	0.100	0.109
V18	C7	32	-0.074	0.159	0.160
V19	C6	25	0.013	0.151	0.153
Total		**127**			
Average			**-0.011**	**0.145**	**0.149**

Table 8.16. Results of t-Test for Paired Values for Each Project for AC

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V01	C1	29	-0.006	0.173	0.175
V02	C2	30	-0.026	0.287	0.289
V03	C2	29	-0.051	0.380	0.383
V04	C1	23	0.036	0.149	0.151
V06	C4	23	0.067	0.212	0.214
V08	C5	14	0.056	0.140	0.143
V09	C2	15	0.021	0.120	0.122
V10	C2	10	-0.112	0.211	0.217
		4	-0.090	0.100	0.109
V11	C2	31	0.010	0.263	0.265
V14	C6	64	-0.053	0.202	0.203
V18	C7	32	-0.074	0.159	0.160
		30	0.062	0.166	0.167
V19	C6	25	0.013	0.151	0.153
Total		**359**			
Average			**-0.011**	**0.194**	**0.197**
			Percentiles	**50%**	**0.171**
				60%	**0.197**
				70%	**0.214**
				75%	**0.216**
				80%	**0.236**
				90%	**0.282**

Tables 8.14 and 8.15 show clearly that these is essentially no difference in the mean of the differences between Surface A and Surface B mixes, but that there is a considerable difference in the standard deviations of the differences between the 2 Mix Types. However, it is not possible to draw the conclusion that Surface A mixes are different than Surface B mixes due to the confounding effect of the Contractors involved.

The average standard deviation of the differences on the 8 Surface A projects was 0.233, while the same value for the 6 Surface B projects was 0.149. The problem with trying to compare these numbers is the fact that 5 of 8 of the Surface A projects had the same Contractor, C2. The average standard deviation for these 5 projects was 0.255, whereas the average standard deviation for the other 3 projects was 0.195. Therefore, the difference between the Surface A and Surface B mixes might have been attributed to Contractor C2 rather than to the Mix Types. For this reason, further analyses and evaluations were performed on the combined results from Table 8.16.

Percentile values for the standard deviations of the AC split sample differences are shown in Table 8.16 and the CDFs for the Surface A, Surface B, and the 2 mixes combined are shown in Figure 8.1.

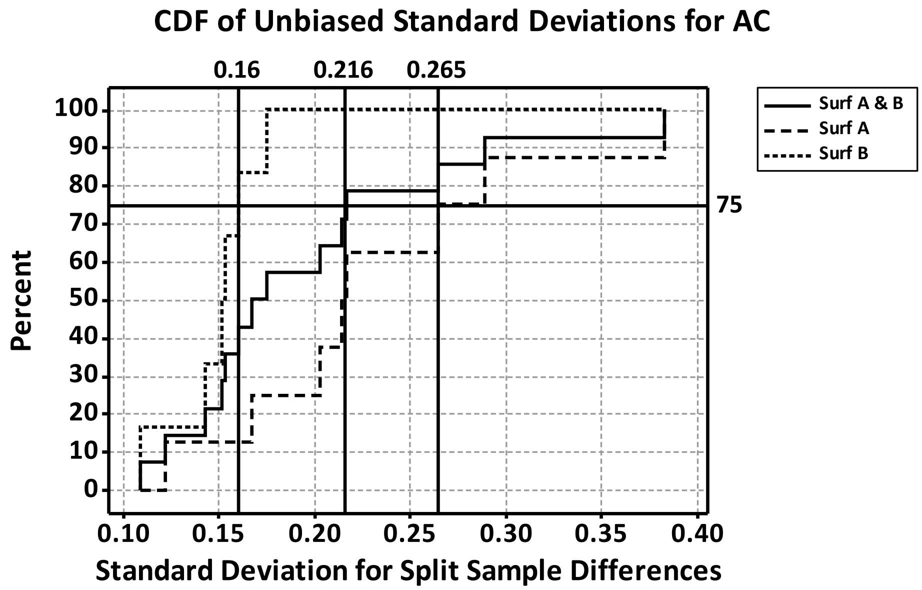

Figure 8.1. CDFs for the Project Standard Deviations of Split Sample Differences for AC

SCDOT can use the percentile values from Table 8.16 and the CDFs shown in Figure 8.1 to assist in selecting the "typical" variability to use for establishing allowable tolerance limits for the differences between split samples for AC. There is no single "correct" way to establish this value. A subjective decision must be made regarding the standard deviation to select. This table and figure should assist in making the subjective decision regarding the "typical" standard deviation to use.

The reference line for the 75th percentile shown in Figure 8.1 is for illustration purposes. SCDOT must make whatever subjective decision they feel is appropriate. The 75th percentile shows the difference between the Surface A (0.160) and Surface B (0.265) standard deviation results. The higher the percentile selected, the lower the risk to the Contractor, but the higher the risk that SCDOT will not identify actual differences between the split samples.

Strictly for illustration purposes, the 0.215 standard deviation, which corresponds to the 75th percentile, is used for further calculations in this report.

Air Voids. Tables 8.17 and 8.18 show for AV the unbiased standard deviations for the differences between split samples for each project for Surface A mixes and Surface B mixes, respectively. Table 8.19 shows similar values for each project without separating the project standard deviations by Mix Type.

Table 8.17. Results of t-Test for Paired Values for Surface A Mixes for Each Project for AV

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V02	C2	30	0.011	0.651	0.657
V03	C2	29	0.431	0.693	0.699
V06	C4	23	0.155	0.617	0.624
V09	C2	15	-0.634	0.459	0.467
V10	C2	10	-0.398	0.384	0.395
V11	C2	31	0.403	0.779	0.785
V14	C6	64	0.070	0.554	0.556
V18	C7	30	0.514	0.524	0.529
Total		**232**			
Average			**0.069**	**0.583**	**0.589**

Table 8.18. Results of t-Test for Paired Values for Surface B Mixes for Each Project for AV

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V01	C1	29	-0.662	0.335	0.338
V04	C1	23	-0.604	0.399	0.404
V08	C5	14	-0.071	0.664	0.677
V11	C2	4	0.047	0.921	1.000
V18	C7	32	0.409	0.442	0.446
V19	C6	25	0.441	0.484	0.489
Total		**127**			
Average			**-0.073**	**0.541**	**0.559**

Table 8.19. Results of t-Test for Paired Values for Each Project for AV

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V01	C1	29	-0.662	0.335	0.338
V02	C2	30	0.011	0.651	0.657
V03	C2	29	0.431	0.693	0.699
V04	C1	23	-0.604	0.399	0.404
V06	C4	23	0.155	0.617	0.624
V08	C5	14	-0.071	0.664	0.677
V09	C2	15	-0.634	0.459	0.467
V10	C2	10	-0.398	0.384	0.395
		4	0.047	0.921	1.000
V11	C2	31	0.403	0.779	0.785
V14	C6	64	0.070	0.554	0.556
V18	C7	32	0.409	0.442	0.446
		30	0.514	0.524	0.529
V19	C6	25	0.441	0.484	0.489
Total		**359**			
Average			**0.008**	**0.565**	**0.576**
			Percentiles	**50%**	**0.543**
				60%	**0.610**
				70%	**0.659**
				75%	**0.672**
				80%	**0.686**
				90%	**0.759**

Tables 8.17 and 8.18 do not show a particularly large difference in the averages for the standard deviations of the differences between the 2 Mix Types. Also, no difference was identified in the variances when the F-test and Levene's test were performed (see Table 8.12). For this reason, further analyses and evaluations were performed on the combined results from Table 8.19.

Percentile values for the standard deviations of the AV split sample differences are shown in Table 8.19 and the CDFs for the Surface A, Surface B, and the 2 mixes combined are shown in Figure 8.2.

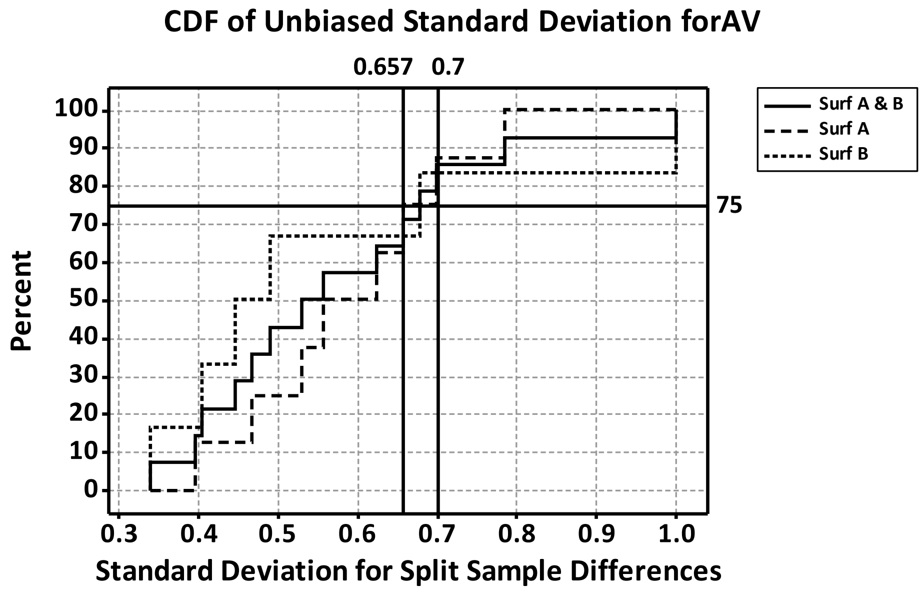

Figure 8.2. CDFs for the Project Standard Deviations of Split Sample Differences for AV

The reference line for the 75th percentile shown in Figure 8.2 is for illustration purposes. SCDOT must make whatever subjective decision they feel is appropriate. The 75th percentile from Table 8.19 (0.672) is consistent with the CDF 75th percentile for Surface A & B in Figure 8.2, which is about 0.677.

Strictly for illustration purposes, a standard deviation value of 0.675 is used for further calculations in this report.

VMA. Tables 8.20 and 8.21 show for VMA the unbiased standard deviations for the differences between split samples for each project for Surface A mixes and Surface B mixes, respectively. Table 8.22 shows similar values for each project without separating the project standard deviations by Mix Type.

Tables 8.20 and 8.21 do not show a particularly large difference in the averages for the standard deviations of the differences between the 2 Mix Types. Also, no difference was identified in the variances when the F-test and Levene's test were performed (see Table 8.12). For this reason, further analyses and evaluations were performed on the combined results from Table 8.21.

Percentile values for the standard deviations of the VMA split sample differences are shown in Table 8.21 and the CDFs for the Surface A, Surface B, and the 2 mixes combined are shown in Figure 8.3.

Table 8.20. Results of t-Test for Paired Values for Surface A Mixes for Each Project for VMA

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V02	C2	30	-0.062	0.635	0.640
V03	C2	29	0.279	0.853	0.861
V06	C4	23	0.290	0.503	0.509
V09	C2	15	-0.520	0.524	0.533
V10	C2	10	-0.597	0.713	0.733
V11	C2	31	0.427	0.640	0.645
V14	C6	64	0.059	0.565	0.567
V18	C7	30	0.597	0.571	0.576
Total		**232**			
Average			**0.059**	**0.626**	**0.633**

Table 8.21. Results of t-Test for Paired Values for Surface B Mixes for Each Project for VMA

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V01	C1	29	-0.628	0.505	0.510
V04	C1	23	-0.397	0.616	0.623
V08	C5	14	0.124	0.769	0.784
V10	C2	4	-0.143	0.837	0.908
V18	C7	32	0.210	0.605	0.610
V19	C6	25	0.435	0.551	0.557
Total		**127**			
Average			**-0.067**	**0.647**	**0.665**

Table 8.22. Results of t-Test for Paired Values for Each Project for VMA

Project	Contractor	No. of Splits	Mean Diff.	St Dev of Diff.	Unbiased St Dev of Diff.
V01	C1	29	-0.628	0.505	0.510
V02	C2	30	-0.062	0.635	0.640
V03	C2	29	0.279	0.853	0.861
V04	C1	23	-0.397	0.616	0.623
V06	C4	23	0.290	0.503	0.509
V08	C5	14	0.124	0.769	0.784
V09	C2	15	-0.520	0.524	0.533
V10	C2	10	-0.597	0.713	0.733
		4	-0.143	0.837	0.908
V11	C2	31	0.427	0.640	0.645
V14	C6	64	0.059	0.565	0.567
V18	C7	32	0.210	0.605	0.610
		30	0.597	0.571	0.576
V19	C6	25	0.435	0.551	0.557
Total		**359**			
Average			**0.005**	**0.635**	**0.647**
			Percentiles	**50%**	**0.617**
				60%	**0.637**
				70%	**0.654**
				75%	**0.711**
				80%	**0.753**
				90%	**0.838**

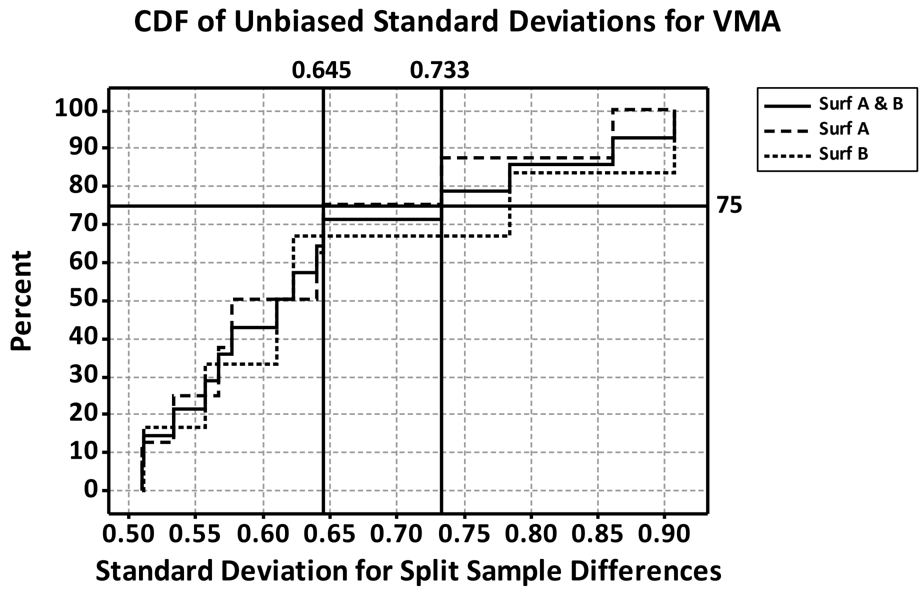

Figure 8.3. CDFs for the Project Standard Deviations of Split Sample Differences for VMA

The reference line for the 75th percentile shown in Figure 8.3 is for illustration purposes. SCDOT must make whatever subjective decision they feel is appropriate. The 75th percentile from Table 8.19 is 0.711. This is an interpolated value that can be compared with the CDF in Table 8.3. The reference line at 0.733 in Figure 8.3 actually corresponds to the 78.5th percentile. Strictly for illustration purposes, a standard deviation value of 0.71 is used for further calculations in this report.

Establishing the Allowable Tolerances

The procedure in SC-T-97 of comparing the differences between split sample test results is similar in concept to the D2S method in AASHTO test method precision statements. In the D2S method, a test is performed on a single split sample to compare DOT and Contractor test results. If we assume both of these samples are from normally distributed populations, then we can calculate the variance of the difference and use it to calculate 2 standard deviation, or approximately 95%, limits for the sample difference quantity.

The D2S method uses the variance (i.e., square of the test standard deviation) to calculate the variance and ultimately the standard deviation for the population of the test differences. In the case of this report, the standard deviations for the test differences are determined from the results shown in Tables 8.14-8.22 and Figures 8.1-8.3.

In general, using D2S concepts, the allowable tolerances can be established as 2 times the value for the standard deviation for the population of split sample test differences. In such a case, the α value is approximately 0.05 (actually, it is 0.455 for 2 sigma limits).

If we assume that the population means of the Contractor and SCDOT split sample results are equal, then under our assumptions the population for the split sample test results is normally distributed with mean equal 0 and standard deviation equal to the value selected from the above tables.

For the illustrative values selected above, this would yield the following allowable tolerances for Surface A and Surface B mixes:

AC: $0.215 \times 2 = 0.43$

AV: $0.675 \times 2 = 1.35$

VMA: $0.710 \times 2 = 1.42.$

Figure 8.4 illustrates the process for establishing the 2σ limits, where σ_{limits} is the standard deviation determined for the population of split sample differences. From the figure it can be seen that the population is centered at 0 (i.e., the means of the populations for the SCDOT and Contractor split samples are equal) and the population standard deviation is σ_{limits}.

If an individual split sample difference is outside of the limits shown in Figure 8.4, it will be rejected and it will be considered that the Contractor and SCDOT results are different. If, indeed, the Contractor and SCDOT populations are equal, then a result in the shaded regions in Figure 8.4 will be rejected even though the population in the figure shows clearly that the Contractor and SCDOT populations have the same means. This is the α risk to the Contractor and is 0.0455 for limits based on $2\sigma_{\text{limits}}$.

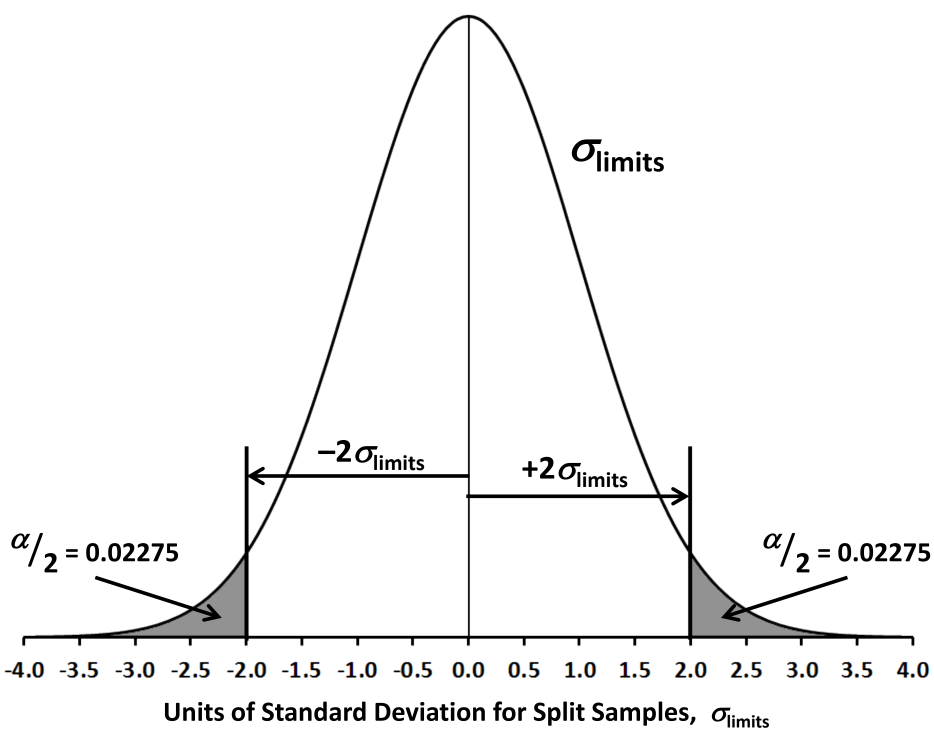

Figure 8.4. Illustration of the Determination of Allowable Tolerances for Split Sample Tests

Important Caveat. It must be noted that while the above methodology is sound, the appropriateness of the limits depends upon the validity of the test results data that were provided. This methodology should be applied for data that SCDOT believes to be appropriate for the type of work that they consider acceptable and that they believe to be representative of the work performed by typical Contractors in the state. The allowable limits calculated by this approach are only as good as the data that were used to determine the standard deviation for the population of split sample differences.

The standard deviations derived from using the CDFs of the split sample differences will yield allowable tolerances that are considerably larger than the D2S limits from the corresponding test method. D2S limits are established from a scenario in which the samples are artificially prepared to be as identical as possible. The samples are sent to the testing lab under the same conditions and are tested under conditions that are as close as possible to the same. Therefore, D2S limits are "best case" limits that are not directly applicable to the verification scenarios that are encountered on actual projects.

For example, due to material, sampling, and splitting variabilities, the split samples will not be nearly as "identical" as the samples used when developing the 1S and D2S values. Verification split samples also may differ in the manner in which they are tested. The Contractor split sample may not require reheating and may be tested within hours of being sampled, whereas the SCDOT verification split sample will require reheating and may not be tested for several days after the sample is taken and split.

By using the test results summarized in Tables 8.14-8.16 and Figure 8.1, there is the implicit assumption that the test results that were analyzed are indeed representative of the quality of construction that is acceptable to SCDOT and that is achievable by the typical Contractor that performs work for SCDOT. If these data are not representative of the type of construction that SCDOT considers acceptable, then using them to establish allowable tolerances for split samples may yield tolerances that are not appropriate.

Power of the Split Sample Comparison

The power of the comparison of split samples can be determined based on the assumptions made in calculating the allowable tolerances. For example, if we assume a case where the actual difference between the population mean for the Contractor's split samples differs from the population mean for the SCDOT's split samples, we can determine the power by calculating the probability that a single split sample difference will fall outside of the allowable tolerances established in Figure 8.4.

Suppose, for example, that the actual difference between the Contractor and SCDOT population means is equal to $0.5\sigma_{\text{limits}}$, where σ_{limits} is the standard deviation that was used when establishing the allowable tolerances. Then, if the population of the split sample differences has standard deviation equal to σ_{limits}, then the probability of detecting the difference in population means (i.e., the power) can be calculated as shown in Figure 8.5.

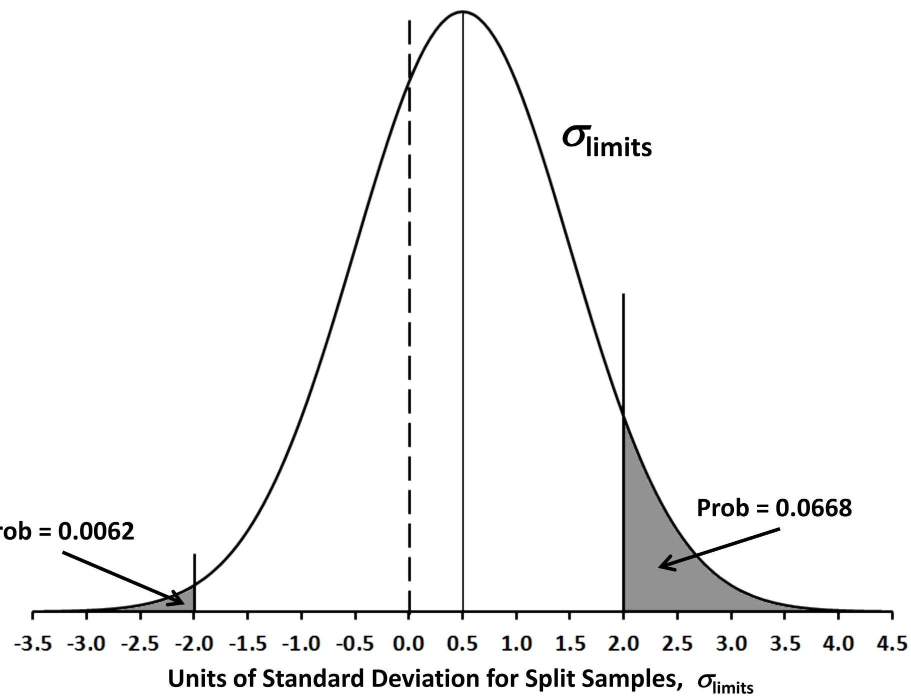

Figure 8.5. Illustration of the Power to Identify Differences between Split Sample Population Means

The split sample difference will be rejected when it is greater than the upper tolerance (2 σ_{limits} in this case) or less than the lower tolerance (–2 σ_{limits} in this case). In Figure 8.5, the probabilities of these occurrences are 0.0668 and 0.0062, respectively. The power, therefore, is the sum of these probabilities or 0.073. There is a 0.073, or 7.3%, chance of detecting the difference when the population means of the split sample differences differ by 0.5σ_{limits}.

If we hold the standard deviation of the Contractor and SCDOT split sample populations constant and equal to σ_{limits}, we can vary the difference between population means to develop the power curve shown in Figure 8.6. If we project up from a value of 0.5 on the horizontal axis to the power curve, and then project left to the vertical axis, we get the power of 0.073 that we calculated in Figure 8.5.

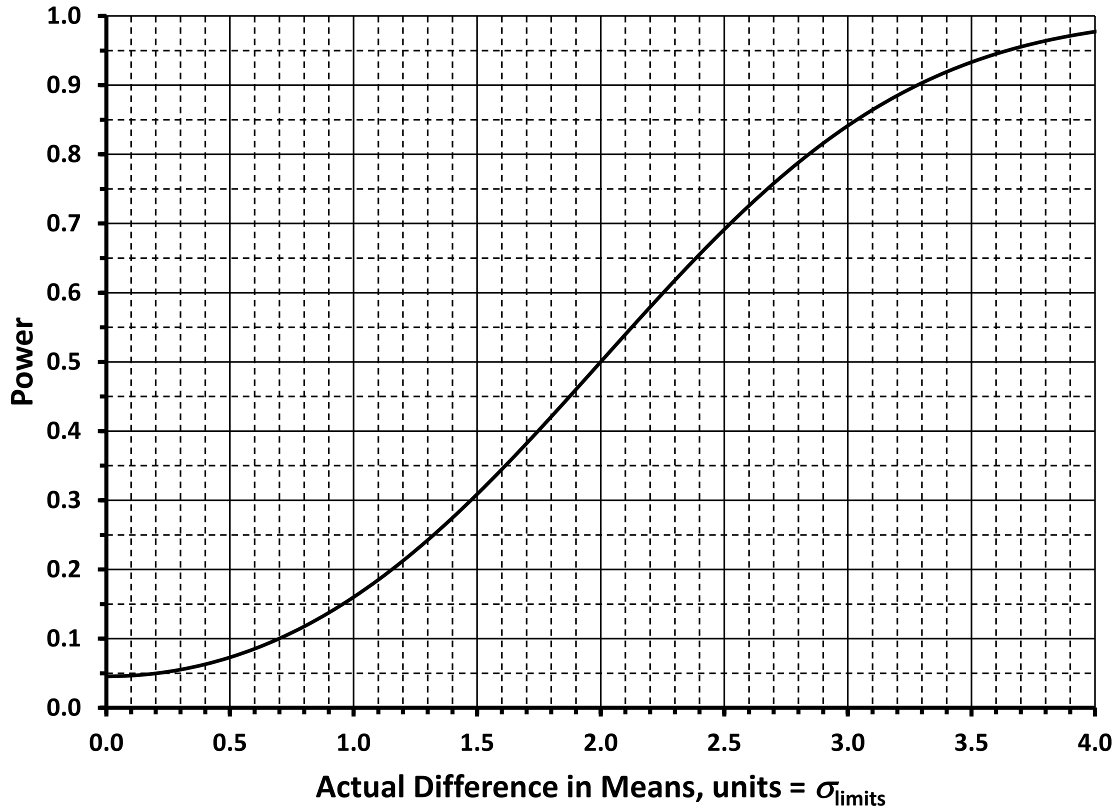

Figure 8.6. Power Curve for Differences between Split Sample Population Means when the Population Standard Deviations Equal the Standard Deviation Used to Establish the Allowable Tolerances

There is a wide array of possibilities for the relationships among the Contractor and SCDOT split sample populations. We will consider the case where the standard deviation of the split sample differences varies from σ_{limits} (the standard deviation used to establish the allowable tolerances). Figure 8.7 shows the power curves for the case where the actual standard deviation of the split sample differences (σ_{actual}) equal 0.5, 1.0, 1.25, 1.50, and 2.0 times the standard deviation used to establish the allowable tolerances, σ_{limits}. As the figure shows, the power curves can vary dramatically depending upon the standard deviation of the population of split sample differences.

Since the horizontal axis in Figure 8.7 is in standard deviation units it can be applied to any case in which the standard deviation of the population of split sample differences is known or assumed to be known.

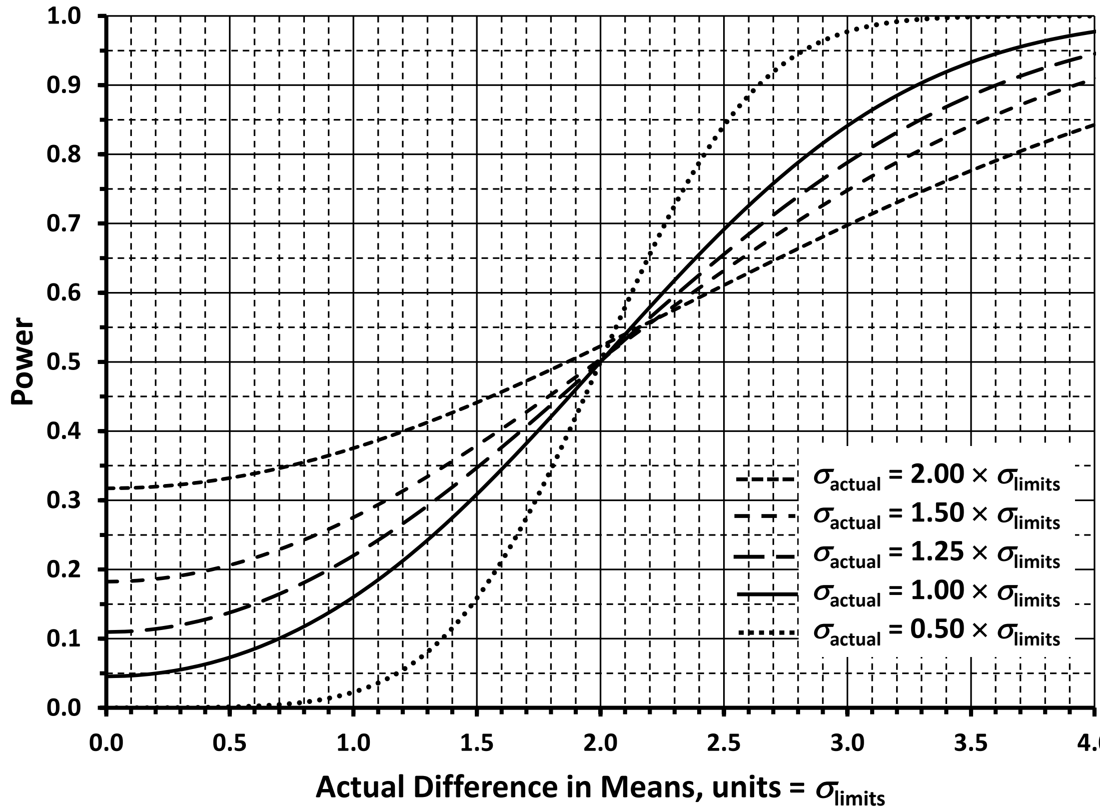

Figure 8.7. Power Curve for Differences between Split Sample Populations for Various Ratios of Actual Population Standard Deviations to the Standard Deviation Used to Establish the Allowable Tolerances

For example, if the standard deviation for AC differences were selected as 0.215 (as shown in a previous example in this chapter), 1.0 on the horizontal axis in Figure 8.7 would correspond to a difference between means of 0.215%. Similarly, 0.5 would correspond to 0.1075%, 2.0 would correspond to 0.43%, etc. To make it specific to this situation, the power curve for σ_{actual} = σ_{limits} could be pLotted in terms of percent difference as shown in Figure 8.8. Just substituting 0.215% for 1.0 σ_{limits} provides the correct power curve, but the horizontal axis has “awkward” limits. Figure 8.8 pLots the same power curve with “user friendly” limits.

Similarly, Figures 8.10 and 8.11 include power curves for AV and VMA using the standard deviation for split sample differences from previous examples in this chapter. That is, 0.675% for AV and 0.710% for VMA.

Important. After reviewing this report and the power curves in Figure 8.7, SCDOT will need to make a subjective decision regarding the allowable limits. What is obvious from the power curves is that any comparison procedure that is based on a single split sample test result will have relatively low power to detect actual differences when they are present.

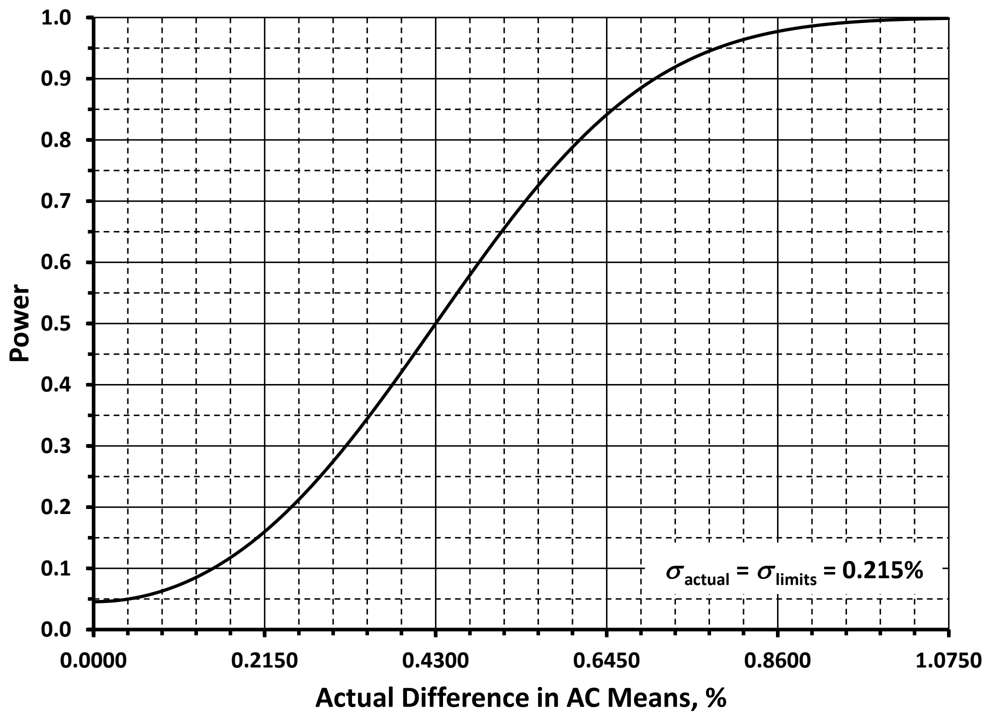

Figure 8.8. Power Curve for Differences between Split Sample Population AC Means when $\sigma_{actual} = \sigma_{limits} = 0.215\%$

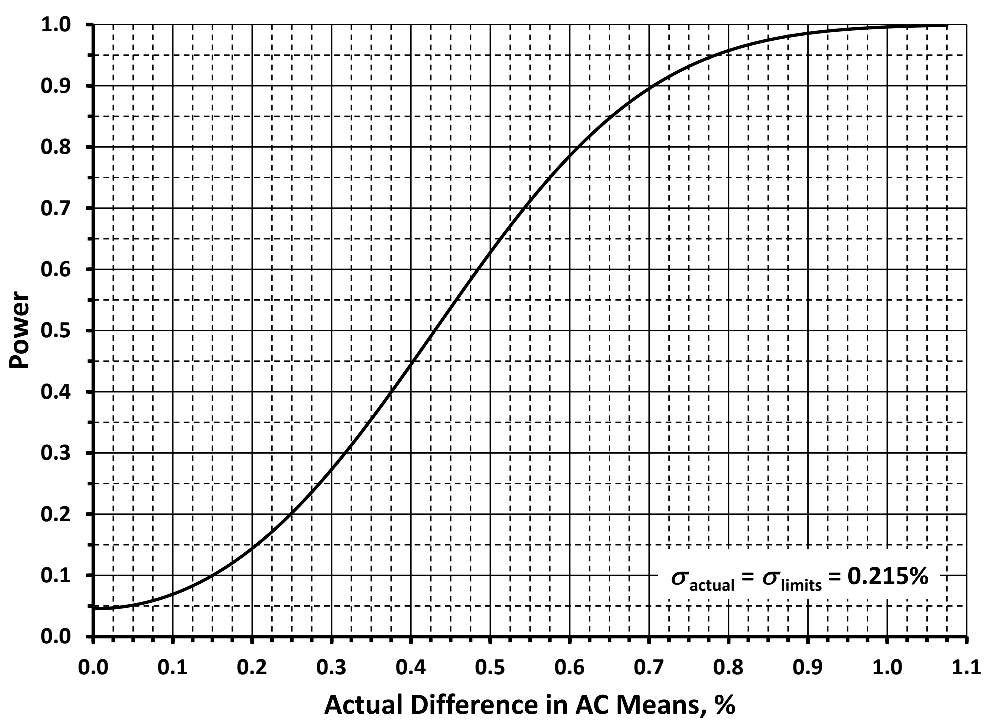

Figure 8.9. Power Curve, with "User Friendly" Horizontal Axis, for Differences between AC Split Sample Population Means when $\sigma_{actual} = \sigma_{limits} = 0.215\%$

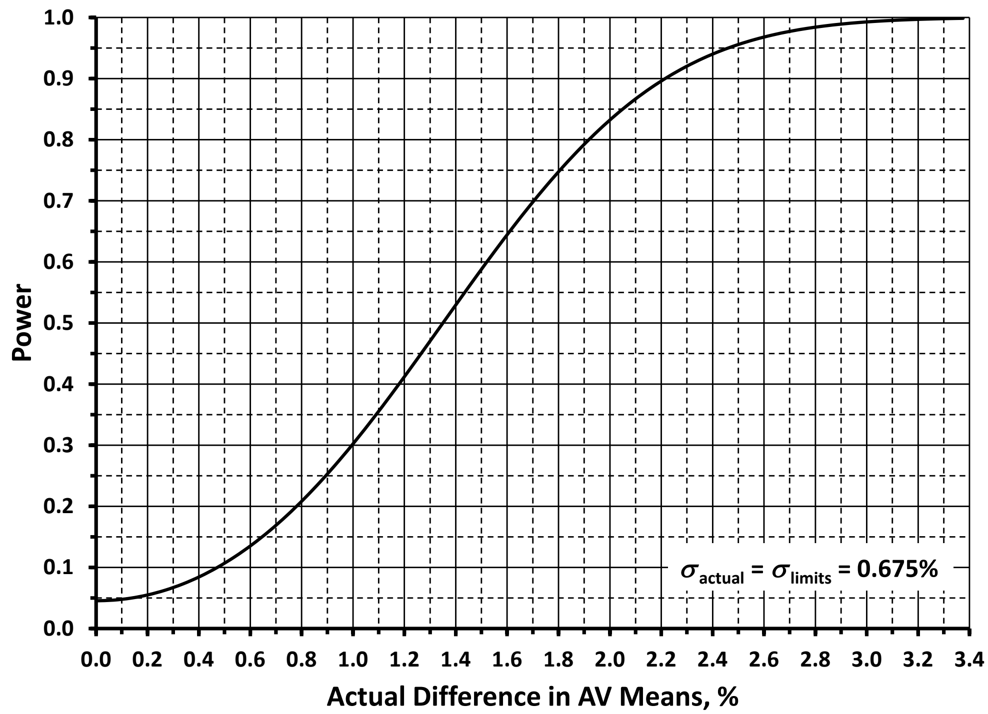

Figure 8.10. Power Curve for Differences between Split Sample Population AV Means when $\sigma_{actual} = \sigma_{limits} = 0.675\%$

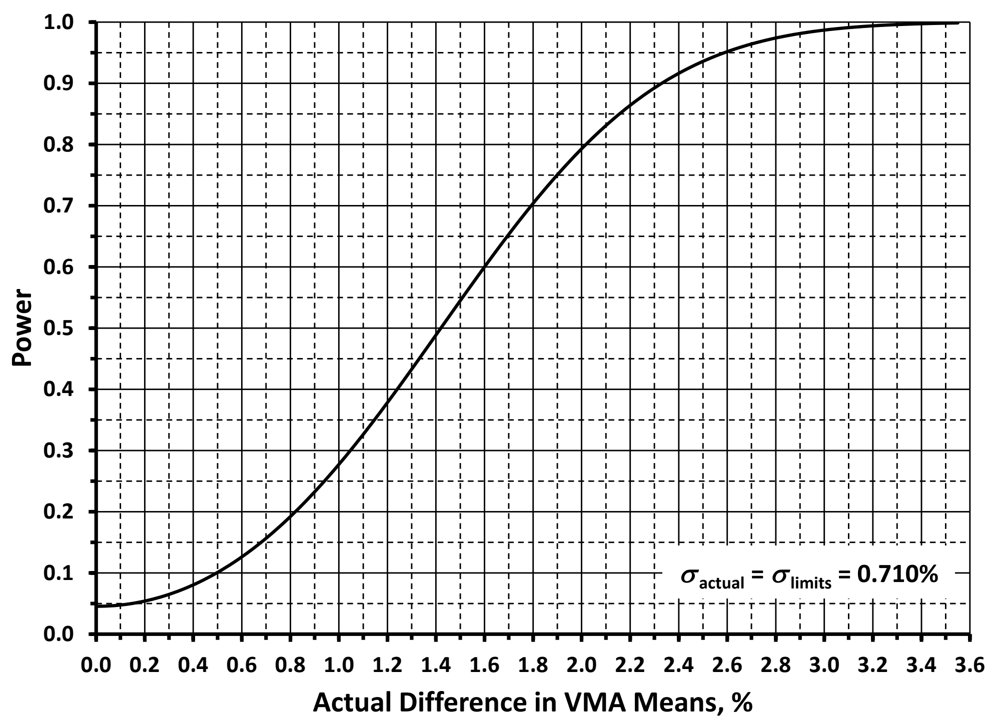

Figure 8.11. Power Curve for Differences between Split Sample Population VMA Means when $\sigma_{actual} = \sigma_{limits} = 0.710\%$

Cause of Differences between Contractor and SCDOT Tests

F-tests, t-tests, and split-sample comparisons can determine when a difference between the contractor acceptance tests and the SCDOT verification tests is likely. However, the fact that a test does not conclude that there is a difference does not prove that the 2 sets of test results or the 2 tests are the same. A major drawback of the F-test and t-test procedures is that they can determine only whether a difference between the 2 data sets is likely. They do not, however, provide any information regarding the reason for the difference between the acceptance and verification tests.

These tests attempt to identify when two data sets differ. They cannot indicate which of the data sets is "correct" and which is "wrong." Indeed, regardless of the result of the hypothesis test, either of the data sets could be "wrong," they both could be "wrong," or they both could be "correct." The lower the P-value the more confident we are that the 2 data sets actually are different, but they both could still be "wrong." However, most state transportation departments (STDs), SCDOT included, will assume that their data are "correct" in the event that the F-test or t-test finds a difference between the acceptance and verification tests. In reality, an investigation should be conducted in an effort to determine "why" the 2 sets of tests were found to be different.

The smaller sample, which is usually the verification tests, could be influenced by 1 bad truck load from which 1 of the limited number of verification samples was taken. With a smaller sample size, 1 errant value would have a bigger impact on the sample mean and standard deviation. It could be that only 1 "bad" Lot caused the statistical tests to not compare. In such an instance, the Contractor could be penalized on all 3-7 Lots for errors that occurred on only 1 of the Lots in the comparison data.

Any differences between the 2 sets of tests may be due to a number of different factors. The one that a STD is likely to first think of is that the contractor has "manipulated" the results to ensure that full payment is obtained. While there is always some chance that this is the case, other possibilities may be more likely. For example, differences in sampling or testing procedures could account for differences. In this event, the material sampled by both parties could be identical but differences still might be identified when comparing the results. This may be of particular concern in the current research where there were many differences between Contractor and SCDOT results for AV and VMA, and where in every case the Contractor acceptance tests had less variability than the SCDOT verification tests. These differences likely are related to issues other than differences in the materials.

The differences between Contractor acceptance and SCDOT verification test results could be due to differences in test procedures that are an inherent part of the process. For example, the acceptance samples taken by the Contractor may very well be split, prepared, and tested within a very short time after being taken from the truck at the plant. In such cases, the sample likely would not need to be re-heated. On the other hand, the SCDOT verification sample must be transported to another lab and likely will require re-heating. Additionally, the verification tests may be conducted anywhere from a few hours to a few days after the sample was taken from the truck.

As a result, any differences between the acceptance and verification tests may well be due to differences in testing procedures rather than differences in the material. It may be that, due to the differences in procedures, the 2 sets of tests should not be expected to compare on a routine basis. The verification procedures used by SCDOT, and indeed by most if not all STDs, are based on the assumption that sampling, storage, and testing procedures do not contribute to any differences detected when comparing the different test results.

Recommendation. It is strongly recommended, therefore, that SCDOT implement a research study to examine whether or not re-heating, lack of re-heating, delays before testing, and lack of delays have any effect on the resulting test results. Without such a study, it is difficult to state with confidence that differences between the acceptance tests and verification tests are due to differences in the material that was sampled and tested by the 2 parties.

CHAPTER 9 — SUMMARY, FINDINGS, AND RECOMMENDATIONS

Summary

This study was conducted in response to an FHWA Quality Assurance (QA) Stewardship Review that concluded that changes were needed to the then current QC/Acceptance and Independent Assurance (IA) processes used by SCDOT. The Stewardship Review concluded that the SCDOT allowable differences in HMA test data were 2 to 3 times the current practice in other states and that the IA tolerances were in a similar need of analyzing and updating. This review is what led to the Phase II study presented in this report.

Extensive statistical analyses were conducted to determine appropriate standard deviation values to represent the variability for asphalt content (AC), air voids (AV), voids in mineral aggregate (VMA), and Density. SCDOT provided test result data from their projects. A total of 2,789 AC tests, 2,234 AV tests, and 2,230 VMA tests were provided from 20 different projects, with some projects having multiple Mix Types and JMFs involved. The reason that there were fewer AV and VMA tests is that voids testing was not done for all Mix Types (e.g., Base course mixes, open graded friction course (OGFC) mixes, or Surface E mixes). A total of 2,010 density test results also were provided from 15 of the 20 projects.

Analyses were conducted on the project test results for, AC, AV, VMA, and Density with the primary goal of determining values to use to represent the typical variability for each characteristic. This is a subjective decision that ultimately must be made by SCDOT. These variabilities are necessary to evaluate the appropriateness of the existing specification limits.

Also, since SCDOT's allowable tolerances for differences between split sample test results was a major concern from the Stewardship Review, test result data from the SCDOT verification testing program also were provided from 16 of the 20 projects. These data consisted of 487 AC and 452 AV and VMA test results from SCDOT. In addition, the data set included 411 AC, and 387 AV and VMA Contractor verification test results.

Major Concerns with the Available Data

There are a number of issues with the data provided by SCDOT. The biggest concern is with the lack of certain data. The proposal for this project included the following statement:

> *To have a sufficient database from which to draw conclusions, it will be necessary to have data from at least 20, and preferably more, projects of relatively large size*. *The "large size" is necessary so the data are available from projects that had multiple verification data sets*.

While there are test results data from 20 projects, and there are a large total number of test results, there are a number of significant issues with these data. Some of these concerns relate to the distribution of data values among Projects and Contractors. A total of 7 different Contractors conducted the 20 Projects from which data were obtained. These concerns are presented and discussed in detail throughout the report. Some of the issues can be summarized as follows.

Analysis Data Set for Plant Tests. While nearly 2,800 test results for AC and over 2,200 test results for AV and VMA were provided by SCDOT, issues with the data required that some of these tests be eliminated from the analysis data set and also brought into question the applicability of these data for the purpose of this project.

Data Distribution by Project. While data were obtained from 20 projects, there is a widely uneven distribution of tests data among the projects. This uneven distribution is summarized in Table 9.1. As the table shows, well over half of the test data comes from only 6 of the 20 projects, and the 2 largest projects account for 32% to 40% of the test data. Any analysis results are likely to be biased towards the larger projects.

Table 9.1. Distribution of Plant Test Result Data by Project

Characteristic	2 Largest Projects	6 Largest Projects	14 Smallest Projects	Total
AC	1,115 40.0%	1,797 64.4%	992 35.6%	2,789 100%
AV	720 32.2%	1,326 59.4%	908 40.6%	2,234 100%
VMA	720 32.3%	1,326 59.5%	904 40.5%	2,230 100%

Data Distribution by Contractor. Another concern with the provided test result data is the limited number of Contractors on the Projects from which data were supplied. While data were obtained from 20 projects, only 7 different Contractors were represented on these projects. Two of the 7 Contractors performed 11 (55%) of the projects from which data were obtained. And, 3 of the 7 Contractors performed 14 (70%) of the projects. The distribution by Contractor is even more pronounced when the number of tests is considered. Table 9.2 shows the breakdown of test results data by Contractor. With such heavy weighting of the data among only 2 Contractors, it is questionable whether the results of the analyses are applicable for the “typical” Contractor that does work for SCDOT.

Table 9.2. Distribution of Plant Test Result Data by Project

Characteristic	2 Largest Contractors	5 Smallest Contractors	Total
AC	1,918 68.8%	871 31.2%	2,789 100%
AV	1,380 61.8%	854 38.2%	2,234 100%
VMA	1,376 61.7%	854 38.3%	2,230 100%

Data Distribution by Course. The data that were provided were heavily weighted towards Surface course mixes. In fact, the number of Base and Intermediate course test results was so small as to make them inappropriate for analysis and they therefore were eliminated from the data set that was analyzed. The distribution of test result data by Course is shown in Table 9.3.

Table 9.3. Distribution of Plant Test Result Data by Course

Course	No. of Tests	Percent of Total
AC		
Base	164	5.9%
Intermediate	136	4.9%
Surface	2,489	89.2%
AV		
Base	80	3.6%
Intermediate	102	4.6%
Surface	2,052	91.8%
VMA		
Base	80	3.6%
Intermediate	102	4.6%
Surface	2,048	91.8%

Elimination of Selected Lots. One of the important objectives in analyzing an acceptance process is determining the typical within-Lot standard deviation to use when developing acceptance limits. Since it is not possible to determine a standard deviation when the sample size is 1, it was necessary to eliminate from the analyses any Lots for which there was only 1 test result available.

The original data set had test results from 1008 Lots. Of these, 314 had only a single test in each Lot, thereby leaving a total of 694 Lots in the data set. After eliminating single test Lots, the data set had 2,489 AC tests, 2,052 AV tests, and 2,048 VMA tests.

Data Distribution by Surface Mix Type. After eliminating Base and Intermediate courses and single-test Lots, the distribution of data among the Surface Mix Types was then considered. Table 9.4 shows this distribution. The number of data points for OGFC, Surface C, and Surface E are not sufficient from which to draw valid conclusions. As a result, the analyses for this project were done on a data set consisting only of Surface A and Surface B Mix Types.

Table 9.4. Summary of Test Results for Surface Mix types for the Abridged Data Set

Mix Type	AC		AV		VMA	
	Projects	Tests	Projects	Tests	Projects	Tests
OGFC	2	151	0	0	0	0
Surface A	9	826	9	826	9	822
Surface B	12	1005	12	1005	12	1005
Surface C	4	78	4	78	4	78
Surface E	4	205	0	0	0	0
TOTALS		**2265**		**1909**		**1905**

Table 9.4 shows the limited amount of data available for the OGFC (2 projects, 151 tests), Surface C (4 projects, 78 tests), and Surface E (4 projects, 205 tests) Mix Types compared with Surface A (9 projects, 826 tests) and Surface B (12 projects, 1,005 tests) Mix Types. Also note that for the OGFC and Surface E Mix Types only AC tests were performed.

None of the Surface Mix Types meet the following requirement that was stated in the proposal for this project:

> *To have a sufficient database from which to draw conclusions, it will be necessary to have data from at least 20, and preferably more, projects of relatively large size*.

While it is somewhat of a stretch using 9 and 12 projects, using data from 4 or fewer projects with 205 or fewer test results is totally unrealistic and unacceptable. Therefore, the final Analysis data set was comprised only of the test results for Surface A and Surface B Mix Types.

Major Limitation**:** The analyses for this project were done on a data set consisting only of Surface A and Surface B Mix Types. Any conclusions or recommendations therefore can apply only to these 2 Mix Types.

Analysis Data Set for Density Tests. The Density data set had the same concerns as the Plant data set. For example, 4 of the 15 Projects accounted for over half of the test results. Similarly, 1 of the 7 Contractors accounted for nearly half (47.8%) of all Density test results, and 3 of the 7 accounted for nearly 80% of the test results.

When reviewing the Density data the first thing that stands out is the small number of test results that were obtained for Base (1 Project, 201 Tests) and Intermediate (2 Projects, 39 Tests) Courses. The relatively small number of Nuclear Gage test results (2 Projects, 343 Tests) is also apparent. This means that the Surface Mix data, which are from 14 of the 15 Projects, are 88% of the total data set (81% from Cores, 7% from Nuclear Gages).

Major Limitation**:** Realistically, there are not sufficient Density test results data for Nuclear Gages or for Base or Intermediate Mix Types to consider valid any analyses of these data. Additionally, only 1 Contractor had data for Base course and only 2 had data for Intermediate course. These data simply are not sufficient for evaluating the performance of a "typical" Contractor in SC.

Results of Data Analyses

The results of analyses are presented as they relate to the specific Objectives of the research.

Objective: *To evaluate the current SCDOT random number table in SC-T-101, and to develop a new statistically-valid procedure, preferably web-based, that provides the random numbers both to the Contractor and to SCDOT along with all identifying information needed by SCDOT.*

When the proposal for this project was submitted, there were no specifications for the programming requirements necessary to meet this objective. It was assumed that the department of Clemson Computing and Information Technology (CCIT) would be able to perform whatever programming was necessary and would be able to interact with SCDOT information technology (IT) personnel to achieve this objective.

Once the contract was awarded, SCDOT IT personnel prepared a set of requirements and specifications necessary for the programming on this project to be compatible with SCDOT's programming environment. Unfortunately, CCIT did not support the programming environment that was required by SCDOT.

This was discussed at a meeting of the Research Steering and Implementation Committee and it was decided that this objective would be eliminated from this project and that SCDOT IT personnel would work with SCDOT Materials Lab to determine if the program would be developed.

Objective: *To develop new verification procedures that will allow SCDOT to make valid verification decisions in situations in which the job mix formula (JMF) is changed within a Lot or within a given day's production.*

The biggest issue with this objective is whether or not it is necessary to establish a new Lot each time the JMF is changed. All of the analyses in this research project were conducted by "standardizing" the test results from multiple projects so that they could be considered as a collective data set. Since each Project, and indeed each JMF, can have different target values, it is not appropriate to combine the actual test results from multiple Projects or multiple JMFs into one data set.

To do this, it is necessary to use not the actual AC, AV, or VMA test result, but the difference between the test result and the target value. In this way the fact that the data come from JMFs with different target values becomes a non-issue. This is the obvious first step in considering how SCDOT might combine test results from more than 1 JMF into the same Lot for acceptance or verification procedures.

Analyses were performed to compare Surface A and Surface B Mix Types with respect to their variabilities. On a macro level (i.e., comparing all Surface A with all Surface B tests) no difference in variabilities was found for AC. A definite difference was found for VMA. While the comparison for AV was inconclusive with 1 test declaring a difference and 2 tests finding no difference. Therefore, it probably is not safe to combine different Mix Types together when making acceptance or verification decisions.

Four of the Projects had both Surface A and Surface B mixes on the same project. When comparing the variabilities of these 2 mixes within a given project, no difference was found for AC for any of the 4 projects. AV and VMA both had a difference on 1 project and no difference on 3 projects.

Finally, 9 of the Projects had more than 1 JMF of the same Mix Type. When these 9 Projects were compared for differences in variabilities among the different within-Project JMFs, no differences were identified for AC, AV, or VMA on any of the 9 Projects.

When Density was considered, the variabilities of the overall data set for Surface A and Surface B mixes were declared different. When the 7 Projects that had more than 1 JMF were considered, 4 did not show a difference and 3 did show a difference. However, on the 4 Projects for which the JMFs were of the same Mix Type, 3 showed no difference and only 1 was declared different. On the 4 for which the multiple JMFs were from different Mix Types, 1 showed no difference and on 3 a difference was identified.

***Recommendation*:** While it is not appropriate to draw conclusions given the concerns expressed concerning the overall data set, these results certainly support switching to combining the AC, AV, and VMA test results of multiple JMFs on a Project provided they are for the same Mix Type (i.e., Surface A or Surface B). The available data probably are too limited to support combining multiple JMFs from different Mix Types.

Objective: *To evaluate whether or not SCDOT should modify its acceptance procedures to base acceptance testing on a frequency of production quantities rather than on a daily or Lot basis.*

To explore whether or not a recommendation could be made based on the provided data, the data were evaluated on a Lot basis. Three items were considered in this analysis:

- The number of tests per Lot.
- The number of days per Lot.
- The tonnage placed per day.

The first thing that became obvious when exploring the number of tests/Lot was the very large number of Lots for which it was not possible to calculate a percent within limits (PWL) value to use for payment determination.

PWL-based specifications, such as the 1 being evaluated in this research project, are designed for mainline paving where there is a relatively large and consistent amount of tonnage placed from 1 day to the next. PWL-based specifications are not designed for low volume paving applications.

A full 43% of the Lots in the data set had either a single test (33.2%) or 2 tests (9.8%). These Lots were not added with other Lots to determine a PWL value and payment factor. It is difficult to see how switching to defining a Lot by production quantity would help with this significant number of single test Lots. Depending upon the quantities selected for Lot or sublot sizes, the productions for multiple days probably would need to be added together. However, this often is done with the current day's production definition for a Lot.

The current procedures call for combining tests from multiple Lots until at least 3 tests are available to determine PWL. It is not known why this was not done for the Lots for which there were only 1 or 2 tests; but, if it was not done under the current Lot definition, there is no reason to believe it would be more likely to be done if the Lot definition were based on quantity of production.

Currently, if there are fewer than 3 tests from a day's production, then that day is combined with subsequent paving days until at least 3 test results are available and the combined days then become 1 Lot. To explore how often multiple days paving had to be combined into one Lot, the number of days per Lot was evaluated.

There were 705 (or 72.6%) of the Lots that had a single day for the Lot. However, 322 of these had only 1 test and another 95 had only 2 tests in the Lot. This means that there were only 288 PWL Lots (i.e., 705 – 322 – 95) that had all tests from a single day's production. Taking this new number of PWL Lots into consideration, 52.0% of the PWL Lots were based on a single day's production, 37.9% had 2 days combined, 9.6% had 3 days combined, 0.4% had 4 days combined, and 0.2% had 5 paving days combined into 1 Lot.

The average number of tons per paving day varied greatly depending upon the Mix Type. Surface A and Surface B mixes each averaged about 1,300 tons per day, while the Base A mix averaged about 1,100 tons per day. Surface C and Surface E averaged 753 and 876, respectively.

***Recommendation*:** Any recommendation concerning whether SCDOT should consider switching to a specified quantity rather than a day's production as the definition of a Lot must be tempered with the knowledge of the data set. The biggest issues are the limited amount of data that were available and that, of the data available, nearly 70% of the data came from only 2 Contractors. This makes it highly questionable as to whether these data can be considered representative of "typical" contractors in the State.

However, there is nothing in the limited data that were analyzed that indicates that switching to a specified quantity would improve the acceptance process over the current day's production definition.

Objective: *To recommend procedures for SCDOT to use when the last Lot on a project does not have a sufficient number of tests to make a valid comparison with the Contractor's test results.*

There really is nothing in the data that were provided that helps to address this objective. The current procedure in SC-T-97 states for the last Lot: "If the last data set is less than the minimum of 7 verification tests, then go back to the previous LOTS far enough to yield the number of test needed in the data set."

This approach can create a sort of "double jeopardy" situation for the Contractor. If the last complete verification data set is verified and the Contractor tests are used, and if the Contractor's tests indicate full payment or even a bonus, then a portion of this Lot will be evaluated again when it is combined with the last partial verification data set.

The issues that apply to any verification testing procedure apply to the SCDOT procedures. When the verification tests do not compare and they are used to determine acceptance and payment, the Lot size will be larger and the number of tests used to evaluate the Lot will be smaller. This inherently creates more risk for both parties, but is of particular concern for the Contractor.

***Recommendations*:** Concerning a last partial verification data set, rather than using the same test results in 2 different verification decisions, it is recommended that SCDOT consider 1 of 2 options:

- Increase the size of the last verification data set to include the last partial set with the previous complete verification data set.
- Add the last partial data set to the previous complete verification data set and then divide the resulting data set into 2 equally sized verification data sets.

Objective: *To determine appropriate standard deviations to use when establishing split-sample allowable tolerances.*

The split sample analysis data set had 232 sets of split samples for Surface A mixes and 127 sets for Surface B mixes. For information purposes, t-tests for paired values were performed on the split sample analysis data set. The tests were conducted on a Project basis and they were broken down by Mix Type if there was both Surface A and Surface B mixes on a particular Project.

For AC, only 3 of 14 t-tests showed significant differences at $\alpha = 0.05$ and none of these differences were significant at $\alpha = 0.01$. Also, 2 of them were from the same project. For AV, 9 of the 14 t-tests showed significant differences at $\alpha = 0.01$. For VMA, 6 of the 14 t-tests showed significant differences at $\alpha = 0.01$ and an additional 2 were different at $\alpha = 0.05$.

While none of the above numbers relates to allowable limits for individual split samples, they do indicate that the Contractor and SCDOT portions will likely come from different populations with respect to AV and VMA in particular.

To establish allowable tolerances for the difference between the Contractor and SCDOT split sample result, it is necessary to decide on a population for the differences for AC, AV, and VMA. Since a subjective decision is required when establishing the standard deviation to use to represent the population of split sample differences for the typical Contractor, the PI cannot recommend a specific answer for the allowable tolerances. However, a procedure for establishing these tolerances is presented in Chapter 8.

The procedure is similar to the one used for establishing the typical standard deviation to use for establishing specification limits. In fact, the two are essentially the same procedure. Once a typical standard deviation is selected for the split sample differences, then $\pm 2\sigma$ limits can be used to establish the allowable tolerances.

In the example calculations in Chapter 8, the 75th percentile was used as the starting point for establishing the standard deviation for the split sample differences. Using this value, the following <u>*example*</u> 2σ tolerance limits were calculated for Surface A and Surface B mixes:

AC: $0.215 \times 2 = 0.43$

AV: $0.675 \times 2 = 1.35$

VMA: $0.710 \times 2 = 1.42$.

***Major Limitations*:** It must be noted that while this methodology is sound, the appropriateness of the limits depends upon the validity of the test results data that were provided. The allowable limits calculated by this approach are only as good as the data that were used to determine the standard deviation for the population of split sample differences.

The standard deviations of the split sample differences derived by this method will yield allowable tolerances that are considerably larger than the D2S limits from the corresponding test method. D2S limits are established from a scenario in which the samples are artificially prepared to be as identical as possible. The samples are sent to the testing lab under the same conditions and are tested under conditions that are as close as possible to the same. Therefore, D2S limits are “best case” limits that are not applicable to the verification scenarios that are encountered on actual projects.

For example, due to material, sampling, and splitting variabilities, the split samples will not be nearly as “identical” as the samples used when developing the 1S and D2S values. Verification split samples also may differ in the manner in which they are tested. The Contractor split sample may not require reheating and may be tested within hours of being sampled, whereas the SCDOT verification split sample will require reheating and may not be tested for several days after the sample is taken and split.

By using the test results supplied for this research, there is the implicit assumption that the test results that were analyzed are indeed representative of the quality of construction that is acceptable to SCDOT and that is achievable by the typical Contractor that performs work for SCDOT. If these data are not representative of the type of construction that SCDOT considers acceptable, then using them to establish allowable tolerances for split samples may yield tolerances that are not appropriate.

A question that needs to be addressed is what power has the split sample comparison to declare various differences between the split samples to be statistically significant differences. Power curves can be used to answer this question. In Chapter 8, power curves were developed for the split sample comparisons.

After reviewing this report and the power curves in Chapter 8, SCDOT will need to make a subjective decision regarding the allowable limits. What is obvious from the power curves is that any comparison procedure that is based on a single split sample test result will have relatively low power to detect actual differences when they are present.

Objective: *To determine appropriate standard deviation values to use to establish the specification limits that are used when the Contractor acceptance tests do not compare during the verification process and the SCDOT verification tests are subsequently used to determine the payment factors.*

Establishing recommendations for standard deviation values to use when the SCDOT verification tests are used for acceptance first required an analysis to evaluate the standard deviation values to use for Lot-by-Lot acceptance. The standard deviation values for the verification tests could then be related to these values.

The potential variability of the population mean about the target value was considered in addition to the within-Lot standard deviation values to develop an overall “process standard deviation” for each of the acceptance characteristics. These standard deviation values were then compared with similar values obtained during the Phase I study to see if there were any obvious differences.

The selection of the process standard deviation to use for each acceptance characteristic is a subjective decision that ultimately must be made by SCDOT. To illustrate this selection process, this report contains examples that led to the ranges of possible values shown in Table 9.5. In the table the “Using Within-Lot and Target Miss St Dev’s” column refers to determining a within-Lot standard deviation and combining it with the standard deviation for the Lot means (the target miss standard deviation) to come up with the process standard deviation. The “All Project Tests” column calculates a standard deviation using all of the tests on a given project. In this way the value would capture any within-Lot and target miss variability.

Table 9.5. Comparison of Potential Typical “Process” Standard Deviation Values

Characteristic	Phase I Value, %	Using Within-Lot and Target Miss St Dev’s*	All Project Tests, %*
AC	0.21 – 0.23	0.181 – 0.189	0.202
AV	0.63 – 0.69	0.496 – 0.535	0.579 – 0.626
VMA	0.64 – 0.71	0.494 – 0.537	0.562 – 0.581

* These numbers are for illustration only. SCDOT must make a subjective decision concerning the appropriate values to use.

***Major Limitation*:** The values for typical process standard deviations are all lower than the corresponding values from the Phase I study. SCDOT will have to consider whether, given the data set concerns expressed in this report, they have sufficient confidence in the Phase II data to use them to evaluate their existing specification limits.

To investigate how the “typical” standard deviation varied with the number of Lots that were included in the evaluation, the projects in the analysis data set were divided into 3-, 5-, and 7-Lot Group data sets. As expected, the standard deviation values increased as the number of Lots in each Group increased.

Since the magnitudes of the standard deviations differ for AC, AV, and VMA, to allow for more direct comparison, Figures 9.1 and 9.2 present the mean and 75th percentile standard deviation values in terms of the ratio of the given standard deviation to the 1-Lot standard deviation values. In this way the trends for AC, AV and VMA can all be plotted on the same graph.

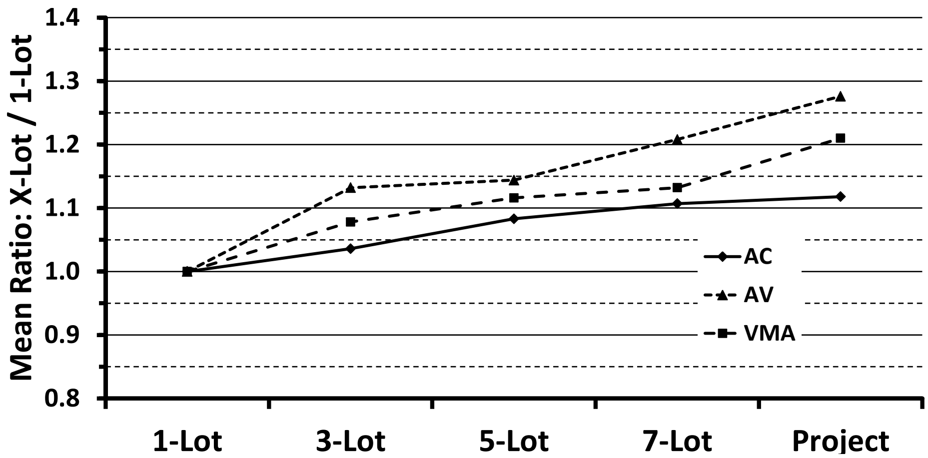

Figure 9.1. Ratio of Mean Standard Deviations to the 1-Lot Standard Deviations

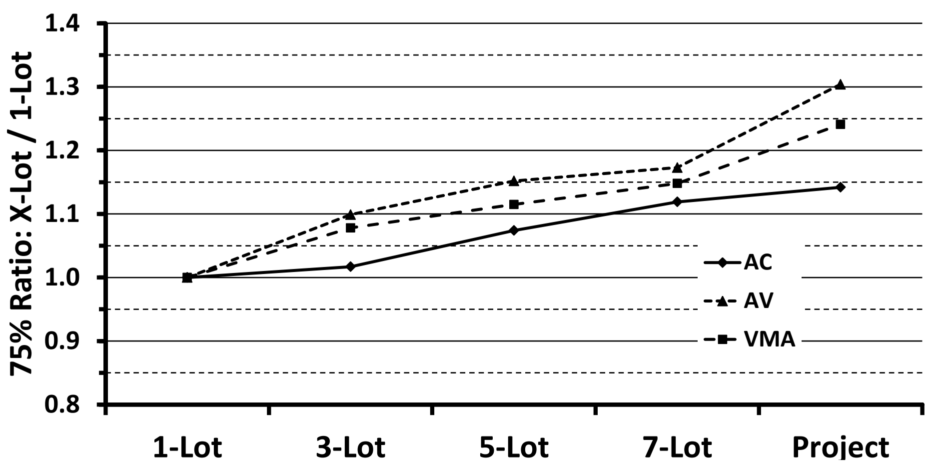

Figure 9.2. Ratio of 75th Percentile Standard Deviations to the 1-Lot Standard Deviations

For comparison purposes, Table 9.6 shows a summary of the current SCDOT acceptance limits for the cases when Contractor acceptance tests and SCDOT verification tests are used for acceptance. It also includes the percent increase between these values along with the percent increases from 1-Lot to 7-Lot Groups for the mean standard deviations from Figure 9.1. The 7-Lot allowable tolerances are also shown. These were determined by multiplying the 7-Lot 75th percentile standard deviations by 1.645 for 90 PWL limits.

Table 9.6. Comparison of Allowable Tolerances for Surface Course Mixes

Characteristic	Contr. Accept. Tests	SCDOT Verif. Tests	7-Lot SD	Ratio: S_{Verif}/C_{Acc}	Ratio: 7-Lot/ C_{Acc}
AC, %	0.36	0.43	0.34	1.194	1.107
AV, %	1.15	1.32	0.96	1.148	1.208
VMA, %	1.15	1.32	0.98	1.148	1.132

Major Limitation: The 7-Lot Group allowable tolerances are all lower than the within-Lot values from the Phase I study. Given the serious concerns with the data that were used in the analysis, SCDOT will have to consider very carefully whether they wish to modify their existing tolerances based on the results of this current study.

Concerns over Verification Testing

Systemic Issues. The verification data for each project were broken into data sets consisting of 7 verification tests and the corresponding number of Contractor acceptance tests. Then, an F-test was conducted on the variances and t-tests for equal variances and for unequal variances were conducted on the means. Some major issues were identified as a result of these analyses. A total of 48 different verification data sets were tested and the results are summarized in Table 9.7.

Table 9.7. Summary of Comparison of Contractor Acceptance and SCDOT Verification Tests for Data Sets with 7 Verification Tests

Test Conducted	Data Sets Tested	Sig. Diff @ α = .01	Sig. Diff @ α = .05	Contr. Value Larger	SCDOT Value Larger
AC					
F-test	48	4 / 8.3%	8 / 16.7%	2	6
t-test, equal	48	1 / 2.1%	1 / 2.1%	1	0
t-test, unequal	48	1 / 2.1%	2 / 4.2%	2	0
AV					
F-test	48	10 / 20.8%	18 / 37.5%	0	18
t-test, equal	48	6 / 12.5%	11 / 22.9%	6	5
t-test, unequal	48	3 / 6.3%	9 / 18.8%	4	5
VMA					
F-test	48	4 / 8.3%	14 / 29.2%	0	14
t-test, equal	48	9 / 18.8%	13 / 27.1%	7	6
t-test, unequal	48	5 / 10.43%	11 / 22.9%	5	6

***Major Concerns*:** The results in Table 9.7 raise some serious concerns about the verification process. For the 144 F-test comparisons, 12.5% were significantly different at the $\alpha = 0.01$ level and a total of 27.5% were significantly different at the $\alpha = 0.05$ level. Similarly, for the equal variance t-test, 11.1% showed differences at the $\alpha = 0.01$ level and a total of 17.4% were significantly different at the $\alpha = 0.05$ level. For the unequal variance t-test, 6.3% showed differences at the $\alpha = 0.01$ level and a total of 15.3% were significantly different at the $\alpha = 0.05$ level.

The F-tests are of particular concern. There were 8 AC differences, but 18 AV differences and 14 VMA differences. What really "jumps out" about the AV and VMA differences is that for all 32 of them the Contractor variance was less than the SCDOT verification variance. Similarly, for AC for 6 of the 8 differences the SCDOT variance was greater. This indicates clearly that some systemic difference is involved. If the differences had been the result of a random process all of them would not have been less for the Contractor's tests.

These data cannot identify the cause of the systemic difference. We can only speculate as to the cause. One likely cause is the fact that the Contractor acceptance tests likely did not require reheating before preparing and testing specimens as was likely necessary for all of the verification test samples. This is a consistent occurrence and is an issue that SCDOT needs to consider. Even for the times that the F-test did not identify significant differences, the majority of the time the Contractor variances were less than the SCDOT verification variances.

***Recommendation*:** It is recommended that SCDOT implement a research study to examine whether re-heating, lack of re-heating, delays before testing, and lack of delay have an effect on the resulting test results. Without such a study it is difficult to state with any confidence that differences between the acceptance tests and verification tests are due to differences in the material that was sampled and tested by the 2 parties, and not due to differences in testing procedures, testing personnel, testing equipment, etc.

Such a study should be a laboratory study as opposed to a field study. In the laboratory, each test specimen can be prepared to be as similar as possible. Also, all of the test specimens can be prepared and tested by the same technician using the same equipment. In this way, any effects of sample splitting, technician, or testing equipment will be minimized to the greatest extent possible. In this way, if any differences were detected in the results they likely would come from re-heating and delays between testing.

Power Curves for Comparison of Contractor Acceptance Tests and SCDOT Verification Tests. SC-T-97 requires the use of the F-test to compare the variances and the t-test to compare the means of the SCDOT verification tests and the Contractor acceptance tests. SCDOT uses $\alpha = 0.01$ as the level of significance. This makes it unlikely to incorrectly declare a difference when there is none, but it also makes it more difficult to declare a difference when one actually exists.

An extensive series of power curves for both the F-test and t-test were developed and are presented in Chapter 7. Figure 9.3 is an example of 1 of these power curves for the F-test.

In the figure, the solid line is the power curve for α = 0.01 and the dashed line is the power curve for α = 0.05. As can be seen, the power for any given s_V / s_C ratio is much higher for the α = 0.05 curve than for the α = 0.01 curve. SCDOT currently uses α = 0.01 for the F-test. This means that there is less and a 0.4 (or 40%) chance of detecting the difference when the SCDOT standard deviation is twice as large as the Contractor's standard deviation. If the test were conducted at the α = 0.05 level, there would be nearly a 0.6 (or 60%) chance of detecting the same difference.

The situation is even worse if the SCDOT standard deviation is half as large as the Contractor's standard deviation. At the α = 0.01 level, there is less than a 0.15 (or 15%) chance of detecting the difference, whereas the power increases to 0.4 (or 40%) for α = 0.05.

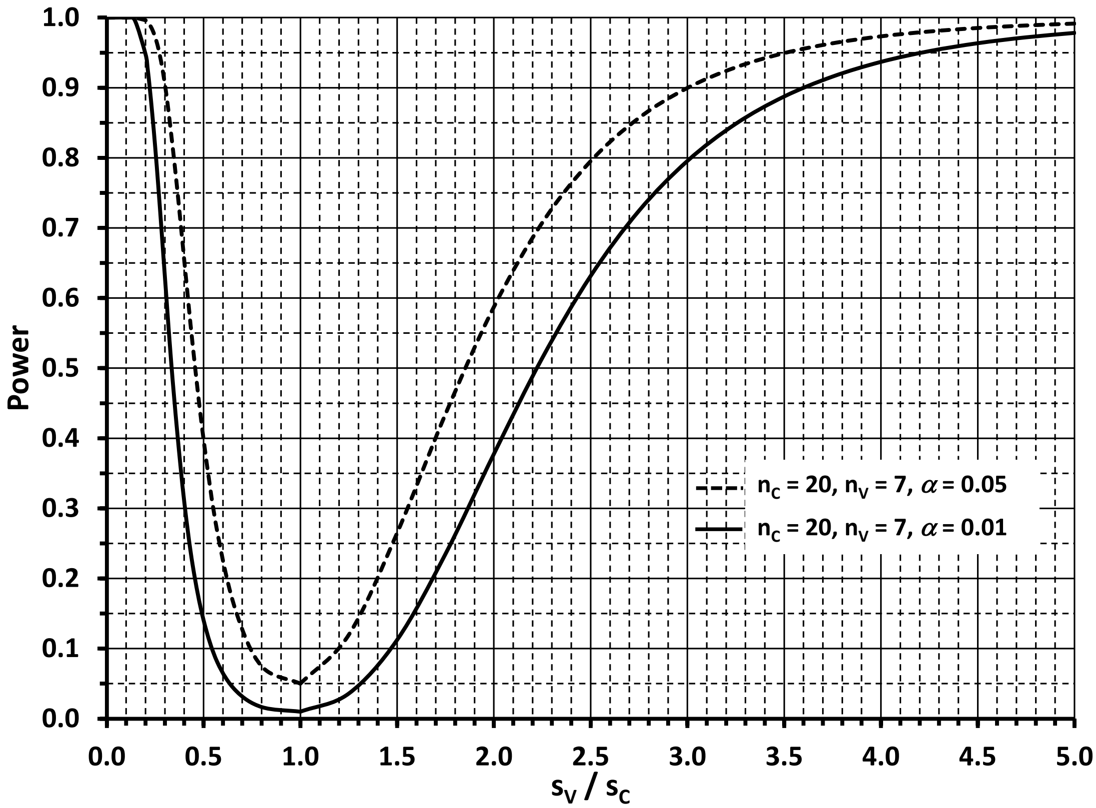

Figure 9.3. Power Curves $H_0 : s_C^2 = s_V^2$ and $H_a : s_C^2 \neq s_V^2$ for the F-test.

The power curves for both the F-test and t-test also show that it is the smaller sample size (i.e., the SCDOT verification tests) that influences the power more than the larger sample size (i.e., the Contractor's acceptance tests). There is a noticeably larger increase in power as the smaller sample size increases from 7 to 8 to 10 than there is when the larger sample size increases from 20 to 25 to 30.

Depending upon the outcome of the F-test, SCDOT uses 2 different versions of the t-test. If the F-test declares a difference, the t-test for unequal variances is used. If the F-test does not declare a difference, the t-test for equal variances is used. In any F-test, if the variances are not declared different this does not mean that the 2 variances actually are equal.

When the variances actually are equal, the t-test for equal variances has a little more power than the t-test for unequal variances, although the difference in power is not particularly large. However, as noted in Minitab 17, the computer software used for all F-tests and t-tests in this report, "*The two-sample t-test with a pooled variance is slightly more powerful than the two-sample t-test with unequal variances*, *but serious error can result if the variances are not equal*."

***Recommendations*:** Considering the verification procedures in SC-T-97, the following recommendations are offered:

- SCDOT should consider using a level of significance of α = 0.05 to increase the power of the F-tests and t-tests that they conduct. It will increase the risk of incorrectly declaring differences when they do not exist, but will greatly increase the likelihood of declaring differences when they actually do exist.
- SCDOT should consider simplifying their verification procedure by always using the t-test for unequal variances regardless of the outcome of the F-test.

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APPENDIX A — PLANT TEST RESULT DATA

The following pages present all of the Plant test result data from projects that were provided by SCDOT. The data include asphalt content (AC), air voids (AV), and voids in mineral aggregate (VMA).

In the following table, each Project is identified with a unique number, ranging from P01 to P20. Each of these numbered projects corresponds with a unique SCDOT project file number. Since many of the projects had more than 1 HMA mixture on the project, they also had more than 1 job mix formula (JMF) that was placed on the project. In the tables, each JMF is identified with a unique number, ranging from J01 to J94.

Table A.1. Plant Test Results Data

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P01	Surf B	J01	1	0.47	-1.01	0.14
P01	Surf B	J01	1	0.13	-0.74	-0.36
P01	Surf B	J01	2	0.04	-0.76	-0.57
P01	Surf B	J01	2	0.31	-0.93	-0.16
P01	Surf B	J01	3	0.07	-0.86	-0.59
P01	Surf B	J01	4	0.08	1.11	1.15
P01	Surf B	J01	5	-0.17	-0.69	-1.03
P01	Surf B	J01	6	0.29	0.11	0.76
P01	Surf B	J01	6	0.20	0.04	0.48
P01	Surf B	J01	7	-0.11	-0.44	-0.61
P01	Surf B	J01	8	-0.22	-0.27	-0.69
P01	Surf B	J01	8	-0.24	-0.28	-0.77
P01	Surf B	J01	9	-0.22	-0.61	-0.99
P01	Surf B	J01	9	-0.22	-0.07	-0.56
P01	Surf B	J01	11	0.01	0.26	0.29
P01	Surf B	J01	11	-0.08	0.63	0.41
P01	Surf B	J01	12	0.05	0.97	1.00
P01	Surf B	J01	13	-0.01	-0.15	-0.15
P01	Surf B	J01	13	-0.01	-0.01	-0.03
P01	Surf B	J01	14	0.14	-0.73	-0.29
P01	Surf B	J01	15	0.27	-0.11	0.51
P01	Surf B	J01	16	0.18	-0.66	-0.16
P01	Surf B	J01	17	0.07	0.28	0.41
P01	Surf B	J01	18	-0.04	0.66	0.50
P01	Surf B	J01	19	0.13	0.35	0.61
P01	Surf B	J01	19	0.01	-0.13	-0.10
P01	Surf B	J01	20	0.04	-0.38	-0.20
P01	Surf B	J01	21	0.35	-0.35	0.47
P01	Surf B	J01	21	0.00	-0.17	-0.14
P01	Surf B	J01	22	0.11	-0.16	0.16
P01	Surf B	J01	23	0.28	-0.38	0.34
P01	Surf B	J01	24	0.17	0.35	0.73
P01	Surf B	J01	25	0.14	-0.28	0.11
P01	Surf B	J01	26	0.24	-0.20	0.41
P01	Surf B	J01	27	0.10	-0.35	-0.03
P01	Surf B	J01	28	0.01	0.31	0.40
P01	Surf B	J01	29	-0.08	0.55	0.34
P01	Surf B	J01	30	-0.03	1.17	1.01
P01	Surf B	J01	31	0.17	-0.36	0.11
P01	Surf B	J01	32	-0.09	-0.60	-0.70
P01	Surf B	J01	33	-0.04	0.01	-0.06
P01	Surf B	J01	34	0.12	-0.70	-0.31
P01	Surf B	J01	35	0.03	0.86	0.84
P01	Surf B	J01	36	0.04	0.28	0.38
P01	Surf B	J01	37	0.01	0.10	0.15
P01	Surf B	J01	38	-0.17	-0.72	-0.93
P01	Surf B	J01	39	-0.21	0.03	-0.36
P01	Surf B	J01	40	0.07	-0.80	-0.48
P01	Surf B	J01	41	-0.07	-0.49	-0.59
P01	Surf B	J01	42	0.04	-0.33	-0.20
P01	Surf B	J01	43	0.15	-0.63	-0.17
P01	Surf B	J01	44	0.19	-1.00	-0.38
P01	Surf B	J01	46	-0.10	-0.15	-0.29
P01	Surf B	J01	46	-0.20	-0.20	-0.54
P01	Surf B	J01	47	0.07	-0.33	-0.07
P01	Surf B	J01	48	0.19	-1.09	-0.52
P01	Surf B	J01	49	0.05	-1.01	-0.73
P01	Surf B	J01	49	-0.05	-0.75	-0.74
P01	Surf B	J01	50	-0.22	-0.62	-1.03
P01	Surf B	J01	51	-0.04	-1.04	-0.95
P01	Surf B	J01	52	-0.06	-0.59	-0.59
P01	Surf B	J01	53	-0.19	0.10	-0.31
P01	Surf B	J01	53	-0.15	0.52	0.12
P01	Surf B	J01	53	-0.35	0.02	-0.73
P01	Surf B	J01	54	-0.15	0.86	0.49
P01	Surf B	J01	55	0.05	0.55	0.62
P01	Surf B	J01	55	-0.19	-0.26	-0.63
P01	Surf B	J01	55	-0.14	-0.54	-0.78
P01	Surf B	J01	56	-0.22	0.11	-0.38
P01	Surf B	J01	57	0.18	0.02	0.46
P01	Surf B	J01	58	0.06	-0.95	-0.66
P01	Surf B	J01	59	0.10	-1.08	-0.67
P01	Surf B	J01	60	0.10	-0.64	-0.33
P01	Surf B	J01	61	-0.02	-0.94	-0.81
P01	Surf B	J01	61	0.16	-0.63	-0.13
P01	Surf B	J01	62	-0.13	-0.08	-0.32
P01	Surf B	J01	62	0.02	0.35	0.39
P01	Surf B	J01	63	0.06	-0.11	0.12
P02	Surf A	J02	1	0.17	-0.23	0.18
P02	Surf A	J02	1	-0.12	-0.01	-0.24
P02	Surf A	J02	1	-0.08	0.03	-0.15
P02	Surf A	J02	2	-0.08	0.52	0.37
P02	Surf A	J02	2	0.03	-0.63	-0.44
P02	Surf A	J02	2	-0.12	0.11	-0.13
P02	Surf A	J02	3	0.37	-0.24	0.61
P02	Surf A	J02	3	-0.18	0.17	-0.21

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P02	Surf A	J02	3	-0.03	-0.22	-0.19
P02	Surf A	J02	3	-0.05	0.24	*
P02	Surf A	J02	4	-0.15	-0.71	*
P02	Surf A	J02	4	-0.14	-0.69	*
P02	Surf A	J02	4	0.31	-0.34	*
P02	Surf A	J03	1	-0.27	0.28	-0.28
P02	Surf A	J03	1	1.78	2.35	1.72
P02	Surf A	J03	1	0.10	0.25	0.49
P02	Surf A	J03	8	-0.08	0.63	0.50
P02	Surf A	J03	8	0.02	-0.11	0.00
P02	Surf A	J03	8	-0.16	0.28	-0.02
P02	Surf A	J03	8	0.21	-0.52	0.05
P02	Surf A	J03	9	0.00	-0.22	-0.12
P02	Surf A	J03	9	-0.12	0.10	-0.11
P02	Surf A	J03	9	-0.48	-0.43	-1.44
P02	Surf A	J03	10	0.22	0.48	0.98
P02	Surf A	J03	10	-0.25	0.69	0.14
P02	Surf A	J03	10	-0.26	1.21	0.59
P02	Surf A	J03	11	-0.04	0.22	0.18
P02	Surf A	J03	11	0.65	0.72	2.19
P02	Surf A	J03	11	0.34	-0.73	0.18
P02	Surf A	J03	12	0.10	-0.01	0.23
P02	Surf A	J03	12	-0.08	0.27	0.10
P02	Surf A	J03	12	-0.36	0.25	-0.62
P02	Surf A	J03	13	-0.10	0.32	0.13
P02	Surf A	J03	13	0.07	0.02	0.22
P02	Surf A	J03	13	-0.15	-0.38	-0.68
P02	Surf A	J03	14	0.32	0.00	0.83
P02	Surf A	J03	14	0.04	0.22	0.33
P02	Surf A	J03	14	0.22	-0.12	0.44
P02	Surf A	J03	14	-0.40	1.06	0.10
P02	Surf A	J03	15	-0.12	0.49	0.21
P02	Surf A	J03	15	0.35	-0.78	0.11
P02	Surf A	J03	15	-0.18	-0.42	-0.77
P02	Surf A	J03	16	0.32	-0.33	0.49
P02	Surf A	J03	16	-0.35	1.42	0.59
P02	Surf A	J03	16	-0.01	-0.33	-0.28
P02	Surf A	J03	16	-0.10	0.02	-0.13
P02	Surf A	J03	16	-0.28	0.49	-0.08
P02	Surf A	J03	17	-0.16	0.19	-0.14
P02	Surf A	J03	17	0.09	1.24	1.40
P02	Surf A	J03	17	0.15	-0.16	0.22
P02	Surf A	J03	17	-0.30	0.82	0.08

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P02	Surf A	J03	17	-0.40	0.63	-0.30
P02	Surf A	J03	18	0.26	0.83	1.35
P02	Surf A	J03	18	-0.35	-0.45	-1.15
P02	Surf A	J03	18	-0.22	0.92	0.44
P02	Surf A	J03	19	0.13	0.43	0.76
P02	Surf A	J03	19	0.20	-0.37	0.20
P02	Surf A	J03	19	-0.15	1.91	1.42
P02	Surf A	J03	20	0.35	-1.23	-0.25
P02	Surf A	J03	20	0.26	-0.47	0.25
P02	Surf A	J03	20	-0.49	0.30	-0.78
P02	Surf A	J03	21	0.04	-0.32	-0.17
P02	Surf A	J03	21	0.14	0.80	1.12
P02	Surf A	J03	21	0.20	0.66	1.09
P02	Surf A	J03	21	-0.07	0.92	0.69
P02	Surf A	J03	22	-0.39	0.45	-0.39
P02	Surf A	J03	22	-0.18	-0.11	-0.45
P02	Surf A	J03	22	0.02	0.67	0.67
P02	Surf A	J03	32	-0.01	0.02	-0.04
P02	Surf A	J03	32	-0.16	-0.86	-1.15
P02	Surf A	J03	32	-0.13	0.33	0.00
P03	Surf A	J03	6	0.04	0.18	0.29
P03	Surf A	J03	6	-0.28	0.46	-0.20
P03	Surf A	J03	6	0.06	0.29	0.45
P03	Surf A	J03	7	-0.25	0.14	-0.41
P03	Surf A	J03	7	-0.23	0.52	-0.07
P03	Surf A	J03	7	-0.14	0.12	-0.19
P03	Surf A	J03	7	0.13	0.26	0.57
P03	Surf A	J03	8	0.06	0.42	0.55
P03	Surf A	J03	8	-0.08	0.61	0.41
P03	Surf A	J03	8	-0.09	0.23	0.00
P03	Surf A	J03	9	0.39	-0.58	0.41
P03	Surf A	J03	9	-0.11	0.91	0.62
P03	Surf A	J03	9	-0.05	-0.37	-0.39
P03	Surf A	J03	10	0.25	-0.33	0.36
P03	Surf A	J03	10	-0.51	0.42	-0.72
P03	Surf A	J03	10	-0.25	0.30	-0.95
P03	Surf A	J03	10	-0.03	-1.36	0.30
P03	Surf A	J03	11	0.24	-1.36	-0.65
P03	Surf A	J03	11	0.42	-0.01	1.04
P03	Surf A	J03	11	-0.08	0.18	0.00
P03	Surf A	J03	11	-0.16	0.81	0.41
P03	Surf A	J03	11	0.25	0.12	0.73
P03	Surf A	J03	12	0.19	-0.20	0.30

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA	Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P03	Surf A	J03	12	-0.27	0.87	0.21	P03	Surf A	J03	42	0.19	-0.21	0.25
P03	Surf A	J03	12	-0.15	0.31	-0.06	P03	Surf A	J03	43	-0.01	-0.57	-0.49
P03	Surf A	J03	12	-0.58	0.93	-0.48	P03	Surf A	J03	43	0.22	-1.05	-0.38
P03	Surf A	J03	12	-0.19	0.90	0.36	P03	Surf A	J03	43	-0.28	-0.56	-1.06
P03	Surf A	J03	12	0.16	0.56	0.87	P03	Surf A	J03	44	0.02	-0.46	-0.27
P03	Surf A	J03	13	0.18	0.30	0.67	P03	Surf A	J03	44	0.21	-0.18	0.42
P03	Surf A	J03	13	0.14	0.22	0.51	P03	Surf A	J03	44	-0.15	-0.51	-0.75
P03	Surf A	J03	13	0.26	0.45	0.96	P03	Surf A	J03	45	-0.15	-0.77	-0.99
P03	Surf A	J03	13	-0.01	-0.11	-0.17	P03	Surf A	J03	46	0.02	-0.86	-0.64
P03	Surf A	J03	14	0.13	0.42	0.67	P03	Surf A	J03	46	0.14	-0.78	-0.28
P03	Surf A	J03	14	-0.05	0.76	0.62	P03	Surf A	J03	46	0.21	-0.63	0.00
P03	Surf A	J03	14	0.15	0.73	1.06	P03	Surf A	J03	46	0.02	-0.66	-0.46
P03	Surf A	J03	15	-0.07	0.82	0.61	P03	Surf A	J06	1	0.13	-0.76	-0.22
P03	Surf A	J03	15	-0.04	0.40	0.30	P03	Surf A	J06	1	0.02	-0.19	0.05
P03	Surf A	J03	15	-0.02	0.00	-0.06	P03	Surf A	J06	1	-0.20	-1.06	-1.29
P03	Surf A	J03	15	-0.33	0.10	-0.68	P04	Surf B	J01	1	-0.02	0.77	0.67
P03	Surf A	J03	16	0.01	0.65	0.63	P04	Surf B	J01	1	0.06	0.35	0.47
P03	Surf A	J03	16	0.12	0.07	0.37	P04	Surf B	J01	1	0.06	-0.07	0.07
P03	Surf A	J03	16	-0.01	1.11	0.99	P04	Surf B	J01	2	-0.08	-0.73	-0.77
P03	Surf A	J03	16	-0.07	1.03	0.83	P04	Surf B	J01	2	0.31	-0.29	0.44
P03	Surf A	J03	17	-0.09	0.92	0.67	P04	Surf B	J01	2	0.17	-0.39	0.04
P03	Surf A	J03	17	0.14	0.55	0.84	P04	Surf B	J01	3	0.24	-0.86	-0.21
P03	Surf A	J03	17	-0.16	0.72	0.31	P04	Surf B	J01	3	0.02	-0.16	-0.07
P03	Surf A	J03	17	0.10	1.31	1.46	P04	Surf B	J01	3	0.04	-0.86	-0.67
P03	Surf A	J03	18	-0.15	0.12	-0.18	P04	Surf B	J01	5	-0.03	0.36	0.30
P03	Surf A	J03	18	0.08	0.04	0.21	P04	Surf B	J01	5	0.03	-0.02	0.09
P03	Surf A	J03	18	0.01	1.01	0.99	P04	Surf B	J01	5	0.13	0.83	1.07
P03	Surf A	J03	19	-0.09	-0.13	-0.33	P04	Surf B	J01	5	0.21	0.44	0.85
P03	Surf A	J03	19	-0.12	0.80	0.48	P04	Surf B	J01	6	0.05	-0.19	0.01
P03	Surf A	J03	19	0.33	-0.28	0.47	P04	Surf B	J01	6	0.18	0.06	0.51
P03	Surf A	J03	19	0.19	-0.31	0.11	P04	Surf B	J01	6	0.30	-0.07	0.63
P03	Surf A	J03	20	0.10	1.01	1.10	P04	Surf B	J01	7	0.25	-0.01	0.57
P03	Surf A	J03	20	0.26	0.36	0.92	P04	Surf B	J01	7	0.35	0.92	1.57
P03	Surf A	J03	20	-0.17	0.25	-0.15	P04	Surf B	J01	7	-0.06	0.46	0.32
P03	Surf A	J03	21	-0.26	0.77	0.11	P04	Surf B	J01	8	0.00	0.17	0.18
P03	Surf A	J03	40	-0.05	-0.37	-0.45	P04	Surf B	J01	8	0.19	0.65	0.99
P03	Surf A	J03	40	-0.22	0.58	0.10	P04	Surf B	J01	8	0.25	0.18	0.77
P03	Surf A	J03	40	0.16	-0.62	-0.16	P04	Surf B	J01	8	0.06	0.11	0.33
P03	Surf A	J03	41	0.53	-0.43	0.91	P04	Surf B	J01	8	0.09	-0.59	-0.25
P03	Surf A	J03	41	0.22	-1.01	-0.42	P04	Surf B	J01	9	0.28	-0.28	0.42
P03	Surf A	J03	41	-0.22	0.95	0.40	P04	Surf B	J01	9	-0.09	-0.28	-0.48
P03	Surf A	J03	42	0.09	-0.83	-0.56	P04	Surf B	J01	9	-0.04	-0.19	-0.19
P03	Surf A	J03	42	-0.01	-0.78	-0.70	P04	Surf B	J01	9	-0.12	-0.02	-0.20

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA	Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P04	Surf B	J01	9	-0.08	-0.09	-0.20	P04	Surf B	J01	24	-0.31	0.15	-0.50
P04	Surf B	J01	9	-0.17	-0.01	-0.31	P04	Surf B	J01	24	-0.06	0.95	0.76
P04	Surf B	J01	10	-0.25	1.56	0.88	P04	Surf B	J01	24	0.18	0.02	0.46
P04	Surf B	J01	10	-0.18	0.99	0.50	P04	Surf B	J01	25	0.13	-0.12	0.22
P04	Surf B	J01	10	0.13	-0.44	-0.05	P04	Surf B	J01	26	-0.35	0.18	-0.60
P04	Surf B	J01	10	0.01	-0.21	-0.09	P04	Surf B	J01	27	-0.27	-0.22	-0.77
P04	Surf B	J01	10	0.28	-0.16	0.53	P05	Inter C	J07	1	0.07	0.84	1.08
P04	Surf B	J01	11	-0.04	-0.68	-0.61	P05	Inter C	J07	2	0.02	0.81	0.94
P04	Surf B	J01	11	-0.05	-0.09	-0.13	P05	Inter C	J07	3	-0.04	0.21	0.20
P04	Surf B	J01	11	-0.06	-0.74	-0.77	P05	Inter C	J07	3	0.02	0.63	0.72
P04	Surf B	J01	12	-0.13	-0.31	-0.52	P05	Inter C	J07	4	-0.04	0.21	0.20
P04	Surf B	J01	12	0.08	-0.83	-0.52	P05	Inter C	J07	4	0.02	0.63	0.72
P04	Surf B	J01	12	0.07	-0.95	-0.65	P05	Inter C	J07	5	0.42	0.06	1.14
P04	Surf B	J01	12	0.03	-0.73	-0.54	P05	Inter C	J07	5	-0.04	1.05	1.00
P04	Surf B	J01	13	0.09	0.05	0.28	P05	Inter C	J07	6	0.08	0.96	1.18
P04	Surf B	J01	13	0.12	-0.77	-0.35	P05	Inter C	J07	7	-0.03	1.06	0.97
P04	Surf B	J01	13	-0.06	-0.44	-0.49	P05	Inter C	J07	8	0.03	0.48	0.53
P04	Surf B	J01	13	0.02	-0.89	-0.71	P05	Inter C	J07	8	0.03	0.48	0.53
P04	Surf B	J01	14	-0.05	0.10	0.02	P05	Inter C	J07	8	-0.33	0.86	0.06
P04	Surf B	J01	14	0.06	0.08	0.26	P05	Inter C	J07	9	-0.14	0.73	0.40
P04	Surf B	J01	14	-0.07	0.28	0.15	P05	Inter C	J07	10	-0.06	0.96	0.77
P04	Surf B	J01	15	-0.07	-0.08	-0.19	P05	Inter C	J07	11	-0.05	0.30	0.23
P04	Surf B	J01	17	0.01	-0.70	-0.58	P05	Inter C	J07	12	0.16	0.05	0.45
P04	Surf B	J01	17	0.30	0.44	1.05	P05	Inter C	J07	13	-0.18	0.39	0.04
P04	Surf B	J01	17	0.25	0.23	0.78	P05	Inter C	J07	14	0.22	-0.50	0.10
P04	Surf B	J01	18	0.03	-0.90	-0.72	P05	Inter C	J07	15	-0.16	0.93	0.54
P04	Surf B	J01	18	0.03	-0.78	-0.63	P05	Inter C	J07	16	0.02	0.93	0.91
P04	Surf B	J01	18	0.01	-1.02	-0.88	P05	Inter C	J07	17	0.35	0.19	1.00
P04	Surf B	J01	19	0.25	-1.03	-0.32	P05	Inter C	J07	18	0.11	-0.18	0.16
P04	Surf B	J01	19	0.14	-1.43	-0.94	P05	Inter C	J07	19	0.14	-0.84	-0.41
P04	Surf B	J01	19	0.32	-0.30	0.49	P05	Inter C	J07	20	0.15	1.13	1.42
P04	Surf B	J01	20	-0.16	0.20	-0.15	P05	Surf B	J08	1	0.27	-1.13	-0.35
P04	Surf B	J01	20	-0.11	0.99	0.62	P05	Surf B	J08	2	0.12	0.62	0.83
P04	Surf B	J01	20	-0.06	-0.21	-0.31	P05	Surf B	J08	2	-0.18	0.16	-0.28
P04	Surf B	J01	21	-0.02	-0.15	-0.17	P05	Surf B	J08	2	0.06	0.52	0.59
P04	Surf B	J01	21	0.16	0.05	0.42	P05	Surf B	J08	3	0.11	-0.88	-0.52
P04	Surf B	J01	21	-0.05	0.33	0.20	P05	Surf B	J08	3	0.19	-0.68	-0.17
P04	Surf B	J01	21	-0.15	-0.38	-0.65	P05	Surf B	J08	3	-0.23	-0.10	-0.59
P04	Surf B	J01	21	-0.10	-0.10	-0.28	P05	Surf B	J08	4	-0.07	0.25	0.08
P04	Surf B	J01	22	-0.02	-0.15	-0.17	P05	Surf B	J08	4	-0.16	-0.22	-0.54
P04	Surf B	J01	23	-0.09	-0.28	-0.43	P05	Surf B	J08	5	0.17	-1.10	-0.57
P04	Surf B	J01	23	0.05	-0.30	-0.12	P05	Surf B	J08	6	-0.19	-0.38	-0.75
P04	Surf B	J01	23	0.03	-0.57	-0.39	P05	Surf B	J08	6	-0.23	0.35	-0.20

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P05	Surf B	J08	6	0.08	-0.59	-0.27
P05	Surf B	J08	6	0.06	-0.55	-0.30
P05	Surf B	J08	7	-0.29	0.14	-0.51
P05	Surf B	J08	7	-0.46	0.28	-0.76
P05	Surf B	J08	7	-0.13	-0.18	-0.42
P05	Surf B	J08	8	-0.29	0.14	-0.51
P05	Surf B	J08	9	0.14	0.09	0.42
P05	Surf B	J08	9	-0.46	0.28	-0.76
P05	Surf B	J08	9	-0.13	-0.18	-0.42
P05	Surf B	J09	1	0.40	0.72	1.53
P05	Surf B	J09	1	0.22	-0.37	0.13
P05	Surf B	J09	2	0.14	0.31	0.59
P05	Surf B	J09	2	0.24	0.27	0.77
P05	Surf B	J09	3	-0.14	0.78	0.34
P05	Surf B	J09	3	0.03	0.69	0.67
P05	Surf B	J09	4	0.08	0.29	0.43
P05	Surf B	J09	4	0.33	-0.28	0.43
P05	Surf B	J09	4	0.27	-0.39	0.23
P05	Surf B	J09	5	-0.01	-0.13	-0.19
P05	Surf B	J09	5	0.25	-0.94	-0.31
P05	Surf B	J09	5	0.12	-0.57	-0.28
P05	Surf B	J09	6	0.25	-0.04	0.49
P05	Surf B	J09	6	0.13	0.38	0.58
P05	Surf B	J09	7	0.07	0.89	0.90
P05	Surf B	J09	7	0.13	-0.03	0.23
P05	Surf B	J09	8	0.07	-0.13	0.02
P05	Surf B	J09	9	-0.02	-0.25	-0.30
P05	Surf B	J09	9	0.14	0.47	0.68
P05	Surf B	J09	10	-0.08	-0.63	-0.79
P05	Surf B	J09	11	0.02	-0.51	-0.46
P05	Surf B	J09	11	0.11	-0.63	-0.36
P05	Surf B	J09	11	0.23	-0.55	-0.02
P05	Surf B	J09	12	-0.13	-0.11	-0.43
P05	Surf B	J09	12	-0.15	0.23	-0.17
P05	Surf B	J09	13	-0.24	0.40	-0.25
P05	Surf B	J09	13	-0.14	-0.10	-0.46
P05	Surf E	J10	1	0.07	*	*
P05	Surf E	J10	2	0.32	*	*
P05	Surf E	J10	3	-0.19	*	*
P05	Surf E	J10	3	0.02	*	*
P05	Surf E	J10	4	-0.22	*	*
P05	Surf E	J10	4	-0.06	*	*
P05	Surf E	J10	5	0.16	*	*

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P05	Surf E	J10	6	-0.01	*	*
P05	Surf E	J10	7	0.00	*	*
P05	Surf E	J10	8	0.16	*	*
P05	Surf E	J10	8	0.22	*	*
P05	Surf E	J10	9	0.08	*	*
P05	Surf E	J11	1	0.04	*	*
P05	Surf E	J11	2	0.00	*	*
P05	Surf E	J11	2	-0.01	*	*
P05	Surf E	J11	3	-0.07	*	*
P05	Surf E	J11	4	0.04	*	*
P06	Surf A	J12	1	0.51	-0.04	0.93
P06	Surf A	J12	1	0.26	-0.78	-0.28
P06	Surf A	J12	1	-0.47	0.81	-0.48
P06	Surf A	J12	2	-0.12	1.06	0.52
P06	Surf A	J12	2	0.00	0.75	0.50
P06	Surf A	J12	2	0.22	-0.27	0.09
P06	Surf A	J12	2	0.03	-0.68	-0.68
P06	Surf A	J12	3	-0.04	0.76	0.47
P06	Surf A	J12	3	-0.18	1.08	0.44
P06	Surf A	J12	3	-0.01	0.38	0.17
P06	Surf A	J12	4	-0.15	1.07	0.51
P06	Surf A	J12	4	-0.35	1.13	0.14
P06	Surf A	J12	4	-0.19	0.06	0.52
P06	Surf A	J12	4	-0.17	0.88	0.29
P06	Surf A	J12	5	0.02	0.12	0.04
P06	Surf A	J12	5	0.00	-0.11	-0.24
P06	Surf A	J12	5	-0.10	0.19	-0.19
P06	Surf A	J12	5	-0.24	0.38	-0.30
P06	Surf A	J12	6	-0.29	0.40	-0.40
P06	Surf A	J12	6	0.20	0.04	0.31
P06	Surf A	J12	6	-0.02	0.77	0.49
P06	Surf A	J12	7	-0.29	0.51	-0.31
P06	Surf A	J12	7	-0.05	-0.48	-0.69
P06	Surf A	J12	7	-0.23	0.04	-0.58
P06	Surf A	J12	8	0.21	-0.27	0.07
P06	Surf A	J12	8	-0.10	0.11	-0.25
P06	Surf A	J12	8	-0.26	0.35	-0.39
P06	Surf A	J12	8	0.15	-0.51	-0.29
P06	Surf A	J12	9	-0.06	-0.52	-0.74
P06	Surf A	J12	9	-0.01	-0.40	-0.51
P06	Surf A	J12	9	0.00	0.60	0.39
P06	Surf A	J12	9	-0.01	-0.12	-0.26
P06	Surf A	J12	10	-0.03	0.01	-0.20

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P06	Surf A	J12	10	-0.02	0.10	-0.12
P06	Surf A	J12	10	0.07	-0.75	-0.65
P06	Surf A	J12	10	0.15	-0.76	-0.49
P06	Surf A	J12	11	-0.07	0.15	-0.15
P06	Surf A	J12	11	-0.04	0.06	-0.20
P06	Surf A	J12	11	-0.02	-0.11	-0.30
P06	Surf A	J12	12	-0.06	-0.02	-0.26
P06	Surf A	J12	12	-0.10	0.04	-0.29
P06	Surf A	J12	12	0.08	-0.16	-0.10
P06	Surf A	J12	14	0.06	0.44	0.38
P06	Surf A	J12	14	-0.14	-0.04	-0.47
P06	Surf A	J12	14	0.19	0.68	0.84
P06	Surf A	J12	15	0.01	-0.72	-0.76
P06	Surf A	J12	15	-0.12	-0.10	0.51
P06	Surf A	J12	15	-0.03	-1.11	-1.21
P06	Surf A	J12	15	-0.03	-0.18	-0.36
P06	Surf A	J12	16	-0.32	0.02	-0.81
P06	Surf A	J12	16	0.14	-0.22	-0.06
P06	Surf A	J12	16	-0.26	0.38	-0.39
P06	Surf A	J12	17	0.03	-0.34	-0.38
P06	Surf A	J12	17	-0.08	0.62	0.23
P06	Surf A	J12	17	0.08	-0.50	-0.41
P06	Surf A	J12	18	-0.21	-0.56	-1.12
P06	Surf A	J12	18	-0.17	-0.40	-0.86
P06	Surf A	J12	18	0.03	-0.66	-0.66
P06	Surf A	J12	18	-0.16	-0.12	-0.59
P06	Surf A	J12	19	0.00	0.17	0.03
P06	Surf A	J12	19	-0.07	0.05	-0.25
P06	Surf A	J12	19	0.00	-0.18	-0.28
P06	Surf A	J12	19	0.06	-0.01	-0.01
P06	Surf A	J12	20	0.09	-0.72	-0.60
P06	Surf A	J12	20	0.05	-0.50	-0.49
P06	Surf A	J12	20	0.10	-0.69	-0.53
P06	Surf A	J12	20	0.08	-0.70	-0.60
P06	Surf A	J12	21	-0.06	-0.46	-0.69
P06	Surf A	J12	21	-0.04	-0.05	-0.27
P06	Surf A	J12	21	-0.05	-0.56	-0.76
P06	Surf A	J12	21	-0.36	0.38	-0.58
P06	Surf A	J12	22	-0.16	0.64	0.08
P06	Surf A	J12	22	-0.20	0.58	-0.07
P06	Surf A	J12	22	-0.22	0.33	-0.32
P06	Surf A	J12	22	-0.24	0.43	-0.28
P06	Surf A	J12	23	0.07	-0.79	-0.73

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P06	Surf A	J12	23	0.03	0.63	0.46
P06	Surf A	J12	23	-0.05	-0.56	-0.76
P06	Surf A	J12	23	-0.02	-0.64	-0.76
P06	Surf A	J12	23	0.31	-0.98	-0.37
P06	Surf A	J12	24	0.12	-0.45	-0.31
P06	Surf A	J12	24	-0.03	-0.17	-0.39
P06	Surf A	J12	24	-0.04	-0.56	-0.75
P06	Surf A	J12	24	-0.20	-0.26	-0.82
P06	Surf A	J12	25	0.11	-0.29	-0.17
P06	Surf A	J12	25	0.39	1.59	2.07
P06	Surf A	J12	25	-0.25	0.17	-0.54
P06	Surf A	J12	26	-0.10	-0.46	-0.80
P06	Surf A	J12	26	-0.22	-0.24	-0.84
P07	Surf A	J14	1	-0.05	0.29	0.15
P07	Surf A	J14	2	0.09	-0.94	-0.67
P07	Surf A	J14	3	0.12	-0.58	-0.26
P07	Surf A	J14	4	-0.07	0.18	0.02
P07	Surf A	J14	5	-0.11	0.96	0.63
P07	Surf A	J14	6	0.13	-0.45	-0.10
P07	Surf A	J14	7	-0.13	1.32	0.90
P07	Surf A	J14	8	0.11	-0.20	0.05
P07	Surf A	J14	9	-0.18	0.65	0.17
P07	Surf A	J14	11	-0.09	0.01	-0.20
P07	Surf A	J14	12	-0.03	0.70	0.59
P07	Surf A	J14	13	0.01	1.10	1.02
P07	Surf A	J14	14	-0.22	-0.15	-0.64
P07	Surf A	J14	15	-0.04	-0.53	-0.55
P07	Surf A	J14	16	0.17	-0.43	0.01
P07	Surf A	J14	17	-0.27	-0.03	-0.65
P07	Surf A	J14	18	0.26	-0.62	0.02
P07	Surf A	J14	19	0.11	-0.99	-0.70
P08	Surf B	J15	1	0.28	-0.85	-0.20
P08	Surf B	J15	1	0.03	0.25	0.28
P08	Surf B	J15	1	-0.21	0.35	-0.18
P08	Surf B	J15	2	-0.03	-0.26	-0.36
P08	Surf B	J15	2	0.07	0.16	0.25
P08	Surf B	J15	2	0.01	-0.17	-0.18
P08	Surf B	J15	3	-0.45	0.65	-0.46
P08	Surf B	J15	3	0.08	-0.51	-0.33
P08	Surf B	J15	3	0.00	-0.15	-0.19
P08	Surf B	J15	4	0.01	-0.88	-0.84
P08	Surf B	J15	4	0.08	0.06	0.16
P08	Surf B	J15	4	0.00	-0.10	-0.09

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P08	Surf B	J15	4	-0.15	-0.41	-0.77
P08	Surf B	J15	4	-0.18	0.32	-0.17
P08	Surf B	J15	4	-0.31	0.84	0.02
P08	Surf B	J15	5	0.01	-0.35	-0.34
P08	Surf B	J15	5	-0.08	0.25	0.02
P08	Surf B	J15	5	-0.20	0.21	-0.29
P08	Surf B	J15	5	0.09	-0.29	-0.10
P08	Surf B	J15	5	-0.16	0.53	0.10
P08	Surf B	J15	5	-0.01	-0.36	-0.37
P08	Surf B	J15	6	-0.05	-0.43	-0.56
P08	Surf B	J15	6	0.09	-0.27	-0.08
P08	Surf B	J15	6	-0.35	0.35	-0.51
P08	Surf B	J15	6	-0.29	0.32	-0.38
P08	Surf B	J15	7	0.00	-0.03	-0.05
P08	Surf B	J15	7	-0.12	0.46	0.10
P08	Surf B	J15	7	-0.09	0.46	0.17
P08	Surf B	J15	7	-0.05	0.47	0.28
P08	Surf B	J15	8	-0.07	0.21	0.01
P08	Surf B	J15	8	-0.26	-0.01	-0.63
P08	Surf B	J15	8	-0.29	0.57	-0.15
P08	Surf B	J15	9	-0.31	0.80	0.04
P08	Surf B	J15	9	-0.27	0.27	-0.35
P08	Surf B	J15	9	-0.36	0.81	-0.09
P08	Surf B	J15	10	-0.31	0.80	0.04
P08	Surf B	J15	11	-0.24	0.05	-0.53
P08	Surf B	J15	11	-0.01	0.56	0.50
P08	Surf B	J15	11	-0.34	0.67	-0.19
P08	Surf B	J15	11	-0.14	-0.25	-0.59
P08	Surf B	J15	12	-0.12	-0.29	-0.59
P08	Surf B	J15	12	-0.20	0.79	0.26
P08	Surf B	J15	12	-0.03	-0.65	-0.67
P08	Surf B	J15	13	-0.07	-0.84	-0.97
P08	Surf B	J15	13	0.13	-0.76	-0.45
P08	Surf B	J15	13	0.20	-0.48	-0.01
P08	Surf B	J15	13	0.16	-0.87	-0.50
P08	Surf B	J15	13	0.23	-0.88	-0.31
P08	Surf B	J15	14	-0.14	-0.74	-1.02
P08	Surf B	J15	14	-0.01	-0.68	-0.70
P08	Surf B	J15	14	0.34	-0.74	0.08
P08	Surf B	J15	15	-0.33	-0.07	-0.85
P08	Surf B	J15	15	-0.30	-0.34	-1.01
P08	Surf B	J15	15	0.11	-0.17	0.06
P08	Surf B	J15	15	-0.24	-0.59	-1.14

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P08	Surf B	J15	15	-0.11	-0.11	-0.32
P08	Surf B	J15	15	-0.20	0.33	-0.17
P08	Surf B	J15	16	-0.10	0.18	-0.06
P08	Surf B	J15	16	-0.11	-0.31	-0.59
P08	Surf B	J15	16	-0.22	-0.09	-0.64
P08	Surf B	J15	16	-0.23	0.13	-0.44
P08	Surf B	J15	16	0.12	-0.40	-0.10
P08	Surf B	J15	16	0.13	0.03	0.30
P08	Surf B	J15	17	-0.20	-0.80	-1.22
P08	Surf B	J15	17	0.02	-0.11	-0.09
P08	Surf B	J15	17	-0.09	0.47	0.19
P08	Surf B	J15	17	0.20	-0.40	0.08
P08	Surf B	J15	18	-0.17	0.03	-0.41
P08	Surf B	J15	18	-0.25	0.86	0.17
P08	Surf B	J15	18	-0.09	0.04	-0.17
P08	Surf B	J15	18	0.08	-0.64	-0.44
P08	Surf B	J15	19	0.31	-0.85	-0.14
P08	Surf B	J15	19	-0.26	0.41	-0.24
P08	Surf B	J15	19	-0.16	-0.59	-0.96
P08	Surf B	J15	19	0.02	-0.52	-0.45
P08	Surf B	J15	19	-0.07	-0.36	-0.52
P09	Surf A	J16	1	-0.26	-0.57	-1.10
P09	Surf A	J16	1	0.04	-1.06	-0.86
P09	Surf A	J16	1	-0.20	-0.80	-1.12
P09	Surf A	J16	1	-0.08	-1.67	-1.67
P09	Surf A	J16	2	-0.19	-0.68	-1.06
P09	Surf A	J16	2	-0.06	-1.02	-1.10
P09	Surf A	J16	3	0.11	-1.22	-0.82
P09	Surf A	J16	3	0.37	-2.24	-1.20
P09	Surf A	J16	3	0.10	-0.92	-0.58
P09	Surf A	J16	4	0.00	-0.06	-0.04
P09	Surf A	J16	4	-0.42	0.30	-0.64
P09	Surf A	J16	4	-0.17	-0.49	-0.79
P09	Surf A	J16	4	0.06	-0.73	-0.49
P09	Surf A	J16	4	-0.29	-0.05	-0.65
P09	Surf A	J16	4	-0.06	-0.93	-0.98
P09	Surf A	J16	5	-0.47	0.21	-0.83
P09	Surf A	J16	5	-0.32	-0.23	-0.90
P09	Surf A	J16	5	-0.38	-0.49	-1.22
P09	Surf A	J16	6	0.02	-1.18	-0.98
P09	Surf A	J16	6	-0.11	0.30	0.06
P09	Surf A	J16	6	-0.26	-0.16	-0.71
P09	Surf A	J16	6	-0.16	-0.43	-0.74

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P09	Surf A	J16	6	-0.09	-0.49	-0.63
P09	Surf A	J16	7	-0.32	-0.49	-1.14
P09	Surf A	J16	7	0.42	-1.20	-0.13
P09	Surf A	J16	7	-0.16	-0.26	-0.52
P09	Surf A	J16	7	-0.10	-0.80	-0.98
P09	Surf A	J16	7	0.08	-0.78	-0.48
P09	Surf A	J16	7	-0.08	-0.90	-0.95
P09	Surf A	J16	8	0.02	-1.61	-1.42
P09	Surf A	J16	8	-0.11	-0.59	-0.75
P09	Surf A	J16	8	-0.26	-1.41	-1.82
P09	Surf A	J16	9	-0.25	-0.69	-1.16
P09	Surf A	J16	9	-0.06	-0.29	-0.36
P09	Surf A	J16	9	-0.19	-0.31	-0.68
P09	Surf A	J16	10	-0.14	-1.02	-1.20
P09	Surf A	J16	10	0.04	-0.98	-0.76
P09	Surf A	J16	10	-0.16	-0.21	-0.52
P09	Surf A	J16	10	-0.06	-0.49	-0.55
P09	Surf A	J16	11	-0.12	-0.36	-0.59
P09	Surf A	J16	11	0.02	-0.30	-0.21
P09	Surf A	J16	11	-0.02	-1.17	-1.03
P09	Surf A	J16	11	-0.13	-0.07	-0.31
P09	Surf A	J16	11	-0.13	-0.25	-0.47
P09	Surf A	J17	1	-0.07	0.22	0.08
P09	Surf A	J17	1	0.14	-0.73	-0.31
P09	Surf A	J17	1	-0.28	-0.49	-1.05
P09	Surf A	J17	2	-0.08	-0.45	-0.57
P09	Surf A	J17	2	-0.15	-0.84	-1.04
P09	Surf A	J17	2	-0.13	-0.71	-0.91
P09	Surf A	J17	3	-0.18	0.31	-0.07
P09	Surf A	J17	3	0.00	-0.90	-0.75
P09	Surf A	J17	3	-0.13	-0.64	-0.79
P09	Surf A	J17	3	0.05	-0.23	-0.06
P09	Surf A	J17	3	-0.14	-0.46	-0.68
P09	Surf A	J17	4	-0.11	-0.30	-0.45
P09	Surf A	J17	4	0.08	-0.94	-0.63
P09	Surf A	J17	4	-0.11	-0.39	-0.56
P09	Surf A	J17	4	-0.04	-0.91	-0.90
P09	Surf A	J17	4	-0.07	-0.29	-0.38
P09	Surf A	J17	5	-0.05	-1.14	-1.09
P09	Surf A	J17	5	0.04	-1.12	-0.89
P09	Surf A	J17	5	-0.32	-0.44	-1.07
P09	Surf A	J17	5	-0.20	-0.77	-1.06
P10	Surf A	J18	1	0.05	-0.31	-0.17
P10	Surf A	J18	1	0.13	0.35	0.62
P10	Surf A	J18	1	0.07	-0.41	-0.21
P10	Surf A	J18	1	-0.07	-0.26	-0.38
P10	Surf A	J18	2	0.15	-0.58	-0.15
P10	Surf A	J18	2	0.04	-0.56	-0.39
P10	Surf A	J18	2	-0.03	-0.52	-0.52
P10	Surf A	J18	3	0.17	0.31	0.68
P10	Surf A	J18	3	0.13	-0.20	0.16
P10	Surf A	J18	3	0.09	-0.76	-0.44
P10	Surf A	J18	4	-0.22	-0.62	-1.03
P10	Surf A	J18	4	-0.31	0.29	-0.39
P10	Surf A	J18	4	-0.35	0.27	-0.52
P10	Surf A	J18	5	0.19	0.12	0.58
P10	Surf A	J18	5	-0.21	-0.69	-1.05
P10	Surf A	J18	5	-0.41	0.04	-0.89
P10	Surf A	J18	6	0.07	-0.66	-0.42
P10	Surf A	J18	6	-0.06	-0.47	-0.51
P10	Surf A	J18	7	0.20	-0.83	-0.21
P10	Surf A	J18	10	-0.03	-0.79	-0.72
P10	Surf A	J18	10	-0.33	-0.28	-0.98
P10	Surf A	J18	10	0.08	0.75	0.92
P10	Surf A	J18	11	-0.25	-0.37	-0.84
P10	Surf A	J18	11	-0.28	0.15	-0.44
P10	Surf A	J18	11	0.02	-0.45	-0.28
P10	Surf B	J19	1	0.05	0.31	0.43
P10	Surf B	J19	1	-0.20	-0.11	-0.52
P10	Surf B	J19	2	0.04	-0.11	0.03
P10	Surf B	J20	1	0.08	-0.06	-0.08
P10	Surf B	J20	1	0.06	-0.03	-0.06
P10	Surf B	J20	1	0.09	0.09	0.13
P10	Surf B	J20	2	0.30	0.28	0.80
P10	Surf B	J20	2	0.08	-0.10	-0.06
P10	Surf B	J20	2	0.31	-0.90	-0.24
P10	Surf B	J20	3	0.19	0.10	0.38
P10	Surf B	J21	2	-0.03	0.42	0.27
P10	Surf B	J21	2	-0.01	0.90	0.87
P10	Surf B	J21	2	0.19	1.08	1.44
P10	Surf B	J21	2	0.17	0.64	0.99
P10	Surf B	J21	3	0.07	0.60	0.62
P10	Surf B	J21	3	-0.25	0.47	-0.25
P10	Surf B	J21	3	0.45	-1.22	-0.15
P10	Surf B	J21	3	-0.12	0.66	0.24
P10	Surf B	J21	4	0.25	0.28	0.76

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P10	Surf B	J21	4	0.06	1.05	0.98
P10	Surf B	J21	4	0.13	0.90	0.98
P10	Surf B	J21	4	-0.89	2.83	0.50
P10	Surf B	J21	5	-0.14	0.91	0.73
P10	Surf B	J21	5	-0.03	0.08	0.19
P10	Surf B	J21	5	-0.08	-0.87	-0.83
P10	Surf C	J22	1	-0.15	0.60	0.37
P10	Surf C	J22	2	0.15	1.06	1.20
P10	Surf C	J22	3	0.32	0.42	1.10
P10	Surf C	J22	4	0.17	-0.26	0.09
P10	Surf C	J22	5	-0.30	0.01	-0.70
P10	Surf C	J22	6	-0.16	0.08	-0.31
P10	Surf C	J22	7	0.03	-0.14	-0.07
P10	Surf C	J22	8	0.18	0.18	0.57
P10	Surf C	J22	9	0.11	0.90	1.08
P10	Surf C	J22	9	0.00	0.45	0.43
P10	Surf C	J22	10	-0.22	0.04	-0.40
P11	Surf A	J23	1	0.05	-0.93	-0.68
P11	Surf A	J23	2	0.07	-0.32	-0.13
P11	Surf A	J23	3	-0.17	0.91	0.47
P11	Surf A	J24	1	0.08	-0.69	-0.41
P11	Surf A	J24	1	-0.24	-0.55	-1.02
P11	Surf A	J24	2	0.10	-0.08	0.16
P11	Surf A	J24	2	0.23	-0.80	-0.23
P11	Surf A	J24	2	-0.09	-0.78	-0.86
P11	Surf A	J24	2	0.08	-0.94	-0.62
P11	Surf A	J24	3	-0.11	-0.63	-0.79
P11	Surf A	J24	3	-0.02	-0.87	-0.83
P11	Surf A	J24	3	-0.19	-0.55	-0.90
P11	Surf A	J24	4	0.35	-1.05	-0.18
P11	Surf A	J24	4	0.06	-1.03	-0.81
P11	Surf A	J24	4	0.32	-0.61	0.12
P11	Surf A	J24	5	-0.12	-0.03	-0.31
P11	Surf A	J24	5	0.03	0.19	0.25
P11	Surf A	J24	5	-0.26	0.22	-0.36
P11	Surf A	J24	5	0.01	-0.38	-0.33
P11	Surf A	J24	5	-0.46	-0.86	-1.80
P11	Surf A	J24	5	0.14	-0.21	0.11
P11	Surf A	J24	6	-0.02	-0.06	-0.07
P11	Surf A	J24	6	-0.07	-0.20	-0.33
P11	Surf A	J24	6	-0.04	-0.37	-0.47
P11	Surf A	J24	6	-0.23	-0.35	-0.80
P11	Surf A	J24	7	0.06	-0.25	-0.03
P11	Surf A	J24	7	-0.01	-0.03	0.00
P11	Surf A	J24	7	0.12	-0.14	0.16
P11	Surf A	J24	8	-0.13	0.44	0.15
P11	Surf A	J24	8	-0.29	0.23	-0.44
P11	Surf A	J24	8	0.01	-0.35	-0.25
P11	Surf A	J24	10	0.07	0.39	0.53
P11	Surf A	J24	10	0.08	0.58	0.76
P11	Surf A	J24	10	0.01	0.08	0.12
P11	Surf A	J24	10	-0.04	0.04	-0.01
P11	Surf A	J24	10	0.20	-0.65	-0.10
P11	Surf A	J24	11	-0.07	0.14	-0.01
P11	Surf A	J24	11	0.05	-0.56	-0.42
P11	Surf A	J24	11	0.08	-0.80	-0.51
P11	Surf A	J24	12	0.01	-0.46	-0.40
P11	Surf A	J24	12	-0.11	0.45	0.17
P11	Surf A	J24	12	0.13	-0.04	0.21
P11	Surf A	J24	12	0.25	-1.05	-0.40
P11	Surf A	J24	12	-0.10	-0.50	-0.67
P11	Surf A	J24	13	-0.20	-0.47	-0.87
P11	Surf A	J24	13	-0.05	-0.90	-0.85
P11	Surf A	J24	13	0.07	-0.83	-0.57
P11	Surf A	J24	13	-0.11	-0.42	-0.62
P11	Surf A	J24	14	0.21	-0.49	0.00
P11	Surf A	J24	14	-0.12	-0.52	-0.76
P11	Surf A	J24	14	-0.07	-0.44	-0.57
P11	Surf A	J24	14	0.02	-0.89	-0.78
P11	Surf A	J24	15	0.23	-1.00	-0.34
P11	Surf A	J24	15	-0.13	-0.96	-1.13
P11	Surf A	J24	15	-0.11	-0.15	-0.35
P11	Surf A	J24	15	0.02	-0.63	-0.51
P11	Surf A	J24	15	0.04	-0.29	-0.19
P11	Surf A	J24	15	-0.26	0.13	-0.47
P11	Surf A	J24	16	0.18	-1.01	-0.50
P11	Surf A	J24	16	-0.27	-0.36	-0.93
P11	Surf A	J24	16	0.11	-0.18	0.10
P11	Surf A	J24	16	-0.09	-0.54	-0.70
P11	Surf A	J24	17	0.12	-0.36	-0.03
P11	Surf A	J24	17	-0.42	-0.46	-1.31
P11	Surf A	J24	17	0.00	-0.47	-0.39
P11	Surf A	J24	17	0.08	-1.03	-0.67
P11	Surf A	J24	18	-0.19	0.40	-0.03
P11	Surf A	J24	18	-0.19	-0.06	-0.46
P11	Surf A	J24	18	-0.27	0.87	0.17

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P11	Surf A	J24	18	-0.22	-0.17	-0.62
P11	Surf A	J24	19	0.17	-1.81	-1.23
P11	Surf A	J24	19	-0.34	1.10	0.24
P11	Surf A	J24	19	0.00	0.02	0.04
P11	Surf A	J24	19	0.17	-0.27	0.13
P11	Surf A	J24	20	-0.14	0.01	-0.31
P11	Surf A	J24	20	-0.03	0.24	0.13
P11	Surf A	J24	20	0.35	-0.20	0.62
P11	Surf A	J24	20	-0.17	-0.01	-0.40
P11	Surf A	J24	21	0.03	-0.39	-0.25
P11	Surf A	J24	21	-0.10	-0.85	-1.00
P11	Surf A	J24	21	-0.33	-0.35	-1.02
P11	Surf A	J24	21	-0.03	0.01	-0.06
P11	Surf A	J24	22	0.11	-1.00	-0.63
P11	Surf A	J24	22	0.14	-0.38	-0.03
P11	Surf A	J24	22	-0.11	0.23	-0.04
P11	Surf A	J24	22	-0.09	0.16	-0.04
P11	Surf A	J24	23	0.16	0.25	0.60
P11	Surf A	J24	23	-0.21	-0.70	-1.07
P11	Surf A	J24	23	-0.09	0.16	-0.04
P11	Surf A	J25	1	0.19	-0.63	-0.28
P11	Surf B	J26	1	0.27	-0.14	0.53
P11	Surf B	J27	1	0.27	-0.40	0.12
P11	Surf B	J27	1	0.19	-0.12	0.20
P11	Surf B	J27	1	0.30	-1.31	-0.66
P11	Surf B	J27	1	-0.13	-1.16	-1.46
P11	Surf B	J27	2	0.27	-0.36	0.10
P11	Surf B	J27	2	0.12	-0.34	-0.17
P11	Surf B	J27	2	0.14	-0.53	-0.34
P11	Surf B	J27	2	0.04	0.00	-0.07
P11	Surf B	J27	2	-0.17	0.25	-0.29
P11	Surf B	J27	3	0.09	-0.52	-0.39
P11	Surf B	J27	3	-0.25	0.34	-0.38
P11	Surf B	J27	3	0.09	0.24	0.27
P11	Surf B	J27	4	0.26	-0.83	-0.26
P11	Surf B	J27	4	-0.02	-0.17	-0.30
P11	Surf B	J27	4	0.18	-0.87	-0.49
P11	Surf B	J27	5	0.23	-0.39	0.07
P11	Surf B	J27	5	0.15	-0.24	0.01
P11	Surf B	J27	5	0.03	-0.41	-0.41
P11	Surf B	J27	6	0.21	-1.08	-0.60
P11	Surf B	J27	6	0.09	-0.61	-0.44
P11	Surf B	J27	6	-0.05	-0.51	-0.69
P11	Surf B	J27	6	0.12	-0.44	-0.26
P11	Surf B	J27	6	-0.20	-0.30	-0.84
P11	Surf B	J27	7	0.23	-0.13	0.27
P11	Surf B	J27	7	0.06	-0.91	-0.80
P11	Surf B	J27	7	-0.20	-0.30	-0.84
P11	Surf B	J28	1	-0.24	-1.18	-1.53
P11	Surf B	J28	1	-0.22	0.02	-0.40
P11	Surf B	J28	1	-0.16	-1.34	-1.46
P11	Surf B	J28	2	0.10	-0.96	-0.36
P11	Surf B	J28	2	0.07	0.12	0.62
P11	Surf B	J28	2	0.07	-0.21	0.26
P11	Surf B	J28	3	-0.24	0.05	-0.13
P11	Surf B	J28	3	0.16	-0.51	0.24
P11	Surf B	J28	3	0.05	-0.16	0.30
P11	Surf B	J28	4	0.20	-0.81	0.04
P11	Surf B	J28	4	-0.26	-0.10	-0.35
P11	Surf B	J28	4	0.01	-0.36	0.03
P11	Surf B	J28	4	0.34	-1.12	0.13
P11	Surf B	J28	5	-0.07	0.35	0.48
P11	Surf B	J28	5	0.03	-0.24	0.19
P11	Surf B	J28	5	-0.07	-0.43	-0.19
P11	Surf B	J28	6	0.11	-0.76	-0.07
P11	Surf B	J28	6	-0.24	-0.55	-0.70
P11	Surf B	J28	6	-0.08	-0.14	0.03
P11	Surf B	J28	6	0.05	-0.30	0.15
P11	Surf B	J28	6	-0.17	-0.45	-0.46
P11	Surf B	J28	6	-0.05	-0.86	-0.54
P11	Surf B	J28	7	-0.23	0.43	0.19
P11	Surf B	J28	7	0.20	-0.97	-0.11
P11	Surf B	J28	7	-0.12	-1.06	-0.88
P11	Surf B	J28	7	-0.12	-0.47	-0.37
P11	Surf B	J28	8	-0.04	0.07	0.27
P11	Surf B	J28	8	0.10	-0.40	0.17
P11	Surf B	J28	8	0.08	-1.00	-0.35
P11	Surf B	J28	9	0.07	0.11	0.58
P11	Surf B	J28	9	-0.22	0.05	-0.16
P11	Surf B	J28	9	-0.30	-0.44	-0.76
P11	Surf B	J28	10	-0.02	0.27	0.52
P11	Surf B	J28	10	-0.17	-0.28	-0.32
P11	Surf B	J28	10	0.04	-0.27	0.13
P11	Surf B	J28	11	0.30	-0.74	0.31
P11	Surf B	J28	11	0.21	0.15	0.92
P11	Surf B	J28	11	-0.13	0.35	0.33

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P11	Surf B	J28	12	-0.22	0.39	0.13
P11	Surf B	J28	12	-0.43	1.64	0.87
P11	Surf B	J28	12	0.11	0.47	0.93
P11	Surf B	J28	12	0.23	0.10	0.88
P11	Surf B	J28	13	-0.07	0.46	0.60
P11	Surf B	J28	13	0.11	0.47	0.93
P11	Surf B	J28	13	0.23	0.10	0.88
P11	Surf E	J68	1	0.32	*	*
P11	Surf E	J68	2	-0.01	*	*
P11	Surf E	J68	2	-0.04	*	*
P11	Surf E	J68	3	0.15	*	*
P11	Surf E	J68	3	0.09	*	*
P11	Surf E	J68	3	0.21	*	*
P11	Surf E	J68	4	0.13	*	*
P11	Surf E	J68	4	-0.35	*	*
P11	Surf E	J68	4	0.10	*	*
P11	Surf E	J68	5	-0.13	*	*
P11	Surf E	J68	6	-0.02	*	*
P11	Surf E	J68	6	0.06	*	*
P11	Surf E	J68	7	0.20	*	*
P11	Surf E	J68	7	0.18	*	*
P11	Surf E	J68	8	-0.65	*	*
P11	Surf E	J68	9	0.05	*	*
P11	Surf E	J68	10	0.07	*	*
P11	Surf E	J68	11	-0.01	*	*
P11	Surf E	J68	12	0.11	*	*
P11	Surf E	J68	13	0.09	*	*
P11	Surf E	J68	14	0.09	*	*
P11	Surf E	J68	14	0.08	*	*
P11	Surf E	J68	20	-0.09	*	*
P11	Surf E	J68	20	-0.12	*	*
P11	Surf E	J68	20	-0.07	*	*
P11	Surf E	J68	21	0.29	*	*
P11	Surf E	J68	21	0.02	*	*
P11	Surf E	J68	21	0.16	*	*
P11	Surf E	J68	21	0.11	*	*
P11	Surf E	J68	22	-0.31	*	*
P11	Surf E	J68	22	0.54	*	*
P11	Surf E	J68	22	0.29	*	*
P11	Surf E	J68	22	0.04	*	*
P11	Surf E	J68	23	-0.09	*	*
P11	Surf E	J68	23	0.21	*	*
P11	Surf E	J68	23	0.26	*	*
P11	Surf E	J68	24	0.22	*	*
P11	Surf E	J68	24	0.04	*	*
P11	Surf E	J68	24	-0.15	*	*
P11	Surf E	J68	24	0.33	*	*
P11	Surf E	J68	25	0.07	*	*
P11	Surf E	J68	25	0.06	*	*
P11	Surf E	J68	25	0.18	*	*
P11	Surf E	J68	26	0.31	*	*
P11	Surf E	J68	26	0.32	*	*
P11	Surf E	J68	26	0.27	*	*
P11	Surf E	J68	26	0.01	*	*
P11	Surf E	J68	27	-0.11	*	*
P11	Surf E	J68	27	-0.14	*	*
P11	Surf E	J69	15	0.17	*	*
P11	Surf E	J69	15	0.06	*	*
P11	Surf E	J69	15	0.10	*	*
P11	Surf E	J69	16	-0.11	*	*
P11	Surf E	J69	16	-0.16	*	*
P11	Surf E	J69	16	-0.07	*	*
P11	Surf E	J69	17	0.00	*	*
P11	Surf E	J69	17	0.12	*	*
P11	Surf E	J69	17	0.18	*	*
P11	Surf E	J69	18	0.02	*	*
P11	Surf E	J69	18	0.06	*	*
P11	Surf E	J69	18	0.14	*	*
P11	Surf E	J69	19	0.12	*	*
P11	Surf E	J69	19	0.03	*	*
P11	Surf E	J69	19	0.17	*	*
P11	Surf E	J69	19	0.17	*	*
P11	Surf E	J69	28	-0.07	*	*
P11	Surf E	J69	29	-0.06	*	*
P11	Surf E	J69	30	-0.01	*	*
P11	Surf E	J69	31	0.34	*	*
P11	Surf E	J69	32	0.20	*	*
P11	Surf E	J69	33	0.47	*	*
P11	Surf E	J69	34	-0.13	*	*
P11	Surf E	J69	36	0.09	*	*
P11	Surf E	J69	37	-0.15	*	*
P11	Surf E	J69	38	-0.12	*	*
P11	Surf E	J70	1	0.53	*	*
P12	Surf B	J31	1	-0.31	1.39	0.52
P12	Surf B	J32	1	-0.21	1.20	0.60
P12	Surf B	J32	1	0.14	0.10	0.39

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Surf B	J32	1	-0.28	1.15	0.36
P12	Surf B	J32	1	-0.22	1.92	1.25
P12	Surf B	J32	2	0.44	-0.65	0.37
P12	Surf B	J32	2	0.40	-0.32	0.54
P12	Surf B	J32	2	-0.01	-0.29	-0.38
P12	Surf B	J32	2	0.00	-0.05	-0.12
P12	Surf B	J32	2	0.01	0.19	0.13
P12	Surf B	J32	2	0.85	-1.17	0.80
P12	Surf B	J32	3	0.29	-1.15	-0.49
P12	Surf B	J32	3	0.01	-0.39	-0.41
P12	Surf B	J32	3	0.04	-0.40	-0.38
P12	Surf B	J32	3	-0.03	-0.11	-0.25
P12	Surf B	J32	3	0.20	-0.25	0.16
P12	Surf B	J32	4	0.25	-1.50	-0.91
P12	Surf B	J32	4	0.15	-0.39	-0.08
P12	Surf B	J32	4	0.73	-1.39	0.34
P12	Surf B	J32	5	0.02	-0.69	-0.66
P12	Surf B	J32	5	0.05	0.08	0.14
P12	Surf B	J32	5	0.38	-0.94	-0.01
P12	Surf B	J32	5	0.15	0.33	0.62
P12	Surf B	J32	5	0.67	-1.88	-0.24
P12	Surf B	J32	6	0.31	-0.98	-0.19
P12	Surf B	J32	6	0.07	-0.89	-0.65
P12	Surf B	J32	6	0.34	-1.09	-0.16
P12	Surf B	J32	6	0.37	-1.99	-0.96
P12	Surf B	J32	6	-0.06	0.36	0.13
P12	Surf B	J32	7	-0.12	0.56	0.22
P12	Surf B	J32	7	0.06	0.37	0.46
P12	Surf B	J32	7	-0.38	0.62	-0.32
P12	Surf B	J32	7	-0.02	0.01	-0.05
P12	Surf B	J32	8	0.33	-0.88	-0.05
P12	Surf B	J32	8	0.61	-1.98	-0.43
P12	Surf B	J32	8	0.52	-1.28	-0.01
P12	Surf B	J32	9	-0.13	0.60	0.30
P12	Surf B	J32	9	-0.27	1.10	0.42
P12	Surf B	J32	9	0.12	0.23	0.53
P12	Surf B	J32	9	-0.36	1.13	0.26
P12	Surf B	J32	9	0.05	-0.81	-0.69
P12	Surf B	J32	9	-0.34	1.13	0.25
P12	Surf B	J32	9	-0.01	0.68	0.59
P12	Surf B	J32	10	0.04	-0.96	-0.80
P12	Surf B	J32	10	-0.48	0.48	-0.68
P12	Surf B	J32	10	-0.04	0.44	0.32
P12	Surf B	J32	10	-0.12	0.79	0.48
P12	Surf B	J32	11	-0.20	-0.19	-0.63
P12	Surf B	J32	11	0.08	0.14	0.34
P12	Surf B	J32	11	-0.04	-0.20	-0.31
P12	Surf B	J32	11	-0.19	0.00	-0.43
P12	Surf B	J32	11	0.19	-0.78	-0.32
P12	Surf B	J32	12	-0.14	0.52	0.14
P12	Surf B	J32	12	0.38	-0.97	0.02
P12	Surf B	J32	12	0.08	-0.62	-0.41
P12	Surf B	J32	12	0.53	-0.99	0.33
P12	Surf B	J32	12	0.65	-1.02	0.58
P12	Surf B	J32	13	-0.18	-0.08	-0.45
P12	Surf B	J32	13	-0.22	0.64	0.14
P12	Surf B	J32	13	0.01	0.15	0.22
P12	Surf B	J32	13	-0.26	0.75	0.16
P12	Surf B	J32	13	-0.37	0.48	-0.35
P12	Surf B	J32	13	0.21	-0.23	0.29
P12	Surf B	J32	14	-0.29	-0.44	-1.03
P12	Surf B	J32	14	0.04	-0.17	-0.06
P12	Surf B	J32	14	-0.21	-0.13	-0.56
P12	Surf B	J32	14	-0.20	0.29	-0.16
P12	Surf B	J32	14	0.10	0.08	0.34
P12	Surf B	J32	15	0.33	-0.65	0.17
P12	Surf B	J32	15	0.05	-0.46	-0.27
P12	Surf B	J32	15	0.06	-0.67	-0.44
P12	Surf B	J32	15	0.19	-0.50	-0.03
P12	Surf B	J32	15	0.15	-0.03	0.37
P12	Surf B	J32	16	0.13	-0.48	-0.09
P12	Surf B	J32	16	0.10	-0.42	-0.10
P12	Surf B	J32	16	0.09	-0.16	0.09
P12	Surf B	J32	17	-0.01	0.04	0.05
P12	Surf B	J32	17	0.12	-0.85	-0.48
P12	Surf B	J32	17	-0.06	-0.29	-0.33
P12	Surf B	J32	17	0.13	-0.22	0.15
P12	Surf B	J32	18	-0.07	0.22	0.06
P12	Surf B	J32	18	-0.02	-0.22	-0.22
P12	Surf B	J32	18	-0.27	-0.12	-0.73
P12	Surf B	J32	19	-0.04	-0.50	-0.51
P12	Surf B	J32	19	0.21	-0.70	-0.11
P12	Surf B	J32	19	-0.01	-0.52	-0.46
P12	Surf B	J32	20	0.08	-0.29	-0.08
P12	Surf B	J32	20	0.04	-0.54	-0.37
P12	Surf B	J32	20	0.19	-0.83	-0.30

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Surf B	J32	20	0.13	-0.96	-0.60
P12	Surf B	J32	20	0.14	-0.47	-0.08
P12	Surf B	J32	20	0.19	-0.61	-0.11
P12	Surf B	J32	21	-0.02	0.05	-0.02
P12	Surf B	J32	21	0.42	-0.41	0.60
P12	Surf B	J32	21	0.00	-0.15	-0.14
P12	Surf B	J32	22	-0.13	0.30	-0.01
P12	Surf B	J32	22	-0.23	0.82	0.27
P12	Surf B	J32	22	0.16	0.34	0.70
P12	Surf B	J32	23	-0.32	0.80	0.04
P12	Surf B	J32	23	-0.25	0.53	-0.05
P12	Surf B	J32	23	0.13	0.34	0.69
P12	Surf B	J32	23	-0.02	0.03	0.03
P12	Surf B	J32	23	0.19	0.29	0.74
P12	Surf B	J32	24	-0.16	0.45	0.07
P12	Surf B	J32	24	-0.10	0.23	0.04
P12	Surf B	J32	24	-0.08	0.14	0.01
P12	Surf B	J32	24	-0.04	0.10	0.09
P12	Surf B	J32	25	-0.34	0.74	-0.06
P12	Surf B	J32	25	0.03	-0.34	-0.19
P12	Surf B	J32	25	0.03	-0.28	-0.14
P12	Surf B	J32	25	0.33	-0.56	0.33
P12	Surf B	J32	25	0.00	0.22	0.28
P12	Surf B	J32	26	0.29	-0.48	0.27
P12	Surf B	J32	26	-0.10	-0.05	-0.22
P12	Surf B	J32	26	-0.01	-0.15	-0.10
P12	Surf B	J32	26	0.18	-0.58	-0.06
P12	Surf B	J32	26	0.28	-0.46	0.30
P12	Surf B	J32	26	0.01	-0.04	0.03
P12	Surf B	J32	26	0.16	0.07	0.41
P12	Surf B	J32	27	0.19	-0.27	0.27
P12	Surf B	J32	27	0.23	-0.31	0.32
P12	Surf B	J32	27	-0.05	-0.17	-0.19
P12	Surf B	J32	27	0.10	-0.46	-0.16
P12	Surf B	J32	27	0.08	-0.16	0.09
P12	Surf B	J32	28	0.04	-0.51	-0.30
P12	Surf B	J32	28	0.40	-0.48	0.56
P12	Surf B	J32	28	0.32	-0.54	0.32
P12	Surf B	J32	29	0.13	-0.49	-0.05
P12	Surf B	J32	29	0.46	-0.49	0.73
P12	Surf B	J32	29	0.01	-0.41	-0.28
P12	Surf B	J32	29	-0.03	-0.15	-0.08
P12	Surf B	J32	29	0.14	-0.21	0.20
P12	Surf B	J32	29	-0.05	0.31	0.28
P12	Surf B	J32	29	0.17	-0.04	0.39
P12	Surf B	J32	30	0.07	0.24	0.41
P12	Surf B	J32	30	0.09	-0.28	0.01
P12	Surf B	J32	30	-0.10	-0.41	-0.60
P12	Surf B	J32	30	-0.09	0.26	0.12
P12	Surf B	J32	30	0.18	0.24	0.65
P12	Surf B	J32	31	0.22	-0.17	0.42
P12	Surf B	J32	31	-0.02	-0.17	-0.20
P12	Surf B	J32	31	0.05	-0.34	-0.16
P12	Surf B	J32	31	0.00	-0.55	-0.49
P12	Surf B	J32	31	0.17	-0.52	-0.04
P12	Surf B	J32	32	0.67	-1.63	0.13
P12	Surf B	J32	32	0.01	-1.10	-0.93
P12	Surf B	J32	32	0.21	-0.92	-0.26
P12	Surf B	J32	32	0.04	-0.74	-0.52
P12	Surf B	J32	33	-0.23	-0.33	-0.77
P12	Surf B	J32	33	0.33	-0.68	0.22
P12	Surf B	J32	33	0.12	-0.16	0.18
P12	Surf B	J32	33	0.19	-0.72	-0.14
P12	Surf B	J32	33	0.10	-0.29	0.05
P12	Surf B	J32	34	0.03	-0.52	-0.35
P12	Surf B	J32	34	-0.03	-0.59	-0.54
P12	Surf B	J32	34	0.01	-0.49	-0.36
P12	Surf B	J32	35	0.04	-0.65	-0.40
P12	Surf B	J32	35	0.66	-1.35	0.35
P12	Surf B	J32	35	-0.15	0.30	0.05
P12	Surf B	J32	35	0.07	-0.02	0.25
P12	Surf B	J32	35	-0.08	0.10	-0.01
P12	Surf B	J32	35	-0.10	0.05	-0.11
P12	Surf B	J32	36	0.09	-0.15	0.16
P12	Surf B	J32	36	0.16	-0.61	-0.08
P12	Surf B	J32	36	0.19	-0.44	0.18
P12	Surf B	J32	36	-0.04	-0.71	-0.63
P12	Surf B	J32	36	0.13	-0.58	-0.19
P12	Surf B	J32	36	-0.06	-0.35	-0.38
P12	Surf B	J32	36	0.07	-0.20	0.09
P12	Surf B	J32	37	-0.02	-0.56	-0.49
P12	Surf B	J32	37	-0.01	0.22	0.26
P12	Surf B	J32	37	0.20	-0.37	0.21
P12	Surf B	J32	37	0.16	-0.36	0.10
P12	Surf B	J32	37	0.07	-0.27	-0.07
P12	Surf B	J32	37	0.08	-0.22	0.03

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Surf B	J32	38	0.09	-0.17	0.14
P12	Surf B	J32	38	0.16	-0.05	0.40
P12	Surf B	J32	38	-0.03	-0.48	-0.46
P12	Surf B	J32	38	0.01	-0.33	-0.20
P12	Surf B	J32	38	-0.05	-0.13	-0.18
P12	Surf B	J32	39	-0.18	-0.14	-0.50
P12	Surf B	J32	39	-0.55	2.38	0.97
P12	Surf B	J32	39	-0.01	-0.12	-0.04
P12	Surf B	J32	39	0.07	-0.37	-0.07
P12	Surf B	J32	39	-0.10	-0.40	-0.46
P12	Surf B	J32	39	-0.21	-0.41	-0.71
P12	Surf B	J32	40	0.43	-1.38	-0.14
P12	Surf B	J32	40	0.00	-0.38	-0.24
P12	Surf B	J32	40	-0.07	-0.25	-0.25
P12	Surf B	J32	40	0.18	-0.68	-0.07
P12	Surf B	J32	40	0.12	-0.26	0.17
P12	Surf B	J32	41	0.08	-0.95	-0.58
P12	Surf B	J32	41	0.08	-0.61	-0.18
P12	Surf B	J32	41	0.31	-1.80	-0.78
P12	Surf B	J32	42	-0.05	-1.05	-0.96
P12	Surf B	J32	42	-0.05	-0.85	-0.81
P12	Surf B	J32	42	0.02	-0.09	0.08
P12	Surf B	J32	42	0.15	-0.30	0.19
P12	Surf B	J32	42	-0.05	-0.15	-0.11
P12	Surf B	J32	42	0.14	-0.32	0.13
P12	Surf B	J32	42	0.10	-0.75	-0.35
P12	Surf B	J32	43	0.37	-0.59	0.42
P12	Surf B	J32	43	0.07	-0.30	0.01
P12	Surf B	J32	43	0.12	-0.02	0.35
P12	Surf B	J32	43	0.15	0.51	0.91
P12	Surf B	J32	43	0.17	-0.68	-0.25
P12	Surf B	J32	44	0.24	-0.16	0.51
P12	Surf B	J32	44	0.23	-0.28	0.33
P12	Surf B	J32	44	0.22	-0.11	0.48
P12	Surf B	J32	44	-0.01	0.03	0.07
P12	Surf B	J32	45	0.04	0.13	0.27
P12	Surf B	J32	46	-0.06	0.20	0.13
P12	Surf B	J32	46	0.07	-0.18	0.05
P12	Surf B	J32	46	0.10	0.03	0.33
P12	Surf B	J32	47	-0.25	-0.46	-0.98
P12	Surf B	J32	47	-0.04	0.02	0.01
P12	Surf B	J32	47	0.30	-0.13	0.65
P12	Surf B	J32	47	-0.10	0.12	-0.03

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Surf B	J32	48	-0.03	0.04	0.00
P12	Surf B	J32	48	0.12	-0.32	0.10
P12	Surf B	J32	48	0.00	0.03	0.15
P12	Surf B	J32	48	0.06	0.16	0.39
P12	Surf B	J32	48	0.03	0.04	0.19
P12	Surf B	J32	48	-0.01	-0.23	-0.16
P12	Surf B	J32	49	0.17	-1.56	-0.94
P12	Surf B	J32	49	-0.03	-0.40	-0.32
P12	Surf B	J32	49	-0.11	0.01	-0.12
P12	Surf B	J32	49	0.04	-0.21	0.04
P12	Surf B	J32	49	-0.15	0.03	-0.21
P12	Surf B	J32	49	0.05	-0.11	0.10
P12	Surf B	J32	49	0.12	0.34	0.67
P12	Surf B	J32	50	0.27	-0.71	0.09
P12	Surf B	J32	50	-0.01	-0.14	-0.06
P12	Surf B	J32	50	0.13	-0.55	-0.11
P12	Surf B	J32	50	0.04	0.12	0.31
P12	Surf B	J32	51	0.03	-0.70	-0.49
P12	Surf B	J32	51	0.18	-0.92	-0.35
P12	Surf B	J32	51	0.02	-0.77	-0.57
P12	Surf B	J32	52	-0.11	0.04	-0.12
P12	Surf B	J32	52	0.18	-0.63	-0.06
P12	Surf B	J32	52	-0.04	-0.83	-0.75
P12	Surf B	J32	52	0.12	-0.84	-0.42
P12	Surf B	J32	53	0.06	-0.31	-0.14
P12	Surf B	J32	53	0.14	-0.30	0.02
P12	Surf B	J32	53	0.34	-0.11	0.61
P12	Surf B	J32	54	0.60	-0.97	0.53
P12	Surf B	J32	54	-0.10	-0.25	-0.53
P12	Surf B	J32	54	0.21	-0.69	-0.23
P12	Surf B	J32	55	-0.06	-1.17	-1.29
P12	Surf B	J32	55	0.13	-0.56	-0.23
P12	Surf B	J32	56	0.12	-0.21	0.02
P12	Surf B	J32	56	-0.43	-0.25	-1.23
P12	Surf B	J32	56	-0.56	1.37	-0.03
P12	Surf B	J33	1	-0.36	1.00	0.15
P12	Surf B	J33	1	-0.01	0.37	0.36
P12	Surf B	J33	1	-0.02	0.21	0.20
P12	Surf B	J33	1	-0.12	0.13	-0.11
P12	Surf B	J34	1	0.02	2.52	2.28
P12	Surf B	J34	1	0.20	-0.54	-0.04
P12	Inter C	J35	1	0.26	-0.18	0.45
P12	Inter C	J35	2	0.34	-0.28	0.49

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Inter C	J35	3	-0.11	-0.68	-0.92
P12	Inter C	J35	4	0.40	-1.10	-0.12
P12	Inter C	J35	5	0.18	*	*
P12	Inter C	J35	5	-0.01	*	*
P12	Inter C	J35	6	0.20	-0.22	0.22
P12	Inter C	J35	7	0.31	-1.10	-0.39
P12	Inter C	J35	8	0.12	*	*
P12	Inter C	J35	8	0.03	*	*
P12	Inter C	J35	9	0.24	*	*
P12	Inter C	J35	10	-0.03	*	*
P12	Inter C	J35	10	-0.34	*	*
P12	Inter C	J35	11	-0.40	0.27	-0.70
P12	Inter C	J35	11	-0.07	-0.57	-0.74
P12	Inter C	J35	12	0.17	-0.44	-0.05
P12	Inter C	J35	13	-0.16	0.25	-0.18
P12	Inter C	J35	14	0.01	0.25	0.16
P12	Inter C	J35	15	-0.20	1.04	0.42
P12	Inter C	J36	1	0.06	-0.27	-0.16
P12	Inter C	J36	1	0.16	0.21	0.50
P12	Inter C	J36	2	0.38	-0.06	0.72
P12	Inter C	J36	3	-0.10	1.71	1.22
P12	Inter C	J36	3	0.05	0.51	0.50
P12	Inter C	J36	4	0.06	0.46	0.46
P12	Inter C	J36	5	0.57	*	*
P12	Inter C	J36	5	0.64	-0.88	0.58
P12	Inter C	J36	6	-0.17	1.60	1.05
P12	Inter C	J36	7	0.15	1.12	1.40
P12	Inter C	J36	8	0.08	0.50	0.59
P12	Inter C	J37	1	0.39	-0.94	-0.09
P12	Inter C	J37	1	0.45	-0.57	0.43
P12	Inter C	J38	1	0.31	-0.68	0.04
P12	Inter C	J39	1	0.41	-1.10	-0.02
P12	Inter C	J39	2	0.00	0.79	0.71
P12	Inter C	J39	2	-0.22	*	*
P12	Inter C	J39	3	0.17	*	*
P12	Inter C	J39	4	0.12	*	*
P12	Inter C	J39	5	-0.05	*	*
P12	Inter C	J39	6	-0.06	*	*
P12	Inter C	J39	7	-0.06	-0.23	-0.33
P12	Inter C	J39	8	-0.08	*	*
P12	Inter C	J39	8	0.24	*	*
P12	Inter C	J39	9	0.12	*	*
P12	Inter C	J39	10	-0.11	*	*

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Inter C	J39	11	0.27	-0.51	0.16
P12	Inter C	J40	1	-0.50	*	*
P12	Inter C	J40	2	0.36	*	*
P12	Inter C	J40	3	0.06	*	*
P12	Inter C	J40	4	0.40	*	*
P12	Inter C	J40	5	0.22	*	*
P12	Inter C	J40	6	-0.16	*	*
P12	Inter C	J40	6	0.05	*	*
P12	Inter C	J40	7	0.26	*	*
P12	Inter C	J40	7	-0.46	*	*
P12	Inter C	J40	8	0.09	0.94	1.00
P12	Inter C	J40	9	0.23	*	*
P12	Inter C	J40	10	0.42	*	*
P12	Inter C	J40	11	-0.08	*	*
P12	Inter C	J40	12	-0.12	*	*
P12	Inter C	J40	13	0.09	*	*
P12	Inter C	J40	14	-0.13	*	*
P12	Inter C	J40	14	-0.28	*	*
P12	Inter C	J40	14	0.02	*	*
P12	Inter C	J40	15	0.06	1.11	1.15
P12	Inter C	J40	16	0.03	0.53	0.49
P12	Inter C	J40	17	0.26	0.47	0.97
P12	Inter C	J40	17	-0.09	1.13	0.78
P12	Inter C	J40	18	0.07	0.90	0.93
P12	Surf C	J41	1	0.03	0.59	0.56
P12	Surf C	J41	2	-0.16	0.41	-0.03
P12	Surf C	J42	1	-0.07	0.34	0.09
P12	Surf C	J42	2	0.00	0.34	0.19
P12	Surf C	J42	3	-0.01	-0.72	-0.70
P12	Surf C	J43	1	-0.28	-0.26	-0.80
P12	Surf C	J43	2	-0.18	0.27	-0.11
P12	Surf C	J43	3	-0.09	-0.20	-0.37
P12	Surf C	J43	4	0.29	-0.41	0.21
P12	Base A	J92	1	0.18	*	*
P12	Base A	J92	1	-0.17	*	*
P12	Base A	J92	2	-0.12	*	*
P12	Base A	J93	1	-0.46	*	*
P12	Base A	J93	2	0.37	*	*
P12	Base A	J93	2	0.27	*	*
P12	Base A	J93	3	-0.22	*	*
P12	Base A	J93	4	-0.79	*	*
P12	Base A	J93	5	-0.13	*	*
P12	Base A	J93	5	-0.02	*	*

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Base A	J93	6	-0.40	*	*
P12	Base A	J93	7	0.12	*	*
P12	Base A	J93	7	-0.02	*	*
P12	Base A	J93	8	-0.37	*	*
P12	Base A	J93	9	-0.56	*	*
P12	Base A	J94	1	-0.28	*	*
P12	Base A	J94	2	0.09	*	*
P12	Base A	J29	1	0.31	-0.21	0.59
P12	Base A	J29	1	0.99	-1.29	1.14
P12	Base A	J29	1	0.11	0.25	0.56
P12	Base A	J29	1	0.11	-0.49	-0.13
P12	Base A	J29	1	-0.02	-0.21	-0.18
P12	Base A	J29	2	0.10	0.80	1.01
P12	Base A	J29	2	0.28	0.53	1.08
P12	Base A	J29	2	0.20	0.42	0.89
P12	Base A	J29	3	0.06	0.54	0.68
P12	Base A	J29	3	0.04	0.42	0.54
P12	Base A	J29	3	-0.08	0.53	0.37
P12	Base A	J29	4	0.02	-0.05	0.03
P12	Base A	J29	4	0.09	0.60	0.80
P12	Base A	J29	4	-0.10	0.47	0.28
P12	Base A	J29	4	-0.30	0.49	-0.12
P12	Base A	J29	4	0.48	-0.90	0.36
P12	Base A	J29	5	-0.18	0.15	-0.20
P12	Base A	J29	5	0.06	0.25	0.45
P12	Base A	J29	5	0.06	-0.06	0.15
P12	Base A	J29	6	0.24	-0.03	0.63
P12	Base A	J29	6	0.01	0.14	0.22
P12	Base A	J29	6	0.14	0.49	0.84
P12	Base A	J29	7	0.35	-1.66	-0.64
P12	Base A	J29	7	-0.12	-0.79	-0.94
P12	Base A	J29	7	0.03	-0.08	0.01
P12	Base A	J29	7	0.01	-0.11	-0.08
P12	Base A	J29	7	0.14	0.11	0.45
P12	Base A	J29	8	-0.01	-0.60	-0.56
P12	Base A	J29	8	0.43	0.02	1.08
P12	Base A	J29	8	0.37	-1.37	-0.38
P12	Base A	J29	9	-0.22	0.15	-0.35
P12	Base A	J29	9	-0.08	0.40	0.23
P12	Base A	J29	9	0.08	0.31	0.49
P12	Base A	J29	10	0.14	-0.41	-0.06
P12	Base A	J29	10	-0.03	0.27	0.21
P12	Base A	J29	10	0.00	0.74	0.72
P12	Base A	J29	10	0.15	0.37	0.72
P12	Base A	J29	10	0.20	-0.08	0.42
P12	Base A	J29	11	0.31	0.39	1.09
P12	Base A	J29	11	-0.23	1.13	0.55
P12	Base A	J29	11	0.08	0.21	0.41
P12	Base A	J29	11	-0.24	0.42	-0.19
P12	Base A	J29	11	0.28	0.11	0.73
P12	Base A	J29	12	0.22	-0.28	0.26
P12	Base A	J29	12	0.31	0.22	0.92
P12	Base A	J29	12	-0.05	0.96	0.79
P12	Base A	J29	13	0.57	-0.02	1.26
P12	Base A	J29	13	-0.08	0.15	-0.02
P12	Base A	J29	13	0.04	1.01	1.02
P12	Base A	J29	13	-0.16	0.88	0.46
P12	Base A	J29	13	0.01	0.52	0.50
P12	Base A	J29	14	0.14	0.62	0.93
P12	Base A	J29	14	-0.06	0.07	-0.04
P12	Base A	J29	14	0.22	-0.20	0.33
P12	Base A	J29	14	0.03	0.56	0.58
P12	Base A	J29	14	-0.23	1.12	0.52
P12	Base A	J29	15	-0.11	0.10	-0.18
P12	Base A	J29	15	-0.01	-0.30	-0.34
P12	Base A	J29	15	0.06	0.07	0.17
P12	Base A	J29	15	0.26	-0.33	0.29
P12	Base A	J29	16	-0.38	0.58	-0.32
P12	Base A	J29	16	-0.01	0.00	-0.03
P12	Base A	J29	16	-0.13	-0.02	-0.31
P12	Base A	J29	17	-0.07	0.56	0.32
P12	Base A	J29	17	-0.02	0.41	0.35
P12	Base A	J29	17	-0.26	0.18	-0.42
P12	Base A	J29	18	0.00	0.05	0.02
P12	Base A	J29	18	0.15	0.43	0.72
P12	Base A	J29	18	0.30	0.13	0.71
P12	Base A	J29	19	0.06	-0.11	-0.05
P12	Base A	J29	19	0.18	0.34	0.72
P12	Base A	J30	1	0.00	0.02	-0.11
P12	Base A	J30	1	0.74	-1.97	-0.34
P12	Base A	J30	1	-0.73	1.07	-0.83
P12	Base A	J30	2	-0.22	-0.05	-0.70
P12	Base A	J30	2	-0.31	1.01	0.21
P12	Base A	J30	2	0.09	0.49	0.62
P12	Base A	J30	2	-0.18	0.12	-0.37
P12	Base A	J30	2	-0.05	-0.12	-0.33

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Base A	J14	1	0.04	-1.13	-0.91
P12	Surf E	J71	1	0.09	*	*
P12	Surf E	J71	2	-0.07	*	*
P12	Surf E	J71	3	-0.40	*	*
P12	Surf E	J71	4	0.23	*	*
P12	Surf E	J71	5	-0.48	*	*
P12	Surf E	J71	6	0.13	*	*
P12	Surf E	J71	7	-0.47	*	*
P12	Surf E	J71	8	-0.12	*	*
P12	Surf E	J71	9	-0.32	*	*
P12	Surf E	J71	10	-0.42	*	*
P12	Surf E	J72	2	0.20	*	*
P12	Surf E	J72	2	0.23	*	*
P12	Surf E	J72	3	-0.18	*	*
P12	Surf E	J72	4	0.07	*	*
P12	Surf E	J72	4	-0.11	*	*
P12	Surf E	J72	5	-0.19	*	*
P12	Surf E	J72	6	0.31	*	*
P12	Surf E	J72	7	-0.06	*	*
P12	Surf E	J72	7	-0.07	*	*
P12	Surf E	J72	8	0.03	*	*
P12	Surf E	J72	9	-0.30	*	*
P12	Surf E	J72	9	-0.03	*	*
P12	Surf E	J72	10	0.04	*	*
P12	Surf E	J72	10	-0.06	*	*
P12	Surf E	J72	10	-0.07	*	*
P12	Surf E	J72	11	-0.81	*	*
P12	Surf E	J72	11	0.11	*	*
P12	Surf E	J72	12	0.09	*	*
P12	Surf E	J72	12	-0.04	*	*
P12	Surf E	J72	12	0.06	*	*
P12	Surf E	J72	13	0.25	*	*
P12	Surf E	J72	13	0.12	*	*
P12	Surf E	J72	14	-0.22	*	*
P12	Surf E	J72	14	0.10	*	*
P12	Surf E	J72	14	0.10	*	*
P12	Surf E	J72	15	-0.10	*	*
P12	Surf E	J72	15	-0.15	*	*
P12	Surf E	J72	15	0.07	*	*
P12	Surf E	J72	16	0.02	*	*
P12	Surf E	J72	16	0.04	*	*
P12	Surf E	J72	16	0.12	*	*
P12	Surf E	J72	17	0.12	*	*
P12	Surf E	J72	17	-0.04	*	*
P12	Surf E	J72	17	0.13	*	*
P12	Surf E	J72	18	0.21	*	*
P12	Surf E	J72	18	0.09	*	*
P12	Surf E	J72	19	0.15	*	*
P12	Surf E	J72	19	-0.08	*	*
P12	Surf E	J72	19	0.06	*	*
P12	Surf E	J72	20	0.02	*	*
P12	Surf E	J72	21	-0.09	*	*
P12	Surf E	J72	21	-0.04	*	*
P12	Surf E	J72	22	-0.03	*	*
P12	Surf E	J72	22	-0.11	*	*
P12	Surf E	J72	22	0.04	*	*
P12	Surf E	J72	23	0.01	*	*
P12	Surf E	J72	23	0.10	*	*
P12	Surf E	J72	23	0.10	*	*
P12	Surf E	J72	23	0.11	*	*
P12	Surf E	J72	23	0.30	*	*
P12	Surf E	J72	24	0.28	*	*
P12	Surf E	J72	24	0.04	*	*
P12	Surf E	J72	25	-0.03	*	*
P12	Surf E	J72	25	0.00	*	*
P12	Surf E	J72	25	-0.09	*	*
P12	Surf E	J72	25	-0.10	*	*
P12	Surf E	J72	26	-0.18	*	*
P12	Surf E	J72	26	-0.13	*	*
P12	Surf E	J72	26	-0.29	*	*
P12	Surf E	J72	26	-0.11	*	*
P12	Surf E	J72	26	-0.11	*	*
P12	Surf E	J72	26	-0.06	*	*
P12	Surf E	J72	27	-0.16	*	*
P12	Surf E	J72	28	0.03	*	*
P12	Surf E	J72	28	0.00	*	*
P12	Surf E	J72	28	-0.04	*	*
P12	Surf E	J72	28	0.08	*	*
P12	Surf E	J72	29	0.00	*	*
P12	Surf E	J72	29	0.02	*	*
P12	Surf E	J72	29	0.03	*	*
P12	Surf E	J72	29	0.08	*	*
P12	Surf E	J72	29	-0.08	*	*
P12	Surf E	J72	31	-0.08	*	*
P12	Surf E	J72	31	-0.02	*	*
P12	Surf E	J72	31	0.10	*	*

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	Surf E	J72	32	-0.03	*	*
P12	Surf E	J72	32	-0.05	*	*
P12	Surf E	J72	33	-0.05	*	*
P12	Surf E	J72	33	-0.13	*	*
P12	Surf E	J72	33	0.13	*	*
P12	Surf E	J72	34	0.02	*	*
P12	Surf E	J72	34	-0.01	*	*
P12	Surf E	J72	34	-0.01	*	*
P12	Surf E	J72	34	-0.05	*	*
P12	Surf E	J72	35	-0.10	*	*
P12	Surf E	J72	35	0.02	*	*
P12	Surf E	J72	35	0.00	*	*
P12	Surf E	J72	35	-0.15	*	*
P12	Surf E	J72	35	0.10	*	*
P12	Surf E	J72	36	-0.22	*	*
P12	Surf E	J72	36	-0.06	*	*
P12	Surf E	J72	36	-0.08	*	*
P12	Surf E	J72	36	0.13	*	*
P12	Surf E	J72	37	0.28	*	*
P12	Surf E	J72	37	0.22	*	*
P12	Surf E	J72	37	-0.26	*	*
P12	Surf E	J72	38	0.08	*	*
P12	Surf E	J72	38	-0.20	*	*
P12	Surf E	J72	39	0.04	*	*
P12	Surf E	J72	39	-0.50	*	*
P12	Surf E	J72	39	0.13	*	*
P12	Surf E	J72	39	0.01	*	*
P12	Surf E	J72	40	-0.01	*	*
P12	Surf E	J72	41	0.20	*	*
P12	Surf E	J72	41	0.17	*	*
P12	Surf E	J72	41	0.16	*	*
P12	Surf E	J72	41	0.04	*	*
P12	Surf E	J72	41	-0.09	*	*
P12	Surf E	J72	42	0.12	*	*
P12	Surf E	J72	42	-0.01	*	*
P12	Surf E	J72	42	0.00	*	*
P12	Surf E	J72	43	0.11	*	*
P12	Surf E	J72	43	0.10	*	*
P12	Surf E	J72	43	-0.13	*	*
P12	Surf E	J72	44	0.14	*	*
P12	Surf E	J72	45	-0.04	*	*
P12	Surf E	J72	46	-0.04	*	*
P12	Surf E	J72	47	0.43	*	*
P12	Surf E	J72	48	-0.35	*	*
P12	Surf E	J72	49	-0.22	*	*
P12	Surf E	J72	50	0.00	*	*
P12	Surf E	J73	1	0.02	*	*
P12	Surf E	J73	2	-0.25	*	*
P12	Surf E	J73	3	-0.06	*	*
P12	OGFC	J90	1	-0.62	*	*
P12	OGFC	J90	1	1.30	*	*
P12	OGFC	J90	2	-0.06	*	*
P12	OGFC	J90	2	0.01	*	*
P12	OGFC	J90	2	-0.06	*	*
P12	OGFC	J90	3	-0.06	*	*
P12	OGFC	J90	3	-0.09	*	*
P12	OGFC	J90	3	-0.27	*	*
P12	OGFC	J90	3	-0.11	*	*
P12	OGFC	J90	4	0.06	*	*
P12	OGFC	J90	4	0.02	*	*
P12	OGFC	J90	4	-0.45	*	*
P12	OGFC	J90	5	0.35	*	*
P12	OGFC	J90	5	0.18	*	*
P12	OGFC	J90	5	-0.09	*	*
P12	OGFC	J90	6	-0.01	*	*
P12	OGFC	J90	6	-0.19	*	*
P12	OGFC	J90	6	0.01	*	*
P12	OGFC	J90	7	-0.20	*	*
P12	OGFC	J90	7	0.02	*	*
P12	OGFC	J90	7	-0.18	*	*
P12	OGFC	J90	7	-0.05	*	*
P12	OGFC	J90	8	-0.03	*	*
P12	OGFC	J90	8	-0.01	*	*
P12	OGFC	J90	8	0.13	*	*
P12	OGFC	J90	8	-0.17	*	*
P12	OGFC	J90	9	0.14	*	*
P12	OGFC	J90	9	-0.04	*	*
P12	OGFC	J90	9	0.42	*	*
P12	OGFC	J90	10	-0.19	*	*
P12	OGFC	J90	10	-0.24	*	*
P12	OGFC	J90	10	-0.10	*	*
P12	OGFC	J90	10	0.05	*	*
P12	OGFC	J90	11	-0.07	*	*
P12	OGFC	J90	11	0.09	*	*
P12	OGFC	J90	11	-0.25	*	*
P12	OGFC	J90	12	-0.15	*	*

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P12	OGFC	J90	12	-0.15	*	*
P12	OGFC	J90	12	0.10	*	*
P12	OGFC	J90	13	0.03	*	*
P12	OGFC	J90	13	0.09	*	*
P12	OGFC	J90	13	0.04	*	*
P12	OGFC	J90	13	-0.22	*	*
P12	OGFC	J90	14	0.13	*	*
P12	OGFC	J90	14	0.00	*	*
P12	OGFC	J90	14	0.08	*	*
P12	OGFC	J90	14	0.00	*	*
P12	OGFC	J90	15	0.19	*	*
P12	OGFC	J90	15	-0.15	*	*
P12	OGFC	J90	15	0.11	*	*
P12	OGFC	J90	15	-0.25	*	*
P12	OGFC	J90	15	0.07	*	*
P12	OGFC	J90	16	-0.21	*	*
P12	OGFC	J90	16	-0.34	*	*
P12	OGFC	J90	16	0.16	*	*
P12	OGFC	J90	16	-0.10	*	*
P12	OGFC	J90	17	0.01	*	*
P12	OGFC	J90	17	0.17	*	*
P12	OGFC	J90	17	0.01	*	*
P12	OGFC	J90	18	-0.04	*	*
P12	OGFC	J90	18	-0.04	*	*
P12	OGFC	J90	18	-0.40	*	*
P12	OGFC	J90	18	-0.35	*	*
P12	OGFC	J90	19	0.01	*	*
P12	OGFC	J90	19	0.14	*	*
P12	OGFC	J90	19	0.09	*	*
P12	OGFC	J90	19	0.14	*	*
P12	OGFC	J90	20	0.00	*	*
P12	OGFC	J90	20	0.04	*	*
P12	OGFC	J90	20	-0.03	*	*
P12	OGFC	J90	20	0.08	*	*
P12	OGFC	J90	21	-0.18	*	*
P12	OGFC	J90	21	0.31	*	*
P12	OGFC	J90	21	-0.18	*	*
P12	OGFC	J90	22	0.04	*	*
P12	OGFC	J90	22	-0.08	*	*
P12	OGFC	J90	22	0.15	*	*
P12	OGFC	J90	23	-0.01	*	*
P12	OGFC	J90	23	-0.15	*	*
P12	OGFC	J90	23	0.08	*	*
P12	OGFC	J90	24	0.28	*	*
P12	OGFC	J90	24	-0.06	*	*
P12	OGFC	J90	24	0.12	*	*
P12	OGFC	J90	24	0.01	*	*
P12	OGFC	J90	24	-0.05	*	*
P12	OGFC	J90	25	-0.35	*	*
P12	OGFC	J90	26	0.34	*	*
P13	Surf A	J44	1	-0.11	1.54	1.07
P13	Surf A	J44	1	-0.11	1.13	0.72
P13	Surf A	J44	1	0.10	-0.50	-0.29
P13	Surf A	J44	2	0.26	-0.36	0.22
P13	Surf A	J44	2	0.14	0.29	0.58
P13	Surf A	J44	2	0.16	-0.25	0.10
P13	Surf A	J44	2	-0.10	-0.12	-0.39
P13	Surf A	J44	3	0.12	-0.46	-0.20
P13	Surf A	J44	3	0.05	0.06	0.12
P13	Surf A	J44	3	0.22	0.21	0.67
P13	Surf A	J44	3	0.07	0.01	0.14
P13	Surf A	J44	4	0.05	0.56	0.58
P13	Surf A	J44	4	0.44	0.05	0.98
P13	Surf A	J44	4	0.05	-0.34	-0.25
P13	Surf A	J44	4	-0.09	0.00	-0.27
P13	Surf A	J44	4	0.11	0.11	0.26
P13	Surf A	J44	4	-0.09	-0.05	-0.33
P13	Surf A	J44	5	-0.27	0.38	-0.32
P13	Surf A	J44	5	0.07	0.38	0.46
P13	Surf A	J44	5	-0.04	0.70	0.51
P13	Surf A	J44	7	0.05	-0.21	-0.15
P13	Surf A	J44	7	0.22	-0.55	-0.11
P13	Surf A	J44	7	-0.09	0.40	0.12
P13	Surf A	J44	7	0.04	0.66	0.65
P13	Surf A	J44	7	0.16	-0.01	0.27
P13	Surf A	J44	7	0.13	0.12	0.35
P13	Surf A	J44	8	0.00	0.33	0.29
P13	Surf A	J44	8	-0.19	0.44	-0.08
P13	Surf A	J44	8	0.01	0.48	0.42
P13	Surf A	J44	8	-0.11	0.45	0.09
P13	Surf A	J44	9	-0.04	0.06	-0.10
P13	Surf A	J44	9	0.09	0.75	0.83
P13	Surf A	J44	9	-0.24	0.62	-0.03
P13	Surf A	J44	9	0.38	0.29	1.06
P13	Surf A	J44	9	-0.17	0.29	-0.19
P13	Surf A	J44	9	-0.05	0.79	0.54

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P13	Surf A	J44	9	-0.16	0.46	0.00
P13	Surf A	J44	10	-0.21	0.57	-0.02
P13	Surf A	J44	10	-0.16	0.26	-0.17
P13	Surf A	J44	10	0.03	0.14	0.15
P13	Surf A	J44	11	-0.21	0.10	-0.43
P13	Surf A	J44	11	0.21	0.38	0.79
P13	Surf A	J44	11	-0.39	0.48	-0.49
P13	Surf A	J44	12	-0.07	0.74	0.48
P13	Surf A	J44	12	0.15	0.34	0.61
P13	Surf A	J44	12	0.08	0.68	0.76
P13	Surf A	J44	12	-0.02	0.31	0.23
P13	Surf A	J44	13	0.21	-0.69	-0.10
P13	Surf A	J44	16	-0.03	0.01	-0.09
P13	Surf A	J44	16	-0.06	-0.28	-0.45
P13	Surf A	J44	16	0.18	-0.52	-0.06
P13	Surf A	J44	16	-0.04	0.17	0.04
P13	Surf A	J44	16	-0.02	0.02	-0.02
P13	Surf A	J44	16	-0.09	0.95	0.64
P13	Surf A	J13	1	-0.07	-0.33	-0.49
P13	Surf A	J13	1	0.04	-0.23	-0.13
P13	Surf A	J13	1	-0.06	-0.39	-0.51
P13	Surf A	J13	1	0.21	-0.67	-0.15
P13	Surf A	J13	2	-0.16	-0.20	-0.60
P13	Surf A	J13	2	0.01	-0.11	-0.10
P13	Surf A	J13	2	0.13	-0.31	-0.01
P13	Surf A	J13	2	-0.18	0.07	-0.37
P13	Surf A	J13	2	-0.05	-0.45	-0.55
P13	Surf A	J13	2	0.25	-0.17	0.33
P13	Surf A	J13	3	-0.18	0.32	-0.17
P13	Surf A	J13	3	-0.46	1.08	-0.08
P13	Surf A	J13	3	-0.30	0.05	-0.67
P13	Surf A	J13	3	0.21	-0.79	-0.29
P13	Surf A	J13	4	-0.16	-0.23	-0.61
P13	Surf A	J13	4	-0.33	0.19	-0.60
P13	Surf A	J13	4	0.26	-0.43	0.18
P13	Surf A	J13	5	-0.13	0.19	-0.15
P13	Surf A	J13	5	-0.03	-0.25	-0.34
P13	Surf A	J13	5	-0.34	-0.22	-1.05
P13	Surf A	J13	5	0.15	-0.26	0.03
P13	Surf A	J13	6	0.09	-0.22	-0.01
P13	Surf A	J13	6	-0.05	-0.34	-0.44
P13	Surf A	J13	6	-0.03	-0.17	-0.26
P13	Surf A	J13	7	0.16	-1.01	-0.60

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P13	Surf A	J13	7	-0.11	-0.52	-0.72
P13	Surf A	J13	7	0.12	-0.60	-0.29
P13	Surf A	J13	7	0.12	-0.03	0.23
P13	Surf A	J13	7	0.11	-0.52	-0.21
P13	Surf A	J13	8	0.12	-0.07	0.19
P13	Surf A	J13	8	-0.18	-0.60	-0.96
P13	Surf A	J13	8	-0.03	-0.18	-0.22
P13	Surf A	J13	9	-0.05	-0.69	-0.79
P13	Surf A	J13	9	0.17	-0.86	-0.39
P13	Surf A	J13	9	0.13	-0.79	-0.39
P13	Surf A	J13	9	0.01	-0.80	-0.71
P13	Surf A	J13	10	-0.12	-0.38	-0.63
P13	Surf A	J13	10	-0.01	-0.11	-0.15
P13	Surf A	J13	10	-0.21	-0.01	-0.51
P13	Surf A	J13	11	0.08	-0.61	-0.40
P13	Surf A	J13	11	-0.05	-0.24	-0.34
P13	Surf A	J45	1	-0.18	0.45	-0.03
P13	Surf A	J45	1	-0.11	1.01	0.67
P13	Surf A	J45	1	-0.05	0.43	0.25
P13	Surf A	J45	1	-0.10	-0.06	-0.32
P13	Surf A	J45	1	0.09	-0.06	0.10
P13	Surf A	J45	2	-0.23	0.06	-0.58
P13	Surf A	J45	2	-0.10	0.42	0.11
P13	Surf A	J45	2	-0.07	0.58	0.32
P13	Surf A	J45	2	-0.05	0.41	0.20
P13	Surf A	J45	2	0.22	-0.17	0.28
P13	Surf A	J45	2	-0.20	-0.03	-0.56
P13	Surf A	J45	3	-0.07	-0.32	-0.49
P13	Surf A	J45	3	0.07	0.43	0.48
P13	Surf A	J45	3	-0.17	0.59	0.08
P13	Surf A	J45	4	-0.24	0.47	-0.15
P13	Surf A	J45	4	-0.17	0.06	-0.38
P13	Surf A	J45	4	-0.21	0.40	-0.15
P13	Surf A	J45	4	0.00	0.36	0.28
P13	Surf A	J45	4	-0.30	0.07	-0.69
P13	Surf A	J45	5	-0.07	-0.11	-0.33
P13	Surf A	J45	5	0.00	0.28	0.20
P13	Surf A	J45	5	-0.15	0.09	-0.34
P13	Surf A	J14	1	0.17	-0.63	-0.24
P13	Surf A	J14	1	0.19	-0.60	-0.15
P13	Surf A	J14	1	-0.03	-0.20	-0.30
P13	Surf A	J14	2	0.31	-0.61	0.11
P13	Surf A	J14	2	-0.09	-0.12	-0.33

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA	Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P13	Surf A	J14	2	-0.06	-0.13	-0.31	P13	Surf A	J46	1	0.03	0.33	0.39
P13	Surf A	J14	2	0.01	-0.40	-0.37	P13	Surf A	J46	1	0.07	-0.49	-0.24
P13	Surf A	J14	2	0.03	0.21	0.26	P13	Surf A	J46	2	0.12	-0.67	-0.26
P13	Surf A	J14	3	-0.04	-0.42	-0.45	P13	Surf A	J46	3	0.28	-0.31	0.33
P13	Surf A	J14	3	0.11	-0.41	-0.10	P13	Surf A	J46	4	0.15	-0.75	-0.35
P13	Surf A	J14	3	-0.02	0.33	0.31	P13	Surf A	J46	5	0.09	1.21	1.22
P13	Surf A	J14	3	-0.20	-0.37	-0.80	P13	Surf A	J46	6	0.09	-0.55	-0.33
P13	Surf A	J14	4	-0.34	0.09	-0.70	P13	Surf A	J47	1	0.00	0.76	0.63
P13	Surf A	J14	4	-0.30	-0.33	-0.98	P13	Surf A	J48	1	-0.19	0.00	-0.47
P13	Surf A	J14	4	-0.43	0.56	-0.48	P13	Surf A	J48	6	0.23	-0.74	-0.23
P13	Surf A	J14	4	0.16	-0.32	0.05	P13	Surf A	J48	6	0.06	0.68	0.67
P13	Surf A	J14	5	0.08	-0.39	-0.17	P13	Surf A	J48	6	0.06	0.13	0.20
P13	Surf A	J14	5	-0.28	0.40	-0.26	P13	Surf A	J48	6	0.06	-0.23	-0.14
P13	Surf A	J14	5	-0.10	-0.16	-0.39	P13	Surf B	J49	1	0.00	0.37	0.32
P13	Surf A	J14	6	-0.13	-0.52	-0.79	P13	Surf B	J49	1	-0.02	0.49	0.38
P13	Surf A	J14	6	-0.09	0.34	0.12	P13	Surf B	J49	1	0.02	-0.87	-0.69
P13	Surf A	J14	6	-0.07	-0.12	-0.24	P13	Surf B	J49	2	-0.26	0.49	-0.12
P13	Surf A	J14	7	0.14	-0.90	-0.50	P13	Surf B	J49	2	-0.23	0.69	0.12
P13	Surf A	J14	7	-0.17	-0.24	-0.64	P13	Surf B	J49	2	0.28	-0.38	0.33
P13	Surf A	J14	7	-0.19	0.88	0.38	P13	Surf B	J49	2	0.26	-0.52	0.16
P13	Surf A	J14	7	-0.33	0.88	0.04	P13	Surf B	J49	3	0.30	0.38	1.06
P13	Surf A	J14	7	-0.19	0.18	-0.32	P13	Surf B	J49	3	0.11	0.72	0.97
P13	Surf A	J14	7	-0.18	0.35	-0.09	P13	Surf B	J49	3	0.02	0.76	0.77
P13	Surf A	J14	7	-0.34	-0.04	-0.84	P13	Surf B	J49	4	0.15	0.06	0.41
P13	Surf A	J14	8	-0.01	-0.09	-0.10	P13	Surf B	J49	4	0.18	-0.55	-0.11
P13	Surf A	J14	8	0.03	0.43	0.45	P13	Surf B	J49	4	-0.28	0.92	0.19
P13	Surf A	J14	8	0.13	-0.05	0.26	P13	Surf B	J49	4	0.02	0.78	0.80
P13	Surf A	J14	9	0.08	-0.14	0.04	P13	Surf B	J49	5	0.05	-0.42	-0.25
P13	Surf A	J14	9	0.21	-0.38	0.11	P13	Surf B	J49	5	0.31	0.41	1.12
P13	Surf A	J14	9	0.12	-0.37	-0.04	P13	Surf B	J49	5	0.46	-0.97	0.19
P13	Surf A	J14	10	0.05	-0.70	-0.53	P13	Surf B	J49	5	0.14	0.29	0.63
P13	Surf A	J14	10	0.16	-0.69	-0.23	P13	Surf B	J49	5	0.22	0.57	1.06
P13	Surf A	J14	10	0.28	-0.64	0.07	P13	Surf B	J49	5	-0.14	1.39	1.00
P13	Surf A	J14	11	0.02	0.30	0.30	P13	Surf B	J49	6	0.04	0.31	0.40
P13	Surf A	J14	11	0.10	-0.79	-0.49	P13	Surf B	J49	6	-0.14	0.32	-0.02
P13	Surf A	J14	11	0.27	-1.03	-0.30	P13	Surf B	J49	6	0.04	0.36	0.43
P13	Surf A	J14	13	0.21	-1.10	-0.51	P13	Surf B	J49	6	0.01	0.53	0.54
P13	Surf A	J14	14	-0.01	-0.56	-0.54	P13	Surf B	J49	7	-0.23	0.27	-0.26
P13	Surf A	J14	15	0.21	-0.62	-0.09	P13	Surf B	J49	7	0.07	0.09	0.28
P13	Surf A	J14	16	0.07	-0.63	-0.40	P13	Surf B	J49	7	0.07	0.06	0.22
P13	Surf A	J14	16	0.06	-0.73	-0.50	P13	Surf B	J49	7	0.26	0.20	0.79
P13	Surf A	J14	17	0.30	-0.84	-0.10	P13	Surf B	J49	7	-0.28	0.94	0.21
P13	Surf A	J46	1	0.10	0.19	0.36	P13	Surf B	J49	8	0.02	0.75	0.76

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P13	Surf B	J49	8	-0.16	0.37	0.00
P13	Surf B	J49	8	-0.17	1.10	0.63
P13	Surf B	J49	8	0.18	0.61	1.05
P13	Surf B	J49	8	-0.08	0.99	0.78
P13	Surf B	J49	9	0.18	0.27	0.69
P13	Surf B	J49	9	0.36	-0.29	0.54
P13	Surf B	J49	9	-0.05	-0.17	-0.29
P13	Surf B	J50	1	-0.01	-0.29	-0.39
P13	Surf B	J50	1	-0.07	0.14	-0.12
P13	Surf B	J50	1	-0.35	-0.02	-0.91
P13	Surf B	J50	1	0.21	-0.74	-0.32
P13	Surf B	J50	2	0.08	0.56	0.60
P13	Surf B	J50	2	0.08	-0.07	0.02
P13	Surf B	J50	2	-0.04	0.73	0.47
P13	Surf B	J50	3	-0.27	0.18	-0.54
P13	Surf B	J50	3	-0.13	0.57	0.11
P13	Surf B	J50	3	-0.40	1.03	-0.06
P13	Surf B	J50	4	-0.17	1.02	0.44
P13	Surf B	J50	4	-0.09	0.70	0.38
P13	Surf B	J51	1	0.19	-0.12	0.28
P13	Surf B	J51	1	0.00	0.47	0.39
P13	Surf B	J51	1	0.11	0.32	0.54
P13	Surf B	J51	1	0.23	0.71	1.13
P13	Surf B	J51	1	-0.09	1.20	0.83
P13	Surf B	J51	1	-0.03	1.35	1.09
P13	Surf B	J52	1	0.03	0.82	0.84
P13	Surf B	J52	1	0.02	0.81	0.80
P13	Surf B	J52	1	0.13	0.24	0.51
P13	Surf B	J52	1	-0.13	0.93	0.54
P13	Surf B	J52	2	0.37	-0.08	0.76
P13	Surf B	J52	2	-0.05	0.01	-0.11
P13	Surf B	J52	2	0.17	-0.50	-0.07
P13	Surf B	J52	2	0.09	-0.22	-0.01
P13	Surf B	J52	2	-0.06	0.16	-0.01
P13	Surf B	J52	2	0.17	-0.10	0.28
P13	Surf B	J52	3	-0.23	0.26	-0.30
P13	Surf B	J52	3	0.01	0.57	0.54
P13	Surf B	J52	3	-0.12	0.01	-0.25
P13	Surf B	J52	3	0.04	-0.11	0.01
P13	Surf B	J52	3	0.07	-0.22	-0.05
P13	Surf B	J52	4	-0.21	0.41	-0.11
P13	Surf B	J52	4	-0.32	0.88	0.08
P13	Surf B	J52	4	0.07	-0.17	0.02

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P13	Surf B	J52	4	0.06	0.75	0.84
P13	Surf B	J52	5	0.08	0.26	0.41
P13	Surf B	J53	1	-0.21	0.81	0.19
P13	Surf B	J54	1	-0.16	1.29	0.81
P13	Surf B	J54	1	0.23	-0.45	0.12
P13	Surf B	J54	2	0.02	-0.10	-0.06
P13	Surf B	J54	2	0.11	0.13	0.33
P13	Surf B	J54	2	0.19	-0.40	0.05
P13	Surf B	J54	2	0.04	-0.36	-0.27
P13	Surf B	J54	3	0.20	-0.56	-0.09
P13	Surf B	J54	3	0.31	-0.62	0.11
P13	Surf B	J54	3	-0.22	0.46	-0.06
P13	Surf B	J54	4	0.00	0.20	0.15
P13	Surf B	J54	4	-0.12	-0.34	-0.62
P13	Surf B	J54	4	-0.08	-0.44	-0.62
P13	Surf B	J54	4	-0.04	-0.31	-0.43
P13	Surf B	J54	5	-0.07	-0.30	-0.47
P13	Surf B	J54	5	-0.17	-0.43	-0.78
P13	Surf B	J54	5	-0.10	-0.38	-0.61
P13	Surf B	J54	6	-0.13	-0.30	-0.60
P13	Surf B	J54	6	0.08	-0.24	-0.06
P13	Surf B	J54	6	0.03	-0.73	-0.61
P13	Surf B	J54	6	0.16	-0.49	-0.08
P13	Surf B	J54	6	0.39	-1.67	-0.62
P13	Surf B	J54	7	-0.06	-0.24	-0.38
P13	Surf B	J54	7	0.01	-0.22	-0.21
P13	Surf B	J54	7	-0.07	-0.23	-0.42
P13	Surf B	J54	8	-0.20	0.17	-0.35
P13	Surf B	J54	8	0.08	-0.12	0.04
P13	Surf B	J54	8	0.04	-0.41	-0.34
P13	Surf B	J54	8	0.20	-0.91	-0.44
P13	Surf B	J54	9	0.05	-0.39	-0.31
P13	Surf B	J54	9	-0.07	-0.16	-0.33
P13	Surf B	J54	9	0.05	-0.38	-0.28
P13	Surf B	J54	9	-0.06	-0.88	-0.97
P13	Surf B	J54	11	-0.27	-0.45	-1.04
P13	Surf B	J54	11	0.07	-1.05	-0.81
P13	Surf B	J54	11	0.04	-0.92	-0.78
P13	Surf B	J54	12	0.16	-0.66	-0.26
P13	Surf B	J54	12	0.23	-0.87	-0.33
P13	Surf B	J54	12	0.00	-0.28	-0.27
P13	Surf B	J54	13	-0.21	-0.57	-1.01
P13	Surf B	J54	13	-0.03	-0.40	-0.45

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P13	Surf B	J54	13	0.20	-0.85	-0.39
P13	Surf B	J55	1	0.14	-0.87	-0.54
P13	Surf B	J55	1	0.37	-0.98	-0.15
P13	Surf B	J55	1	0.03	0.53	0.45
P13	Surf B	J56	1	0.16	-0.64	-0.26
P13	Surf B	J56	1	0.40	-0.29	0.65
P13	Surf B	J56	1	0.06	0.47	0.53
P13	Surf B	J56	1	-0.24	0.35	-0.28
P13	Surf B	J56	1	0.00	0.58	0.50
P13	Surf B	J56	3	-0.10	0.18	-0.12
P13	Surf B	J56	3	-0.01	-0.78	-0.84
P13	Surf B	J56	3	-0.29	0.99	0.23
P13	Surf B	J56	3	0.33	-1.08	-0.30
P13	Surf B	J56	4	0.03	-0.57	-0.48
P13	Surf B	J56	4	0.09	0.04	0.22
P13	Inter C	J57	1	-0.24	0.02	-0.62
P13	Inter C	J57	2	0.02	-0.10	-0.06
P13	Inter C	J57	3	0.20	-0.49	-0.09
P13	Inter C	J57	4	0.15	-0.90	-0.53
P13	Inter C	J57	4	0.33	-0.55	0.18
P13	Inter C	J57	5	-0.16	-0.81	-1.13
P13	Inter C	J57	7	0.10	-0.71	-0.52
P13	Inter C	J57	8	-0.13	0.26	-0.11
P13	Inter C	J57	9	-0.06	-0.32	-0.49
P13	Inter C	J57	10	-0.19	-0.31	-0.76
P13	Inter C	J57	11	0.06	-0.60	-0.46
P13	Inter C	J57	11	0.02	0.71	0.71
P13	Inter C	J57	12	-0.11	-0.51	-0.84
P13	Inter C	J57	13	0.18	-0.48	-0.14
P13	Inter C	J57	14	-0.19	-0.89	-1.33
P13	Inter C	J57	15	-0.01	-0.59	-0.64
P13	Inter C	J57	16	-0.21	-0.14	-0.69
P13	Inter C	J57	17	-0.11	-0.44	-0.72
P13	Inter C	J57	18	-0.91	1.24	-0.94
P13	Inter C	J57	19	-0.11	-0.24	-0.47
P13	Inter C	J57	20	-0.11	-0.65	-0.85
P13	Inter C	J57	21	0.12	-0.97	-0.67
P13	Inter C	J58	1	0.23	-0.58	-0.09
P13	Inter C	J58	3	0.33	-0.95	-0.15
P13	Inter C	J58	4	0.34	-1.50	-0.66
P13	Inter C	J59	1	0.40	-0.93	-0.02
P13	Inter C	J60	1	0.39	-0.04	0.94
P13	Inter C	J61	1	-0.07	0.19	0.15

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P13	Surf E	J74	1	0.28	*	*
P13	Surf E	J74	2	0.08	*	*
P13	Surf E	J74	3	0.35	*	*
P13	Surf E	J74	4	0.20	*	*
P13	Surf E	J74	5	0.08	*	*
P13	Surf E	J74	5	0.34	*	*
P13	Surf E	J74	6	0.05	*	*
P13	Surf E	J74	7	0.35	*	*
P13	Surf E	J74	8	0.19	*	*
P13	Surf E	J74	9	0.36	*	*
P13	Surf E	J74	10	0.19	*	*
P13	Surf E	J74	11	0.10	*	*
P13	Surf E	J74	11	0.11	*	*
P13	Surf E	J74	12	-0.13	*	*
P13	Surf E	J74	12	-0.10	*	*
P13	Surf E	J74	13	-0.15	*	*
P13	Surf E	J74	14	-0.12	*	*
P13	Surf E	J74	14	-0.04	*	*
P13	Surf E	J74	15	0.10	*	*
P13	Surf E	J74	15	-0.15	*	*
P13	Surf E	J74	16	-0.19	*	*
P13	Surf E	J74	17	-0.23	*	*
P13	Surf E	J74	17	0.08	*	*
P13	Surf E	J74	17	0.00	*	*
P13	Surf E	J75	1	-0.22	*	*
P13	Surf E	J75	1	-0.10	*	*
P13	Surf E	J75	2	-0.14	*	*
P13	Surf E	J75	2	-0.08	*	*
P13	Surf E	J75	3	-0.17	*	*
P13	Surf E	J75	3	-0.18	*	*
P13	Surf E	J75	3	0.06	*	*
P13	Surf E	J75	4	-0.17	*	*
P13	Surf E	J75	4	-0.13	*	*
P13	Surf E	J75	4	-0.08	*	*
P13	Surf E	J75	5	-0.03	*	*
P13	Surf E	J75	5	-0.07	*	*
P13	Surf E	J75	5	-0.09	*	*
P13	Surf E	J75	6	0.07	*	*
P13	Surf E	J75	7	-0.04	*	*
P13	Surf E	J75	8	-0.20	*	*
P13	Surf E	J75	9	0.11	*	*
P13	Surf E	J75	9	0.22	*	*
P13	Surf E	J75	9	-0.06	*	*

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P13	Surf E	J75	10	0.08	*	*
P13	Surf E	J76	1	-0.22	*	*
P13	Surf E	J76	1	0.24	*	*
P13	Surf E	J76	2	0.42	*	*
P13	Surf E	J76	2	0.61	*	*
P13	Surf E	J76	3	-0.24	*	*
P13	Surf E	J76	4	-0.05	*	*
P13	Surf E	J76	5	-0.22	*	*
P13	Surf E	J76	6	-0.35	*	*
P13	Surf E	J76	7	-0.12	*	*
P13	Surf E	J76	8	-0.20	*	*
P13	Surf E	J76	9	0.17	*	*
P13	Surf E	J76	10	-0.08	*	*
P13	OGFC	J95	1	-0.30	*	*
P13	OGFC	J95	1	-0.07	*	*
P13	OGFC	J95	1	-0.22	*	*
P13	OGFC	J95	1	-0.01	*	*
P13	OGFC	J95	2	-0.03	*	*
P13	OGFC	J95	2	0.35	*	*
P13	OGFC	J95	2	0.08	*	*
P13	OGFC	J95	3	-0.05	*	*
P13	OGFC	J95	3	-0.87	*	*
P13	OGFC	J95	3	0.09	*	*
P13	OGFC	J95	4	0.20	*	*
P13	OGFC	J95	4	-0.05	*	*
P13	OGFC	J95	4	-0.04	*	*
P13	OGFC	J95	5	-0.12	*	*
P13	OGFC	J95	5	0.17	*	*
P13	OGFC	J95	5	0.21	*	*
P13	OGFC	J95	6	-0.22	*	*
P13	OGFC	J96	1	0.10	*	*
P13	OGFC	J96	1	0.24	*	*
P13	OGFC	J96	1	-0.35	*	*
P13	OGFC	J96	2	-0.13	*	*
P13	OGFC	J96	2	0.17	*	*
P13	OGFC	J96	2	0.10	*	*
P13	OGFC	J96	3	0.41	*	*
P13	OGFC	J96	3	-0.17	*	*
P13	OGFC	J96	3	0.23	*	*
P13	OGFC	J96	4	0.17	*	*
P13	OGFC	J96	4	-0.26	*	*
P13	OGFC	J96	4	-0.04	*	*
P13	OGFC	J96	4	-0.12	*	*
P13	OGFC	J96	5	-0.11	*	*
P13	OGFC	J96	5	-0.33	*	*
P13	OGFC	J96	5	-0.15	*	*
P13	OGFC	J96	5	-0.04	*	*
P13	OGFC	J96	6	0.06	*	*
P13	OGFC	J96	6	0.05	*	*
P13	OGFC	J96	6	-0.09	*	*
P13	OGFC	J96	7	0.02	*	*
P13	OGFC	J96	7	-0.02	*	*
P13	OGFC	J96	7	0.04	*	*
P13	OGFC	J96	7	0.16	*	*
P13	OGFC	J96	8	-0.48	*	*
P13	OGFC	J96	8	-0.35	*	*
P13	OGFC	J96	8	0.02	*	*
P13	OGFC	J96	9	-0.02	*	*
P13	OGFC	J96	9	-0.24	*	*
P13	OGFC	J96	9	-0.23	*	*
P13	OGFC	J96	10	-0.13	*	*
P13	OGFC	J96	10	-0.20	*	*
P13	OGFC	J96	10	-0.63	*	*
P13	OGFC	J96	10	-0.20	*	*
P13	OGFC	J96	11	-0.03	*	*
P13	OGFC	J96	11	-0.27	*	*
P13	OGFC	J96	11	-0.49	*	*
P13	OGFC	J96	11	0.37	*	*
P13	OGFC	J96	12	-0.13	*	*
P13	OGFC	J96	12	0.13	*	*
P13	OGFC	J96	12	-0.17	*	*
P13	OGFC	J96	13	-0.02	*	*
P13	OGFC	J96	13	0.24	*	*
P13	OGFC	J96	13	-0.01	*	*
P13	OGFC	J96	14	-0.15	*	*
P13	OGFC	J96	14	-0.26	*	*
P13	OGFC	J96	14	-0.29	*	*
P13	OGFC	J96	15	0.11	*	*
P13	OGFC	J96	15	-0.11	*	*
P13	OGFC	J96	15	-0.01	*	*
P14	Surf A	J62	1	-0.13	1.03	0.36
P14	Surf A	J62	1	0.09	-0.13	-0.21
P14	Surf A	J62	1	0.34	-0.76	-0.20
P14	Surf A	J62	1	0.06	-0.07	-0.22
P14	Surf A	J62	2	0.13	-0.67	-0.56
P14	Surf A	J62	2	0.15	-0.64	-0.53

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P14	Surf A	J62	2	-0.03	-0.72	-1.00
P14	Surf A	J62	3	0.29	-0.45	-0.03
P14	Surf A	J62	3	-0.01	-0.72	-0.94
P14	Surf A	J62	3	-0.08	1.26	0.62
P14	Surf A	J62	3	0.20	1.02	1.09
P14	Surf A	J62	3	0.18	1.11	1.15
P14	Surf A	J62	4	-0.01	0.16	-0.13
P14	Surf A	J62	4	0.17	-0.36	-0.19
P14	Surf A	J62	4	0.29	-0.42	0.01
P14	Surf A	J62	4	-0.07	0.37	-0.10
P14	Surf A	J62	5	0.08	-0.67	-0.67
P14	Surf A	J62	5	0.26	-0.77	-0.32
P14	Surf A	J62	5	0.16	-0.67	-0.46
P14	Surf A	J62	5	-0.17	-0.22	-0.85
P14	Surf A	J62	6	0.04	-0.65	-0.73
P14	Surf A	J62	6	0.24	-0.20	0.12
P14	Surf A	J62	6	0.28	-0.71	-0.24
P14	Surf A	J62	6	0.02	1.24	0.92
P14	Surf A	J62	7	-0.14	-0.89	-1.38
P14	Surf A	J62	7	0.31	0.04	0.48
P14	Surf A	J62	7	0.05	0.45	0.23
P14	Surf A	J62	8	0.25	-0.62	-0.27
P14	Surf A	J62	8	0.17	-0.48	-0.31
P14	Surf A	J62	8	0.22	-0.61	-0.27
P14	Surf A	J62	8	-0.17	0.51	-0.21
P14	Surf A	J62	8	-0.09	-0.74	-1.15
P14	Surf A	J62	8	-0.04	0.37	-0.02
P14	Surf A	J62	8	-0.08	-0.22	-0.64
P14	Surf A	J62	9	0.40	-0.05	0.58
P14	Surf A	J62	9	-0.13	-0.04	-0.60
P14	Surf A	J62	9	0.68	-1.11	0.23
P14	Surf A	J62	9	0.75	-0.81	0.67
P14	Surf A	J62	10	-0.21	-0.05	-0.69
P14	Surf A	J62	10	0.39	-0.24	0.41
P14	Surf A	J62	10	0.16	-1.09	-0.89
P14	Surf A	J62	11	0.27	-0.72	-0.32
P14	Surf A	J62	11	0.15	-0.61	-0.47
P14	Surf A	J62	11	0.04	0.13	-0.09
P14	Surf A	J62	11	-0.10	0.42	-0.12
P14	Surf A	J62	12	0.29	-0.38	0.02
P14	Surf A	J62	12	0.01	0.02	-0.29
P14	Surf A	J62	12	0.08	-0.48	-0.53
P14	Surf A	J62	13	0.18	-0.98	-0.78

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P14	Surf A	J62	13	0.11	-0.54	-0.53
P14	Surf A	J62	13	0.07	0.10	-0.02
P14	Surf A	J62	14	0.15	0.02	0.09
P14	Surf A	J62	14	-0.05	-0.46	-0.81
P14	Surf A	J62	14	0.12	0.45	0.39
P14	Surf A	J62	15	0.31	-0.11	0.31
P14	Surf A	J62	15	0.11	-0.41	-0.44
P14	Surf A	J62	15	0.04	-0.48	-0.65
P14	Surf A	J62	15	0.21	0.93	0.99
P14	Surf A	J63	1	0.30	1.07	1.60
P14	Surf A	J63	1	-0.29	0.18	-0.48
P14	Surf A	J63	1	0.09	-0.31	-0.03
P14	Surf A	J63	2	0.05	0.30	0.39
P14	Surf A	J63	2	-0.24	0.81	0.19
P14	Surf A	J63	2	-0.07	0.03	-0.16
P14	Surf A	J63	3	0.13	-0.14	0.17
P14	Surf A	J63	3	-0.25	0.58	-0.07
P14	Surf A	J63	3	0.13	0.70	0.90
P14	Surf A	J63	4	-0.14	0.59	0.23
P14	Surf A	J63	4	-0.07	1.04	0.82
P14	Surf A	J63	4	-0.01	-0.13	-0.17
P14	Surf A	J63	4	0.04	-0.80	-0.67
P14	Surf A	J63	4	-0.28	-0.61	-1.18
P14	Surf A	J63	5	-0.37	0.38	-0.40
P14	Surf A	J63	5	0.32	-0.31	0.41
P14	Surf A	J63	5	0.10	0.53	0.70
P14	Surf A	J63	5	-0.31	1.15	0.35
P14	Surf A	J63	5	0.07	0.80	0.86
P14	Surf A	J63	6	-0.22	0.74	0.28
P14	Surf A	J63	6	-0.02	1.00	0.84
P14	Surf A	J63	6	0.19	0.73	1.07
P14	Surf A	J63	6	-0.37	0.94	0.04
P14	Surf A	J63	7	-0.48	0.97	-0.16
P14	Surf A	J63	7	-0.07	0.55	0.33
P14	Surf A	J63	7	-0.26	0.19	-0.43
P14	Surf A	J63	7	0.15	0.38	0.63
P14	Surf A	J63	8	0.30	0.36	1.01
P14	Surf A	J63	8	-0.12	0.69	0.37
P14	Surf A	J63	8	0.27	0.31	0.88
P14	Surf A	J63	8	-0.15	-0.26	-0.57
P14	Surf A	J63	8	0.12	-0.03	0.23
P14	Surf A	J63	8	0.17	0.29	0.63
P14	Surf A	J63	9	-0.11	0.64	0.36

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA	Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P14	Surf A	J63	9	-0.03	0.90	0.78	P14	Surf A	J63	20	0.07	0.47	0.57
P14	Surf A	J63	9	-0.03	0.44	0.34	P14	Surf A	J63	21	-0.08	0.30	0.12
P14	Surf A	J63	10	0.14	-0.81	-0.39	P14	Surf A	J63	21	-0.02	0.97	0.84
P14	Surf A	J63	10	-0.14	-0.03	-0.35	P14	Surf A	J63	21	0.31	-1.09	-0.28
P14	Surf A	J63	10	-0.07	-0.23	-0.31	P14	Surf A	J63	21	0.00	-0.11	-0.10
P14	Surf A	J63	11	-0.16	1.09	0.63	P14	Surf A	J63	21	0.20	-0.17	0.28
P14	Surf A	J63	11	0.36	-0.06	0.71	P14	Surf A	J63	21	0.08	0.24	0.37
P14	Surf A	J63	11	-0.09	1.14	0.78	P14	Surf A	J63	22	0.11	-0.91	-0.58
P14	Surf A	J63	11	-0.36	0.97	0.08	P14	Surf A	J63	22	0.18	-0.77	-0.28
P14	Surf A	J63	11	-0.12	0.25	-0.07	P14	Surf A	J63	22	-0.11	-0.59	-0.77
P14	Surf A	J63	11	-0.20	0.73	0.22	P14	Surf A	J63	22	0.18	-0.77	-0.29
P14	Surf A	J63	12	0.01	0.55	0.52	P14	Surf A	J63	22	0.13	-0.43	-0.12
P14	Surf A	J63	12	0.02	-0.14	-0.09	P14	Surf A	J63	23	-0.20	-0.23	-0.64
P14	Surf A	J63	12	0.08	0.28	0.45	P14	Surf A	J63	23	-0.17	0.39	0.01
P14	Surf A	J63	13	0.26	-0.59	0.06	P14	Surf A	J63	23	-0.22	-0.65	-1.06
P14	Surf A	J63	13	-0.01	0.60	0.53	P14	Surf A	J63	24	-0.19	-0.08	-0.51
P14	Surf A	J63	13	0.10	0.49	0.71	P14	Surf A	J63	24	0.02	0.06	0.13
P14	Surf A	J63	13	-0.20	1.07	0.52	P14	Surf A	J63	24	-0.12	-0.30	-0.47
P14	Surf A	J63	14	-0.12	0.95	0.60	P14	Surf A	J63	24	-0.16	0.00	-0.31
P14	Surf A	J63	14	-0.09	0.33	0.10	P14	Surf A	J63	25	-0.04	-0.51	-0.52
P14	Surf A	J63	14	-0.19	1.07	0.55	P14	Surf A	J63	25	0.24	-0.23	0.38
P14	Surf A	J63	15	0.16	0.90	1.11	P14	Surf A	J63	25	0.02	-0.75	-0.62
P14	Surf A	J63	15	-0.12	0.97	0.62	P14	Surf A	J63	26	0.21	-0.84	-0.24
P14	Surf A	J63	15	-0.09	0.86	0.56	P14	Surf A	J63	26	0.01	0.09	0.15
P14	Surf A	J63	16	0.14	0.46	0.70	P14	Surf A	J63	26	-0.01	-0.02	0.03
P14	Surf A	J63	16	0.13	0.69	0.86	P14	Surf A	J63	26	0.34	-0.31	0.53
P14	Surf A	J63	16	-0.10	0.46	0.15	P14	Surf A	J63	27	-0.14	0.26	-0.12
P14	Surf A	J63	17	0.02	0.32	0.29	P15	Surf B	J97	1	-0.04	0.12	0.06
P14	Surf A	J63	17	-0.13	0.80	0.40	P15	Surf B	J97	1	0.18	-0.67	-0.16
P14	Surf A	J63	17	0.07	0.59	0.64	P15	Surf B	J97	1	-0.08	-0.61	-0.70
P14	Surf A	J63	17	-0.18	0.32	-0.09	P15	Surf B	J97	1	-0.38	-0.52	-1.30
P14	Surf A	J63	17	-0.08	0.71	0.41	P15	Surf B	J97	2	0.14	-0.67	-0.25
P14	Surf A	J63	18	0.11	1.60	1.64	P15	Surf B	J97	2	0.11	-0.35	-0.02
P14	Surf A	J63	18	0.18	0.88	1.13	P15	Surf B	J97	2	0.15	-0.76	-0.29
P14	Surf A	J63	18	-0.10	-0.66	-0.78	P15	Surf B	J97	2	0.08	-0.50	-0.26
P14	Surf A	J63	18	-0.01	0.10	0.09	P15	Surf B	J97	3	0.24	-0.12	0.45
P14	Surf A	J63	19	-0.07	0.13	0.00	P15	Surf B	J97	4	0.06	-0.52	-0.33
P14	Surf A	J63	19	0.17	-0.22	0.17	P15	Surf B	J97	5	0.29	-0.92	-0.19
P14	Surf A	J63	19	0.28	-0.47	0.17	P15	Surf B	J97	3	0.29	-0.92	-0.19
P14	Surf A	J63	19	0.10	-0.03	0.18	P15	Surf B	J97	3	0.29	0.36	1.04
P14	Surf A	J63	20	0.23	-0.05	0.46	P15	Surf B	J97	6	0.00	0.02	0.02
P14	Surf A	J63	20	0.34	-0.21	0.56	P15	Surf B	J97	6	-0.20	0.16	-0.26
P14	Surf A	J63	20	0.23	-0.45	0.08	P15	Surf B	J97	6	-0.14	0.31	-0.02

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P15	Surf B	J97	6	0.01	0.87	0.87
P15	Surf B	J97	7	0.27	-0.92	-0.24
P15	Surf B	J97	7	-0.29	-0.37	-0.90
P15	Surf B	J97	7	-0.12	-0.42	-0.60
P15	Surf B	J97	8	0.31	-1.09	-0.24
P15	Surf B	J97	9	-0.07	-0.67	-0.74
P15	Surf B	J97	9	0.23	-0.68	-0.09
P15	Surf B	J97	9	-0.07	-0.86	-0.93
P15	Surf B	J97	9	-0.12	0.15	-0.13
P15	Surf B	J97	10	-0.09	-0.13	-0.31
P15	Surf B	J97	10	0.01	-0.49	-0.39
P15	Surf B	J97	10	0.04	-0.57	-0.39
P15	Surf B	J97	10	-0.01	-0.37	-0.33
P15	Surf B	J97	10	-0.26	0.22	-0.34
P15	Surf B	J97	10	-0.11	-0.63	-0.81
P15	Surf B	J97	11	0.02	-0.37	-0.26
P15	Surf B	J97	11	0.11	-0.21	0.08
P15	Surf B	J97	11	0.08	-0.50	-0.27
P15	Surf B	J97	11	-0.03	0.12	0.09
P15	Surf B	J97	11	-0.10	0.24	0.05
P15	Surf B	J97	12	-0.08	-0.16	-0.33
P15	Surf B	J97	12	-0.02	-0.51	-0.48
P15	Surf B	J97	12	0.40	-0.42	0.08
P15	Surf B	J98	1	0.10	0.92	1.11
P15	Surf B	J98	1	0.43	0.07	1.11
P15	Surf B	J98	1	0.13	0.43	0.78
P15	Surf B	J98	2	-0.02	-0.07	-0.05
P15	Surf B	J98	2	0.06	0.13	0.36
P15	Surf B	J98	2	-0.28	0.23	-0.34
P15	Surf B	J97	13	-0.16	-0.25	-0.58
P15	Surf B	J97	13	-0.18	-0.26	-0.60
P15	Surf B	J97	13	-0.05	-0.19	-0.31
P15	Surf B	J98	3	0.07	0.49	0.70
P15	Surf B	J98	3	0.43	0.07	1.11
P15	Surf B	J98	3	0.13	0.43	0.78
P15	Surf B	J99	1	-0.51	-0.28	-1.43
P15	Surf B	J99	2	-0.07	-0.93	-1.10
P15	Surf B	J99	2	0.18	-0.84	0.52
P15	Surf B	J97	16	0.09	0.05	0.28
P15	Surf B	J97	14	-0.03	0.51	0.42
P15	Surf B	J97	14	-0.15	-0.48	-0.78
P15	Surf B	J97	14	-0.04	0.22	0.14
P15	Surf B	J97	17	-0.13	0.36	0.01
P15	Surf B	J97	18	-0.13	0.36	0.01
P15	Surf B	J97	18	-0.15	-0.48	-0.78
P15	Surf B	J97	18	-0.04	0.22	0.14
P15	Surf B	J97	19	0.25	-0.47	0.12
P15	Surf B	J100	20	-0.03	-1.03	-0.98
P15	Surf B	J100	20	0.13	-0.87	-0.50
P15	Surf B	J100	20	0.29	-0.85	-0.18
P15	Surf B	J100	21	-0.03	-0.36	-0.44
P15	Surf B	J100	21	0.25	-0.76	-0.16
P15	Surf B	J100	21	-0.06	-0.70	-0.81
P15	Surf B	J100	21	-0.08	-0.64	-0.79
P15	Surf B	J100	22	0.23	-0.97	-0.36
P15	Surf B	J100	22	-0.19	-1.00	-1.38
P15	Surf B	J100	22	-0.11	-0.54	-0.78
P15	Surf B	J100	23	0.21	-0.67	-0.18
P15	Surf B	J100	23	0.10	-0.84	-0.59
P15	Surf B	J100	23	0.17	-0.69	-0.29
P15	Surf B	J100	24	0.15	-0.65	-0.30
P15	Surf B	J100	24	-0.15	-0.05	-0.44
P15	Surf B	J100	24	-0.15	-0.16	-0.53
P15	Surf B	J100	24	-0.10	-0.06	-0.32
P15	Surf B	J100	24	-0.15	0.04	-0.35
P15	Surf B	J100	24	0.06	-0.49	-0.31
P15	Surf B	J100	24	-0.14	0.77	0.37
P15	Surf B	J100	24	0.04	-0.49	-0.34
P15	Surf B	J100	25	-0.30	0.11	-0.59
P15	Surf B	J100	25	-0.20	0.02	-0.46
P15	Surf B	J100	25	-0.23	0.00	-0.55
P15	Surf B	J100	25	-0.06	0.10	-0.06
P15	Surf B	J100	25	-0.28	0.31	-0.36
P15	Surf B	J100	26	0.05	-0.61	-0.43
P15	Surf B	J100	26	-0.26	-0.52	-1.03
P15	Surf B	J100	26	-0.12	-0.28	-0.51
P15	Surf B	J100	27	-0.08	0.02	-0.14
P15	Surf B	J100	27	0.09	-0.09	0.14
P15	Surf B	J100	27	-0.22	0.07	-0.39
P15	Surf B	J100	28	-0.04	-0.29	-0.34
P15	Surf B	J100	28	0.19	-0.82	-0.33
P15	Surf B	J100	28	-0.12	0.19	-0.11
P15	Surf B	J100	29	0.09	0.06	0.24
P15	Surf B	J100	30	0.17	-0.80	-0.29
P15	Surf B	J100	30	0.25	-0.47	0.16
P15	Surf B	J100	30	-0.17	0.03	-0.36

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P15	Surf B	J100	30	-0.19	0.15	-0.29
P15	Surf B	J100	31	-0.09	0.36	0.13
P15	Surf B	J100	31	0.12	-0.05	0.25
P15	Surf B	J100	31	-0.06	0.56	0.39
P15	Surf B	J100	32	-0.26	-0.08	-0.63
P16	Base A	J77	1	-0.05	*	*
P16	Base A	J77	1	-0.35	*	*
P16	Base A	J77	1	-0.53	*	*
P16	Base A	J77	2	0.21	*	*
P16	Base A	J77	2	-0.13	*	*
P16	Base A	J77	2	-0.96	*	*
P16	Base A	J77	3	0.50	*	*
P16	Base A	J77	3	-0.37	*	*
P16	Base A	J77	3	-0.47	*	*
P16	Base A	J77	4	0.08	*	*
P16	Base A	J77	4	-0.25	*	*
P16	Base A	J77	4	-0.36	*	*
P16	Base A	J77	5	0.35	*	*
P16	Base A	J77	5	-0.28	*	*
P16	Base A	J77	5	-0.08	*	*
P16	Base A	J77	5	-0.08	*	*
P16	Base A	J77	6	-0.11	*	*
P16	Base A	J77	6	-0.13	*	*
P16	Base A	J77	6	-0.12	*	*
P16	Base A	J77	7	-0.72	*	*
P16	Base A	J77	7	-0.43	*	*
P16	Base A	J77	7	-0.65	*	*
P16	Base A	J77	8	-0.09	*	*
P16	Base A	J77	8	-0.07	*	*
P16	Base A	J77	8	0.09	*	*
P16	Base A	J77	8	0.16	*	*
P16	Base A	J77	9	0.27	*	*
P16	Base A	J77	9	0.00	*	*
P16	Base A	J77	9	-0.06	*	*
P16	Base A	J77	9	-0.52	*	*
P16	Base A	J77	10	-0.21	*	*
P16	Base A	J77	10	0.01	*	*
P16	Base A	J77	10	-0.57	*	*
P16	Base A	J77	11	0.25	*	*
P16	Base A	J77	11	0.12	*	*
P16	Base A	J77	11	-0.08	*	*
P16	Base A	J77	11	-0.11	*	*
P16	Base A	J77	12	0.32	*	*

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P16	Base A	J77	12	0.03	*	*
P16	Base A	J77	12	-0.14	*	*
P16	Base A	J77	12	0.18	*	*
P16	Base A	J77	13	0.37	*	*
P16	Base A	J77	13	0.26	*	*
P16	Base A	J77	13	1.10	*	*
P16	Base A	J77	14	0.22	*	*
P16	Base A	J77	14	-0.37	*	*
P16	Base A	J77	14	-0.60	*	*
P16	Base A	J77	14	0.23	*	*
P16	Base A	J77	15	-0.67	*	*
P16	Base A	J77	15	0.44	*	*
P16	Base A	J77	15	0.02	*	*
P16	Base A	J77	16	-0.13	*	*
P16	Base A	J77	16	0.36	*	*
P16	Base A	J77	16	0.09	*	*
P16	Base A	J77	17	0.52	*	*
P16	Base A	J77	17	-0.04	*	*
P16	Base A	J78	1	-0.07	*	*
P16	Base A	J78	1	-0.04	*	*
P16	Base A	J78	1	0.00	*	*
P16	Base A	J78	2	-0.46	*	*
P16	Base A	J78	2	0.08	*	*
P16	Base A	J78	2	-0.38	*	*
P16	Base A	J78	3	-0.03	*	*
P16	Base A	J78	3	-0.63	*	*
P16	Base A	J78	3	-0.17	*	*
P16	Base A	J78	3	-0.36	*	*
P16	Base A	J78	3	-0.38	*	*
P16	Surf C	J79	1	-0.06	-0.37	-0.31
P16	Surf C	J79	1	-0.21	0.32	-0.07
P16	Surf C	J79	1	0.07	-1.07	-0.73
P16	Surf C	J79	1	-0.11	-0.59	-0.83
P16	Surf C	J79	2	-0.29	0.55	-0.06
P16	Surf C	J80	1	-0.05	0.86	0.61
P16	Surf C	J80	1	-0.37	0.72	-0.30
P16	Surf C	J80	1	-0.16	0.27	-0.21
P16	Surf C	J80	1	-0.57	0.66	-0.76
P16	Surf C	J80	2	-0.15	-0.31	-0.66
P16	Surf C	J80	2	-0.38	-0.16	-1.04
P16	Surf C	J80	2	-0.26	0.16	-0.46
P16	Surf C	J80	2	-0.34	0.69	-0.19
P16	Surf C	J80	3	-0.13	-0.23	-0.55

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P16	Surf C	J80	3	0.17	-0.14	0.20
P16	Surf C	J80	3	-0.29	0.33	-0.40
P16	Surf C	J80	4	-0.20	-0.11	-0.60
P16	Surf C	J80	4	-0.11	-0.21	-0.48
P16	Surf C	J80	4	-0.25	0.49	-0.15
P16	Surf C	J80	5	-0.29	1.10	0.32
P17	Surf C	J81	1	-0.44	0.27	-0.98
P17	Surf C	J81	1	-0.04	0.14	-0.17
P17	Surf C	J81	1	-0.17	-0.27	-0.83
P17	Surf C	J81	2	-0.06	-0.23	-0.47
P17	Surf C	J81	2	-0.01	0.17	0.02
P17	Surf C	J81	2	-0.47	0.12	-1.07
P17	Surf C	J82	1	-0.15	1.24	0.65
P17	Surf C	J82	1	0.02	0.27	0.24
P17	Surf C	J82	1	-0.10	-0.70	-0.96
P17	Surf C	J82	1	-0.05	0.03	-0.20
P17	Surf C	J82	2	0.07	-0.70	-0.61
P17	Surf C	J82	2	-0.12	-0.79	-1.07
P17	Surf C	J82	3	0.00	-1.75	-1.72
P17	Surf C	J82	3	-0.10	-0.49	-0.83
P17	Surf C	J82	3	-0.11	-0.65	-0.92
P17	Surf C	J82	3	0.05	-0.38	-0.34
P17	Surf C	J82	3	0.09	0.01	0.10
P17	Surf C	J82	4	-0.17	0.14	-0.36
P17	Surf C	J82	4	0.04	-0.07	-0.08
P17	Surf C	J82	4	0.05	-0.47	-0.45
P17	Surf C	J82	5	-0.05	0.94	0.60
P17	Surf C	J82	5	0.00	-0.14	-0.23
P17	Surf C	J82	5	-0.07	-0.13	-0.35
P17	Surf C	J82	6	-0.01	-0.78	-0.85
P17	Surf C	J82	7	-0.03	-0.25	-0.36
P17	Surf C	J82	7	0.05	0.05	0.09
P17	Surf C	J82	7	-0.11	0.15	-0.23
P17	Surf C	J82	7	-0.20	0.45	-0.16
P17	Surf C	J82	8	-0.11	-0.22	-0.54
P17	Surf C	J82	8	-0.23	0.69	-0.05
P17	Surf C	J82	8	-0.33	1.17	0.24
P17	Surf C	J82	9	-0.06	-0.27	-0.45
P17	Surf C	J82	10	-0.21	0.45	-0.13
P17	Surf C	J82	11	-0.20	-0.04	-0.59
P17	Surf C	J82	12	-0.14	0.24	-0.25
P17	Surf C	J82	12	-0.23	0.03	-0.61
P17	Surf C	J82	12	-0.20	0.43	-0.18
P17	Surf C	J82	13	-0.25	0.72	-0.01
P17	Surf C	J82	13	0.04	0.70	0.63
P17	Surf C	J82	13	-0.31	0.36	-0.47
P17	Surf C	J82	13	0.08	0.11	0.10
P17	Surf C	J82	13	-0.12	0.53	0.10
P17	Surf C	J82	14	-0.11	0.73	0.30
P17	Surf C	J82	14	0.09	0.39	0.43
P17	Surf C	J82	14	0.00	0.39	0.24
P17	Surf C	J82	15	0.13	0.11	0.22
P17	Surf C	J82	15	-0.07	-0.07	-0.35
P17	Surf C	J82	15	0.00	0.39	0.24
P17	Surf C	J82	16	-0.27	-0.24	-0.93
P17	Surf C	J83	1	-0.57	0.98	-0.36
P18	Surf B	J84	1	0.05	-0.06	0.12
P18	Surf B	J84	1	0.02	0.13	0.24
P18	Surf B	J84	1	-0.32	0.87	0.15
P18	Surf B	J84	1	-0.07	-0.05	-0.13
P18	Surf B	J84	1	0.21	0.26	0.77
P18	Surf B	J84	1	-0.06	0.34	0.24
P18	Surf B	J84	2	-0.13	0.09	-0.13
P18	Surf B	J84	3	0.04	0.12	0.27
P18	Surf B	J84	3	-0.05	-0.03	-0.06
P18	Surf B	J84	3	0.05	0.73	0.97
P18	Surf B	J84	4	0.07	-0.17	0.10
P18	Surf B	J84	4	0.11	0.29	0.60
P18	Surf B	J84	4	0.13	-0.70	-0.23
P18	Surf B	J84	5	0.22	-0.28	0.31
P18	Surf B	J84	6	0.20	-0.22	0.32
P18	Surf B	J84	7	0.05	0.69	0.83
P18	Surf B	J84	7	0.11	-0.84	-0.41
P18	Surf B	J84	7	0.19	-0.79	-0.15
P18	Surf B	J84	7	0.24	-0.18	0.50
P18	Surf B	J84	7	0.23	-0.13	0.51
P18	Surf B	J84	8	0.33	-0.13	0.72
P18	Surf B	J84	8	0.16	-0.34	0.16
P18	Surf B	J84	8	0.10	-0.23	0.10
P18	Surf B	J84	8	-0.12	0.25	0.04
P18	Surf B	J84	9	0.15	-0.15	0.30
P18	Surf B	J84	9	0.15	-0.07	0.37
P18	Surf B	J84	9	0.35	-0.05	0.85
P18	Surf B	J84	10	-0.23	0.06	-0.36
P18	Surf B	J84	10	0.15	-0.15	0.28
P18	Surf B	J84	10	0.16	-0.50	0.01

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P18	Surf B	J84	10	-0.03	0.07	0.09
P18	Surf B	J84	10	0.16	-0.45	0.06
P18	Surf B	J84	10	0.08	-0.68	-0.34
P18	Surf B	J84	10	0.13	-0.09	0.30
P18	Surf B	J84	10	0.07	-0.43	-0.14
P18	Surf B	J84	11	0.13	-0.43	0.00
P18	Surf B	J84	11	-0.02	-1.01	-0.84
P18	Surf B	J84	11	0.10	-0.48	-0.10
P18	Surf B	J84	11	0.11	-0.52	-0.12
P18	Surf B	J84	12	0.18	0.12	0.58
P18	Surf B	J84	12	0.14	-0.86	-0.37
P18	Surf B	J84	12	0.26	0.05	0.73
P18	Surf B	J84	13	0.19	-0.32	0.24
P18	Surf B	J84	13	0.15	-0.76	-0.24
P18	Surf B	J84	13	-0.15	0.23	-0.05
P18	Surf B	J84	14	0.12	-0.58	-0.15
P18	Surf B	J84	14	0.10	-0.28	0.07
P18	Surf B	J84	14	0.28	-0.82	0.00
P18	Surf B	J84	14	0.33	-0.68	0.24
P18	Surf B	J84	15	0.25	-0.58	0.16
P18	Surf B	J84	15	0.20	0.01	0.56
P18	Surf B	J84	15	0.17	-0.40	0.14
P18	Surf B	J84	15	-0.05	0.09	0.06
P18	Surf B	J84	16	0.20	-0.75	-0.14
P18	Surf B	J84	16	-0.05	-0.19	-0.20
P18	Surf B	J84	16	0.21	-0.57	0.05
P18	Surf B	J84	16	0.16	-0.64	-0.11
P18	Surf B	J84	16	0.23	0.33	0.92
P18	Surf B	J84	17	-0.11	-0.17	-0.32
P18	Surf B	J84	17	0.14	0.03	0.43
P18	Surf B	J84	17	-0.02	-0.28	-0.19
P18	Surf B	J84	17	-0.03	0.15	0.16
P18	Surf B	J84	17	-0.05	-0.05	-0.06
P18	Surf B	J84	17	-0.06	-0.16	-0.17
P18	Surf B	J84	18	-0.05	0.04	0.03
P18	Surf B	J84	18	0.39	-1.10	0.00
P18	Surf B	J84	18	0.22	-0.52	0.13
P18	Surf B	J84	18	0.10	-0.30	0.07
P18	Surf B	J84	19	0.03	-0.27	-0.08
P18	Surf B	J84	19	0.09	-0.11	0.19
P18	Surf B	J84	19	0.13	-0.03	0.35
P18	Surf B	J84	19	-0.04	-0.34	-0.30
P18	Surf B	J84	20	0.14	0.05	0.47

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P18	Surf B	J84	20	-0.20	0.92	0.48
P18	Surf B	J84	20	-0.01	-0.12	-0.03
P18	Surf B	J84	20	0.13	-0.28	0.15
P18	Surf B	J84	20	0.05	-0.32	-0.07
P18	Surf B	J84	20	-0.03	0.55	0.52
P18	Surf B	J84	21	0.03	-0.52	-0.28
P18	Surf B	J84	21	-0.01	-0.79	-0.62
P18	Surf B	J84	21	-0.06	0.51	0.42
P18	Surf B	J84	21	-0.14	0.08	-0.14
P18	Surf B	J84	22	-0.02	-0.56	-0.44
P18	Surf B	J84	22	0.02	-0.42	-0.23
P18	Surf B	J84	22	0.20	-0.12	0.45
P18	Surf B	J84	22	0.03	-0.87	-0.60
P18	Surf B	J84	23	0.06	0.20	0.43
P18	Surf B	J84	23	-0.13	0.16	-0.04
P18	Surf B	J84	23	0.03	-0.12	0.06
P18	Surf A	J85	1	-0.13	-0.25	-0.52
P18	Surf A	J85	1	0.12	-0.24	0.04
P18	Surf A	J85	1	0.11	-0.71	-0.38
P18	Surf A	J85	1	0.15	-0.61	-0.20
P18	Surf A	J85	2	0.00	-0.64	-0.55
P18	Surf A	J85	2	0.09	-0.25	-0.03
P18	Surf A	J85	2	-0.18	-0.41	-0.77
P18	Surf A	J85	2	0.05	-0.67	-0.49
P18	Surf A	J85	3	-0.08	-0.03	-0.21
P18	Surf A	J85	3	0.12	-0.75	-0.39
P18	Surf A	J85	3	0.10	-0.16	0.07
P18	Surf A	J85	4	-0.26	0.07	-0.52
P18	Surf A	J85	4	0.25	-0.81	-0.16
P18	Surf A	J85	4	-0.01	0.14	0.10
P18	Surf A	J85	5	0.05	-0.36	-0.23
P18	Surf A	J85	5	0.14	-0.53	-0.15
P18	Surf A	J85	5	-0.04	-0.27	-0.33
P18	Surf A	J85	6	0.05	0.44	0.49
P18	Surf A	J85	6	0.21	-0.34	0.15
P18	Surf A	J85	6	-0.03	-0.85	-0.84
P18	Surf A	J85	7	0.22	-0.77	-0.19
P18	Surf A	J85	7	0.07	-0.75	-0.51
P18	Surf A	J85	7	-0.13	-0.31	-0.58
P18	Surf A	J85	8	0.14	-0.96	-0.53
P18	Surf A	J85	8	-0.02	-0.74	-0.69
P18	Surf A	J85	8	0.11	-0.55	-0.24
P18	Surf A	J85	8	0.01	-0.63	-0.54

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P18	Surf A	J85	9	0.22	-0.52	0.02
P18	Surf A	J85	9	0.25	-0.97	-0.30
P18	Surf A	J85	9	0.04	-0.65	-0.49
P18	Surf A	J85	10	0.02	-0.76	-0.63
P18	Surf A	J85	10	-0.06	-0.74	-0.80
P18	Surf A	J85	10	-0.07	-0.84	-0.91
P18	Surf A	J85	10	-0.18	-0.11	-0.50
P18	Surf A	J85	11	0.05	-0.63	-0.46
P18	Surf A	J85	11	0.00	-0.76	-0.67
P18	Surf A	J85	11	-0.09	-0.63	-0.77
P18	Surf A	J85	11	-0.02	-0.43	-0.43
P18	Surf A	J85	12	-0.10	-0.23	-0.42
P18	Surf A	J85	12	-0.23	0.13	-0.40
P18	Surf A	J85	12	-0.08	-0.66	-0.76
P18	Surf A	J85	13	0.00	-0.11	-0.05
P18	Surf A	J85	13	-0.06	-0.22	-0.29
P18	Surf A	J85	13	0.19	-0.04	0.43
P18	Surf A	J85	13	-0.18	0.05	-0.31
P18	Surf A	J85	14	0.06	-0.38	-0.18
P18	Surf A	J85	14	0.41	0.12	1.01
P18	Surf A	J85	14	0.06	-0.57	-0.32
P18	Surf A	J85	15	0.01	-0.67	-0.54
P18	Surf A	J85	15	0.15	-0.99	-0.51
P18	Surf A	J85	15	-0.32	0.31	-0.38
P18	Surf A	J85	15	-0.26	0.47	-0.11
P18	Surf A	J85	15	-0.25	-0.29	-0.77
P18	Surf A	J85	16	0.10	-0.30	-0.01
P18	Surf A	J85	16	-0.22	-0.02	-0.48
P18	Surf A	J85	16	0.02	-0.52	-0.39
P18	Surf A	J85	16	0.16	-0.42	0.02
P18	Surf A	J85	16	0.00	-0.79	-0.66
P18	Surf A	J85	17	0.22	0.31	0.80
P18	Surf A	J85	17	0.11	-0.28	0.04
P18	Surf A	J85	17	-0.07	-0.31	-0.40
P18	Surf A	J85	17	0.02	0.30	0.36
P18	Surf A	J85	18	0.05	-0.10	0.04
P18	Surf A	J85	18	0.15	-0.40	0.01
P18	Surf A	J85	18	0.08	-0.34	-0.09
P18	Surf A	J85	18	0.06	0.35	0.47
P18	Surf A	J85	19	0.10	-0.44	-0.14
P18	Surf A	J85	19	0.14	0.09	0.41
P18	Surf A	J85	19	0.07	-0.53	-0.27
P18	Surf A	J85	20	0.09	-0.56	-0.28

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P18	Surf A	J85	20	-0.03	-0.64	-0.62
P18	Surf A	J85	20	0.03	-0.58	-0.43
P18	Surf A	J85	20	-0.17	-0.75	-1.02
P18	Surf A	J85	21	-0.14	-0.55	-0.76
P18	Surf A	J85	21	-0.13	-0.21	-0.44
P18	Surf A	J85	21	0.28	-0.17	0.49
P18	Surf A	J85	22	-0.25	-0.68	-1.11
P18	Surf A	J85	22	0.13	-0.30	0.07
P18	Surf A	J85	22	0.00	-0.19	-0.12
P18	Surf A	J85	22	-0.02	-0.35	-0.31
P18	Surf A	J85	22	0.08	-0.39	-0.12
P18	Surf A	J85	23	0.24	-0.65	0.01
P18	Surf A	J85	23	0.29	0.49	1.11
P18	Surf A	J85	23	0.11	-0.83	-0.46
P18	Surf A	J85	23	0.04	-0.75	-0.55
P18	Surf A	J85	23	0.21	0.09	0.57
P19	Surf B	J86	11	-0.08	0.43	0.10
P19	Surf B	J86	11	-0.19	0.57	-0.01
P19	Surf B	J86	11	-0.01	-0.12	-0.24
P19	Surf B	J86	11	-0.13	0.55	0.11
P19	Surf B	J86	11	-0.10	-0.37	-0.65
P19	Surf B	J86	11	-0.14	-0.03	-0.48
P19	Surf B	J86	12	-0.10	0.29	-0.07
P19	Surf B	J86	12	0.06	-0.36	-0.31
P19	Surf B	J86	12	-0.02	-0.40	-0.52
P19	Surf B	J86	12	0.01	0.24	0.10
P19	Surf B	J86	13	0.40	-0.15	-0.16
P19	Surf B	J86	13	0.07	0.17	0.20
P19	Surf B	J86	13	-0.11	-0.38	-0.71
P19	Surf B	J86	13	0.19	-0.45	-0.05
P19	Surf B	J86	13	-0.13	-0.71	-1.05
P19	Surf B	J86	13	-0.01	-0.10	-0.20
P19	Surf B	J86	14	0.29	-1.09	-0.43
P19	Surf B	J86	14	-0.12	-0.46	-0.80
P19	Surf B	J86	14	0.17	-0.92	-0.52
P19	Surf B	J86	14	-0.02	-0.28	-0.39
P19	Surf B	J86	15	-0.02	-0.82	-0.85
P19	Surf B	J86	15	-0.20	0.86	0.26
P19	Surf B	J86	15	-0.29	0.98	0.21
P19	Surf B	J86	18	0.19	-0.07	0.30
P19	Surf B	J86	18	0.39	-0.32	0.50
P19	Surf B	J86	18	0.10	-0.35	-0.18
P19	Surf B	J86	19	0.26	-1.57	-0.89

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P19	Surf B	J86	19	-0.09	0.09	-0.20
P19	Surf B	J86	19	0.27	-1.02	-0.38
P19	Surf B	J86	21	-0.30	0.32	-0.48
P19	Surf B	J86	21	0.14	-0.20	0.05
P19	Surf B	J86	21	-0.10	0.10	-0.23
P19	Surf B	J86	22	-0.04	0.36	0.15
P19	Surf B	J86	22	0.26	-0.36	0.16
P19	Surf B	J86	22	-0.08	0.95	0.58
P19	Surf B	J86	23	0.01	-0.31	-0.33
P19	Surf B	J86	23	-0.02	-0.47	-0.56
P19	Surf B	J86	23	0.01	0.14	0.06
P19	Surf B	J86	23	-0.15	0.17	-0.25
P19	Surf B	J86	23	-0.02	-0.62	-0.67
P19	Surf B	J86	24	0.54	-1.88	-0.54
P19	Surf B	J86	24	-0.18	-0.39	-0.78
P19	Surf B	J86	24	-0.05	-0.75	-0.90
P19	Surf B	J86	25	0.05	-0.84	-0.70
P19	Surf B	J86	25	-0.23	0.20	-0.39
P19	Surf B	J86	25	-0.04	-0.47	-0.61
P19	Surf B	J86	26	-0.25	-1.13	-1.67
P19	Surf B	J86	26	-0.06	0.01	-0.19
P19	Surf B	J86	26	-0.04	-0.33	-0.47
P19	Surf B	J86	27	-0.04	-0.45	-0.58
P19	Surf B	J86	27	-0.15	-0.48	-0.83
P19	Surf B	J86	27	-0.13	0.01	-0.36
P19	Surf B	J86	27	0.03	-0.17	-0.14
P19	Surf B	J86	28	-0.04	-0.29	-0.42
P19	Surf B	J86	28	0.17	-0.14	0.15
P19	Surf B	J86	28	0.02	-0.23	-0.24
P19	Surf B	J86	28	0.01	-0.27	-0.30
P19	Surf B	J86	30	-0.12	-0.17	-0.50
P19	Surf B	J86	30	0.17	0.04	0.32
P19	Surf B	J86	30	-0.15	-0.19	-0.60
P19	Surf B	J86	30	0.11	-0.37	-0.18
P19	Surf C	J87	17	-0.28	-0.41	-1.02
P19	Surf C	J87	17	-0.20	-1.56	-1.93
P19	Surf C	J87	17	-0.19	-0.64	-1.07
P19	Surf C	J87	17	0.06	-0.55	-0.45
P19	Surf C	J87	22	-0.28	-0.33	-1.00
P19	Surf C	J87	22	-0.09	-0.53	-0.78
P19	Surf C	J87	22	-0.05	-0.27	-0.45
P19	Surf C	J87	22	-0.09	-0.35	-0.61
P19	Surf C	J87	23	0.06	-0.71	-0.62
P19	Surf C	J87	23	0.10	-0.85	-0.64
P19	Surf C	J87	23	0.00	-0.46	-0.52
P19	Surf C	J87	27	0.01	-0.67	-0.69
P19	Surf C	J87	27	0.13	-1.09	-0.79
P19	Surf C	J87	27	0.09	-0.21	-0.12
P19	Inter C	J88	17	0.14	-0.30	-0.16
P19	Inter C	J88	17	0.07	-0.87	-0.84
P19	Inter C	J88	17	0.14	-0.17	-0.01
P19	Inter C	J88	17	-0.12	0.17	-0.29
P19	Inter C	J88	18	-0.45	-0.43	-1.56
P19	Inter C	J88	18	-0.27	-0.05	-0.78
P19	Inter C	J88	18	0.29	-0.74	-0.17
P19	Inter C	J88	19	0.24	-0.97	-0.49
P19	Inter C	J88	19	0.20	-0.85	-0.46
P19	Inter C	J88	19	0.01	-0.21	-0.30
P19	Inter C	J88	19	0.22	-0.36	0.02
P19	Inter C	J88	21	-0.15	-0.24	-0.73
P19	Inter C	J88	21	0.04	-0.19	-0.27
P19	Inter C	J88	21	0.12	-0.13	-0.02
P20	Surf B	J91	1	0.02	-0.33	-0.22
P20	Surf B	J91	1	-0.18	0.40	-0.03
P20	Surf B	J91	1	-0.19	0.23	-0.18
P20	Surf B	J91	1	-0.13	0.40	0.13
P20	Surf B	J91	1	0.05	0.30	0.41
P20	Surf B	J91	2	-0.14	-0.18	-0.44
P20	Surf B	J91	2	-0.04	-0.33	-0.37
P20	Surf B	J91	2	-0.08	0.27	0.04
P20	Surf B	J91	3	-0.09	-0.15	-0.30
P20	Surf B	J91	3	-0.10	-0.33	-0.50
P20	Surf B	J91	3	-0.10	-0.18	-0.34
P20	Surf B	J91	3	0.12	-0.40	-0.04
P20	Surf B	J91	4	-0.60	0.29	-1.01
P20	Surf B	J91	4	-0.07	0.21	0.07
P20	Surf B	J91	4	-0.26	0.41	-0.19
P20	Surf B	J91	5	0.23	1.10	1.49
P20	Surf B	J91	5	0.26	0.55	1.08
P20	Surf B	J91	5	0.26	0.82	1.31
P20	Surf B	J91	5	0.01	1.05	0.97
P20	Surf B	J91	6	0.25	-0.31	0.30
P20	Surf B	J91	6	0.49	-0.25	0.91
P20	Surf B	J91	6	0.46	-0.60	0.48
P20	Surf B	J91	7	-0.06	-0.47	-0.54
P20	Surf B	J91	7	-0.06	-0.19	-0.43

Table A.1. Plant Test Results Data (continued)

Proj. No.	Mix Type	JMF No.	Lot No.	AC	AV	VMA
P20	Surf B	J91	7	-0.12	-0.31	-0.49
P20	Surf B	J91	7	-0.09	-0.38	-0.47
P20	Surf B	J91	9	-0.05	-0.47	-0.45
P20	Surf B	J91	9	-0.12	-0.19	0.16
P20	Surf B	J91	9	-0.14	-0.31	0.34
P20	Surf B	J91	9	0.32	-0.38	0.71
P20	Surf B	J91	10	0.09	-0.32	-0.60
P20	Surf B	J91	10	-0.16	-0.02	-0.42
P20	Surf B	J91	10	-0.20	-0.48	-0.10
P20	Surf B	J91	10	0.12	-0.11	0.09
P20	Surf B	J91	11	0.07	-0.63	-0.71
P20	Surf B	J91	12	-0.09	-0.67	-0.87
P20	Surf B	J91	12	-0.12	-0.41	-0.31
P20	Surf B	J91	12	0.02	-0.65	-0.47
P20	Surf B	J91	13	0.05	-0.88	-1.04
P20	Surf B	J91	13	-0.12	-0.96	-1.03
P20	Surf B	J91	13	-0.08	-0.28	-0.48
P20	Surf B	J91	13	-0.12	-0.33	-0.37
P20	Surf B	J91	13	-0.04	-0.54	-0.51
P20	Surf B	J91	13	-0.03	-0.62	-0.19
P20	Surf B	J91	14	0.15	-0.28	-0.48
P20	Surf B	J91	15	-0.12	-0.77	-0.87
P20	Surf B	J91	15	-0.10	-0.86	-0.38
P20	Surf B	J91	15	0.17	-0.82	-1.00
P20	Surf B	J91	16	-0.12	-0.82	-1.00
P20	Surf B	J91	17	-0.12	-1.10	-0.45
P20	Surf B	J91	17	0.23	-0.31	-0.05
P20	Surf B	J91	17	0.09	-0.82	-1.00
P20	Surf B	J91	18	-0.12	-0.23	-0.22
P20	Surf B	J91	18	0.01	-0.53	-0.76
P20	Surf B	J91	18	-0.12	-1.09	-0.08
P20	Surf B	J91	19	0.41	-0.59	-0.46
P20	Surf B	J91	19	0.03	-0.44	-0.40
P20	Surf B	J91	19	0.00	-0.22	-0.03
P20	Surf B	J91	20	0.09	-0.14	1.09
P20	Surf B	J91	20	0.51	-0.50	-0.22
P20	Surf B	J91	20	0.11	-0.22	-0.03

APPENDIX B — DENSITY TEST RESULT DATA

The following pages present all of the Density test result data from projects that were provided by SCDOT.

In the following table, each Project is identified with a unique number, ranging from D02 to D19. Each of these numbered projects corresponds with a unique SCDOT project file number. Since many of the projects had more than 1 HMA mixture on the project, they also had more than 1 job mix formula (JMF) that was placed on the project. In the tables, each JMF is identified with a unique number, ranging from J01 to J94.

In the table Density results obtained from cores are labeled ‘C’ whereas density results obtained from nuclear density gages are labeled as ‘G’.

Table B.1. Density Test Results Data

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D02	Surf A	J02	1	C	93.45
D02	Surf A	J02	1	C	93.15
D02	Surf A	J02	1	C	94.09
D02	Surf A	J02	1	C	95.08
D02	Surf A	J02	1	C	94.34
D02	Surf A	J02	1	C	92.18
D02	Surf A	J02	1	C	92.63
D02	Surf A	J02	1	C	95.31
D02	Surf A	J02	2	C	94.17
D02	Surf A	J02	2	C	94.08
D02	Surf A	J02	2	C	92.00
D02	Surf A	J02	2	C	95.18
D02	Surf A	J02	3	C	94.57
D02	Surf A	J02	3	C	92.09
D02	Surf A	J02	3	C	93.85
D02	Surf A	J02	3	C	93.24
D02	Surf A	J02	3	C	93.95
D02	Surf A	J02	3	C	94.21
D02	Surf A	J02	3	C	92.85
D02	Surf A	J02	4	C	94.99
D02	Surf A	J02	4	C	94.28
D02	Surf A	J02	4	C	93.48
D02	Surf A	J02	4	C	93.19
D02	Surf A	J02	4	C	93.44
D02	Surf A	J02	4	C	94.54
D02	Surf A	J02	4	C	93.49
D02	Surf A	J02	4	C	93.39
D02	Surf A	J03	1	C	94.32
D02	Surf A	J03	1	C	91.82
D02	Surf A	J03	1	C	93.77
D02	Surf A	J03	1	C	92.82
D02	Surf A	J03	1	C	93.07
D02	Surf A	J03	8	C	95.78
D02	Surf A	J03	8	C	93.94
D02	Surf A	J03	8	C	93.38
D02	Surf A	J03	9	C	93.34
D02	Surf A	J03	9	C	94.02
D02	Surf A	J03	9	C	93.73
D02	Surf A	J03	9	C	92.90
D02	Surf A	J03	9	C	93.91
D02	Surf A	J03	10	C	93.64
D02	Surf A	J03	10	C	93.50
D02	Surf A	J03	10	C	93.49
D02	Surf A	J03	10	C	93.21
D02	Surf A	J03	11	C	92.52
D02	Surf A	J03	11	C	92.05
D02	Surf A	J03	11	C	93.26
D02	Surf A	J03	11	C	91.82
D02	Surf A	J03	11	C	92.65
D02	Surf A	J03	11	C	95.48
D02	Surf A	J03	12	C	93.64
D02	Surf A	J03	12	C	94.35
D02	Surf A	J03	12	C	94.48
D02	Surf A	J03	12	C	93.05
D02	Surf A	J03	13	C	93.11
D02	Surf A	J03	13	C	94.09
D02	Surf A	J03	13	C	94.59
D02	Surf A	J03	13	C	94.65
D02	Surf A	J03	14	C	93.05
D02	Surf A	J03	14	C	92.86
D02	Surf A	J03	14	C	94.76
D02	Surf A	J03	14	C	94.13
D02	Surf A	J03	15	C	95.47
D02	Surf A	J03	15	C	95.76
D02	Surf A	J03	15	C	93.70
D02	Surf A	J03	15	C	94.29
D02	Surf A	J03	16	C	94.09
D02	Surf A	J03	16	C	92.67
D02	Surf A	J03	16	C	94.02
D02	Surf A	J03	16	C	93.96
D02	Surf A	J03	16	C	93.84
D02	Surf A	J03	16	C	93.39
D02	Surf A	J03	16	C	94.83
D03	Surf A	J03	6	C	94.07
D03	Surf A	J03	6	C	94.08
D03	Surf A	J03	6	C	95.10
D03	Surf A	J03	6	C	93.99
D03	Surf A	J03	6	C	93.82
D03	Surf A	J03	7	C	94.00
D03	Surf A	J03	7	C	93.32
D03	Surf A	J03	7	C	93.61
D03	Surf A	J03	7	C	93.28
D03	Surf A	J03	8	C	94.38
D03	Surf A	J03	8	C	94.00
D03	Surf A	J03	8	C	94.30
D03	Surf A	J03	8	C	94.37

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D03	Surf A	J03	9	C	94.98
D03	Surf A	J03	9	C	94.12
D03	Surf A	J03	9	C	94.87
D03	Surf A	J03	9	C	93.16
D03	Surf A	J03	9	C	94.11
D03	Surf A	J03	10	C	95.26
D03	Surf A	J03	10	C	94.56
D03	Surf A	J03	10	C	94.42
D03	Surf A	J03	10	C	94.61
D03	Surf A	J03	10	C	94.81
D03	Surf A	J03	11	C	95.95
D03	Surf A	J03	11	C	94.60
D03	Surf A	J03	11	C	94.48
D03	Surf A	J03	11	C	95.14
D03	Surf A	J03	11	C	93.45
D03	Surf A	J03	11	C	94.61
D03	Surf A	J03	11	C	94.47
D03	Surf A	J03	12	C	92.50
D03	Surf A	J03	12	C	93.32
D03	Surf A	J03	12	C	94.39
D03	Surf A	J03	12	C	94.34
D03	Surf A	J03	12	C	94.61
D03	Surf A	J03	12	C	95.00
D03	Surf A	J03	12	C	93.84
D03	Surf A	J03	12	C	95.28
D03	Surf A	J03	13	C	94.45
D03	Surf A	J03	13	C	93.58
D03	Surf A	J03	13	C	95.26
D03	Surf A	J03	13	C	93.93
D03	Surf A	J03	13	C	93.31
D03	Surf A	J03	13	C	93.62
D03	Surf A	J03	13	C	93.84
D03	Surf A	J03	14	C	93.31
D03	Surf A	J03	14	C	92.71
D03	Surf A	J03	14	C	95.41
D03	Surf A	J03	14	C	92.54
D03	Surf A	J03	14	C	95.11
D03	Surf A	J03	15	C	92.40
D03	Surf A	J03	15	C	95.16
D03	Surf A	J03	15	C	92.92
D03	Surf A	J03	15	C	94.69
D03	Surf A	J03	15	C	94.41
D03	Surf A	J03	16	C	92.82
D03	Surf A	J03	16	C	93.25
D03	Surf A	J03	16	C	94.13
D03	Surf A	J03	16	C	93.34
D03	Surf A	J03	16	C	93.89
D03	Surf A	J03	16	C	93.31
D03	Surf A	J03	16	C	93.49
D03	Surf A	J03	17	C	94.30
D03	Surf A	J03	17	C	92.80
D03	Surf A	J03	17	C	91.06
D03	Surf A	J03	17	C	93.64
D03	Surf A	J03	18	C	94.47
D03	Surf A	J03	18	C	93.87
D03	Surf A	J03	18	C	93.21
D03	Surf A	J03	18	C	92.32
D03	Surf A	J03	18	C	92.95
D03	Surf A	J03	18	C	93.67
D03	Surf A	J03	18	C	92.18
D03	Surf A	J03	18	C	92.74
D03	Surf A	J03	19	C	92.71
D03	Surf A	J03	19	C	87.33
D03	Surf A	J03	19	C	95.71
D03	Surf A	J03	19	C	95.02
D03	Surf A	J03	19	C	94.54
D03	Surf A	J03	19	C	94.18
D03	Surf A	J03	20	C	93.25
D03	Surf A	J03	20	C	92.72
D03	Surf A	J03	20	C	92.86
D03	Surf A	J03	20	C	92.54
D03	Surf A	J03	20	C	94.65
D03	Surf A	J03	21	C	92.52
D03	Surf A	J03	40	C	92.50
D03	Surf A	J03	40	C	94.67
D03	Surf A	J03	40	C	95.13
D03	Surf A	J03	41	C	93.73
D03	Surf A	J03	41	C	94.92
D03	Surf A	J03	41	C	93.76
D03	Surf A	J03	41	C	95.60
D03	Surf A	J03	42	C	94.94
D03	Surf A	J03	42	C	95.88
D03	Surf A	J03	42	C	96.34
D03	Surf A	J03	42	C	93.86
D03	Surf A	J03	43	C	92.41
D03	Surf A	J03	43	C	94.45

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D03	Surf A	J03	43	C	95.62
D03	Surf A	J03	43	C	92.18
D03	Surf A	J03	44	C	93.88
D03	Surf A	J03	44	C	94.34
D03	Surf A	J03	44	C	94.30
D03	Surf A	J03	44	C	93.03
D03	Surf A	J03	44	C	92.92
D03	Surf A	J03	46	C	96.13
D03	Surf A	J03	46	C	94.61
D03	Surf A	J03	46	C	94.52
D03	Surf A	J03	46	C	94.02
D04	Surf B	J01	1	C	91.79
D04	Surf B	J01	1	C	93.78
D04	Surf B	J01	1	C	95.08
D04	Surf B	J01	1	C	93.25
D04	Surf B	J01	2	C	94.58
D04	Surf B	J01	2	C	95.56
D04	Surf B	J01	2	C	93.36
D04	Surf B	J01	3	C	94.47
D04	Surf B	J01	3	C	94.35
D04	Surf B	J01	3	C	94.63
D04	Surf B	J01	3	C	92.35
D04	Surf B	J01	3	C	93.09
D04	Surf B	J01	3	C	95.28
D04	Surf B	J01	5	C	93.19
D04	Surf B	J01	5	C	92.46
D04	Surf B	J01	5	C	94.24
D04	Surf B	J01	5	C	92.17
D04	Surf B	J01	5	C	93.96
D04	Surf B	J01	6	C	95.05
D04	Surf B	J01	6	C	92.22
D04	Surf B	J01	6	C	93.64
D04	Surf B	J01	6	C	91.97
D04	Surf B	J01	6	C	93.15
D04	Surf B	J01	6	C	92.54
D04	Surf B	J01	7	C	94.43
D04	Surf B	J01	7	C	92.19
D04	Surf B	J01	7	C	92.56
D04	Surf B	J01	8	C	92.86
D04	Surf B	J01	8	C	91.97
D04	Surf B	J01	8	C	92.33
D04	Surf B	J01	9	C	92.01
D04	Surf B	J01	9	C	93.76
D04	Surf B	J01	9	C	92.18
D04	Surf B	J01	9	C	93.96
D04	Surf B	J01	9	C	93.35
D04	Surf B	J01	9	C	93.11
D04	Surf B	J01	9	C	93.76
D04	Surf B	J01	9	C	94.16
D04	Surf B	J01	9	C	93.23
D04	Surf B	J01	9	C	93.07
D04	Surf B	J01	10	C	91.89
D04	Surf B	J01	10	C	93.92
D04	Surf B	J01	10	C	92.70
D04	Surf B	J01	10	C	93.88
D04	Surf B	J01	10	C	94.08
D04	Surf B	J01	10	C	94.20
D04	Surf B	J01	10	C	93.11
D04	Surf B	J01	10	C	94.12
D04	Surf B	J01	10	C	93.64
D04	Surf B	J01	11	C	93.64
D04	Surf B	J01	11	C	92.95
D04	Surf B	J01	11	C	94.20
D04	Surf B	J01	11	C	93.31
D04	Surf B	J01	11	C	94.77
D04	Surf B	J01	11	C	94.16
D04	Surf B	J01	12	C	93.03
D04	Surf B	J01	12	C	92.30
D04	Surf B	J01	12	C	92.38
D04	Surf B	J01	12	C	93.07
D04	Surf B	J01	12	C	94.48
D04	Surf B	J01	13	C	93.06
D04	Surf B	J01	13	C	93.22
D04	Surf B	J01	13	C	94.32
D04	Surf B	J01	13	C	93.55
D04	Surf B	J01	13	C	92.86
D04	Surf B	J01	13	C	93.83
D04	Surf B	J01	14	C	92.79
D04	Surf B	J01	14	C	93.84
D04	Surf B	J01	14	C	92.95
D04	Surf B	J01	17	C	93.73
D04	Surf B	J01	17	C	94.42
D04	Surf B	J01	17	C	93.12
D04	Surf B	J01	17	C	93.00
D04	Surf B	J01	17	C	94.79
D04	Surf B	J01	18	C	94.22

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.	Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D04	Surf B	J01	18	C	94.09	D05	Surf B	J08	1	C	94.96
D04	Surf B	J01	18	C	93.60	D05	Surf B	J08	1	C	94.14
D04	Surf B	J01	18	C	93.73	D05	Surf B	J08	2	C	92.72
D04	Surf B	J01	18	C	93.32	D05	Surf B	J08	2	C	93.33
D04	Surf B	J01	19	C	93.25	D05	Surf B	J08	2	C	93.65
D04	Surf B	J01	19	C	93.04	D05	Surf B	J08	2	C	93.17
D04	Surf B	J01	19	C	93.69	D05	Surf B	J08	2	C	92.11
D04	Surf B	J01	20	C	93.62	D05	Surf B	J08	3	C	93.86
D04	Surf B	J01	20	C	94.23	D05	Surf B	J08	3	C	91.62
D04	Surf B	J01	20	C	93.46	D05	Surf B	J08	3	C	94.02
D04	Surf B	J01	20	C	93.21	D05	Surf B	J08	3	C	93.45
D04	Surf B	J01	21	C	93.99	D05	Surf B	J08	3	C	92.92
D04	Surf B	J01	21	C	93.70	D05	Surf B	J08	6	C	92.09
D04	Surf B	J01	21	C	93.74	D05	Surf B	J08	6	C	93.63
D04	Surf B	J01	21	C	93.54	D05	Surf B	J08	6	C	92.45
D04	Surf B	J01	21	C	93.30	D05	Surf B	J08	6	C	93.23
D04	Surf B	J01	21	C	93.70	D05	Surf B	J08	6	C	92.13
D04	Surf B	J01	21	C	92.81	D05	Surf B	J08	6	C	94.73
D04	Surf B	J01	23	C	93.34	D05	Surf B	J08	6	C	92.90
D04	Surf B	J01	23	C	93.14	D05	Surf B	J08	7	C	90.79
D04	Surf B	J01	23	C	93.22	D05	Surf B	J08	7	C	91.00
D04	Surf B	J01	23	C	94.28	D05	Surf B	J08	7	C	90.43
D04	Surf B	J01	23	C	93.59	D05	Surf B	J08	7	C	93.39
D04	Surf B	J01	23	C	93.06	D05	Surf B	J08	7	C	92.94
D04	Surf B	J01	23	C	93.54	D05	Surf B	J08	9	C	91.97
D04	Surf B	J01	24	C	94.29	D05	Surf B	J08	9	C	93.10
D04	Surf B	J01	24	C	93.76	D05	Surf B	J08	9	C	95.42
D04	Surf B	J01	24	C	94.37	D06	Surf A	J12	1	C	92.73
D04	Surf B	J01	24	C	92.63	D06	Surf A	J12	1	C	93.42
D04	Surf B	J01	25	C	93.96	D06	Surf A	J12	1	C	93.71
D04	Surf B	J01	25	C	93.63	D06	Surf A	J12	1	C	94.37
D05	Inter C	J07	4	C	91.60	D06	Surf A	J12	1	C	94.37
D05	Inter C	J07	4	C	91.80	D06	Surf A	J12	1	C	93.30
D05	Inter C	J07	4	C	93.18	D06	Surf A	J12	2	C	93.14
D05	Inter C	J07	4	C	92.61	D06	Surf A	J12	2	C	92.98
D05	Inter C	J07	6	C	91.38	D06	Surf A	J12	2	C	93.02
D05	Inter C	J07	6	C	91.54	D06	Surf A	J12	2	C	93.43
D05	Inter C	J07	6	C	92.92	D06	Surf A	J12	2	C	93.72
D05	Inter C	J07	6	C	92.35	D06	Surf A	J12	3	C	93.49
D05	Inter C	J07	11	C	92.99	D06	Surf A	J12	3	C	92.84
D05	Inter C	J07	11	C	93.16	D06	Surf A	J12	3	C	92.76
D05	Inter C	J07	11	C	93.81	D06	Surf A	J12	3	C	92.84
D05	Surf B	J08	1	C	93.29	D06	Surf A	J12	3	C	92.02

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D06	Surf A	J12	3	C	94.76
D06	Surf A	J12	4	C	93.14
D06	Surf A	J12	4	C	92.24
D06	Surf A	J12	4	C	93.10
D06	Surf A	J12	4	C	92.45
D06	Surf A	J12	4	C	92.69
D06	Surf A	J12	4	C	92.45
D06	Surf A	J12	5	C	92.80
D06	Surf A	J12	5	C	92.65
D06	Surf A	J12	5	C	93.62
D06	Surf A	J12	5	C	93.21
D06	Surf A	J12	5	C	92.43
D06	Surf A	J12	5	C	93.29
D06	Surf A	J12	6	C	93.07
D06	Surf A	J12	6	C	91.89
D06	Surf A	J12	6	C	92.50
D06	Surf A	J12	6	C	92.66
D06	Surf A	J12	6	C	92.59
D06	Surf A	J12	6	C	92.79
D06	Surf A	J12	7	C	93.05
D06	Surf A	J12	7	C	92.92
D06	Surf A	J12	7	C	92.72
D06	Surf A	J12	8	C	93.03
D06	Surf A	J12	8	C	94.51
D06	Surf A	J12	8	C	93.77
D06	Surf A	J12	8	C	94.26
D06	Surf A	J12	8	C	92.78
D06	Surf A	J12	8	C	93.52
D06	Surf A	J12	9	C	93.85
D06	Surf A	J12	9	C	93.65
D06	Surf A	J12	9	C	92.70
D06	Surf A	J12	9	C	93.93
D06	Surf A	J12	9	C	93.98
D06	Surf A	J12	10	C	93.07
D06	Surf A	J12	10	C	93.60
D06	Surf A	J12	10	C	93.43
D06	Surf A	J12	10	C	93.35
D06	Surf A	J12	10	C	94.99
D06	Surf A	J12	10	C	93.64
D06	Surf A	J12	11	C	92.25
D06	Surf A	J12	11	C	92.21
D06	Surf A	J12	11	C	93.32
D06	Surf A	J12	11	C	93.15

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D06	Surf A	J12	11	C	93.28
D06	Surf A	J12	11	C	92.05
D06	Surf A	J12	11	C	93.73
D06	Surf A	J12	12	C	93.58
D06	Surf A	J12	12	C	91.12
D06	Surf A	J12	12	C	90.18
D06	Surf A	J12	12	C	93.25
D06	Surf A	J12	12	C	89.28
D06	Surf A	J12	12	C	91.70
D06	Surf A	J12	14	C	91.84
D06	Surf A	J12	14	C	91.10
D06	Surf A	J12	14	C	92.95
D06	Surf A	J12	14	C	91.18
D06	Surf A	J12	14	C	91.47
D06	Surf A	J12	14	C	94.30
D06	Surf A	J12	15	C	93.73
D06	Surf A	J12	15	C	94.06
D06	Surf A	J12	15	C	93.52
D06	Surf A	J12	15	C	94.43
D06	Surf A	J12	15	C	93.52
D06	Surf A	J12	15	C	94.10
D06	Surf A	J12	16	C	94.06
D06	Surf A	J12	16	C	94.18
D06	Surf A	J12	16	C	94.02
D06	Surf A	J12	16	C	93.44
D06	Surf A	J12	16	C	93.48
D06	Surf A	J12	17	C	94.46
D06	Surf A	J12	17	C	94.26
D06	Surf A	J12	17	C	93.68
D06	Surf A	J12	17	C	94.26
D06	Surf A	J12	18	C	94.59
D06	Surf A	J12	18	C	93.90
D06	Surf A	J12	18	C	93.28
D06	Surf A	J12	18	C	94.06
D06	Surf A	J12	18	C	93.61
D06	Surf A	J12	18	C	93.81
D06	Surf A	J12	18	C	93.90
D06	Surf A	J12	18	C	93.53
D06	Surf A	J12	19	C	94.67
D06	Surf A	J12	19	C	93.04
D06	Surf A	J12	19	C	93.04
D06	Surf A	J12	19	C	92.75
D06	Surf A	J12	19	C	93.08

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D06	Surf A	J12	19	C	93.20
D06	Surf A	J12	20	C	96.01
D06	Surf A	J12	20	C	93.22
D06	Surf A	J12	20	C	93.34
D06	Surf A	J12	20	C	94.57
D06	Surf A	J12	20	C	93.92
D06	Surf A	J12	21	C	94.07
D06	Surf A	J12	21	C	94.72
D06	Surf A	J12	21	C	91.97
D06	Surf A	J12	21	C	94.14
D06	Surf A	J12	21	C	95.04
D06	Surf A	J12	22	C	92.56
D06	Surf A	J12	22	C	93.91
D06	Surf A	J12	22	C	93.46
D06	Surf A	J12	22	C	93.21
D06	Surf A	J12	23	C	93.10
D06	Surf A	J12	23	C	92.85
D06	Surf A	J12	23	C	93.30
D06	Surf A	J12	23	C	93.39
D06	Surf A	J12	23	C	93.02
D06	Surf A	J12	23	C	92.32
D06	Surf A	J12	23	C	94.58
D06	Surf A	J12	23	C	92.93
D06	Surf A	J12	24	C	92.64
D06	Surf A	J12	24	C	92.89
D06	Surf A	J12	24	C	92.68
D06	Surf A	J12	24	C	92.40
D06	Surf A	J12	24	C	93.51
D06	Surf A	J12	24	C	94.57
D06	Surf A	J12	24	C	92.68
D06	Surf A	J12	25	C	94.13
D06	Surf A	J12	25	C	93.56
D06	Surf A	J12	25	C	92.69
D06	Surf A	J12	26	C	95.25
D06	Surf A	J12	26	C	95.21
D06	Surf A	J12	26	C	92.50
D07	Surf A	J14	1	C	94.0
D07	Surf A	J14	2	C	94.5
D07	Surf A	J14	3	C	94.8
D07	Surf A	J14	4	C	94.5
D07	Surf A	J14	5	C	94.1
D07	Surf A	J14	6	C	94.6
D07	Surf A	J14	11	C	93.7

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D07	Surf A	J14	12	C	93.4
D07	Surf A	J14	13	C	93.2
D07	Surf A	J14	14	C	94.9
D07	Surf A	J14	15	C	94.3
D07	Surf A	J14	16	C	92.3
D08	Surf B	J15	1	C	94.20
D08	Surf B	J15	1	C	94.57
D08	Surf B	J15	1	C	94.16
D08	Surf B	J15	1	C	94.82
D08	Surf B	J15	2	C	94.07
D08	Surf B	J15	2	C	94.27
D08	Surf B	J15	2	C	94.23
D08	Surf B	J15	2	C	93.33
D08	Surf B	J15	2	C	94.68
D08	Surf B	J15	2	C	94.68
D08	Surf B	J15	3	C	94.65
D08	Surf B	J15	3	C	92.97
D08	Surf B	J15	3	C	92.28
D08	Surf B	J15	3	C	92.52
D08	Surf B	J15	3	C	91.83
D08	Surf B	J15	4	C	93.22
D08	Surf B	J15	4	C	93.58
D08	Surf B	J15	4	C	95.38
D08	Surf B	J15	4	C	94.89
D08	Surf B	J15	4	C	93.09
D08	Surf B	J15	4	C	94.40
D08	Surf B	J15	4	C	93.46
D08	Surf B	J15	5	C	91.52
D08	Surf B	J15	5	C	93.43
D08	Surf B	J15	5	C	90.91
D08	Surf B	J15	5	C	93.92
D08	Surf B	J15	5	C	94.54
D08	Surf B	J15	5	C	91.60
D08	Surf B	J15	5	C	90.29
D08	Surf B	J15	5	C	94.74
D08	Surf B	J15	5	C	93.92
D08	Surf B	J15	5	C	92.21
D08	Surf B	J15	6	C	91.72
D08	Surf B	J15	6	C	94.21
D08	Surf B	J15	6	C	92.90
D08	Surf B	J15	6	C	94.00
D08	Surf B	J15	6	C	93.23
D08	Surf B	J15	6	C	92.21

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D08	Surf B	J15	6	C	93.35
D08	Surf B	J15	7	C	90.33
D08	Surf B	J15	7	C	92.54
D08	Surf B	J15	7	C	92.74
D08	Surf B	J15	7	C	92.50
D08	Surf B	J15	7	C	92.99
D08	Surf B	J15	7	C	91.03
D08	Surf B	J15	8	C	93.56
D08	Surf B	J15	8	C	92.75
D08	Surf B	J15	8	C	90.10
D08	Surf B	J15	8	C	90.63
D08	Surf B	J15	8	C	92.83
D08	Surf B	J15	8	C	93.44
D08	Surf B	J15	9	C	90.87
D08	Surf B	J15	9	C	94.89
D08	Surf B	J15	9	C	91.88
D08	Surf B	J15	9	C	93.06
D08	Surf B	J15	11	C	92.42
D08	Surf B	J15	11	C	93.81
D08	Surf B	J15	11	C	91.57
D08	Surf B	J15	11	C	92.42
D08	Surf B	J15	11	C	95.64
D08	Surf B	J15	11	C	90.71
D08	Surf B	J15	11	C	92.34
D08	Surf B	J15	12	C	92.99
D08	Surf B	J15	12	C	92.01
D08	Surf B	J15	12	C	91.48
D08	Surf B	J15	12	C	94.66
D08	Surf B	J15	13	C	96.44
D08	Surf B	J15	13	C	93.53
D08	Surf B	J15	13	C	91.36
D08	Surf B	J15	13	C	94.14
D08	Surf B	J15	13	C	95.17
D08	Surf B	J15	13	C	93.04
D08	Surf B	J15	13	C	93.28
D08	Surf B	J15	13	C	94.76
D08	Surf B	J15	14	C	92.60
D08	Surf B	J15	14	C	91.37
D08	Surf B	J15	14	C	92.84
D08	Surf B	J15	15	C	94.46
D08	Surf B	J15	15	C	94.46
D08	Surf B	J15	15	C	95.39
D08	Surf B	J15	15	C	92.99

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D08	Surf B	J15	15	C	92.70
D08	Surf B	J15	15	C	92.50
D08	Surf B	J15	15	C	92.05
D08	Surf B	J15	15	C	92.09
D08	Surf B	J15	15	C	92.83
D08	Surf B	J15	16	C	93.23
D08	Surf B	J15	16	C	92.94
D08	Surf B	J15	16	C	90.90
D08	Surf B	J15	16	C	91.23
D08	Surf B	J15	16	C	92.74
D08	Surf B	J15	16	C	92.37
D08	Surf B	J15	16	C	89.68
D08	Surf B	J15	16	C	92.94
D08	Surf B	J15	16	C	91.92
D08	Surf B	J15	17	C	90.90
D08	Surf B	J15	17	C	92.94
D08	Surf B	J15	17	C	91.80
D08	Surf B	J15	17	C	91.96
D08	Surf B	J15	17	C	93.19
D08	Surf B	J15	17	C	95.23
D08	Surf B	J15	18	C	93.22
D08	Surf B	J15	18	C	90.65
D08	Surf B	J15	18	C	92.86
D08	Surf B	J15	18	C	92.24
D08	Surf B	J15	18	C	92.69
D08	Surf B	J15	19	C	93.95
D08	Surf B	J15	19	C	94.56
D08	Surf B	J15	19	C	93.18
D08	Surf B	J15	19	C	95.01
D08	Surf B	J15	19	C	94.20
D08	Surf B	J15	19	C	93.75
D08	Surf B	J15	19	C	93.54
D08	Surf B	J15	19	C	90.07
D08	Surf B	J15	19	C	93.71
D09	Surf A	J16	1	C	92.83
D09	Surf A	J16	1	C	93.61
D09	Surf A	J16	1	C	93.85
D09	Surf A	J16	1	C	95.53
D09	Surf A	J16	1	C	93.57
D09	Surf A	J16	1	C	95.33
D09	Surf A	J16	2	C	94.61
D09	Surf A	J16	2	C	93.58
D09	Surf A	J16	2	C	93.21

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D09	Surf A	J16	2	C	94.98
D09	Surf A	J16	2	C	94.65
D09	Surf A	J89	1	C	94.99
D09	Surf A	J89	1	C	92.44
D09	Surf A	J89	1	C	93.67
D09	Surf A	J89	1	C	92.19
D09	Surf A	J89	1	C	93.05
D09	Surf A	J89	1	C	94.29
D09	Surf A	J89	1	C	94.29
D09	Surf A	J89	1	C	93.46
D09	Surf A	J89	2	C	93.21
D09	Surf A	J89	2	C	93.17
D09	Surf A	J89	2	C	95.30
D09	Surf A	J89	2	C	92.68
D09	Surf A	J89	2	C	93.13
D09	Surf A	J89	2	C	92.39
D09	Surf A	J89	2	C	94.07
D09	Surf A	J89	2	C	93.62
D09	Surf A	J89	2	C	93.78
D09	Surf A	J89	3	C	93.60
D09	Surf A	J89	3	C	94.00
D09	Surf A	J89	3	C	93.60
D09	Surf A	J89	3	C	93.96
D09	Surf A	J89	3	C	92.70
D09	Surf A	J89	4	C	94.11
D09	Surf A	J89	4	C	94.23
D09	Surf A	J89	4	C	93.21
D09	Surf A	J89	4	C	93.29
D09	Surf A	J89	4	C	92.68
D09	Surf A	J89	4	C	95.13
D09	Surf A	J89	5	C	93.61
D09	Surf A	J89	5	C	92.67
D09	Surf A	J89	5	C	92.42
D09	Surf A	J89	5	C	93.12
D09	Surf A	J89	5	C	92.79
D09	Surf A	J89	5	C	93.94
D09	Surf A	J89	5	C	93.04
D09	Surf A	J89	5	C	93.53
D09	Surf A	J89	5	C	93.08
D09	Surf A	J89	5	C	91.61
D09	Surf A	J89	6	C	93.48
D09	Surf A	J89	6	C	93.11
D09	Surf A	J89	6	C	94.75

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D09	Surf A	J89	7	C	94.15
D09	Surf A	J89	7	C	93.25
D09	Surf A	J89	7	C	93.38
D09	Surf A	J89	7	C	93.95
D09	Surf A	J89	7	C	93.42
D09	Surf A	J89	8	C	93.86
D09	Surf A	J89	8	C	93.86
D09	Surf A	J89	8	C	94.39
D09	Surf A	J89	8	C	93.74
D09	Surf A	J89	8	C	93.94
D09	Surf A	J89	8	C	93.90
D09	Surf A	J89	9	C	94.03
D09	Surf A	J89	9	C	93.74
D09	Surf A	J89	9	C	94.11
D09	Surf A	J89	9	C	95.05
D09	Surf A	J89	9	C	94.77
D09	Surf A	J89	9	C	94.44
D09	Surf A	J89	9	C	94.77
D09	Surf A	J17	1	C	93.92
D09	Surf A	J17	1	C	94.49
D09	Surf A	J17	1	C	94.29
D09	Surf A	J17	1	C	94.94
D09	Surf A	J17	1	C	93.68
D09	Surf A	J17	1	C	94.82
D09	Surf A	J17	2	C	93.96
D09	Surf A	J17	2	C	93.92
D09	Surf A	J17	2	C	93.88
D09	Surf A	J17	3	C	93.33
D09	Surf A	J17	3	C	93.49
D09	Surf A	J17	3	C	93.41
D09	Surf A	J17	3	C	93.37
D09	Surf A	J17	3	C	93.94
D09	Surf A	J17	3	C	95.48
D09	Surf A	J17	3	C	94.30
D09	Surf A	J17	3	C	93.16
D09	Surf A	J17	3	C	93.89
D09	Surf A	J17	3	C	93.77
D09	Surf A	J17	4	C	93.84
D09	Surf A	J17	4	C	93.88
D09	Surf A	J17	4	C	93.19
D09	Surf A	J17	4	C	93.39
D09	Surf A	J17	4	C	92.41
D09	Surf A	J17	4	C	94.00

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D09	Surf A	J17	4	C	93.64
D09	Surf A	J17	4	C	94.29
D09	Surf A	J17	4	C	93.31
D09	Surf A	J17	4	C	93.92
D09	Surf A	J17	4	C	92.99
D09	Surf A	J17	4	C	92.86
D09	Surf A	J17	5	C	95.72
D09	Surf A	J17	5	C	94.91
D09	Surf A	J17	5	C	94.83
D09	Surf A	J17	5	C	93.77
D09	Surf A	J17	5	C	93.89
D09	Surf A	J17	5	C	93.48
D10	Surf A	J18	1	C	92.07
D10	Surf A	J18	1	C	93.57
D10	Surf A	J18	1	C	93.97
D10	Surf A	J18	1	C	91.35
D10	Surf A	J18	1	C	93.73
D10	Surf A	J18	1	C	93.37
D10	Surf A	J18	1	C	94.02
D10	Surf A	J18	2	C	94.46
D10	Surf A	J18	2	C	94.79
D10	Surf A	J18	2	C	93.29
D10	Surf A	J18	2	C	94.99
D10	Surf A	J18	2	C	93.78
D10	Surf A	J18	3	C	95.11
D10	Surf A	J18	3	C	95.27
D10	Surf A	J18	3	C	94.75
D10	Surf A	J18	3	C	95.03
D10	Surf A	J18	3	C	91.60
D10	Surf A	J18	3	C	94.14
D10	Surf A	J18	3	C	94.06
D10	Surf A	J18	4	C	94.36
D10	Surf A	J18	4	C	95.69
D10	Surf A	J18	4	C	93.84
D10	Surf A	J18	4	C	94.20
D10	Surf A	J18	5	C	92.25
D10	Surf A	J18	5	C	88.66
D10	Surf A	J18	5	C	91.17
D10	Surf A	J18	5	C	94.23
D10	Surf A	J18	5	C	93.22
D10	Surf A	J18	5	C	93.75
D10	Surf A	J18	5	C	94.35
D10	Surf A	J18	6	C	92.04
D10	Surf A	J18	6	C	93.30
D10	Surf A	J18	6	C	93.62
D10	Surf A	J18	6	C	93.70
D10	Surf A	J18	6	C	92.69
D10	Surf A	J18	10	C	92.72
D10	Surf A	J18	10	C	92.47
D10	Surf A	J18	10	C	93.76
D10	Surf A	J18	10	C	91.63
D10	Surf A	J18	10	C	93.80
D10	Surf A	J18	10	C	90.62
D10	Surf A	J18	10	C	90.50
D10	Surf A	J18	10	C	93.32
D10	Surf A	J18	11	C	94.41
D10	Surf A	J18	11	C	93.49
D10	Surf A	J18	11	C	95.05
D10	Surf A	J18	11	C	94.25
D10	Surf B	J19	1	C	92.16
D10	Surf B	J19	1	C	92.61
D10	Surf B	J19	1	C	93.29
D10	Surf B	J19	1	C	91.35
D10	Surf B	J20	1	C	89.24
D10	Surf B	J20	1	C	86.58
D10	Surf B	J20	1	C	90.17
D10	Surf B	J20	1	C	87.87
D10	Surf B	J20	2	C	91.09
D10	Surf B	J20	2	C	89.19
D10	Surf B	J20	2	C	92.74
D10	Surf B	J20	2	C	92.98
D10	Surf B	J20	3	C	93.47
D10	Surf B	J20	3	C	92.18
D10	Surf B	J21	2	C	92.48
D10	Surf B	J21	2	C	90.51
D10	Surf B	J21	2	C	93.77
D10	Surf B	J21	2	C	91.71
D10	Surf B	J21	2	C	92.48
D10	Surf B	J21	2	C	91.67
D10	Surf B	J21	2	C	89.54
D10	Surf B	J21	2	C	92.56
D10	Surf B	J21	2	C	92.52
D10	Surf B	J21	3	C	92.92
D10	Surf B	J21	3	C	93.36
D10	Surf B	J21	3	C	91.87
D10	Surf B	J21	3	C	92.35

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.	Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D10	Surf B	J21	3	C	90.70	D11	Surf A	J24	5	C	93.98
D10	Surf B	J21	3	C	92.39	D11	Surf A	J24	5	C	94.31
D10	Surf B	J21	3	C	93.28	D11	Surf A	J24	5	C	94.35
D10	Surf B	J21	4	C	93.82	D11	Surf A	J24	5	C	94.11
D10	Surf B	J21	4	C	93.70	D11	Surf A	J24	5	C	93.70
D10	Surf B	J21	4	C	93.26	D11	Surf A	J24	5	C	93.86
D10	Surf B	J21	4	C	94.74	D11	Surf A	J24	5	C	93.70
D10	Surf B	J21	4	C	91.69	D11	Surf A	J24	5	C	93.04
D10	Surf B	J21	4	C	91.21	D11	Surf A	J24	5	C	93.08
D10	Surf B	J21	4	C	90.93	D11	Surf A	J24	5	C	94.68
D10	Surf B	J21	5	C	90.16	D11	Surf A	J24	6	C	93.33
D10	Surf B	J21	5	C	93.17	D11	Surf A	J24	6	C	93.41
D10	Surf B	J21	5	C	93.29	D11	Surf A	J24	6	C	93.61
D10	Surf B	J21	5	C	93.01	D11	Surf A	J24	6	C	94.10
D10	Surf B	J21	5	C	93.45	D11	Surf A	J24	6	C	93.53
D10	Surf B	J21	5	C	91.96	D11	Surf A	J24	6	C	94.14
D10	Surf B	J21	5	C	93.57	D11	Surf A	J24	6	C	92.96
D11	Surf A	J23	1	C	89.25	D11	Surf A	J24	6	C	94.06
D11	Surf A	J23	1	C	93.87	D11	Surf A	J24	6	C	93.20
D11	Surf A	J23	1	C	91.21	D11	Surf A	J24	7	C	93.50
D11	Surf A	J24	1	C	91.25	D11	Surf A	J24	7	C	94.48
D11	Surf A	J24	1	C	90.48	D11	Surf A	J24	7	C	94.12
D11	Surf A	J24	1	C	94.89	D11	Surf A	J24	7	C	93.79
D11	Surf A	J24	1	C	94.69	D11	Surf A	J24	8	C	94.16
D11	Surf A	J24	2	C	94.31	D11	Surf A	J24	8	C	94.93
D11	Surf A	J24	2	C	94.64	D11	Surf A	J24	8	C	94.65
D11	Surf A	J24	2	C	95.62	D11	Surf A	J24	8	C	94.57
D11	Surf A	J24	2	C	95.17	D11	Surf A	J24	10	C	95.10
D11	Surf A	J24	2	C	95.37	D11	Surf A	J24	10	C	94.00
D11	Surf A	J24	3	C	93.49	D11	Surf A	J24	10	C	93.47
D11	Surf A	J24	3	C	93.29	D11	Surf A	J24	10	C	94.20
D11	Surf A	J24	3	C	92.92	D11	Surf A	J24	10	C	93.88
D11	Surf A	J24	3	C	93.78	D11	Surf A	J24	10	C	94.24
D11	Surf A	J24	3	C	93.33	D11	Surf A	J24	10	C	94.32
D11	Surf A	J24	3	C	94.23	D11	Surf A	J24	10	C	94.53
D11	Surf A	J24	3	C	94.88	D11	Surf A	J24	10	C	93.88
D11	Surf A	J24	4	C	93.41	D11	Surf A	J24	10	C	94.53
D11	Surf A	J24	4	C	92.96	D11	Surf A	J24	23	C	95.86
D11	Surf A	J24	4	C	95.78	D11	Surf A	J24	23	C	94.84
D11	Surf A	J24	4	C	93.99	D11	Surf A	J24	23	C	93.85
D11	Surf A	J24	4	C	94.98	D11	Surf A	J24	23	C	92.83
D11	Surf A	J24	4	C	92.71	D11	Surf A	J24	11	C	93.89
D11	Surf A	J24	4	C	93.95	D11	Surf A	J24	11	C	95.08

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D11	Surf A	J24	11	C	94.71
D11	Surf A	J24	11	C	94.42
D11	Surf A	J24	11	C	93.48
D11	Surf A	J24	11	C	94.34
D11	Surf A	J24	12	C	95.74
D11	Surf A	J24	12	C	94.76
D11	Surf A	J24	12	C	94.11
D11	Surf A	J24	12	C	94.68
D11	Surf A	J24	12	C	94.80
D11	Surf A	J24	12	C	93.04
D11	Surf A	J24	12	C	93.99
D11	Surf A	J24	13	C	94.58
D11	Surf A	J24	13	C	94.95
D11	Surf A	J24	13	C	94.08
D11	Surf A	J24	13	C	94.82
D11	Surf A	J24	13	C	94.74
D11	Surf A	J24	13	C	93.51
D11	Surf A	J24	13	C	92.15
D11	Surf A	J24	13	C	96.14
D11	Surf A	J24	14	C	93.61
D11	Surf A	J24	14	C	93.57
D11	Surf A	J24	14	C	94.68
D11	Surf A	J24	14	C	94.06
D11	Surf A	J24	14	C	93.37
D11	Surf A	J24	14	C	94.47
D11	Surf A	J24	14	C	92.67
D11	Surf A	J24	14	C	92.71
D11	Surf A	J24	15	C	95.78
D11	Surf A	J24	15	C	95.53
D11	Surf A	J24	15	C	93.73
D11	Surf A	J24	15	C	94.67
D11	Surf A	J24	15	C	94.92
D11	Surf A	J24	15	C	94.05
D11	Surf A	J24	15	C	93.44
D11	Surf A	J24	15	C	95.24
D11	Surf A	J24	16	C	95.14
D11	Surf A	J24	16	C	94.49
D11	Surf A	J24	16	C	94.90
D11	Surf A	J24	16	C	95.75
D11	Surf A	J24	16	C	94.86
D11	Surf A	J24	16	C	95.02
D11	Surf A	J24	17	C	95.34
D11	Surf A	J24	17	C	93.75
D11	Surf A	J24	17	C	94.08
D11	Surf A	J24	17	C	94.81
D11	Surf A	J24	17	C	94.36
D11	Surf A	J24	17	C	95.51
D11	Surf A	J24	17	C	94.85
D11	Surf A	J24	17	C	94.08
D11	Surf A	J24	18	C	96.27
D11	Surf A	J24	18	C	94.43
D11	Surf A	J24	18	C	94.43
D11	Surf A	J24	18	C	93.69
D11	Surf A	J24	18	C	94.43
D11	Surf A	J24	19	C	95.04
D11	Surf A	J24	19	C	94.96
D11	Surf A	J24	19	C	94.22
D11	Surf A	J24	19	C	94.30
D11	Surf A	J24	19	C	94.88
D11	Surf A	J24	19	C	93.48
D11	Surf A	J24	19	C	95.04
D11	Surf A	J24	20	C	93.33
D11	Surf A	J24	20	C	94.89
D11	Surf A	J24	20	C	94.39
D11	Surf A	J24	20	C	96.40
D11	Surf A	J24	20	C	95.09
D11	Surf A	J24	20	C	94.27
D11	Surf A	J24	20	C	95.13
D11	Surf A	J24	20	C	95.54
D11	Surf A	J24	21	C	97.58
D11	Surf A	J24	21	C	95.41
D11	Surf A	J24	21	C	95.74
D11	Surf A	J24	21	C	95.12
D11	Surf A	J24	21	C	95.74
D11	Surf A	J24	21	C	94.51
D11	Surf A	J24	22	C	95.09
D11	Surf A	J24	22	C	93.95
D11	Surf A	J24	22	C	95.79
D11	Surf A	J24	22	C	95.83
D11	Surf B	J26	1	C	93.18
D11	Surf B	J26	1	C	94.16
D11	Surf B	J27	1	C	93.53
D11	Surf B	J27	1	C	91.40
D11	Surf B	J27	1	C	90.50
D11	Surf B	J27	1	C	89.80
D11	Surf B	J27	1	C	94.80

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D11	Surf B	J27	1	C	93.90
D11	Surf B	J27	1	C	92.05
D11	Surf B	J27	2	C	93.81
D11	Surf B	J27	2	C	92.91
D11	Surf B	J27	2	C	92.37
D11	Surf B	J27	2	C	93.69
D11	Surf B	J27	2	C	92.13
D11	Surf B	J27	2	C	92.17
D11	Surf B	J27	2	C	95.08
D11	Surf B	J27	2	C	93.60
D11	Surf B	J27	2	C	93.89
D11	Surf B	J27	3	C	91.94
D11	Surf B	J27	3	C	94.11
D11	Surf B	J27	3	C	93.37
D11	Surf B	J27	3	C	93.91
D11	Surf B	J27	4	C	93.42
D11	Surf B	J27	4	C	93.10
D11	Surf B	J27	4	C	95.14
D11	Surf B	J27	4	C	95.26
D11	Surf B	J27	4	C	93.59
D11	Surf B	J27	4	C	94.77
D11	Surf B	J27	4	C	93.83
D11	Surf B	J27	5	C	94.00
D11	Surf B	J27	5	C	95.26
D11	Surf B	J27	5	C	95.18
D11	Surf B	J27	5	C	93.55
D11	Surf B	J27	5	C	91.51
D11	Surf B	J27	8	G	98.68
D11	Surf B	J27	8	G	98.02
D11	Surf B	J27	8	G	99.05
D11	Surf B	J27	8	G	99.93
D11	Surf B	J27	8	G	100.73
D11	Surf B	J27	8	G	101.83
D11	Surf B	J27	8	G	100.22
D11	Surf B	J27	8	G	99.05
D11	Surf B	J27	8	G	100.07
D11	Surf B	J27	8	G	99.56
D11	Surf B	J27	6	C	92.15
D11	Surf B	J27	6	C	91.91
D11	Surf B	J27	6	C	93.50
D11	Surf B	J27	6	C	91.58
D11	Surf B	J27	6	C	93.21
D11	Surf B	J27	6	C	96.08

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D11	Surf B	J27	6	C	91.99
D11	Surf B	J27	6	C	91.17
D11	Surf B	J27	7	C	94.65
D11	Surf B	J27	7	C	92.73
D11	Surf B	J27	7	C	91.13
D11	Surf B	J28	16	G	98.61
D11	Surf B	J28	16	G	97.95
D11	Surf B	J28	16	G	102.20
D11	Surf B	J28	16	G	100.37
D11	Surf B	J28	16	G	99.63
D11	Surf B	J28	16	G	99.12
D11	Surf B	J28	16	G	98.32
D11	Surf B	J28	16	G	101.10
D11	Surf B	J28	16	G	97.88
D11	Surf B	J28	16	G	98.76
D11	Surf B	J28	1	C	94.85
D11	Surf B	J28	1	C	94.73
D11	Surf B	J28	1	C	94.15
D11	Surf B	J28	1	C	94.60
D11	Surf B	J28	1	C	95.01
D11	Surf B	J28	2	C	92.79
D11	Surf B	J28	2	C	92.87
D11	Surf B	J28	2	C	92.34
D11	Surf B	J28	2	C	93.57
D11	Surf B	J28	2	C	94.88
D11	Surf B	J28	3	C	94.08
D11	Surf B	J28	3	C	93.72
D11	Surf B	J28	3	C	93.10
D11	Surf B	J28	3	C	93.27
D11	Surf B	J28	4	C	95.14
D11	Surf B	J28	4	C	95.26
D11	Surf B	J28	4	C	95.06
D11	Surf B	J28	15	G	98.24
D11	Surf B	J28	15	G	99.41
D11	Surf B	J28	15	G	100.73
D11	Surf B	J28	15	G	98.02
D11	Surf B	J28	15	G	100.07
D11	Surf B	J28	15	G	99.12
D11	Surf B	J28	15	G	96.85
D11	Surf B	J28	15	G	102.34
D11	Surf B	J28	15	G	98.54
D11	Surf B	J28	15	G	100.37
D11	Surf B	J28	5	G	100.88

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D11	Surf B	J28	5	G	98.17
D11	Surf B	J28	5	G	97.66
D11	Surf B	J28	5	G	97.14
D11	Surf B	J28	5	G	98.68
D11	Surf B	J28	5	G	99.49
D11	Surf B	J28	5	G	97.66
D11	Surf B	J28	5	G	98.54
D11	Surf B	J28	5	G	101.83
D11	Surf B	J28	5	G	100.07
D11	Surf B	J28	6	C	93.26
D11	Surf B	J28	6	C	92.81
D11	Surf B	J28	6	C	92.04
D11	Surf B	J28	6	C	92.24
D11	Surf B	J28	6	C	92.94
D11	Surf B	J28	6	C	91.59
D11	Surf B	J28	6	C	95.43
D11	Surf B	J28	6	C	94.16
D11	Surf B	J28	14	G	98.68
D11	Surf B	J28	14	G	97.07
D11	Surf B	J28	14	G	102.27
D11	Surf B	J28	14	G	99.12
D11	Surf B	J28	14	G	98.02
D11	Surf B	J28	14	G	100.88
D11	Surf B	J28	14	G	99.85
D11	Surf B	J28	14	G	98.02
D11	Surf B	J28	14	G	100.15
D11	Surf B	J28	14	G	99.12
D11	Surf B	J28	7	G	100.88
D11	Surf B	J28	7	G	99.85
D11	Surf B	J28	7	G	101.10
D11	Surf B	J28	7	G	98.66
D11	Surf B	J28	7	G	96.71
D11	Surf B	J28	7	G	98.17
D11	Surf B	J28	7	G	101.10
D11	Surf B	J28	7	G	98.46
D11	Surf B	J28	7	G	97.95
D11	Surf B	J28	7	G	99.49
D11	Surf B	J28	8	G	97.29
D11	Surf B	J28	8	G	99.34
D11	Surf B	J28	8	G	99.78
D11	Surf B	J28	8	G	98.17
D11	Surf B	J28	8	G	98.90
D11	Surf B	J28	8	G	97.95

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D11	Surf B	J28	8	G	100.37
D11	Surf B	J28	8	G	98.61
D11	Surf B	J28	8	G	99.63
D11	Surf B	J28	8	G	98.76
D11	Surf B	J28	9	C	94.27
D11	Surf B	J28	9	C	93.82
D11	Surf B	J28	9	C	93.58
D11	Surf B	J28	9	C	93.70
D11	Surf B	J28	9	C	94.58
D11	Surf B	J28	10	C	94.27
D11	Surf B	J28	10	C	93.78
D11	Surf B	J28	10	C	93.61
D11	Surf B	J28	10	C	93.49
D11	Surf B	J28	10	C	94.23
D11	Surf B	J28	10	C	93.04
D11	Surf B	J28	10	C	94.60
D11	Surf B	J28	11	G	98.76
D11	Surf B	J28	11	G	99.05
D11	Surf B	J28	11	G	97.22
D11	Surf B	J28	11	G	101.46
D11	Surf B	J28	11	G	99.27
D11	Surf B	J28	11	G	97.66
D11	Surf B	J28	11	G	97.95
D11	Surf B	J28	11	G	101.32
D11	Surf B	J28	11	G	99.78
D11	Surf B	J28	11	G	99.49
D11	Surf B	J28	12	C	95.29
D11	Surf B	J28	12	C	93.49
D11	Surf B	J28	12	C	94.23
D11	Surf B	J28	12	C	94.76
D11	Surf B	J28	13	C	93.00
D11	Surf B	J28	13	C	93.53
D14	Surf A	J62	1	C	93.64
D14	Surf A	J62	1	C	92.99
D14	Surf A	J62	1	C	94.90
D14	Surf A	J62	1	C	93.92
D14	Surf A	J62	1	C	95.23
D14	Surf A	J62	2	C	94.00
D14	Surf A	J62	2	C	95.39
D14	Surf A	J62	2	C	93.55
D14	Surf A	J62	2	C	93.92
D14	Surf A	J62	2	C	94.12
D14	Surf A	J62	2	C	95.02

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D14	Surf A	J62	3	C	93.52
D14	Surf A	J62	3	C	93.77
D14	Surf A	J62	3	C	94.42
D14	Surf A	J62	3	C	93.52
D14	Surf A	J62	3	C	93.77
D14	Surf A	J62	3	C	94.42
D14	Surf A	J62	3	C	93.44
D14	Surf A	J62	3	C	94.46
D14	Surf A	J62	4	C	94.47
D14	Surf A	J62	4	C	94.39
D14	Surf A	J62	4	C	93.25
D14	Surf A	J62	4	C	94.47
D14	Surf A	J62	4	C	94.39
D14	Surf A	J62	4	C	93.25
D14	Surf A	J62	4	C	93.00
D14	Surf A	J62	4	C	93.04
D14	Surf A	J62	4	C	91.74
D14	Surf A	J62	4	C	93.12
D14	Surf A	J62	5	C	92.56
D14	Surf A	J62	5	C	94.31
D14	Surf A	J62	5	C	93.70
D14	Surf A	J62	5	C	93.37
D14	Surf A	J62	5	C	94.88
D14	Surf A	J62	5	C	94.63
D14	Surf A	J62	6	C	91.88
D14	Surf A	J62	6	C	92.69
D14	Surf A	J62	6	C	93.01
D14	Surf A	J62	6	C	92.16
D14	Surf A	J62	6	C	92.85
D14	Surf A	J62	7	C	93.69
D14	Surf A	J62	7	C	94.54
D14	Surf A	J62	7	C	94.01
D14	Surf A	J62	7	C	94.14
D14	Surf A	J62	7	C	92.67
D14	Surf A	J62	8	C	93.20
D14	Surf A	J62	8	C	93.89
D14	Surf A	J62	8	C	92.27
D14	Surf A	J62	8	C	93.77
D14	Surf A	J62	8	C	93.77
D14	Surf A	J62	8	C	94.51
D14	Surf A	J62	8	C	93.37
D14	Surf A	J62	8	C	93.73
D14	Surf A	J62	8	C	94.74
D14	Surf A	J62	8	C	91.74
D14	Surf A	J62	8	C	93.53
D14	Surf A	J62	9	C	93.34
D14	Surf A	J62	9	C	92.48
D14	Surf A	J62	9	C	92.81
D14	Surf A	J62	9	C	94.36
D14	Surf A	J62	9	C	94.69
D14	Surf A	J62	9	C	93.50
D14	Surf A	J63	1	C	92.79
D14	Surf A	J63	1	C	94.34
D14	Surf A	J63	1	C	93.64
D14	Surf A	J63	2	C	94.58
D14	Surf A	J63	2	C	94.78
D14	Surf A	J63	2	C	93.92
D14	Surf A	J63	2	C	93.07
D14	Surf A	J63	2	C	94.29
D14	Surf A	J63	3	C	93.27
D14	Surf A	J63	3	C	94.00
D14	Surf A	J63	3	C	93.80
D14	Surf A	J63	3	C	94.94
D14	Surf A	J63	3	C	91.47
D14	Surf A	J63	4	C	93.10
D14	Surf A	J63	4	C	94.00
D14	Surf A	J63	4	C	94.45
D14	Surf A	J63	4	C	94.86
D14	Surf A	J63	6	C	92.15
D14	Surf A	J63	6	C	93.00
D14	Surf A	J63	6	C	92.64
D14	Surf A	J63	6	C	93.17
D14	Surf A	J63	6	C	92.31
D14	Surf A	J63	7	C	94.13
D14	Surf A	J63	7	C	92.83
D14	Surf A	J63	7	C	94.09
D14	Surf A	J63	7	C	94.62
D14	Surf A	J63	7	C	93.03
D14	Surf A	J63	7	C	93.44
D14	Surf A	J63	7	C	90.91
D14	Surf A	J63	8	C	92.66
D14	Surf A	J63	8	C	93.19
D14	Surf A	J63	8	C	94.33
D14	Surf A	J63	8	C	93.80
D14	Surf A	J63	8	C	92.09
D14	Surf A	J63	8	C	93.44

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D14	Surf A	J63	9	C	93.95
D14	Surf A	J63	9	C	92.85
D14	Surf A	J63	9	C	91.91
D14	Surf A	J63	9	C	95.08
D14	Surf A	J63	10	C	94.87
D14	Surf A	J63	10	C	92.99
D14	Surf A	J63	10	C	94.26
D14	Surf A	J63	10	C	92.30
D14	Surf A	J63	10	C	92.46
D14	Surf A	J63	10	C	93.52
D14	Surf A	J63	10	C	93.60
D14	Surf A	J63	10	C	93.60
D14	Surf A	J63	11	C	93.60
D14	Surf A	J63	11	C	94.17
D14	Surf A	J63	11	C	94.42
D14	Surf A	J63	11	C	93.68
D14	Surf A	J63	11	C	93.36
D14	Surf A	J63	11	C	93.40
D14	Surf A	J63	11	C	94.09
D14	Surf A	J63	11	C	92.42
D14	Surf A	J63	11	C	93.89
D14	Surf A	J63	11	C	93.84
D14	Surf A	J63	12	C	92.01
D14	Surf A	J63	12	C	94.13
D14	Surf A	J63	12	C	94.42
D14	Surf A	J63	12	C	94.50
D14	Surf A	J63	13	C	94.62
D14	Surf A	J63	13	C	92.71
D14	Surf A	J63	13	C	93.44
D14	Surf A	J63	13	C	93.97
D14	Surf A	J63	13	C	92.18
D14	Surf A	J63	13	C	93.68
D14	Surf A	J63	14	C	92.43
D14	Surf A	J63	14	C	93.00
D14	Surf A	J63	14	C	90.81
D14	Surf A	J63	14	C	91.13
D14	Surf A	J63	14	C	95.08
D14	Surf A	J63	14	C	92.92
D14	Surf A	J63	15	C	91.55
D14	Surf A	J63	15	C	94.86
D14	Surf A	J63	15	C	91.19
D14	Surf A	J63	15	C	92.82
D14	Surf A	J63	15	C	92.66
D14	Surf A	J63	15	C	92.29
D14	Surf A	J63	16	C	94.73
D14	Surf A	J63	16	C	92.52
D14	Surf A	J63	16	C	92.36
D14	Surf A	J63	16	C	93.58
D14	Surf A	J63	16	C	94.03
D14	Surf A	J63	17	C	94.57
D14	Surf A	J63	17	C	93.59
D14	Surf A	J63	17	C	94.93
D14	Surf A	J63	17	C	94.69
D14	Surf A	J63	17	C	94.36
D14	Surf A	J63	17	C	93.75
D14	Surf A	J63	17	C	93.75
D14	Surf A	J63	18	C	92.90
D14	Surf A	J63	18	C	92.94
D14	Surf A	J63	18	C	93.39
D14	Surf A	J63	18	C	94.21
D14	Surf A	J63	18	C	94.82
D14	Surf A	J63	18	C	94.70
D14	Surf A	J63	18	C	91.80
D14	Surf A	J63	18	C	93.39
D14	Surf A	J63	19	C	93.83
D14	Surf A	J63	19	C	93.67
D14	Surf A	J63	19	C	92.81
D14	Surf A	J63	19	C	93.06
D14	Surf A	J63	19	C	92.49
D14	Surf A	J63	20	C	93.67
D14	Surf A	J63	20	C	94.12
D14	Surf A	J63	20	C	95.50
D14	Surf A	J63	20	C	94.89
D14	Surf A	J63	20	C	94.77
D14	Surf A	J63	21	C	93.43
D14	Surf A	J63	21	C	92.62
D14	Surf A	J63	21	C	95.27
D14	Surf A	J63	21	C	94.25
D14	Surf A	J63	21	C	93.35
D14	Surf A	J63	21	C	93.52
D14	Surf A	J63	21	C	93.64
D14	Surf A	J63	21	C	94.17
D14	Surf A	J63	21	C	94.05
D14	Surf A	J63	21	C	94.17
D14	Surf A	J63	21	C	93.56
D14	Surf A	J63	21	C	94.74

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D14	Surf A	J63	22	C	96.20
D14	Surf A	J63	22	C	95.38
D14	Surf A	J63	22	C	96.77
D14	Surf A	J63	22	C	94.32
D14	Surf A	J63	22	C	94.65
D14	Surf A	J63	22	C	96.81
D14	Surf A	J63	22	C	96.69
D14	Surf A	J63	22	C	96.61
D14	Surf A	J63	22	C	96.00
D14	Surf A	J63	22	C	96.16
D14	Surf A	J63	22	C	95.83
D14	Surf A	J63	23	C	93.24
D14	Surf A	J63	23	C	94.54
D14	Surf A	J63	23	C	95.03
D14	Surf A	J63	23	C	95.03
D14	Surf A	J63	24	C	93.90
D14	Surf A	J63	24	C	93.78
D14	Surf A	J63	24	C	96.14
D14	Surf A	J63	24	C	96.02
D14	Surf A	J63	24	C	95.61
D14	Surf A	J63	24	C	95.73
D14	Surf A	J63	24	C	95.00
D14	Surf A	J63	24	C	95.21
D14	Surf A	J63	25	C	96.05
D14	Surf A	J63	25	C	95.07
D14	Surf A	J63	25	C	95.23
D14	Surf A	J63	25	C	93.85
D14	Surf A	J63	26	C	93.99
D14	Surf A	J63	26	C	94.76
D14	Surf A	J63	26	C	95.82
D14	Surf A	J63	26	C	95.49
D14	Surf A	J63	26	C	96.10
D14	Surf A	J63	26	C	97.20
D14	Surf A	J63	26	C	94.07
D14	Surf A	J63	26	C	92.81
D16	Base A	J77	1	G	100.71
D16	Base A	J77	1	G	100.56
D16	Base A	J77	1	G	99.51
D16	Base A	J77	1	G	99.44
D16	Base A	J77	1	G	98.87
D16	Base A	J77	1	G	101.91
D16	Base A	J77	1	G	99.01
D16	Base A	J77	1	G	99.36

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D16	Base A	J77	1	G	100.71
D16	Base A	J77	1	G	99.93
D16	Base A	J77	2	G	100.69
D16	Base A	J77	2	G	99.52
D16	Base A	J77	2	G	101.86
D16	Base A	J77	2	G	101.38
D16	Base A	J77	2	G	99.31
D16	Base A	J77	2	G	100.14
D16	Base A	J77	2	G	102.69
D16	Base A	J77	2	G	99.66
D16	Base A	J77	2	G	100.69
D16	Base A	J77	2	G	100.14
D16	Base A	J77	3	G	99.03
D16	Base A	J77	3	G	101.93
D16	Base A	J77	3	G	100.62
D16	Base A	J77	3	G	98.55
D16	Base A	J77	3	G	98.83
D16	Base A	J77	3	G	99.24
D16	Base A	J77	3	G	101.66
D16	Base A	J77	3	G	99.31
D16	Base A	J77	3	G	98.69
D16	Base A	J77	3	G	97.79
D16	Base A	J77	4	G	99.59
D16	Base A	J77	4	G	98.00
D16	Base A	J77	4	G	98.21
D16	Base A	J77	4	G	99.72
D16	Base A	J77	4	G	100.41
D16	Base A	J77	4	G	97.52
D16	Base A	J77	4	G	98.69
D16	Base A	J77	4	G	98.69
D16	Base A	J77	4	G	100.14
D16	Base A	J77	4	G	99.17
D16	Base A	J77	5	G	97.03
D16	Base A	J77	5	G	98.55
D16	Base A	J77	5	G	98.41
D16	Base A	J77	5	G	99.10
D16	Base A	J77	5	G	99.93
D16	Base A	J77	5	G	96.34
D16	Base A	J77	5	G	99.59
D16	Base A	J77	5	G	98.41
D16	Base A	J77	5	G	98.00
D16	Base A	J77	5	G	100.28
D16	Base A	J77	5	G	98.60

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D16	Base A	J77	6	G	99.38
D16	Base A	J77	6	G	100.28
D16	Base A	J77	6	G	97.24
D16	Base A	J77	6	G	98.62
D16	Base A	J77	6	G	96.69
D16	Base A	J77	6	G	96.83
D16	Base A	J77	6	G	97.31
D16	Base A	J77	6	G	100.69
D16	Base A	J77	6	G	101.10
D16	Base A	J77	6	G	97.59
D16	Base A	J77	6	G	98.60
D16	Base A	J77	7	G	99.17
D16	Base A	J77	7	G	98.90
D16	Base A	J77	7	G	100.48
D16	Base A	J77	7	G	99.66
D16	Base A	J77	7	G	97.10
D16	Base A	J77	7	G	97.10
D16	Base A	J77	7	G	101.38
D16	Base A	J77	7	G	100.14
D16	Base A	J77	7	G	98.21
D16	Base A	J77	7	G	96.55
D16	Base A	J77	8	G	97.31
D16	Base A	J77	8	G	98.97
D16	Base A	J77	8	G	99.38
D16	Base A	J77	8	G	99.24
D16	Base A	J77	8	G	97.31
D16	Base A	J77	8	G	98.00
D16	Base A	J77	8	G	97.86
D16	Base A	J77	8	G	101.24
D16	Base A	J77	8	G	98.83
D16	Base A	J77	8	G	98.28
D16	Base A	J77	9	G	99.24
D16	Base A	J77	9	G	98.00
D16	Base A	J77	9	G	97.93
D16	Base A	J77	9	G	97.93
D16	Base A	J77	9	G	98.62
D16	Base A	J77	9	G	100.55
D16	Base A	J77	9	G	98.97
D16	Base A	J77	9	G	99.72
D16	Base A	J77	9	G	100.90
D16	Base A	J77	9	G	100.07
D16	Base A	J77	10	G	96.62
D16	Base A	J77	10	G	100.90
D16	Base A	J77	10	G	100.14
D16	Base A	J77	10	G	98.00
D16	Base A	J77	10	G	99.38
D16	Base A	J77	10	G	99.10
D16	Base A	J77	10	G	100.34
D16	Base A	J77	10	G	98.55
D16	Base A	J77	10	G	98.48
D16	Base A	J77	10	G	98.34
D16	Base A	J77	11	G	102.96
D16	Base A	J77	11	G	102.27
D16	Base A	J77	11	G	101.21
D16	Base A	J77	11	G	105.91
D16	Base A	J77	11	G	106.52
D16	Base A	J77	11	G	107.58
D16	Base A	J77	11	G	108.64
D16	Base A	J77	11	G	106.22
D16	Base A	J77	11	G	93.86
D16	Base A	J77	11	G	98.79
D16	Base A	J77	12	G	94.49
D16	Base A	J77	12	G	101.88
D16	Base A	J77	12	G	98.33
D16	Base A	J77	12	G	101.95
D16	Base A	J77	12	G	101.67
D16	Base A	J77	12	G	100.98
D16	Base A	J77	12	G	100.84
D16	Base A	J77	12	G	96.23
D16	Base A	J77	12	G	99.93
D16	Base A	J77	12	G	101.12
D16	Base A	J77	13	G	99.38
D16	Base A	J77	13	G	99.31
D16	Base A	J77	13	G	99.17
D16	Base A	J77	13	G	101.31
D16	Base A	J77	13	G	100.34
D16	Base A	J77	13	G	97.72
D16	Base A	J77	13	G	102.00
D16	Base A	J77	13	G	98.41
D16	Base A	J77	13	G	97.31
D16	Base A	J77	13	G	99.10
D16	Base A	J77	14	G	98.28
D16	Base A	J77	14	G	99.31
D16	Base A	J77	14	G	98.14
D16	Base A	J77	14	G	101.79
D16	Base A	J77	14	G	95.86

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D16	Base A	J77	14	G	100.55
D16	Base A	J77	14	G	99.10
D16	Base A	J77	14	G	98.00
D16	Base A	J77	14	G	100.34
D16	Base A	J77	14	G	99.17
D16	Base A	J77	15	G	101.17
D16	Base A	J77	15	G	98.21
D16	Base A	J77	15	G	100.14
D16	Base A	J77	15	G	100.00
D16	Base A	J77	15	G	101.31
D16	Base A	J77	15	G	100.69
D16	Base A	J77	15	G	100.90
D16	Base A	J77	15	G	99.93
D16	Base A	J77	15	G	96.69
D16	Base A	J77	15	G	98.97
D16	Base A	J77	16	G	101.45
D16	Base A	J77	16	G	98.90
D16	Base A	J77	16	G	97.17
D16	Base A	J77	16	G	98.41
D16	Base A	J77	16	G	100.34
D16	Base A	J77	16	G	96.55
D16	Base A	J77	16	G	95.52
D16	Base A	J77	16	G	102.41
D16	Base A	J77	16	G	99.52
D16	Base A	J77	16	G	100.41
D16	Base A	J77	17	G	97.66
D16	Base A	J77	17	G	102.00
D16	Base A	J77	17	G	99.86
D16	Base A	J77	17	G	101.17
D16	Base A	J77	17	G	99.45
D16	Base A	J77	17	G	99.93
D16	Base A	J77	17	G	98.83
D16	Base A	J77	17	G	99.79
D16	Base A	J77	17	G	99.45
D16	Base A	J77	17	G	101.45
D16	Base A	J78	1	G	96.76
D16	Base A	J78	1	G	100.14
D16	Base A	J78	1	G	99.52
D16	Base A	J78	1	G	98.97
D16	Base A	J78	1	G	101.24
D16	Base A	J78	1	G	102.34
D16	Base A	J78	1	G	97.59
D16	Base A	J78	1	G	102.55

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D16	Base A	J78	1	G	100.14
D16	Base A	J78	2	G	100.62
D16	Base A	J78	2	G	99.45
D16	Base A	J78	2	G	100.76
D16	Base A	J78	2	G	98.14
D16	Base A	J78	2	G	100.07
D16	Base A	J78	2	G	100.69
D16	Base A	J78	2	G	102.55
D16	Base A	J78	2	G	102.48
D16	Base A	J78	2	G	102.07
D16	Base A	J78	2	G	102.14
D16	Base A	J78	3	G	100.14
D16	Base A	J78	3	G	98.85
D16	Base A	J78	3	G	99.07
D16	Base A	J78	3	G	101.79
D16	Base A	J78	3	G	101.36
D16	Base A	J78	3	G	100.22
D16	Base A	J78	3	G	100.57
D16	Base A	J78	3	G	102.58
D16	Base A	J78	3	G	98.21
D16	Base A	J78	3	G	97.78
D16	Surf C	J79	1	G	97.48
D16	Surf C	J79	1	G	100.70
D16	Surf C	J79	1	G	98.46
D16	Surf C	J79	1	G	100.70
D16	Surf C	J79	1	G	101.05
D16	Surf C	J79	1	G	98.95
D16	Surf C	J79	1	G	101.33
D16	Surf C	J79	1	G	99.79
D16	Surf C	J79	1	G	100.91
D16	Surf C	J79	1	G	102.10
D16	Surf C	J79	1	G	100.10
D16	Surf C	J79	2	G	97.90
D16	Surf C	J79	2	G	101.46
D16	Surf C	J79	2	G	98.18
D16	Surf C	J79	2	G	100.70
D16	Surf C	J79	2	G	98.04
D16	Surf C	J79	2	G	98.60
D16	Surf C	J79	2	G	99.37
D16	Surf C	J79	2	G	97.69
D16	Surf C	J79	2	G	100.07
D16	Surf C	J79	2	G	97.20
D16	Surf C	J80	1	G	101.17

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D16	Surf C	J80	1	G	100.96
D16	Surf C	J80	1	G	101.79
D16	Surf C	J80	1	G	100.34
D16	Surf C	J80	1	G	99.24
D16	Surf C	J80	1	G	99.31
D16	Surf C	J80	1	G	101.03
D16	Surf C	J80	1	G	99.10
D16	Surf C	J80	1	G	100.14
D16	Surf C	J80	1	G	99.66
D16	Surf C	J80	2	G	94.42
D16	Surf C	J80	2	G	98.69
D16	Surf C	J80	2	G	100.48
D16	Surf C	J80	2	G	98.41
D16	Surf C	J80	2	G	96.76
D16	Surf C	J80	2	G	96.90
D16	Surf C	J80	2	G	97.73
D16	Surf C	J80	2	G	96.07
D16	Surf C	J80	2	G	100.07
D16	Surf C	J80	2	G	97.24
D16	Surf C	J80	2	G	97.70
D16	Surf C	J80	3	G	97.48
D16	Surf C	J80	3	G	101.96
D16	Surf C	J80	3	G	96.78
D16	Surf C	J80	3	G	101.89
D16	Surf C	J80	3	G	98.04
D16	Surf C	J80	3	G	101.96
D16	Surf C	J80	3	G	95.87
D16	Surf C	J80	3	G	99.58
D16	Surf C	J80	3	G	102.45
D16	Surf C	J80	3	G	100.63
D16	Surf C	J80	4	G	99.58
D16	Surf C	J80	4	G	99.51
D16	Surf C	J80	4	G	96.57
D16	Surf C	J80	4	G	98.95
D16	Surf C	J80	4	G	98.81
D16	Surf C	J80	4	G	99.09
D16	Surf C	J80	4	G	97.27
D16	Surf C	J80	4	G	99.44
D16	Surf C	J80	4	G	102.52
D16	Surf C	J80	4	G	99.86
D17	Surf C	J81	8	C	91.43
D17	Surf C	J81	8	C	92.77
D17	Surf C	J81	8	C	91.14

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D17	Surf C	J81	8	C	90.53
D17	Surf C	J81	11	C	92.42
D17	Surf C	J81	11	C	90.84
D17	Surf C	J81	11	C	91.12
D17	Surf C	J81	11	C	92.67
D17	Surf C	J81	11	C	93.24
D17	Surf C	J81	13	C	90.57
D17	Surf C	J81	13	C	91.50
D17	Surf C	J81	13	C	91.83
D17	Surf C	J81	13	C	92.03
D17	Surf C	J81	13	C	92.80
D17	Surf C	J81	13	C	92.84
D17	Surf C	J81	13	C	90.77
D17	Surf C	J81	13	C	91.38
D17	Surf C	J81	13	C	91.74
D17	Surf C	J81	14	C	91.62
D17	Surf C	J81	14	C	92.11
D17	Surf C	J81	14	C	90.97
D17	Surf C	J81	14	C	91.50
D17	Surf C	J81	14	C	91.17
D17	Surf C	J81	15	C	91.85
D17	Surf C	J81	15	C	92.78
D17	Surf C	J81	15	C	92.17
D17	Surf C	J82	1	C	93.13
D17	Surf C	J82	1	C	91.02
D17	Surf C	J82	1	C	87.85
D17	Surf C	J82	1	C	91.02
D17	Surf C	J82	1	C	92.40
D17	Surf C	J82	1	C	91.79
D17	Surf C	J82	1	C	92.32
D17	Surf C	J82	2	C	93.56
D17	Surf C	J82	2	C	92.91
D17	Surf C	J82	2	C	92.78
D18	Surf B	J84	7	C	92.47
D18	Surf B	J84	7	C	91.49
D18	Surf B	J84	7	C	92.99
D18	Surf B	J84	7	C	92.18
D18	Surf B	J84	7	C	92.95
D18	Surf B	J84	7	C	93.76
D18	Surf B	J84	7	C	91.58
D18	Surf B	J84	8	C	91.97
D18	Surf B	J84	8	C	89.70
D18	Surf B	J84	8	C	93.76

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D18	Surf B	J84	8	C	93.96
D18	Surf B	J84	8	C	91.89
D18	Surf B	J84	8	C	90.55
D18	Surf B	J84	8	C	92.54
D18	Surf B	J84	8	C	92.42
D18	Surf B	J84	9	C	91.89
D18	Surf B	J84	9	C	92.01
D18	Surf B	J84	9	C	94.24
D18	Surf B	J84	9	C	91.65
D18	Surf B	J84	9	C	93.03
D18	Surf B	J84	9	C	91.73
D18	Surf B	J84	9	C	92.62
D18	Surf B	J84	9	C	94.04
D18	Surf B	J84	10	C	92.34
D18	Surf B	J84	10	C	93.51
D18	Surf B	J84	10	C	94.93
D18	Surf B	J84	10	C	91.85
D18	Surf B	J84	10	C	92.58
D18	Surf B	J84	10	C	92.82
D18	Surf B	J84	10	C	93.59
D18	Surf B	J84	10	C	93.35
D18	Surf B	J84	10	C	93.27
D18	Surf B	J84	10	C	93.19
D18	Surf B	J84	11	C	90.19
D18	Surf B	J84	11	C	94.81
D18	Surf B	J84	11	C	95.06
D18	Surf B	J84	11	C	92.91
D18	Surf B	J84	11	C	92.34
D18	Surf B	J84	11	C	94.21
D18	Surf B	J84	11	C	93.31
D18	Surf B	J84	11	C	91.09
D18	Surf B	J84	11	C	92.14
D18	Surf B	J84	12	C	93.30
D18	Surf B	J84	12	C	93.75
D18	Surf B	J84	12	C	93.18
D18	Surf B	J84	12	C	93.63
D18	Surf B	J84	12	C	92.57
D18	Surf B	J84	12	C	91.35
D18	Surf B	J84	12	C	90.91
D18	Surf B	J84	12	C	93.46
D18	Surf B	J84	12	C	92.61
D18	Surf B	J84	13	C	94.33
D18	Surf B	J84	13	C	93.27
D18	Surf B	J84	13	C	93.88
D18	Surf B	J84	13	C	92.54
D18	Surf B	J84	14	C	95.70
D18	Surf B	J84	14	C	94.85
D18	Surf B	J84	14	C	94.28
D18	Surf B	J84	14	C	93.91
D18	Surf B	J84	14	C	94.60
D18	Surf B	J84	14	C	93.96
D18	Surf B	J84	15	C	94.78
D18	Surf B	J84	15	C	94.25
D18	Surf B	J84	15	C	93.60
D18	Surf B	J84	15	C	94.53
D18	Surf B	J84	15	C	92.59
D18	Surf B	J84	15	C	93.32
D18	Surf B	J84	15	C	94.13
D18	Surf B	J84	15	C	94.41
D18	Surf B	J84	15	C	94.25
D18	Surf B	J84	15	C	93.88
D18	Surf B	J84	16	C	92.41
D18	Surf B	J84	16	C	93.10
D18	Surf B	J84	16	C	93.87
D18	Surf B	J84	16	C	92.78
D18	Surf B	J84	16	C	92.49
D18	Surf B	J84	16	C	92.21
D18	Surf B	J84	16	C	92.62
D18	Surf B	J84	16	C	93.35
D18	Surf B	J84	16	C	93.43
D18	Surf B	J84	16	C	93.10
D18	Surf B	J84	17	C	94.33
D18	Surf B	J84	17	C	93.11
D18	Surf B	J84	17	C	92.30
D18	Surf B	J84	17	C	93.97
D18	Surf B	J84	17	C	94.29
D18	Surf B	J84	17	C	93.16
D18	Surf B	J84	17	C	94.17
D18	Surf B	J84	17	C	92.39
D18	Surf B	J84	18	C	93.31
D18	Surf B	J84	18	C	93.51
D18	Surf B	J84	18	C	94.04
D18	Surf B	J84	18	C	93.92
D18	Surf B	J84	18	C	92.95
D18	Surf B	J84	18	C	93.68
D18	Surf B	J84	18	C	93.80

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D18	Surf B	J84	18	C	92.74
D18	Surf B	J84	19	C	94.04
D18	Surf B	J84	19	C	93.72
D18	Surf B	J84	19	C	94.45
D18	Surf B	J84	19	C	92.78
D18	Surf B	J84	19	C	94.81
D18	Surf B	J84	19	C	92.74
D18	Surf B	J84	19	C	93.55
D18	Surf B	J84	19	C	93.23
D18	Surf B	J84	20	C	93.97
D18	Surf B	J84	20	C	92.72
D18	Surf B	J84	20	C	92.03
D18	Surf B	J84	20	C	93.28
D18	Surf B	J84	20	C	93.40
D18	Surf B	J84	20	C	94.37
D18	Surf B	J84	20	C	93.89
D18	Surf B	J84	21	C	94.33
D18	Surf B	J84	21	C	93.48
D18	Surf B	J84	21	C	93.52
D18	Surf B	J84	21	C	93.61
D18	Surf B	J84	21	C	93.32
D18	Surf B	J84	21	C	93.00
D18	Surf B	J84	21	C	92.88
D18	Surf B	J84	22	C	94.05
D18	Surf B	J84	22	C	93.93
D18	Surf B	J84	22	C	93.48
D18	Surf B	J84	22	C	92.27
D18	Surf B	J84	22	C	94.09
D18	Surf B	J84	22	C	92.87
D18	Surf B	J84	22	C	93.85
D18	Surf B	J84	22	C	93.08
D18	Surf B	J84	23	C	90.94
D18	Surf B	J84	23	C	92.96
D18	Surf B	J84	23	C	93.24
D18	Surf B	J84	23	C	92.92
D18	Surf A	J85	1	C	93.36
D18	Surf A	J85	1	C	92.59
D18	Surf A	J85	1	C	91.86
D18	Surf A	J85	1	C	93.40
D18	Surf A	J85	2	C	92.15
D18	Surf A	J85	2	C	93.61
D18	Surf A	J85	2	C	92.11
D18	Surf A	J85	2	C	93.40
D18	Surf A	J85	2	C	92.03
D18	Surf A	J85	3	C	92.75
D18	Surf A	J85	3	C	91.33
D18	Surf A	J85	3	C	94.29
D18	Surf A	J85	3	C	91.54
D18	Surf A	J85	3	C	94.49
D18	Surf A	J85	4	C	93.28
D18	Surf A	J85	4	C	95.22
D18	Surf A	J85	4	C	95.51
D18	Surf A	J85	4	C	93.08
D18	Surf A	J85	4	C	92.47
D18	Surf A	J85	5	C	92.67
D18	Surf A	J85	5	C	92.26
D18	Surf A	J85	5	C	94.04
D18	Surf A	J85	5	C	93.64
D18	Surf A	J85	5	C	94.61
D18	Surf A	J85	6	C	93.11
D18	Surf A	J85	6	C	93.88
D18	Surf A	J85	6	C	91.82
D18	Surf A	J85	6	C	91.65
D18	Surf A	J85	6	C	93.40
D18	Surf A	J85	7	C	93.64
D18	Surf A	J85	7	C	93.48
D18	Surf A	J85	7	C	93.88
D18	Surf A	J85	7	C	93.56
D18	Surf A	J85	7	C	93.76
D18	Surf A	J85	8	C	94.70
D18	Surf A	J85	8	C	93.72
D18	Surf A	J85	8	C	93.64
D18	Surf A	J85	8	C	90.65
D18	Surf A	J85	8	C	93.77
D18	Surf A	J85	9	C	92.83
D18	Surf A	J85	9	C	94.00
D18	Surf A	J85	9	C	94.04
D18	Surf A	J85	9	C	94.69
D18	Surf A	J85	9	C	94.65
D18	Surf A	J85	10	C	94.82
D18	Surf A	J85	10	C	93.57
D18	Surf A	J85	10	C	94.86
D18	Surf A	J85	10	C	93.40
D18	Surf A	J85	10	C	92.43
D18	Surf A	J85	10	C	92.96
D18	Surf A	J85	11	C	94.05

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D18	Surf A	J85	11	C	93.48
D18	Surf A	J85	11	C	93.00
D18	Surf A	J85	11	C	93.04
D18	Surf A	J85	11	C	94.01
D18	Surf A	J85	11	C	92.96
D18	Surf A	J85	12	C	90.74
D18	Surf A	J85	12	C	92.56
D18	Surf A	J85	12	C	93.41
D18	Surf A	J85	12	C	93.61
D18	Surf A	J85	12	C	93.77
D18	Surf A	J85	12	C	93.89
D18	Surf A	J85	13	C	93.16
D18	Surf A	J85	13	C	94.09
D18	Surf A	J85	13	C	93.16
D18	Surf A	J85	13	C	93.64
D18	Surf A	J85	13	C	94.53
D18	Surf A	J85	14	C	92.65
D18	Surf A	J85	14	C	92.77
D18	Surf A	J85	14	C	94.43
D18	Surf A	J85	14	C	92.28
D18	Surf A	J85	14	C	93.78
D18	Surf A	J85	14	C	93.62
D18	Surf A	J85	14	C	95.37
D18	Surf A	J85	14	C	91.87
D18	Surf A	J85	15	C	94.21
D18	Surf A	J85	15	C	93.32
D18	Surf A	J85	15	C	92.67
D18	Surf A	J85	15	C	92.67
D18	Surf A	J85	15	C	92.02
D18	Surf A	J85	15	C	93.24
D18	Surf A	J85	15	C	92.15
D18	Surf A	J85	16	C	93.15
D18	Surf A	J85	16	C	92.62
D18	Surf A	J85	16	C	93.63
D18	Surf A	J85	16	C	93.63
D18	Surf A	J85	16	C	92.01
D18	Surf A	J85	16	C	92.70
D18	Surf A	J85	17	C	92.34
D18	Surf A	J85	17	C	92.38
D18	Surf A	J85	17	C	93.43
D18	Surf A	J85	17	C	93.31
D18	Surf A	J85	17	C	93.80
D18	Surf A	J85	17	C	92.94

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D18	Surf A	J85	18	C	91.60
D18	Surf A	J85	18	C	92.90
D18	Surf A	J85	18	C	92.01
D18	Surf A	J85	18	C	95.01
D18	Surf A	J85	18	C	92.70
D18	Surf A	J85	18	C	92.17
D18	Surf A	J85	18	C	92.49
D18	Surf A	J85	19	C	93.75
D18	Surf A	J85	19	C	92.78
D18	Surf A	J85	19	C	93.95
D18	Surf A	J85	19	C	91.96
D18	Surf A	J85	19	C	91.40
D18	Surf A	J85	20	C	94.40
D18	Surf A	J85	20	C	92.49
D18	Surf A	J85	20	C	94.85
D18	Surf A	J85	20	C	92.49
D18	Surf A	J85	20	C	94.72
D18	Surf A	J85	20	C	93.47
D18	Surf A	J85	20	C	91.96
D18	Surf A	J85	20	C	92.86
D18	Surf A	J85	20	C	92.00
D18	Surf A	J85	21	C	93.88
D18	Surf A	J85	21	C	92.50
D18	Surf A	J85	21	C	93.67
D18	Surf A	J85	22	C	92.83
D18	Surf A	J85	22	C	94.53
D18	Surf A	J85	22	C	92.55
D18	Surf A	J85	22	C	92.47
D18	Surf A	J85	22	C	91.86
D18	Surf A	J85	22	C	93.85
D18	Surf A	J85	22	C	92.71
D18	Surf A	J85	22	C	92.96
D18	Surf A	J85	22	C	93.28
D18	Surf A	J85	23	C	92.82
D18	Surf A	J85	23	C	93.43
D18	Surf A	J85	23	C	91.27
D18	Surf A	J85	23	C	92.41
D18	Surf A	J85	23	C	89.29
D18	Surf A	J85	23	C	91.64
D18	Surf A	J85	23	C	93.14
D19	Surf B	J86	11	C	93.13
D19	Surf B	J86	11	C	92.40
D19	Surf B	J86	11	C	92.48

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.	Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D19	Surf B	J86	11	C	92.97	D19	Surf B	J86	21	C	93.80
D19	Surf B	J86	11	C	94.03	D19	Surf B	J86	21	C	92.13
D19	Surf B	J86	11	C	94.20	D19	Surf B	J86	22	C	94.66
D19	Surf B	J86	11	C	93.18	D19	Surf B	J86	22	C	93.88
D19	Surf B	J86	11	C	90.40	D19	Surf B	J86	22	C	92.21
D19	Surf B	J86	12	C	93.09	D19	Surf B	J86	23	C	94.46
D19	Surf B	J86	12	C	93.17	D19	Surf B	J86	23	C	93.19
D19	Surf B	J86	12	C	93.17	D19	Surf B	J86	23	C	91.97
D19	Surf B	J86	12	C	94.15	D19	Surf B	J86	23	C	91.93
D19	Surf B	J86	12	C	93.29	D19	Surf B	J86	23	C	93.76
D19	Surf B	J86	12	C	92.68	D19	Surf B	J86	23	C	93.03
D19	Surf B	J86	13	C	94.03	D19	Surf B	J86	23	C	94.33
D19	Surf B	J86	13	C	93.25	D19	Surf B	J86	23	C	94.62
D19	Surf B	J86	13	C	91.53	D19	Surf B	J86	24	C	96.78
D19	Surf B	J86	13	C	93.78	D19	Surf B	J86	24	C	93.06
D19	Surf B	J86	13	C	92.64	D19	Surf B	J86	24	C	93.80
D19	Surf B	J86	13	C	93.87	D19	Surf B	J86	24	C	94.61
D19	Surf B	J86	13	C	93.21	D19	Surf B	J86	25	C	91.69
D19	Surf B	J86	13	C	91.00	D19	Surf B	J86	25	C	93.24
D19	Surf B	J86	14	C	94.23	D19	Surf B	J86	25	C	92.99
D19	Surf B	J86	14	C	94.31	D19	Surf B	J86	25	C	91.85
D19	Surf B	J86	14	C	93.13	D19	Surf B	J86	26	C	95.47
D19	Surf B	J86	14	C	91.90	D19	Surf B	J86	26	C	91.85
D19	Surf B	J86	14	C	94.15	D19	Surf B	J86	26	C	92.42
D19	Surf B	J86	15	C	93.06	D19	Surf B	J86	26	C	91.77
D19	Surf B	J86	15	C	93.72	D19	Surf B	J86	27	C	94.75
D19	Surf B	J86	15	C	93.10	D19	Surf B	J86	27	C	94.14
D19	Surf B	J86	15	C	92.94	D19	Surf B	J86	27	C	94.71
D19	Surf B	J86	18	C	91.59	D19	Surf B	J86	27	C	94.75
D19	Surf B	J86	18	C	91.10	D19	Surf B	J86	27	C	94.46
D19	Surf B	J86	18	C	94.61	D19	Surf B	J86	27	C	94.50
D19	Surf B	J86	18	C	91.88	D19	Surf B	J86	27	C	93.69
D19	Surf B	J86	18	C	95.76	D19	Surf B	J86	28	C	93.88
D19	Surf B	J86	18	C	94.00	D19	Surf B	J86	28	C	92.62
D19	Surf B	J86	18	C	94.20	D19	Surf B	J86	28	C	93.23
D19	Surf B	J86	19	C	93.22	D19	Surf B	J86	28	C	92.62
D19	Surf B	J86	19	C	94.45	D19	Surf B	J86	28	C	93.06
D19	Surf B	J86	19	C	95.59	D19	Surf B	J86	28	C	94.53
D19	Surf B	J86	19	C	95.43	D19	Surf B	J86	28	C	94.49
D19	Surf B	J86	19	C	94.69	D19	Surf B	J86	28	C	92.70
D19	Surf B	J86	19	C	91.59	D19	Surf B	J86	28	C	94.49
D19	Surf B	J86	21	C	93.07	D19	Surf B	J86	30	C	93.64
D19	Surf B	J86	21	C	93.97	D19	Surf B	J86	30	C	93.19

Table B.1. Density Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	Core/ Gage	Den.
D19	Surf B	J86	30	C	93.10
D19	Surf B	J86	30	C	92.86
D19	Surf B	J86	30	C	93.23
D19	Surf B	J86	30	C	93.68
D19	Inter C	J88	17	C	94.34
D19	Inter C	J88	17	C	94.42
D19	Inter C	J88	17	C	91.86
D19	Inter C	J88	17	C	95.97
D19	Inter C	J88	17	C	94.22
D19	Inter C	J88	17	C	92.87
D19	Inter C	J88	17	C	92.63
D19	Inter C	J88	17	C	94.58
D19	Inter C	J88	17	C	94.30
D19	Inter C	J88	17	C	94.67
D19	Inter C	J88	18	C	94.28
D19	Inter C	J88	18	C	94.24
D19	Inter C	J88	18	C	94.20
D19	Inter C	J88	18	C	94.28
D19	Inter C	J88	18	C	94.00
D19	Inter C	J88	19	C	93.42
D19	Inter C	J88	19	C	93.87
D19	Inter C	J88	19	C	93.66
D19	Inter C	J88	19	C	94.03
D19	Inter C	J88	19	C	91.35
D19	Inter C	J88	19	C	94.76
D19	Inter C	J88	19	C	92.04
D19	Inter C	J88	19	C	94.35
D19	Inter C	J88	21	C	93.65
D19	Inter C	J88	21	C	94.02
D19	Inter C	J88	21	C	93.53
D19	Inter C	J88	21	C	95.16
D19	Inter C	J88	21	C	92.88

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APPENDIX C — VERIFICATION TEST RESULT DATA

The following pages present all of the Verification test result data from projects that were provided by SCDOT. The data include asphalt content (AC), air voids (AV), and voids in mineral aggregate (VMA) for both Contractor and SCDOT split sample results.

In the following table, each Project is identified with a unique number, ranging from V01 to V20. Each of these numbered projects corresponds with a unique SCDOT project file number. Since many of the projects had more than 1 HMA mixture on the project, they also had more than 1 job mix formula (JMF) that was placed on the project. In the tables, each JMF is identified with a unique number, ranging from J01 to J94.

Table C.1. Verification Test Results Data

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V01	Surf B	J01	11	5.09	4.99	2.42	3.47	14.22	14.93	
V01	Surf B	J01	11	5.17	*5.22*	3.13	*4.20*	15.01	*16.09*	
V01	Surf B	J01	12	4.58	4.79	5.18	5.85	15.62	16.63	
V01	Surf B	J01	14	5.56	5.49	1.28	2.37	14.29	15.11	Y
V01	Surf B	J01	19	5.18	5.17	3.60	4.22	15.43	15.98	
V01	Surf B	J01	20	5.46	5.46	3.38	4.02	15.94	16.46	
V01	Surf B	J01	21	5.66	5.61	2.99	3.77	16.02	16.54	
V01	Surf B	J01	24	5.58	5.54	2.69	3.29	15.62	16.03	
V01	Surf B	J01	25	5.59	5.55	2.40	3.10	15.36	15.89	
V01	Surf B	J01	26	5.36	5.25	4.80	5.27	17.01	17.11	
V01	Surf B	J01	27	5.30	5.10	2.37	3.26	14.70	15.01	
V01	Surf B	J01	30	5.38	5.55	2.91	4.14	15.31	16.79	Y
V01	Surf B	J01	32	5.17	4.99	2.21	2.63	14.26	14.19	
V01	Surf B	J01	33	5.66	5.39	3.63	3.84	16.60	16.14	
V01	Surf B	J01	36	5.32	5.46	3.36	4.09	15.60	16.55	
V01	Surf B	J01	36	5.25	*	2.50	*	14.65	*	
V01	Surf B	J01	39	5.43	5.24	2.59	3.38	15.19	15.45	
V01	Surf B	J01	43	5.35	5.49	3.54	3.54	15.84	16.11	
V01	Surf B	J01	46	5.19	5.47	3.20	3.11	15.16	15.69	
V01	Surf B	J01	47	5.53	5.48	2.19	3.09	15.07	15.71	
V01	Surf B	J01	48	4.97	5.52	2.38	2.80	13.88	15.56	Y
V01	Surf B	J01	51	5.10	5.34	2.76	3.12	14.55	15.43	
V01	Surf B	J01	53	5.26	5.34	3.33	4.34	15.36	16.48	
V01	Surf B	J01	54	5.08	4.99	3.54	4.11	15.22	15.51	
V01	Surf B	J01	55	5.27	5.26	2.68	3.41	14.88	16.50	
V01	Surf B	J01	59	5.08	4.95	3.22	3.56	14.94	14.94	
V01	Surf B	J01	60	5.29	*5.40*	2.31	*2.93*	14.58	*15.35*	
V01	Surf B	J01	61	5.38	*5.28*	2.18	*2.63*	14.64	*14.87*	
V01	Surf B	J01	62	5.30	*5.17*	2.89	*3.49*	15.08	*15.36*	
V01	Surf B	J01	63	5.38	*5.36*	2.14	*3.46*	14.62	*15.80*	
V02	Surf A	J02	1	4.94	4.95	4.48	4.44	15.88	15.88	
V02	Surf A	J02	1	4.48	4.98	4.84	3.59	15.19	15.15	
V02	Surf A	J02	1	5.05	4.97	3.30	3.48	15.06	15.06	
V02	Surf A	J02	2	5.26	5.07	3.84	3.82	16.08	16.61	
V02	Surf A	J02	2	4.85	5.38	3.72	3.70	14.96	16.15	
V02	Surf A	J02	3	5.33	5.21	3.86	4.29	16.2	16.33	
V02	Surf A	J02	3	4.80	4.68	5.43	5.25	16.47	16.07	
V02	Surf A	J02	3	5.03	4.91	4.89	4.81	16.45	15.78	
V02	Surf A	J03	1	4.84	4.85	4.34	4.51	15.58	15.78	
V02	Surf A	J03	1	5.27	5.18	4.85	5.12	16.95	17.00	
V02	Surf A	J03	8	4.79	*4.82*	4.08	*4.10*	15.24	*15.33*	
V02	Surf A	J03	8	4.46	4.89	4.08	4.04	14.42	15.34	
V02	Surf A	J03	9	4.56	*	6.22	*	16.70	*	
V02	Surf A	J03	11	5.19	4.92	3.64	2.98	15.72	14.45	
V02	Surf A	J03	11	5.16	5.17	3.8	2.94	15.84	14.92	
V02	Surf A	J03	11	4.77	5.12	3.74	3.48	14.84	15.37	
V02	Surf A	J03	12	5.57	4.89	1.7	3.53	14.81	14.85	Y
V02	Surf A	J03	13	4.55	*4.80*	4.57	*3.79*	15.04	*14.96*	
V02	Surf A	J03	13	5.07	4.97	3.27	2.47	15.10	14.07	
V02	Surf A	J03	14	5.20	5.04	3.25	3.25	15.31	14.93	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V02	Surf A	J03	14	4.53	4.75	4.87	4.53	15.35	15.51	
V02	Surf A	J03	15	5.47	5.32	3.63	3.79	16.27	16.08	
V02	Surf A	J03	15	4.48	4.73	4.37	4.09	14.75	15.03	
V02	Surf A	J03	15	4.69	5.01	4.29	3.54	15.17	15.17	
V02	Surf A	J03	16	5.16	4.99	2.81	3.33	14.89	14.97	
V02	Surf A	J03	18	5.02	4.99	4.28	4.08	15.85	15.55	
V02	Surf A	J03	19	4.81	5.11	2.90	3.21	14.11	15.12	
V02	Surf A	J03	19	5.22	5.32	2.30	2.78	14.55	15.27	
V02	Surf A	J03	19	5.12	4.69	3.56	3.72	15.44	14.59	
V02	Surf A	J03	20	4.99	4.71	2.34	4.10	14.04	15.01	
V02	Surf A	J03	21	4.72	5.19	3.72	3.67	14.66	15.76	
V03	Surf A	J03	1	4.47	4.62	3.11	3.02	13.56	13.79	
V03	Surf A	J03	6	4.76	5.30	4.36	2.97	15.38	15.29	
V03	Surf A	J03	6	4.88	*4.62*	4.68	*3.93*	15.88	*14.63*	
V03	Surf A	J03	7	5.29	*4.65*	3.21	*3.61*	15.56	*14.42*	
V03	Surf A	J03	8	4.48	4.88	3.96	3.54	14.36	14.90	
V03	Surf A	J03	10	5.17	*5.15*	3.71	*3.14*	15.71	*15.19*	
V03	Surf A	J03	10	4.84	*4.39*	3.96	*3.89*	15.19	*14.11*	
V03	Surf A	J03	11	5.25	*5.14*	2.75	*2.11*	14.98	*14.18*	
V03	Surf A	J03	11	4.82	4.66	4.05	3.40	15.20	14.21	
V03	Surf A	J03	12	4.21	4.88	5.45	3.39	15.10	14.73	
V03	Surf A	J03	12	4.51	5.05	4.20	2.08	14.64	13.98	
V03	Surf A	J03	13	4.20	4.77	4.96	4.53	14.92	15.52	
V03	Surf A	J03	14	5.08	4.51	4.01	3.16	15.79	13.60	
V03	Surf A	J03	15	5.09	4.85	4.01	3.47	15.84	14.71	
V03	Surf A	J03	16	4.28	4.62	4.87	4.00	14.73	14.71	
V03	Surf A	J03	17	4.50	5.01	4.64	4.01	15.01	15.61	
V03	Surf A	J03	18	4.33	4.61	4.19	3.46	14.24	14.71	
V03	Surf A	J03	20	4.51	4.77	4.34	3.36	14.78	14.43	
V03	Surf A	J03	20	4.82	4.97	3.12	2.43	14.34	14.01	
V03	Surf A	J03	20	5.06	4.71	3.44	2.98	15.20	13.95	
V03	Surf A	J03	21	4.51	*4.64*	4.72	*4.24*	15.11	*14.94*	
V03	Surf A	J03	40	4.94	5.36	2.78	2.96	14.29	15.42	
V03	Surf A	J03	41	4.99	5.21	2.26	3.01	13.93	15.15	
V03	Surf A	J03	42	4.89	4.83	3.22	3.57	14.58	14.79	
V03	Surf A	J03	42	5.05	5.05	2.36	2.48	14.16	14.27	
V03	Surf A	J03	43	4.93	5.16	2.38	2.88	13.92	14.97	
V03	Surf A	J03	43	5.36	4.74	2.70	2.58	15.36	13.72	
V03	Surf A	J03	44	5.09	4.97	2.96	3.49	14.84	15.09	
V03	Surf A	J03	44	5.16	4.83	2.46	2.68	14.54	14.02	
V04	Surf B	J01	1	4.96	5.10	4.47	5.30	15.78	16.82	
V04	Surf B	J01	2	5.60	5.59	1.97	2.71	15.00	15.59	
V04	Surf B	J01	3	5.59	5.38	1.79	2.75	14.81	15.16	
V04	Surf B	J01	3	5.48	*	2.23	*	14.98	*	
V04	Surf B	J01	3	5.47	5.19	2.98	2.86	15.62	14.84	
V04	Surf B	J01	5	4.81	4.91	4.55	4.97	15.54	16.11	
V04	Surf B	J01	6	5.61	5.60	2.36	3.50	15.36	16.31	
V04	Surf B	J01	7	5.37	5.26	2.97	3.21	15.39	15.31	
V04	Surf B	J01	8	5.62	5.53	2.62	3.67	15.61	16.35	
V04	Surf B	J01	9	5.08	5.22	2.96	3.57	14.68	15.56	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V04	Surf B	J01	9	5.42	5.15	2.42	3.38	14.99	15.24	
V04	Surf B	J01	10	5.01	5.21	3.54	4.68	15.01	16.51	Y
V04	Surf B	J01	10	5.08	*	3.93	*	15.54	*	
V04	Surf B	J01	10	5.05	5.17	1.51	2.88	13.28	14.83	Y
V04	Surf B	J01	12	5.36	5.43	1.99	2.60	14.46	15.15	
V04	Surf B	J01	14	5.53	5.34	3.94	4.10	16.62	16.33	
V04	Surf B	J01	14	5.48	5.26	3.77	4.40	16.32	16.37	
V04	Surf B	J01	17	5.52	5.51	2.46	2.59	15.24	15.30	
V04	Surf B	J01	17	5.31	5.23	4.52	4.63	16.62	16.47	
V04	Surf B	J01	18	5.10	5.18	1.97	2.67	13.83	14.61	
V04	Surf B	J01	19	5.27	5.45	1.86	2.17	14.18	14.83	
V04	Surf B	J01	20	5.15	5.06	3.18	3.49	15.03	15.04	
V04	Surf B	J01	21	5.50	5.28	3.38	3.64	16.02	15.72	
V04	Surf B	J01	23	5.03	5.05	4.26	4.65	15.76	15.15	
V04	Surf B	J01	24	5.22	5.14	3.51	4.45	15.50	16.17	
V05	Inter C	J07	2	4.94	*	5.21	*	16.43	*	
V05	Inter C	J07	3	5.17	*	5.54	*	17.28	*	
V05	Inter C	J07	3	5.41	*	4.13	*	16.52	*	
V05	Inter C	J07	5	5.44	*	4.29	*	16.72	*	
V05	Inter C	J07	6	4.82	*	5.48	*	16.42	*	
V05	Inter C	J07	12	5.07	*	5.59	*	17.07	*	
V05	Inter C	J07	12	4.91	*	4.90	*	16.11	*	
V05	Inter C	J07	13	5.21	*	3.86	*	15.77	*	
V05	Inter C	J07	14	5.56	*	2.97	*	15.77	*	
V05	Inter C	J07	15	5.18	*	4.78	*	16.55	*	
V05	Inter C	J07	16	5.11	*	5.49	*	17.02	*	
V05	Inter C	J07	17	5.26	*	4.69	*	16.64	*	
V05	Inter C	J07	18	5.42	*	3.86	*	16.26	*	
V05	Inter C	J07	20	5.07	*	4.72	*	16.26	*	
V05	Inter C	J07	20	5.08	*	5.12	*	16.64	*	
V05	Surf B	J08	NA	5.04	*	4.08	*	15.70	*	
V05	Surf B	J08	NA	5.36	*	2.14	*	14.66	*	
V05	Surf B	J08	NA	5.04	*	4.06	*	15.63	*	
V05	Surf B	J08	NA	5.39	*	2.55	*	15.07	*	
V05	Surf B	J08	NA	5.29	*	2.93	*	15.21	*	
V05	Surf B	J08	NA	4.75	*	4.62	*	15.47	*	
V05	Surf B	J08	NA	4.88	*	3.75	*	15.00	*	
V05	Surf B	J08	NA	5.12	*	2.18	*	14.12	*	
V05	Surf B	J08	NA	4.90	*	3.32	*	14.69	*	
V05	Surf B	J09	NA	5.31	*	3.37	*	15.66	*	
V05	Surf B	J09	NA	6.47	*	2.04	*	16.81	*	
V05	Surf B	J09	NA	5.04	*	4.53	*	16.04	*	
V05	Surf B	J09	NA	5.42	*	2.73	*	15.30	*	
V05	Surf B	J09	NA	5.56	*	2.41	*	15.32	*	
V05	Surf B	J09	NA	5.28	*	3.45	*	15.66	*	
V05	Surf B	J09	NA	5.00	*	4.00	*	15.50	*	
V05	Surf B	J09	NA	5.18	*	3.87	*	15.80	*	
V05	Surf B	J09	NA	5.23	*	4.58	*	16.54	*	
V05	Surf B	J09	NA	5.05	*	3.41	*	15.07	*	
V05	Surf E	J10	1	5.88	*	*	*	*	*	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V05	Surf E	J10	2	6.03	*	*	*	*	*	
V05	Surf E	J10	3	5.63	*	*	*	*	*	
V05	Surf E	J10	4	5.51	*	*	*	*	*	
V05	Surf E	J10	5	5.72	*	*	*	*	*	
V05	Surf E	J10	6	5.65	*	*	*	*	*	
V05	Surf E	J10	8	5.86	*	*	*	*	*	
V05	Surf E	J10	8	5.90	*	*	*	*	*	
V05	Surf E	J10	9	5.83	*	*	*	*	*	
V05	Surf E	J11	1	5.87	6.10	*	*	*	*	
V05	Surf E	J11	2	5.79	5.95	*	*	*	*	
V05	Surf E	J11	3	5.81	*	*	*	*	*	
V05	Surf E	J11	4	5.78	*	*	*	*	*	
V06	Surf A	J12	1	5.13	5.04	3.55	4.06	15.19	15.43	
V06	Surf A	J12	1	5.18	5.15	4.44	4.03	16.11	15.63	
V06	Surf A	J12	2	5.24	*	4.33	*	16.16	*	
V06	Surf A	J12	3	4.97	*	4.88	*	16.05	*	
V06	Surf A	J12	4	5.02	*	3.54	*	14.96	*	
V06	Surf A	J12	4	5.09	*	4.00	*	15.55	*	
V06	Surf A	J12	5	5.08	*	3.59	*	15.19	*	
V06	Surf A	J12	6	5.26	*	4.14	*	16.01	*	
V06	Surf A	J12	7	4.99	*	3.37	*	14.75	*	
V06	Surf A	J12	7	5.06	4.95	3.14	2.73	14.72	14.11	
V06	Surf A	J12	8	5.32	5.06	2.24	2.23	14.48	13.91	
V06	Surf A	J12	8	4.99	4.92	2.92	2.92	14.36	14.21	
V06	Surf A	J12	9	4.40	4.89	5.71	3.80	15.56	14.91	
V06	Surf A	J12	9	4.75	5.04	3.81	3.64	14.63	15.09	
V06	Surf A	J12	10	5.12	5.15	3.10	2.81	14.83	14.59	
V06	Surf A	J12	12	5.20	4.98	2.75	3.33	14.71	14.69	
V06	Surf A	J12	12	5.24	5.00	3.92	3.54	15.80	14.91	
V06	Surf A	J12	13	4.79	*	6.14	*	16.77	*	
V06	Surf A	J12	14	4.88	*	4.21	*	15.26	*	
V06	Surf A	J12	14	5.24	4.93	5.01	4.32	16.74	15.43	
V06	Surf A	J12	15	5.29	5.15	2.37	2.61	14.55	14.40	
V06	Surf A	J12	15	5.08	4.96	2.56	2.54	14.21	13.92	
V06	Surf A	J12	16	4.97	4.70	3.71	3.40	15.04	14.16	
V06	Surf A	J12	17	5.19	5.12	2.30	2.17	14.21	13.97	
V06	Surf A	J12	17	5.07	4.99	2.81	2.86	14.40	14.31	
V06	Surf A	J12	18	5.09	4.85	2.41	2.39	14.15	13.59	
V06	Surf A	J12	18	5.12	5.22	2.54	2.28	14.29	14.29	
V06	Surf A	J12	18	4.93	4.73	3.10	2.61	14.39	13.51	
V06	Surf A	J12	19	4.71	*	4.20	*	14.88	*	
V06	Surf A	J12	20	5.00	4.95	3.34	2.69	14.73	14.06	
V06	Surf A	J12	20	4.97	5.37	3.38	2.57	14.69	14.85	
V06	Surf A	J12	21	5.08	5.01	2.30	3.42	13.99	14.83	
V06	Surf A	J12	22	4.83	*	4.27	*	15.19	*	
V06	Surf A	J12	23	5.11	*	3.01	*	14.69	*	
V06	Surf A	J12	23	5.37	*	2.30	*	14.62	*	
V06	Surf A	J12	24	5.35	*	3.11	*	15.32	*	
V06	Surf A	J12	24	5.09	*	2.36	*	14.05	*	
V06	Surf A	J12	25	4.18	*	6.46	*	15.78	*	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V06	Surf A	J12	25	5.45	5.17	2.32	3.22	14.70	15.00	
V06	Surf A	J12	26	5.28	*	1.99	*	14.17	*	
V07	Surf A	J14	1	4.87	*	3.56	*	14.73	*	
V07	Surf A	J14	1	5.43	*	0.79	*	13.69	*	
V07	Surf A	J14	1	4.72	*	2.45	*	13.57	*	
V07	Surf A	J14	2	4.85	*	3.13	*	14.46	*	
V07	Surf A	J14	3	5.13	*	2.51	*	14.56	*	
V07	Surf A	J14	3	4.93	*	2.40	*	14.04	*	
V07	Surf A	J14	5	4.78	*	3.45	*	14.60	*	
V07	Surf A	J14	6	4.95	*	2.82	*	14.45	*	
V07	Surf A	J14	6	4.79	*	2.87	*	14.10	*	
V08	Surf B	J15	1	5.06	4.76	3.26	3.15	14.89	14.05	
V08	Surf B	J15	2	4.62	4.80	3.93	4.04	14.47	14.97	
V08	Surf B	J15	3	4.63	4.80	4.00	3.90	14.58	14.84	
V08	Surf B	J15	9	4.73	4.77	2.86	3.34	13.81	14.24	
V08	Surf B	J15	11	4.77	4.85	2.61	3.38	13.66	14.50	
V08	Surf B	J15	11	4.92	*	3.76	*	15.04	*	
V08	Surf B	J15	11	4.81	4.72	3.27	3.17	14.34	13.99	
V08	Surf B	J15	12	5.10	4.88	3.17	2.88	14.92	14.11	
V08	Surf B	J15	12	4.79	4.70	2.56	3.14	13.65	13.95	
V08	Surf B	J15	13	5.19	5.08	2.01	2.56	14.04	14.25	
V08	Surf B	J15	13	4.97	5.00	2.25	3.26	13.75	14.69	
V08	Surf B	J15	14	4.92	4.80	2.58	3.13	14.01	14.12	
V08	Surf B	J15	14	4.63	*	2.20	*	12.97	*	
V08	Surf B	J15	15	4.65	4.54	4.81	3.49	15.48	13.93	
V08	Surf B	J15	15	5.09	*	2.94	*	14.71	*	
V08	Surf B	J15	16	4.83	4.77	4.08	3.01	15.16	13.95	
V08	Surf B	J15	17	4.52	*	3.76	*	14.20	*	
V08	Surf B	J15	18	4.79	4.61	3.66	3.59	14.68	14.12	
V09	Surf A	J16	1	5.03	4.93	2.31	2.92	13.94	14.24	
V09	Surf A	J16	2	5.12	5.14	2.45	2.67	14.26	14.47	
V09	Surf A	J16	3	5.01	5.01	2.56	3.68	14.11	15.09	
V09	Surf A	J16	3	4.90	4.85	2.62	3.02	13.92	14.18	
V09	Surf A	J16	4	5.16	5.23	1.84	2.90	13.81	14.92	
V09	Surf A	J16	5	5.33	5.20	1.73	1.88	14.04	13.84	
V09	Surf A	J16	5	4.99	5.06	2.23	2.56	13.72	14.21	
V09	Surf A	J16	7	5.12	4.87	1.76	2.91	13.65	14.14	
V09	Surf A	J16	8	4.99	4.87	1.92	1.78	13.52	13.08	
V09	Surf A	J16	8	5.30	5.12	2.50	3.82	14.71	15.49	
V09	Surf A	J16	9	5.17	5.24	2.30	2.94	14.23	14.99	
V09	Surf A	J17	1	4.98	4.91	2.74	3.11	14.21	14.36	
V09	Surf A	J17	3	5.11	5.29	1.21	2.33	13.15	14.58	
V09	Surf A	J17	4	4.91	5.03	1.80	2.79	13.21	14.42	
V09	Surf A	J17	5	4.92	4.97	1.96	2.13	13.36	13.63	
V10	Surf A	J18	1	5.31	5.32	2.49	3.19	14.86	15.52	
V10	Surf A	J18	2	5.01	5.19	2.46	3.14	14.20	15.23	
V10	Surf A	J18	2	5.43	5.51	2.99	3.13	15.61	15.92	
V10	Surf A	J18	3	5.19	5.32	2.68	3.25	14.80	15.58	
V10	Surf A	J18	5	5.33	5.31	3.38	3.45	15.77	15.74	
V10	Surf A	J18	5	5.11	5.45	2.70	2.91	14.62	15.57	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V10	Surf A	J18	6	5.34	5.74	2.08	2.82	14.58	16.23	
V10	Surf A	J18	10	5.19	5.21	3.05	2.68	15.16	14.85	
V10	Surf A	J18	10	4.67	4.97	3.22	4.08	14.15	15.56	
V10	Surf A	J18	11	5.36	5.04	2.57	2.95	15.16	14.68	
V10	Surf B	J20	2	4.91	5.16	4.64	3.72	15.91	15.60	
V10	Surf B	J20	1	5.01	4.83	5.57	3.78	16.99	14.91	Y
V10	Surf B	J21	2	4.90	5.08	4.82	3.89	16.10	15.55	
V10	Surf B	J21	3	5.10	5.13	4.00	3.25	15.83	15.23	
V10	Surf B	J21	5	5.19	5.36	3.25	3.90	15.28	16.28	
V10	Surf B	J21	5	5.05	5.03	3.09	3.93	14.82	15.54	
V10	Surf C	J22	1	5.28	5.33	5.97	3.90	17.92	16.28	Y
V10	Surf C	J22	2	5.58	5.39	4.93	4.79	17.62	16.98	
V10	Surf C	J22	4	5.46	5.51	5.05	3.90	17.50	16.50	
V10	Surf C	J22	9	5.52	5.13	4.01	4.12	16.72	15.90	
V11	Surf A	J24	1	4.88	5.16	6.72	6.39	17.54	17.84	
V11	Surf A	J24	1	4.78	4.33	2.14	2.10	13.26	12.14	
V11	Surf A	J24	1	4.98	4.94	2.57	2.13	14.07	13.55	
V11	Surf A	J24	2	4.66	4.73	3.03	3.36	13.72	14.18	
V11	Surf A	J24	4	5.13	5.06	3.07	2.65	14.83	14.27	
V11	Surf A	J24	5	4.72	4.77	3.69	3.86	14.50	14.73	
V11	Surf A	J24	5	4.80	4.84	3.73	3.22	14.69	14.28	
V11	Surf A	J24	6	5.05	*4.77*	3.17	*2.80*	14.79	*13.78*	
V11	Surf A	J24	7	4.86	*4.99*	3.55	*3.12*	14.67	*14.58*	
V11	Surf A	J24	8	4.35	4.92	5.73	3.60	15.51	14.82	
V11	Surf A	J24	9	4.83	5.04	3.60	3.07	14.61	14.63	
V11	Surf A	J24	9	4.79	*5.01*	3.95	*3.23*	14.83	*14.70*	
V11	Surf A	J24	10	4.92	5.20	3.62	1.93	14.83	13.96	
V11	Surf A	J24	10	5.11	*5.05*	2.50	*2.59*	14.27	*14.16*	
V11	Surf A	J24	11	4.86	4.83	4.16	3.06	15.21	14.09	
V11	Surf A	J24	11	5.20	*5.13*	4.59	*3.11*	16.36	*14.79*	
V11	Surf A	J24	13	5.13	5.39	2.54	2.04	14.34	14.45	
V11	Surf A	J24	14	5.08	*4.89*	2.92	*3.00*	14.60	*14.23*	
V11	Surf A	J24	14	5.03	*5.02*	2.67	*2.52*	14.27	*14.07*	
V11	Surf A	J24	14	*	*5.04*	*	*2.86*	*	*14.39*	
V11	Surf A	J24	15	5.04	*5.11*	2.34	*2.97*	13.94	*14.68*	
V11	Surf A	J24	15	5.25	*4.91*	3.19	*2.61*	15.21	*13.88*	
V11	Surf A	J24	16	4.97	*4.58*	2.04	*2.69*	13.60	*13.27*	
V11	Surf A	J24	16	4.91	*5.00*	2.39	*2.68*	13.76	*14.19*	
V11	Surf A	J24	17	5.16	*4.81*	3.30	*3.09*	15.14	*14.12*	
V11	Surf A	J24	17	5.10	*4.73*	3.66	*4.02*	15.35	*14.75*	
V11	Surf A	J24	18	4.84	4.90	4.21	4.00	15.23	15.16	
V11	Surf A	J24	18	4.79	*5.17*	5.32	*2.88*	16.31	*14.71*	
V11	Surf A	J24	19	4.94	*5.35*	3.64	*2.95*	14.91	*15.20*	
V11	Surf A	J24	19	5.00	*4.83*	4.10	*3.14*	15.47	*14.18*	
V11	Surf A	J24	20	5.19	*4.90*	2.59	*2.30*	14.59	*13.58*	
V11	Surf A	J24	20	*	*4.67*	*	*2.80*	*	*13.55*	
V11	Surf A	J24	21	5.22	*4.89*	2.25	*3.38*	14.34	*14.54*	
V11	Surf A	J24	21	*	*4.91*	*	*3.31*	*	*14.54*	
V14	Surf A	J62	1	4.97	5.21	4.15	4.21	15.49	16.08	
V14	Surf A	J62	2	5.04	5.25	3.74	3.03	15.30	15.13	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V14	Surf A	J62	2	5.17	5.37	4.19	2.83	15.98	15.15	Y
V14	Surf A	J62	3	5.04	5.12	3.27	2.69	14.94	14.50	
V14	Surf A	J62	3	5.58	5.68	4.35	3.99	17.05	16.88	
V14	Surf A	J62	4	5.13	5.36	3.11	3.18	14.97	15.49	
V14	Surf A	J62	5	5.19	5.06	3.13	2.85	15.14	14.53	
V14	Surf A	J62	5	5.32	5.65	2.12	1.80	14.52	14.94	
V14	Surf A	J62	6	5.32	5.33	2.73	2.87	15.07	15.18	
V14	Surf A	J62	6	5.20	5.14	3.67	3.10	15.67	14.91	
V14	Surf A	J62	6	5.08	5.40	2.44	2.75	14.27	15.20	
V14	Surf A	J62	8	5.11	5.12	3.26	2.76	15.04	14.55	
V14	Surf A	J62	8	5.62	5.85	2.93	2.97	15.88	16.38	
V14	Surf A	J62	10	5.39	5.48	3.64	3.50	16.03	16.06	
V14	Surf A	J62	11	4.85	5.13	4.18	3.13	15.35	14.97	
V14	Surf A	J62	12	5.15	5.11	4.35	3.58	16.17	15.24	
V14	Surf A	J62	12	5.20	5.33	4.10	3.62	16.02	15.83	
V14	Surf A	J62	14	5.36	5.31	2.89	3.05	15.30	15.22	
V14	Surf A	J62	15	5.11	5.16	3.43	3.22	15.16	15.01	
V14	Surf A	J62	15	5.47	5.58	3.72	3.70	16.22	16.30	
V14	Surf A	J63	1	4.84	4.88	4.25	3.93	15.37	14.99	
V14	Surf A	J63	2	5.15	5.31	4.03	3.93	15.88	15.94	
V14	Surf A	J63	3	5.23	5.06	3.50	4.28	15.54	15.69	
V14	Surf A	J63	4	5.58	5.26	3.49	4.34	16.31	16.26	
V14	Surf A	J63	4	5.11	5.00	4.51	4.27	16.22	15.58	
V14	Surf A	J63	4	5.21	4.92	3.96	3.83	15.92	15.06	
V14	Surf A	J63	5	5.29	5.27	3.67	3.39	15.82	15.37	
V14	Surf A	J63	5	4.74	4.77	4.91	4.72	15.75	15.45	
V14	Surf A	J63	5	5.13	5.38	4.55	4.44	16.30	16.55	
V14	Surf A	J63	6	5.08	5.25	3.79	3.65	15.49	15.63	
V14	Surf A	J63	6	5.12	5.27	4.41	4.49	16.11	16.33	
V14	Surf A	J63	7	5.16	5.31	4.41	4.29	16.20	16.24	
V14	Surf A	J63	7	4.96	5.21	4.65	4.43	16.01	16.26	
V14	Surf A	J63	7	4.85	4.95	4.97	4.65	16.04	15.76	
V14	Surf A	J63	8	5.09	4.95	3.25	4.17	15.01	15.60	
V14	Surf A	J63	8	5.22	5.14	4.16	4.54	16.12	16.16	
V14	Surf A	J63	8	5.30	5.32	3.10	3.70	15.34	15.76	
V14	Surf A	J63	9	5.09	5.17	4.40	4.63	16.05	16.23	
V14	Surf A	J63	9	4.89	4.91	4.30	4.83	15.51	15.94	
V14	Surf A	J63	10	4.96	4.87	5.31	4.91	16.61	15.83	
V14	Surf A	J63	10	5.04	5.27	3.86	3.80	15.49	15.78	
V14	Surf A	J63	10	5.10	5.32	3.43	3.82	15.20	15.92	
V14	Surf A	J63	11	5.39	5.29	3.86	3.84	16.31	15.85	
V14	Surf A	J63	12	5.39	5.46	3.71	3.81	16.13	16.12	
V14	Surf A	J63	13	5.38	5.30	3.59	4.65	16.02	16.55	
V14	Surf A	J63	13	5.42	5.31	3.31	3.43	15.83	15.49	
V14	Surf A	J63	14	5.29	5.62	4.24	3.86	16.37	16.62	
V14	Surf A	J63	14	5.44	5.56	4.12	3.44	16.53	16.04	
V14	Surf A	J63	17	4.90	4.98	6.69	4.55	17.70	15.73	Y
V14	Surf A	J63	18	5.09	5.21	5.63	5.85	17.18	17.44	
V14	Surf A	J63	18	5.51	5.33	4.51	4.95	17.04	16.84	
V14	Surf A	J63	19	4.98	5.36	4.61	3.93	15.91	16.02	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V14	Surf A	J63	20	5.34	4.89	4.84	4.96	16.96	15.99	
V14	Surf A	J63	20	5.20	5.57	3.09	3.33	15.01	16.00	
V14	Surf A	J63	21	4.98	5.50	3.61	3.01	15.04	15.61	
V14	Surf A	J63	21	4.63	4.91	5.05	4.36	15.55	15.48	
V14	Surf A	J63	21	5.44	4.86	3.59	3.78	16.03	14.88	
V14	Surf A	J63	21	5.66	5.53	2.77	2.57	15.76	15.26	
V14	Surf A	J63	23	5.06	5.03	3.92	4.12	15.50	15.52	
V14	Surf A	J63	24	5.17	5.28	3.01	3.52	14.88	15.54	
V14	Surf A	J63	24	5.50	5.63	2.20	3.02	14.88	15.87	
V14	Surf A	J63	25	5.44	5.13	2.97	2.86	15.47	14.58	
V14	Surf A	J63	26	5.25	5.21	3.24	3.82	15.30	15.66	
V14	Surf A	J63	26	5.29	5.19	2.84	3.71	15.01	15.54	
V16	Base A	J77	1	4.36	4.36	*	*	*	*	
V16	Base A	J77	1	3.66	4.12	*	*	*	*	
V16	Base A	J77	2	4.38	4.66	*	*	*	*	
V16	Base A	J77	3	4.35	4.34	*	*	*	*	
V16	Base A	J77	4	4.47	4.66	*	*	*	*	
V16	Base A	J77	5	4.51	4.78	*	*	*	*	
V16	Base A	J77	5	4.87	4.58	*	*	*	*	
V16	Base A	J77	6	4.71	4.32	*	*	*	*	
V16	Base A	J77	7	4.11	5.12	*	*	*	*	Y
V16	Base A	J77	8	4.69	4.85	*	*	*	*	
V16	Base A	J77	8	4.39	3.94	*	*	*	*	
V16	Base A	J77	9	4.58	4.67	*	*	*	*	
V16	Base A	J77	10	5.08	5.76	*	*	*	*	Y
V16	Base A	J77	11	4.27	4.26	*	*	*	*	
V16	Base A	J77	12	4.08	3.94	*	*	*	*	
V16	Base A	J77	13	4.72	5.23	*	*	*	*	
V16	Base A	J77	14	4.85	4.89	*	*	*	*	
V16	Base A	J77	15	4.90	5.01	*	*	*	*	
V16	Base A	J77	16	4.87	4.88	*	*	*	*	
V16	Base A	J77	17	5.13	4.74	*	*	*	*	
V16	Base A	J78	1	4.92	4.91	*	*	*	*	
V16	Base A	J78	2	4.07	4.37	*	*	*	*	
V16	Surf C	J79	1	5.26	5.31	4.03	4.37	16.09	16.45	
V16	Surf C	J79	2	5.41	5.59	3.58	3.87	16.00	16.68	
V16	Surf C	J79	2	4.97	5.60	5.01	4.19	16.41	17.00	Y
V16	Surf C	J80	1	5.96	6.10	3.17	4.01	16.89	17.94	
V16	Surf C	J80	1	6.08	6.43	2.85	3.62	16.79	18.27	Y
V16	Surf C	J80	4	5.14	5.33	3.79	3.84	15.65	16.05	
V17	Surf C	J81	1	5.36	5.83	4.84	4.08	17.06	17.27	Y
V17	Surf C	J81	2	5.25	5.31	3.58	3.82	15.66	15.91	
V17	Surf C	J82	1	5.67	5.38	3.35	3.17	16.35	15.50	
V17	Surf C	J82	2	5.41	5.35	3.66	3.10	16.14	15.39	
V17	Surf C	J82	3	5.33	5.02	3.84	3.61	16.11	15.16	
V17	Surf C	J82	6	5.35	5.24	3.47	3.42	15.80	15.46	
V17	Surf C	J82	7	5.02	5.14	3.89	3.75	15.45	15.54	
V17	Surf C	J82	7	5.42	5.19	4.33	4.13	16.74	15.96	
V17	Surf C	J82	12	5.44	5.52	3.77	4.19	16.25	16.77	
V17	Surf C	J82	13	5.54	5.37	4.36	4.30	17.00	16.48	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (*continued*)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V17	Surf C	J82	13	5.09	5.10	4.08	4.19	15.77	15.81	
V17	Surf C	J82	14	5.77	5.35	3.42	3.99	16.67	16.21	Y
V17	Surf C	J82	15	5.43	5.62	3.70	3.98	16.14	16.78	
V18	Surf B	J84	1	4.84	5.04	3.97	3.63	15.12	15.26	
V18	Surf B	J84	3	4.90	5.12	3.52	3.21	14.88	15.05	
V18	Surf B	J84	4	4.52	4.79	3.58	3.67	14.03	14.73	
V18	Surf B	J84	5	4.66	5.09	4.11	3.57	14.84	15.31	
V18	Surf B	J84	7	5.12	5.05	3.02	3.02	14.91	14.76	
V18	Surf B	J84	7	4.74	5.03	3.91	3.35	14.83	14.98	
V18	Surf B	J84	8	5.08	4.93	3.69	3.49	15.41	14.89	
V18	Surf B	J84	8	5.02	4.97	3.28	3.55	14.86	15.02	
V18	Surf B	J84	10	4.79	4.86	3.71	3.50	14.82	14.75	
V18	Surf B	J84	10	4.85	4.87	3.31	2.96	14.53	14.27	
V18	Surf B	J84	11	4.82	4.60	5.42	3.95	16.45	14.55	Y
V18	Surf B	J84	11	4.73	4.71	4.15	3.56	15.02	14.45	
V18	Surf B	J84	12	4.84	4.84	4.17	3.73	15.31	14.90	
V18	Surf B	J84	12	4.86	5.00	4.37	3.83	15.47	15.34	
V18	Surf B	J84	13	4.80	5.11	3.17	3.26	14.28	15.10	
V18	Surf B	J84	13	4.80	5.07	3.79	2.95	14.85	14.71	
V18	Surf B	J84	14	4.92	5.00	3.22	3.03	14.63	14.62	
V18	Surf B	J84	14	4.91	5.08	3.71	3.42	15.04	15.18	
V18	Surf B	J84	15	5.02	4.97	3.83	2.89	15.42	14.42	
V18	Surf B	J84	16	4.87	4.96	3.55	2.91	14.80	14.41	
V18	Surf B	J84	16	4.81	5.10	4.04	3.55	15.13	15.31	
V18	Surf B	J84	17	4.82	4.85	2.69	3.06	13.96	14.34	
V18	Surf B	J84	17	4.75	4.59	4.67	3.90	15.59	14.49	
V18	Surf B	J84	18	4.69	4.82	4.19	3.42	15.03	14.59	
V18	Surf B	J84	18	5.02	5.10	3.51	3.37	15.10	15.17	
V18	Surf B	J84	19	4.82	4.69	3.66	3.58	14.80	14.43	
V18	Surf B	J84	20	4.66	4.60	6.13	4.75	16.69	15.28	Y
V18	Surf B	J84	20	4.73	4.85	3.83	3.69	14.74	14.89	
V18	Surf B	J84	21	4.77	4.78	4.57	4.23	15.50	15.22	
V18	Surf B	J84	22	4.78	4.95	4.00	3.55	15.02	14.99	
V18	Surf B	J84	22	5.11	5.12	2.17	2.41	14.14	14.39	
V18	Surf B	J84	23	4.89	4.78	4.93	3.80	16.15	14.84	Y
V18	Surf A	J85	1	5.33	5.13	4.08	2.94	16.27	14.75	Y
V18	Surf A	J85	1	5.05	4.91	4.12	3.04	15.67	14.36	Y
V18	Surf A	J85	2	4.82	4.84	3.79	3.12	14.82	14.27	
V18	Surf A	J85	2	4.91	4.74	3.61	3.37	14.90	14.29	
V18	Surf A	J85	3	5.04	4.79	4.41	3.76	15.88	14.74	
V18	Surf A	J85	3	4.79	4.72	3.95	3.19	14.94	14.08	
V18	Surf A	J85	4	5.09	4.88	3.75	3.37	15.39	14.55	
V18	Surf A	J85	4	5.20	5.08	3.73	2.86	15.63	14.59	
V18	Surf A	J85	5	5.06	5.07	3.17	2.58	14.84	14.30	
V18	Surf A	J85	5	4.68	4.74	4.05	3.54	14.74	14.43	
V18	Surf A	J85	7	4.89	5.03	3.94	3.30	15.14	14.86	
V18	Surf A	J85	9	4.55	4.71	4.81	3.47	15.21	14.32	Y
V18	Surf A	J85	9	5.03	4.98	3.46	3.02	15.01	14.49	
V18	Surf A	J85	10	4.93	4.80	3.38	3.64	14.71	14.66	
V18	Surf A	J85	11	4.80	5.09	3.70	3.14	14.70	14.85	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.

Table C.1. Verification Test Results Data (_continued_)

Proj. No.	Mix Type	JMF No.	Lot No.	AC-V	AC-C	AV-V	AV-C	VMA-V	VMA-C	DR Tested
V18	Surf A	J85	12	5.08	4.73	4.34	3.45	15.93	14.28	Y
V18	Surf A	J85	13	4.74	4.94	2.61	3.22	13.60	14.58	
V18	Surf A	J85	13	5.21	5.02	2.58	2.86	14.62	14.44	
V18	Surf A	J85	14	4.88	4.82	3.97	3.24	15.15	14.33	
V18	Surf A	J85	15	4.98	4.90	2.09	2.59	13.68	13.93	
V18	Surf A	J85	15	4.78	4.66	3.80	4.22	14.76	14.91	
V18	Surf A	J85	16	4.65	4.72	4.39	3.24	15.02	14.16	
V18	Surf A	J85	18	4.95	4.87	4.05	3.34	15.34	14.58	
V18	Surf A	J85	19	4.79	4.95	3.85	3.31	14.80	14.72	
V18	Surf A	J85	20	5.09	4.83	3.29	3.05	14.97	14.20	
V18	Surf A	J85	21	5.19	4.85	3.89	3.20	15.75	14.42	Y
V18	Surf A	J85	21	5.09	5.09	3.67	3.27	15.31	15.00	
V18	Surf A	J85	22	4.72	4.82	4.35	2.89	15.14	14.08	Y
V18	Surf A	J85	22	4.85	4.89	4.04	3.38	15.12	14.67	
V18	Surf A	J85	23	5.37	5.07	3.28	3.14	15.56	14.86	
V19	Surf B	J86	11	5.26	5.21	3.13	2.29	15.20	14.32	
V19	Surf B	J86	11	5.03	4.95	3.75	2.86	14.28	14.24	
V19	Surf B	J86	12	4.87	4.91	4.85	3.77	15.88	14.93	
V19	Surf B	J86	13	5.22	5.27	3.19	3.06	15.16	15.11	
V19	Surf B	J86	13	4.91	4.69	4.20	2.70	15.42	13.52	
V19	Surf B	J86	15	5.33	5.37	2.47	2.01	14.80	14.42	
V19	Surf B	J86	18	5.11	5.10	3.81	3.63	15.51	15.28	
V19	Surf B	J86	19	4.92	5.13	3.28	2.38	14.61	14.21	
V19	Surf B	J86	19	5.12	5.13	2.91	2.52	14.74	14.40	
V19	Surf B	J86	20	5.25	5.14	2.53	2.31	14.67	14.21	
V19	Surf B	J86	21	4.95	4.98	2.75	2.92	14.20	14.38	
V19	Surf B	J86	22	4.94	4.86	5.31	3.79	16.50	14.89	
V19	Surf B	J86	22	4.98	4.82	5.22	5.05	16.47	15.91	
V19	Surf B	J86	23	4.89	4.93	3.84	3.12	15.07	14.45	
V19	Surf B	J86	23	5.08	5.27	3.24	2.88	14.94	14.99	
V19	Surf B	J86	23	4.78	5.12	3.15	2.69	14.21	14.51	
V19	Surf B	J86	24	5.17	4.90	1.79	1.91	13.87	13.32	
V19	Surf B	J86	25	5.30	5.17	2.10	2.52	14.45	14.49	
V19	Surf B	J86	25	4.82	4.73	3.05	2.91	14.20	13.82	
V19	Surf B	J86	26	4.95	4.90	3.17	2.70	14.59	13.98	
V19	Surf B	J86	27	5.02	5.02	2.65	2.32	14.28	13.95	
V19	Surf B	J86	28	5.01	5.06	2.93	2.60	14.52	14.25	
V19	Surf B	J86	28	4.62	4.90	3.39	3.28	14.04	14.53	
V19	Surf B	J86	30	5.12	4.90	3.19	2.55	15.00	13.85	
V19	Surf B	J86	31	5.13	5.00	2.79	2.89	14.66	14.43	

Note: Values in italics had AC, AV, and VMA results all identical to the Contractor acceptance test.