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16. Abstract

This report discusses the variability associated with the production, construction, and testing of structural and paving concrete. The study evaluated data from over 900 projects constructed between 1992 and 1999, representing over 25,000 lots. The data was collected from the DOTD computerized Materials Test Data Reporting System (MATT). The analysis also included an assessment of price reductions for nonconforming lots.

The analysis and evaluation indicated: (1) an overall price reduction of less than 0.2 percent for structure concrete and about 0.5 percent for paving concrete; (2) thickness of concrete cores to be the major contributor to the overall price reduction in paving concrete; (3) good control in the production and testing of structure concrete; and (4) increase in non-uniformity of paving concrete acceptance criteria.

Recommendations include (1) a need to maintain better control of the variability of paving concrete tests through the application of control charts and/or the variability of unknown types of specifications and (2) a need for continued evaluation, such as the one presented here, for monitoring the overall quality control and quality assurance program of the DOTD.

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STATISTICAL QUALITY CONTROL AND QUALITY ASSURANCE EVALUATION OF STRUCTURAL & PAVING CONCRETE

(Phase I Final Report)

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Phase I Final Research Report

Conducted for

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

LOUISIANA TRANSPORTATION RESEARCH CENTER

August, 2000

ABSTRACT

This interim report discusses the variability associated with the production, construction and testing of structure and paving concrete. The study evaluated data from over 900 projects constructed during 1992 through 1999 period and representing over 25,000 lots. The data was collected from the DOTD's computerized MATT system. The analysis also included assessment of price reduction for nonconforming lots.

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Recommendations include a need to maintain better control on the variability of paving concrete tests through application of control chart and/or variability unknown type of specifications; and a need for continued evaluation, such as the one presented here, for monitoring the overall quality control and quality assurance program of the DOTD.

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1. INTRODUCTION

In the early sixties, the then Louisiana Department of Highways initiated an aggressive study to determine the extent of variability encountered in three broad categories of materials and construction - Asphaltic Concrete, Portland Cement Concrete (PCC) and Soil and Aggregate Base Course (*1*, *2*, *3*)*. The major thrust towards this study was to develop statistically based specifications commensurate with variability generally associated with the production processes of these three categories of materials and/or construction.

This initial effort resulted in simulation of asphaltic concrete specifications (*4*). Implementation of these specifications occurred in 1971 with subsequent evaluation of these specifications in 1975 (*5*). Portland Cement concrete (PCC) specifications were implemented in 1973 followed by their evaluation in 1979 (*6*).

In 1978, the Louisiana Department of Transportation and Development (DOTD) implemented a computerized system (the MATerial Test Data Reporting System or, simply, the MATT system) of reporting and archiving material and construction test data (*7*). This implementation envisioned periodic evaluation of such archived data with a view to enhance the overall system of quality control (QC)/quality assurance (QA) on a continuing basis. However, such evaluation never materialized with volumes of MATT system data remaining unevaluated. It was not until 1996, almost 25 years after specification implementation and 20 years after the last such evaluation (*6*), that DOTD launched a formal study to determine the current status of QA/QC of asphaltic concrete materials and construction (*8*).

To continue this evaluation momentum, the DOTD awarded a contract to Southern University of Baton Rouge, through Request For Proposal (RFP) solicitation, to evaluate the overall QA/QC program of concrete construction and determine if specifications changes are needed to enhance concrete QA/QC program. This report discusses the accomplishments of Tasks 1 through 3 of Phase 1 of the study work plan. These tasks are defined in the next section under Objectives and Scope.

(*) - Underlined italic numbers in parenthesis refer to list of references

2. OBJECTIVES AND SCOPE

I Objectives

The broad objective of this study is to evaluate DOTD's MATT system data generated by statistically based specifications for paving and structural concrete. Specific objectives are:

1. Evaluate the MATT system data generated by current specifications on paving and structural concrete materials and construction;

2. Based on above evaluation, determine if specification changes are needed to enhance current QA/QC program; and

3. Evaluate the feasibility of using acceptance sampling using Percent Within Tolerance (PWL) concept.

4. Although not specifically required in the proposal, identify noise in MATT System data and make appropriate recommendations to rectify and enhance the system.

II Scope

In scope, the study will be limited to:

1. MATT system data since the implementation of the 1992 specifications;

2. Analysis and evaluation of slump, air content and compressive strength measurements of structural concrete;

3. Analysis and evaluation of thickness, strength and profile (smoothness) measurements of paving concrete

3. WORK PLAN

The three objectives defined above are to be accomplished through two separate phases with three distinct tasks within each phase as follows:

Phase 1

Task 1. **Literature search** - Review literature pertinent to stated objectives

Task 2. **Evaluation of the current DOTD concrete specifications and test procedures -** In this task, Louisiana's current specifications on materials and construction are to be reviewed in light of other agencies requirements for acceptance. In that respect, there may be an overlap with Task 1, Literature Search.

Task 3. **Analysis of MATT system data -** This task is the crux of the study and involves review of master MATT system data files on paving and structural concrete, retrieval of pertinent records from these files, development of separate data base of these files, analysis and evaluation of acquired data and, lastly, submission of an interim report.

Phase 2 This phase is to commence upon DOTD approval to proceed based on findings and recommendations in interim report

Task 4. Development of proposed revised or additional criteria for QA/QC

Task 5. Formulation of Percent Within Limits (PWL) specification and concurrent specification changes.

Task 6. Submit final report and associated material for implementation of recommendations.

Report Format -

This report is divided into ten sections. To better understand the results of the analysis, it is necessary to provide an understanding of the variability concept and its relationship to specifications. This is discussed in the next section. The accomplishments of ***Task 1, Literature search*** and ***Task 2, Evaluation of Current Specifications*** are discussed in Section 5. Section 6 will discuss the data collection phase relative to database development from the MATT system files and an overview of the type of analysis and the tools used to analyze the data. Assessment of price adjustments is discussed in Section 7 followed by variability analysis in section 8. Section 9 deals with the operating characteristic curves of the current acceptance plans. Summary, conclusions and recommendations make up the last portion of this report.

4. BASIC STATISTICAL QUALITY CONTROL CONCEPTS

Frequency Distribution -

In this section some basic concepts of variability are presented to better understand the quality control and quality assurance procedures, and how these procedures relate to specifications. An appropriate starting point is the understanding of frequency distribution which is one of the most commonly used methods of describing pictorially variations of measurements from within a sample. In examining data of such type, it will be found that the individual data points group themselves about the central value so that there are roughly equal number of measurements on either side of this central value. The curve resulting from this distribution has the typical bell shape and is called the Normal Curve as shown in Figure 4.1. Figure 4.2 is an example of the actual distribution of structure concrete strength data collected for this study. In such curves small divergences occur more frequently than large ones. Also, these curves are unimodal, i.e., have one peak, and are symmetrical. This is one of the most important distributions and forms the basis for applying QA specifications. It is simple and can be defined in terms of two attributes - the mean and standard deviation. Understanding of these two properties, and some of the other properties associated with this normal distribution curve, is important since all these will be referred to later in the data analysis portion of this report.

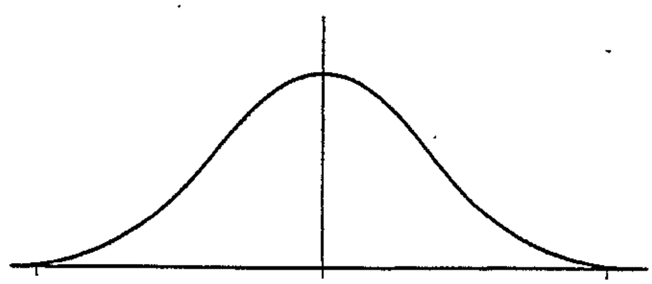


Figure 4.1: A symmetrical or bell shaped curve

<u>**The Mean**</u> - This is a measure of central tendency of a group of measurements. It can be determined by summing the individual observations and dividing by the number of observations, thus:

Mean, $\bar{X} = \sum X_i / n$ where, X_i = individual observations, and
n = number of observations in a group.

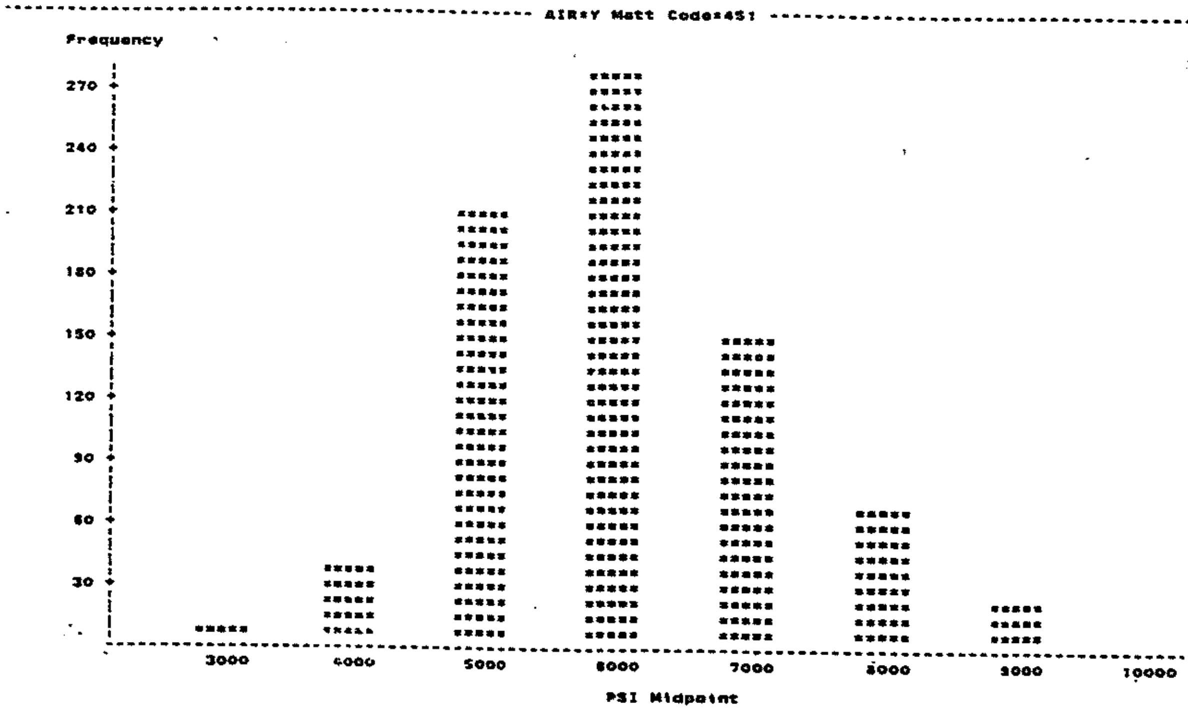


Figure 4.2: Frequency distribution of compressive strength of concrete cores

<u>The Standard Deviation</u> - This property of the normal distribution signifies the spread or dispersion of a group of measurements from it's mean. It has the following form:

Standard Deviation, σ *(sigma)* $= \sqrt{\sum(X_i - \bar{X})^2/(n-1)}$ where, X_i and n are as before.

Thus, two curves can have the same mean and yet have different variability or spread for the same property. This is shown in Figure 4.3 where curve B has more spread than curve A. The standard deviation is expressed in the same unit as the unit representing the measured property.

<u>The Variance</u> - this measure is the basic measure of variability and is the square of the standard deviation.

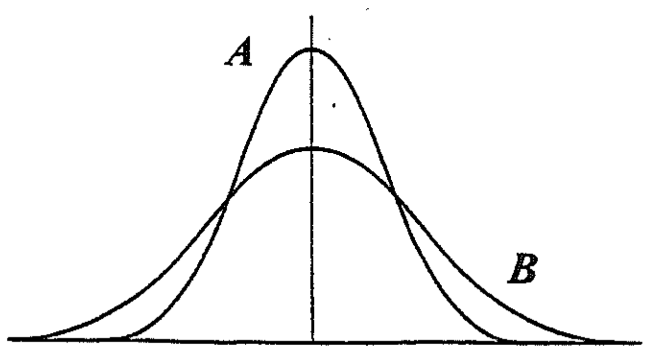


Figure 4.3: Two normal curves with different variabilities

The Standard Error - this is the standard deviation of the mean of several samples and is estimated by:

$$\sigma_{\bar{x}} = \sigma / \sqrt{n}$$

On the basis of this relationship, it is apparent that the distribution of sample means will be narrower (less spread) than the individual measurements.

The Coefficient of Variation - This property is sometimes used as a relative measure of variability. It is expressed as a percent and is calculated thus:

$$CV = (\sigma / \bar{X}) \times 100$$

This measure is widely used in Portland Cement Concrete (PCC) strength evaluation to determine the magnitude of control maintained on concrete production *(9)*.

Skewness - As mentioned before, acceptance plans require that the samples representing the population be normally distributed. Although many construction characteristics have been shown to be normally distributed, it is not always obvious by mere observation of the distribution. Skewness is one measure of testing for normality (or non-normality). The measure of skewness is a pure number and may be either positive or negative. If the distribution has a longer tail toward the higher values (toward the right on the x-axis), it is said to have positive skew. If the longer tail extends towards the lower values, it is said to have negative skewness. Figure 4.4 shows the symmetrical bell shaped and the two types of skewed curves. It is important to determine if the skewness does in fact exist in the collected data since, as mentioned before, standard statistical methods used in QA/QC analysis are not applicable for skewed distribution. Most values of skewness are less than ±1 for a normally distributed property.

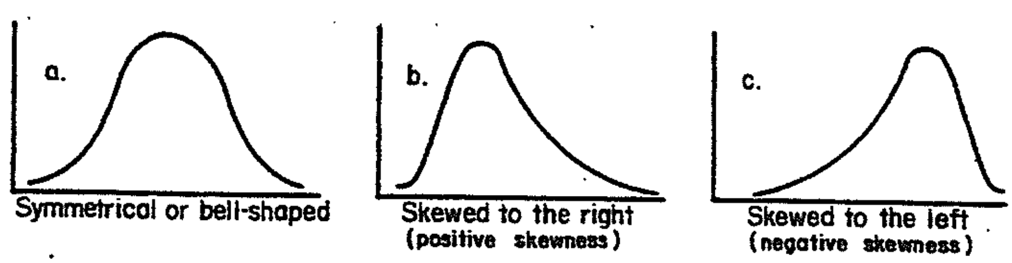


Figure 4.4: Symmetrical and skewed distributions

Relationship between Specifications and Statistical Parameters -

One of the most useful applications of the normal curve is in the development of specifications. Since the normal curve is symmetric about the mean, the area under the curve is one. Because of the symmetry, 50% of the area will be above the mean and 50% below the mean. Furthermore, the proportion of area under the curve between any two values can be completely determined by the mean and standard deviation. The proportion of area under ±1, ±2, and ±3 standard deviations from the mean are shown in Figure 4.5.

The simplest form of specifications often use 2σ limits to specify tolerances for quality control and/or acceptance. Thus, for specification for slump of concrete that has a standard deviation of 0.8 inches, the limits could be the design slump plus and minus 1.6 inches. Under the assumption that the slump measurements are normally distributed, one can expect about five percent of the slumps to fall outside the two limits.

Types of Specifications -

Variability Known specifications

Most of the specifications developed in the early 60s and 70s were based on the ***variability known*** or ***sigma known*** concept. In these type of specifications acceptance and/or rejection was based on the mean of the measured characteristic. Such specifications are simple in nature and requires little, if any, statistical background for its application.

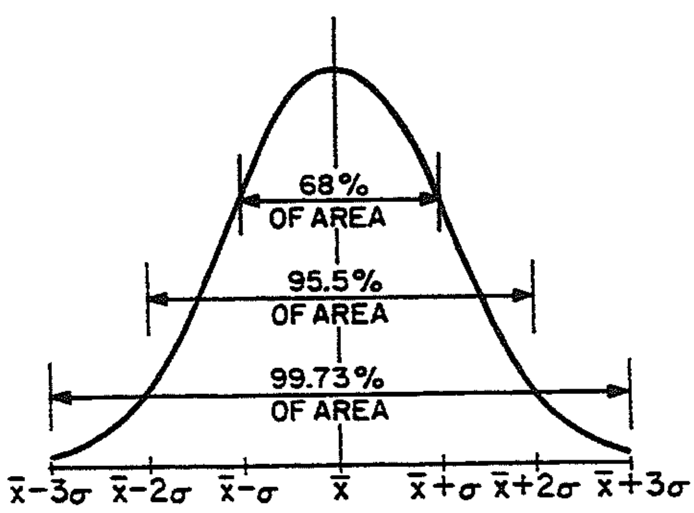


Figure 4.5: The percentages of areas within certain sigma (σ) limits

In these type specifications, two sigma units are generally used to specify the tolerance limits within which the measured characteristic, either individual or the mean, should fall for it to be accepted. This type of specification works well if the variability can be maintained at the level originally used to develop the tolerance limits. Louisiana's current specifications are based on this ***variability known*** concept.

Variability Unknown Specifications -

Unlike the previous type specification where the historical (or assumed) standard deviation is used to accept the lot mean, this type of specification uses both the mean of sample size n (lot) and the standard deviation of the sample or lot. A major advantage of the ***unknown sigma*** sampling plan is that it induces an incentive for the contractor to reduce his process variability. A disadvantage is that it requires computation of standard deviation of each lot.

The acceptance plan for this type of specification is based on the quality level analysis suggested in the AASHTO guide specifications *(10)*. Briefly, this quality level analysis involves determination of two statistics - the mean and standard deviation of a lot of certain sample size n. From these two statistics and the governing specification limit(s) for the test property, Quality Level Indices (Q_U for upper quality index and Q_L for lower quality index) are calculated. The resulting values are checked against tabled values for the sample size to determine ***Percent Within Limits*** or ***PWL***. The lot, represented by the sample, is considered in conformance to the specifications if the ***PWL*** exceeds some preset value.

Acceptable Quality Level(AQL) and Rejectable Quality Level(RQL) -

In developing specifications, it is necessary to define exactly what is desired in terms of acceptable quality. This is the AQL or the acceptable quality level that yields product quality that should be accepted almost all of the time. Likewise, to guard against defective work, it is also necessary to define the quality that should be rejected almost all of the time. This is the RQL or the rejectable quality level. The levels at which AQL and RQL are selected depends on the criticality of the measured characteristic in terms of its performance.

Operating Characteristic (OC) Curve

The OC curve is a graphical representation of the acceptance plan developed from AQL and RQL. It is a presentation of the sampling technique which shows the relationship between the quality of the lot and the probability of its acceptance. An OC curve indicates how well a given plan discriminates between acceptable and non-acceptable lots. There is a relationship between AQL, RQL, and the OC curve. This is shown in Figure 4.6. The development of this curve is discussed in detail in section 8.

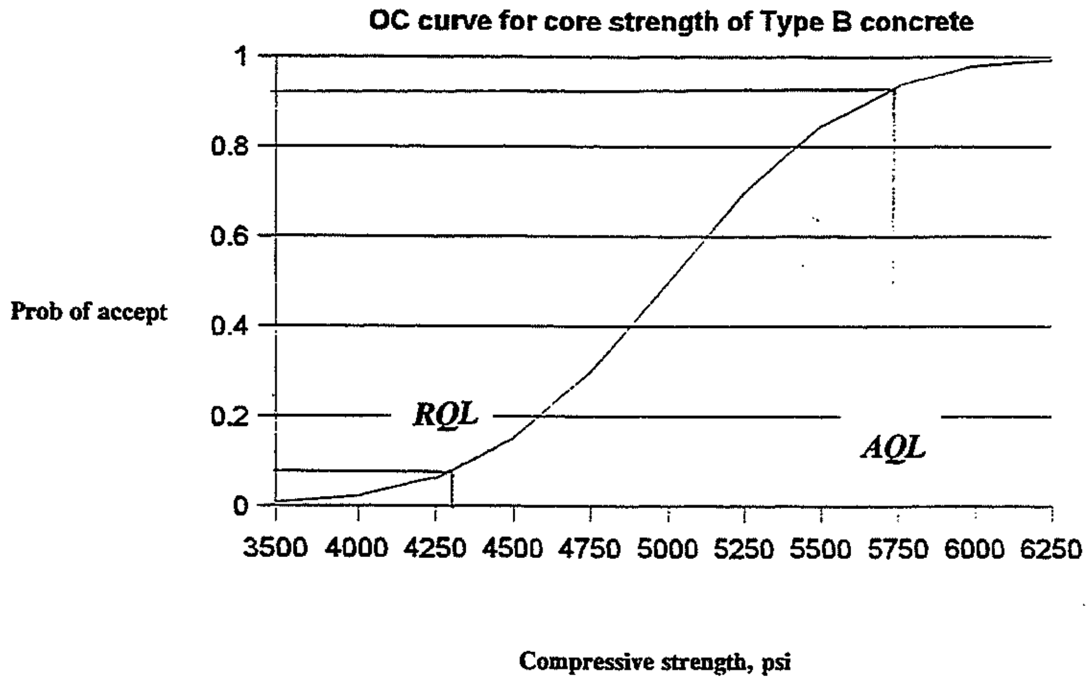


Figure 4.6: A typical OC curve with AQL and RQL

5. LITERATURE SEARCH

The driving force in the development of statistically based specification was the Bureau of Public Roads (BPR) of the Federal Highway Administration(FHWA). One of their earlier publications (*11*) discussed the concepts of quality assurance for several major items of highway construction and materials. The major purpose of this publication was to introduce the application of the statistical concepts to highway agencies.

Unlike asphaltic concrete, the design, development and implementation of statistically based specifications for concrete has been a low key effort by states. As such, literature on the design and application of such specifications is not as widespread as for asphaltic concrete. A primary reason has been that the concrete industry has had good handle on the quality control of fresh concrete, relative to production, sampling and testing, through the assistance of American Concrete Institute(ACI) standards.

An important aspect of this literature search was the review of tests used by other states for quality assurance, and the statistical measures used for control and/or acceptance of concrete. The following information was extracted from TRIS, TRB, FHWA, AASHTO, and ACI.

States QA/QC Practices -

Louisiana was one of the pioneers in the development of statistically-based specifications on three major categories of materials and construction - **Asphaltic Concrete, Portland Cement Concrete(PCC), and Soil and Aggregate Base Courses** (*1*, *2*, *3*). For PCC, the specifications were developed in 1966 from historical data for compressive strength and slump of structural concrete and roadway core strength and thickness of paving concrete (*3*). Implementation of these specifications occurred in 1973. Roadway profile requirements for pavements were introduced at a later date.

State practices regarding specific concrete materials and construction properties (tests) for quality control/quality assurance are quite varied between states. For example, almost all states consider Air Content most important. Some give a higher rating to slump as it is considered an important reflection of water-cement ratio. Likewise, compressive strength and slab thickness are considered important parameters for pay factor considerations. Some states also consider flexure test as important as compressive strength. Results of such ratings of various concrete materials and construction tests by states were reported in the NCHRP Synthesis report and are shown in Table 5.1(*12*). A large majority of states consider most of the tests important (rating of 1).

It is interesting to note from the survey shown in Table 5.1 that most states considered air content of fresh concrete and slump more important than any other test. Likewise, a large number of states consider smoothness important to the comfort of the public but not to durability. Five states do not measure this property.

Another important aspect of the literature search has been the review of the states' practices relative to quality assurance tests they specify for pay factors. Table 5.2 lists such practices for states participating in the FHWA Pooled Fund Study(*13*). What type of statistical measures states use for control/acceptance of concrete? In some cases, these statistical measures for control and/or acceptance can range from the simple range, to some complex form of Quality Index determination. Within this range of parameters, states have a broad choice of using the mean, absolute deviation, running average, percent defective, percent within limits (PWL) and a host of other statistics. Table 5.3 (*11*) shows the choice of statistical parameters that the various states use in their QA/QC program.

Table 5.1: Summary of PCC Tests Ratings for Various States

Test	Number of States Giving Rating of a/				
	1	2	3	4	5
Physical Tests on Cement	31		10	1	
Chemical Tests on Cement	32		3		2
Aggregate Gradation for Concrete	22		17	1	1
Aggregate Soundness	35		3		1
Air-Content of Fresh Concrete	41		1		
Slump	30		7	3	
Cylinder Compressive Strength	25		9		2
Other Strengths					
Flexure Strength	11		6	2	1
Splitting Tensile Strength			2		
Thickness of Hardened Concrete	22	2	13		1
Pavement Smoothness b/	1	31	2		

a/ Rating: 1 - Very important - failure could affect durability
2 - Important to public comfort but probably no effect on durability
3 - Important for contractual compliance; however, "normal" deviations not likely to affect performance
4 - Important during construction phase only. Not important to performance
5 - Other purpose
b/- Five States do not measure this property

In Table 5.2, the majority of the states, including Louisiana, that are participating in the pooled fund study specify compressive strength and thickness of pavement as important criteria for pay purpose (pay factor). Of the 19 states listed, six states have three separate criteria for pay purpose and one state measures as many as four different properties for determination of final pay.

Although the states have a choice of several measures of statistical parameters on which to base acceptance and/or control of concrete construction, the most common measure that is specified is the ***mean***. This is shown in Table 5.3 from the pooled fund study(13). Other measure that is gaining widespread use is the ***Percent Within Limits*** or, simply, ***PWL***. Both these widely used concepts for acceptance have pluses and minuses as was discussed in the previous section. Other measures used by the states are also shown in this table.

Table 5.2: Concrete Properties Measured for Pay Factors by States

State	Measured Property							
	Density	Thickness	St Edge Index	Flexure Strength	Smoothness	Profile Index	Compressive Strength	Air Content
CO		X					X	
FL							X	
IA		X		X	X			
IL		X			X			
LA		X				X	X	
ME							X	X
MD		X				X		
MI							X	
MS		X					X	
NC	X	X	X	X				
NV		X				X	X	
NY	X	X						
OR		X			X		X	
PA		X					X	X
SC		X					X	
TX		X					X	
WA		X				X		
WI		X				X	X	
WY							X	X
19	2	15	1	2	3	5	13	3

From these three tables it is seen that Louisiana's testing requirements for assuring quality, and the statistical parameters used for acceptance of concrete construction follow the trend of majority of the states.

Table 5.3: Statistical Measures Used by States for Acceptance of Concrete Construction

State	Running Avg	Percent Within Limits	Percent Defective	Avg Absolute Deviation	Mean	Mean & Std Dev	Quality Index	Range
CO							X	
FL					X			
IA							X	
IL	X				X			X
LA					X			
MD					X			
ME		X						
MI			X	X				
MS		X						
NC	X							X
NV	X			X	X			X
NY		X			X			
OR		X						
PA		X					X	
SC				X				
TX				X	X			
WA		X						
WI	X					X		X
WY		X					X	
19	4	7	1	4	7	1	4	4

Findings from the literature search on the most commonly defined tests for acceptance of concrete construction, as shown in Tables 5.2 and 5.3, are discussed below.

<u>Variability of Portland Cement Concrete (PCC) Acceptance Tests</u>

Cylinder and Pavement Core Strengths - Although strength is not always the most important characteristic of concrete, it is the one that is most often measured for acceptance and/or rejection of concrete production and construction. It is assumed to be indicative of the water-cement ratio and, accordingly, indicative of durability. The magnitude of variability in strength is, therefore, an indicator of the magnitude of variability of other characteristics.

Results of early studies by some states on compressive strengths variability are presented in Table 5.4(6,14). These strength data show large standard deviation with average strengths well above the usual minimum of 3000 psi. Generally such wide variations are associated with lengthy production periods. It has also been observed that concrete used for incidental (minor structural) construction, where routine control is not as stringent as in major structural concrete production and placement, the variability is generally higher(6,9,14).

The variability in core strengths of concrete pavement can also show wide fluctuations than strength variability of 28-day cylinders for QC purposes. This is because the age of the cores can vary widely, from 30 days to as much as a year within the same project.

Table 5.4: Portland Cement Concrete Variations

State	Average Compressive Strength, psi a/	Type of Concrete	Standard Deviation, psi	Coefficient of Variation, cv
LA(6)	4842	General Structure	635	13.1
LA(6)	2982	Minor Structure	908	30.4
FL(11)	5054	General Structure	585	11.6
NY(14)	4410	"	756	17.3
IL(14)	4465	"	390	8.7
VA(14)	4840	"	660	13.6
ME(14)	5168	"	588	11.4
PA(14)	4647	"	699	15.1
LA(6)	5353	Paving (Cores)	1013	18.9
OH(14)	7403	"	1180	15.9
KS(14)	5166	"	689	13.3

a/ 28-day cylinder strengths for structural PCC
1 psi = 6.9 kpa

In addition to the material and sampling variation, there is testing variation that can contribute to large variation in compressive strengths. American Concrete Institute's (ACI) 214-89 "Recommended Practice for Evaluation of Strength Results of Concrete" (9) provides some guidelines for determining the quality of a laboratory operation based on the within-test coefficient of variation. ACI 214-89 also provides guidelines for rating construction control for the total coefficient of variation values of compressive strengths. These rating values are shown in Table 5.5.

Table 5.5: ACI standards for concrete control

Class of Operation	CV for different control standards				
	Excellent	Very Good	Good	Fair	Poor
Over-all variation: General construction	Below 10.0		10 - 15	15 - 20	Above 20
Within-test variations: Field control	Below 3.0	3.0 - 4.0	4.0 - 5.0	5.0 - 6.0	Above 6.0

* Variation in compressive strength between replicate cylinders tested by the same operator

Pavement Thickness Variability - Large variations in pavement thickness are detrimental and uniformity in core thickness is important for better slab action and, therefore, prolonged pavement life. Variability in core thicknesses as reported by some states are shown in Table 5.6(6,14,15). Statistically significant variations in thickness, between lots for a given project, have also been documented as shown in the same table. Uniformity in this quality characteristic is important to minimize early failures due to concentration of weaker points.

Table 5.6: Variation in PCC Pavement Thickness

State	Plan Thickness, in	Avg Thickness, in	Std Dev, in
LA(6)	8	8.52	0.50
LA	9	9.55	0.56
LA	10	10.35	0.41
OH(14)	9	9.21	0.32
OH	11	11.10	0.39
KS	9	9.21	0.32
GA	10	10.19	0.19
IL(15)	9	9.61(9.87)a/	0.24(0.17)
OH	8	8.11(8.21)	0.83(0.37)

a/ Between sublot values, 1 inch=25.4 mm

Pavement Smoothness Variability - Information on this construction property is limited since not very many states measure this property as indicated in Table 5.2. The method used to evaluate the ride quality has considerable influence on the variability of the measurements.

A study conducted at the University of Texas using the Ames profilograph showed standard deviation between 0.8 to 1.2 in/mile for the average of two results from the same profilograph (*14*). The report states that the overall variability is influenced by the operator of the profilograph variability and the interpreter variability.

Variability of Portland Cement Concrete (PCC) Control Tests

Slump - The slump test is more of a screening test to determine the consistency of the concrete mix. The results of these tests are a good indicator of mix uniformity. Results of studies by states have indicated that material variation contributes more to the overall variability than do sampling and testing (*11*). Depending on the range of specification requirements, the variability is generally between 0.5 to 0.8 inches for the cone method.

Air Content - Although a screening test, it is an important factor in the durability of pavements and bridge decks. Some states consider it important enough as acceptance test for pay purpose. Earlier studies by states showed that the air content using Chace meter gave somewhat higher contents than Pressure meter. The standard deviation ranges from 0.70 to 1.60 (*11,14*).

Summary

The purpose of this literature search was to identify the QA/QC tests and procedures states are using relative to Louisiana's QA/QC system. In that respect it can be said that the current tests for acceptance of concrete construction, as defined in the standard specifications, follow the trend of majority of the states' system reviewed. Likewise, the statistical measures used by LADOTD also follow majority of the states' measures for quality assurance and acceptance of concrete construction and tests. However, the review has also indicated the states' awareness of the need to minimize variability of individual lots. This is evident from Table 5.3 where there may be an increase in the number of states using the mean and standard deviation ***(sigma-unknown or PWL)*** concept for acceptance as an alternate to the more common statistical measure using the mean ***(sigma known)*** concept. The implementation of DOTD's Superpave asphaltic concrete specifications is based on this PWL concept and includes Quality Level Analysis for control and acceptance of mixes produced using Superpave design procedures. This quality level analysis is applied to validate job mix formulas, for project acceptance, and other QC procedures of contractors.

6. DATA COLLECTION AND ANALYSIS

In this section discussion relative to data collection, data base development and, finally, data analysis is presented. The governing DOTD's specifications applicable to data analysis are the 1992 specifications and are summarized in Appendix A *(16)*.

Data Collection -

As stated under scope in section 2, the analysis was to be confined to data collected during post 1992 specifications on structural and paving concrete. Further, this data was to be gathered from the computerized files of the DOTD's Material Test data reporting system (The MATT system) *(17)*. Since the MATT system is an on line system with data entered on daily basis, a cutoff date was set at August 1999. Thus, concrete test records generated by the 1992 specifications through the end of August 1999 formed the data base for analysis.

Data Base -

The data base developed for analysis consisted of three separate files as follows:

MATTA File - structural concrete strength tests file
MATTN File - paving concrete roadway core strength and thickness tests file
MATTI File - Paving concrete profile tests file

Since each record (a record being a set of data representing a unique entity such as a lot) has several items of information, only items pertinent to the analysis were included in the data base for each of the files defined above. Appendix B defines, for each record in the above three files, the various data fields that were included in the data base. The forms used for test data entry and the various material codes representing the various class and type of concrete are also shown in this appendix.

Table 6.1 lists the breakdown of number of projects, lots (records) and quantity of material for each of the three files. Table 6.2 is a further breakdown of the same information by districts. Thus, in Table 6.1 for structural concrete, there were 17,443 lots from 861 projects available for analysis. The total quantity of concrete distributed over these 17,443 lots was 680,624 cubic yards. Likewise, of the 680,624 cu yd of total concrete placed statewide, 93,918 cu yd was placed in district 02 distributed over 2064 lots and 114 projects as shown in Table 6.2.

Table 6.1: Concrete MATT System data file.

MATT Files	No of Records (Observations)	No of Projects	No of Lots	Quantity cu yd/sq yd
Structural concrete file	17,443	861	17,443	680,624
Paving concrete core file	488	55	488	1,720.912
Paving concrete profile file	368	40	368	1,138,129

Table 6.2: MATT System data files by districts

Dist	MATT System for								
	Structure Concrete			Paving Concrete Core Strength and Thickness			Paving Concrete Profile Index		
	No of Proj	No of Records/Lots	Quant, cu yd	No of Proj	No of Records/Lots	Quant, sq yd	No of Proj	No of Records/Lots	Quant, sq yd
02	114	2064	93,918	9	51	161,416	2	28	87,773
03	91	2498	107,055	6	48	174,548	6	36	48,488
04	123	2019	59,799	8	45	134,734	9	26	40,355
05	107	1808	58,480	5	24	86,147	6	27	68,183
07	66	1072	54,939	7	65	235,903	4	20	39,573
08	131	3013	102,002	6	33	112,431	3	18	56,870
58	69	869	20,872	0	00	00	0	00	00
61	87	2418	104,304	11	162	589,555	7	111	401,767
62	73	1682	79,255	3	60	226,178	3	102	395,120
Total	861	17443	680,624	55	488	172,0912	40	368	1,138,129

1 sq yd= 0.836 sq m, 1 cu yd= 0.764 cu m

Data Analysis -

Preliminary to analysis, it was decided that only the data representing MATT file **Purpose Code "3"**, namely, **acceptance**, would be included in the analysis. Data representing extraneous purpose codes representing information, verification, etc., were deleted before creating temporary files for analysis. Also, whenever "noise" in the MATT data file was indicated (and it does exist in spite of data checks and edits), that record was deleted from the analysis. An example of such data would be the presence of zero value for strength (more about validity of data in the MATT system will be discussed under separate heading).

Likewise, data representing special projects not governed by standard specifications were also deleted from the analysis.

The analysis is presented in two separate sections. The assessment of price adjustments for lots that were deficient in acceptance criteria is in the next section, and variability of data in the following section. The Operating Characteristic (OC) curve of the current acceptance plans will be the topic of a separate section including simulation of **PWL** type specifications on selective projects.

Whenever appropriate, reference will be made to the findings reported in the 1979 study *(6)*. Likewise, conclusions will be summarized after each topic discussion as deemed appropriate. All data access, management, analysis, and presentation was accomplished through the ***Statistical Analysis System (SAS)*** *(18)* package at the DOTD's computer division.

7. ASSESSMENT OF PRICE ADJUSTMENT

1. Structural Concrete -

Overview of Acceptance Criteria -

Louisiana's 1992 specifications require adjustment in unit price for lots that do not meet the requirements for 100% pay. The major acceptance criteria for this concrete, identified as class of concrete, is the 28-day compressive strength of cylinders fabricated at job sites by the DOTD's personnel and tested at the district laboratory. Depending on the use, different classes of concrete have different compressive strength requirements. The acceptance is based on the average strength of each lot, a lot being two batches with three cylinders per batch. The average of the two batches is the lot average for pay purpose. The schedule of payments for non conforming concrete is given in Appendix A.

Overall price reduction

Table 7.1 is the summary of pay reduction for non-conforming concrete. The table shows the breakdown of pay reduction by number of projects, lots and quantity. For comparison purpose, data from the 1979 evaluation is also shown *(6)*. Approximately 73% of the projects received 100% pay. On the basis of total lots submitted, about 2.1% had reduced pay. Since the unit of pay is in cubic yards, of importance is the amount of reduction by quantity which is only 1.4% of the total quantity. More than half of this reduction in pay was at the 98% level. Sixty two lots from 48 projects and 1449 cubic yards (0.2%) were deficient at the 50% level. In the 1979 data, the deficiency at this level was 0.13%.

It is interesting to note that although the reduction in pay at the 95% and 80% is not in the acceptance payment schedule for structural concrete specifications (Appendix A), 32 lots from 18 projects representing some 958 cubic yards had received payment at these levels. However, reduction in payment at these levels are defined for paving concrete, and, it is assumed that the class of concrete was substituted for paving concrete and cylinder strengths were used in lieu of roadway cores for acceptance. Also 246 cubic yards were listed with 0% (zero) pay. This is unexplainable since no such pay level is defined in the acceptance schedule. Likewise, no explanation was given in the individual MATT test report for the lot.

Figure 7.1 is the bird's eye view of the data in Table 7.1. Also shown on this chart is the data from the 1979 study. The present data show a decrease in the quantity of concrete receiving reduced pay by almost 3.5% (1.4% versus 4.9%). The data evaluated in the 1979 report represented construction data from 1973 through 1977 on 561 projects and about 500,000 cubic yards concrete.

Table 7.1: Summary of pay reduction for deficiency in structure concrete

Percent Pay	No of Projects (%)	No of Lots (%)	Quantity, cu yd	
			2000 Data (%)	1979 Data (%)*
98	106 *(12.3)*	187 *(1.1)*	5,312 *(0.8)*	16,696 *(3.5)*
95	14 *(1.6)*	22 *(0.1)*	633 *(0.1)*	1,259 *(0.3)*
90	52 *(6.0)*	67 *(0.4)*	1,766 *(0.3)*	4,631 *(1.0)*
80	4 *(0.5)*	10 *(0.0)*	325 *(0.0)*	239 *(0.0)*
50	48 *(5.6)*	62 *(0.4)*	1,449 *(0.2)*	610 *(0.1)*
0	8 *(1.0)*	13 *(0.1)*	246 *(0.0)*	****
Total with reduced pay	232 *(27.0)*	361 *(2.1)*	9,731 *(1.4)*a/	23,435 *(4.9)*
Total with 100% pay	629 *(73.0)*	17,082 *(97.9)*	670,893 *(98.6)*	454,085 *(95.1)*
Total constructed	861	17,443	680,624	477,520

* - Represent class AA, A, R, & A minor concrete only. a/ includes 0% values, 1 cu yd=0.764 cu m

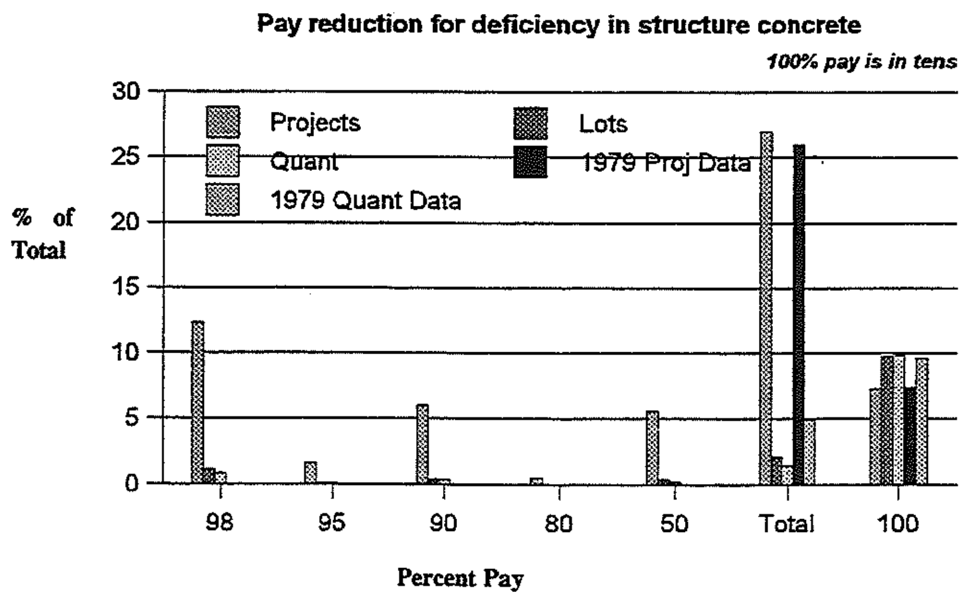


Figure 7.1: Overall distribution of price reduction for structural concrete

Price reduction by class of concrete -

To determine how this reduction in pay is distributed over different classes of concrete, Table 7.2 was prepared. The same data is charted in Figure 7.2 and 7.3. Of the total reduction in pay for quantity, about 85% is contributed by the most commonly used concrete, Class AA, A, R (minor)and A (minor). These four classes also represent about 80% of the total quantity used.

Comparison of this data to the 1979 data follow the same trend as was indicated in Table 7.2 for overall pay reduction. For AA concrete (Table 7.2 and Figure 7.2), only 1.98% of concrete was subjected to 98% pay versus 8.3% for the 1973-1977 construction data. For the same class, the percentage of quantity receiving pay at the 100% level has increased from 91.7% for 1973 - 1977 data to 98% for post 1992 construction data. For class A concrete 98.4% of the total quantity used for this class received 100% pay versus 96.3% for the 1979 data.

Table 7.2: Summary of Pay reduction by class and quantity

% Pay		Concrete Class and Quantity in cu yd (1 cu yd=0.764 cu m)							
		401	402	403-406	414-424	428 429	431 432	500s	Total
98	Quant	2930	1878	3	104		213	184	5312
	%	*(1.41)*	*(1.05)*	*(0.01)*	*(0.50)*		*(0.16)*	*(0.87)*	*(0.78)*
95	Quant	51		104	8	459	11		633
	%	*(0.02)*		*(0.43)*	*(0.04)*	*(0.62)*	*(0.01)*		*(0.09)*
90	Quant	1028	669	35	8		20	6	1766
	%	*(0.49)*	*(0.37)*	*(0.14)*	*(0.04)*		*(0.01)*	*(0.03)*	*(0.26)*
80	Quant					320	5		325
	%					*(0.43)*	*(0.0)*		*(0.05)*
50	Quant	26	270		284	115	652	102	1449
	%	*(0.01)*	*(0.15)*		*(1.36)*	*(0.15)*	*(0.49)*	*(0.48)*	*(0.21)*
0	Quant	82	71	74	16			3	246
	%	*(0.04)*	*(0.04)*	*(0.30)*	*(0.07)*			*(0.01)*	*(0.04)*
Total quantity with reduction		4117	2888	216	420	894	901	295	9731
Total quantity		208,075	179,240	24,468	20,817	74,579	133,837	21,266	680,624
Percent for class (2000)		*1.98*	*1.61*	*0.88*	*2.02*	*1.20*	*0.67*	*1.39*	*(1.43)*
Percent for class (1979)		*(8.3)*	*(3.7)*	*(6.6)*			*(1.3)*		*(4.91)*

Figure 7.3 shows distribution of levels of pay reduction for minor concrete. The reduction for the two classes of minor concrete, R and M, was 0.88 and 0.67, respectively. For the same class of concrete, these reductions were 6.6% and 1.3%, respectively, for the 1979 evaluation. At the 50% level, R concrete had 1.4% versus 1.75% for the 1979 data.

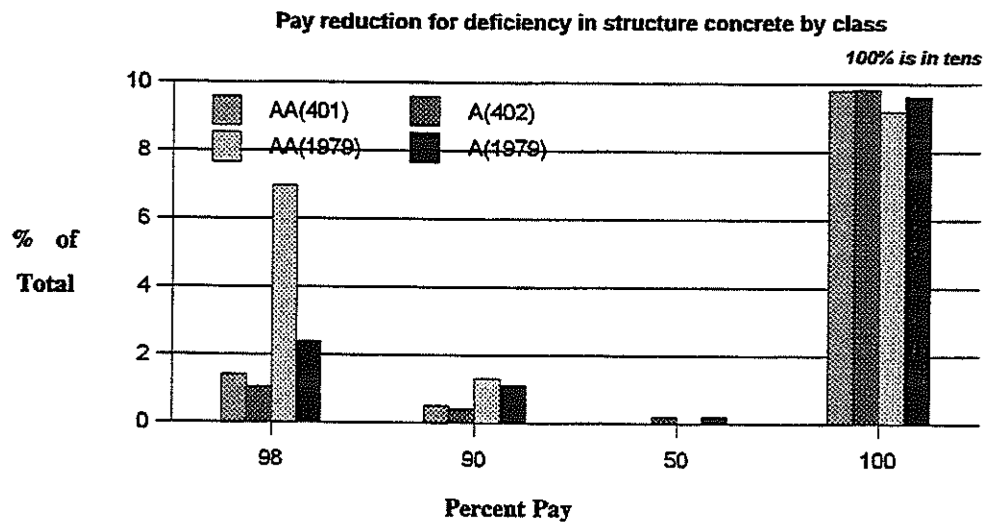


Figure 7.2: Distribution of price reduction for class A & AA concrete

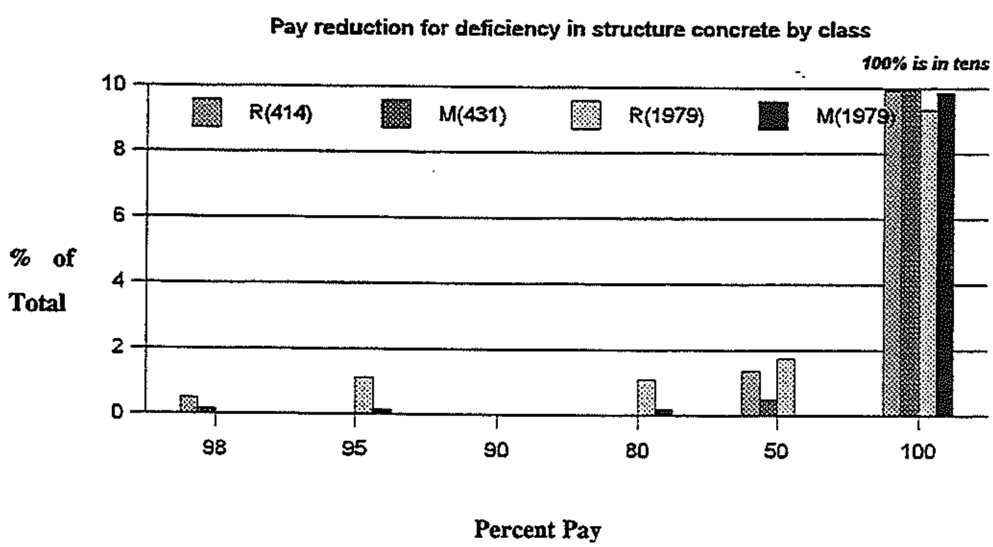


Figure 7.3: Distribution of price reduction for minor concrete

Price reduction by districts -

Table 7.3 is a summary of pay reduction by districts. Projects in districts 2, 4, 6, and 8 have contributed more than half of the total reduction in pay. Whether the level of control maintained with respect to the mean and standard deviation has had any effect on this reduction will be evaluated in the variability portion of the analysis.

Table 7.3: Summary of Pay Reduction by district

Dist	Percent Pay/Quantity, cu yd						
	98	95	90	80	50	0	Total
01	19	56	28	5	62	16	186
02	1,131	14	313	28	32	**	1517
03	1,026	41	80	****	153	77	1378
04	1,417	****	547	****	259	29	2252
05	****	2	11	79	144	122	358
06	934	****	446	****	225	**	1605
07	103	****	12	****	60	3	178
08	415	519	219	213	368	**	1734
09	268	****	110	****	147	**	524
Total	5,312	633	1,766	325	1,449	246	9731

1 cu yd=0.764 cu m

2. Paving Concrete - Strength and Thickness

Overview of Acceptance Criteria -

Concrete used for paving is classified according to type. The major acceptance criteria for this concrete is the 28-day compressive strength and thickness measured on roadway cores. Different types of concrete have compressive strength requirements according to whether air entrainment is used or not. The acceptance is based on the average strength and thickness of each lot, a lot being an identifiable area of pavement constructed. One core from each of five equal segments of the lot is obtained for strength and thickness measurements. The average of these two tests for the lot is evaluated for pay purpose. The schedule of payments for non conforming lots is summarized in Appendix A.

Overall price reduction -

Table 7.4 is a summary of pay reduction for non-conforming concrete. Graphical presentation is shown in Figure 7.4. Of the 55 projects evaluated, 14 or 25% show a reduction in price. In terms of lots, 20 lots had deficiency with 17 of these due to thickness deficiency. Of these 17 lots, seven were from one project. Evaluation of the thickness data of this project showed that the average lot thickness was too close to the plan thickness which resulted in several non-conforming lots. This will be discussed further in the variability section of the analysis.

Table 7.4: Summary of pay reduction for deficiency in Paving concrete

Percent Pay	No of Projects (%)	No of Lots (%)	Quantity, sq yd (%)
95	6 *(10.9)*	12 *(2.5)*	42,473 *(2.47)*
90	3 *(5.5)*	3 *(0.6)*	9,189 *(0.53)*
80	2 *(3.6)*	2 *(0.4)*	8,000 *(0.46)*
75	2 *(3.6)*	2 *(0.4)*	5,253 *(0.31)*
50	1 *(1.8)*	1 *(0.2)*	4,000 *(0.23)*
****	12*(21.8)*	58 *(11.9)*	166,106 *(9.65)*a/
Total with reduced pay	14 *(25.4)*	20 *(4.1)*	68,915 *(4.00)*
Total with 100% Pay	41 *(74.6)*	411 *(95.9)*	1,651,997 *(96.0)*
Total constructed	55	488	1,720,912

a/ included in 100% pay 1 sq yd = 0.836 sq m

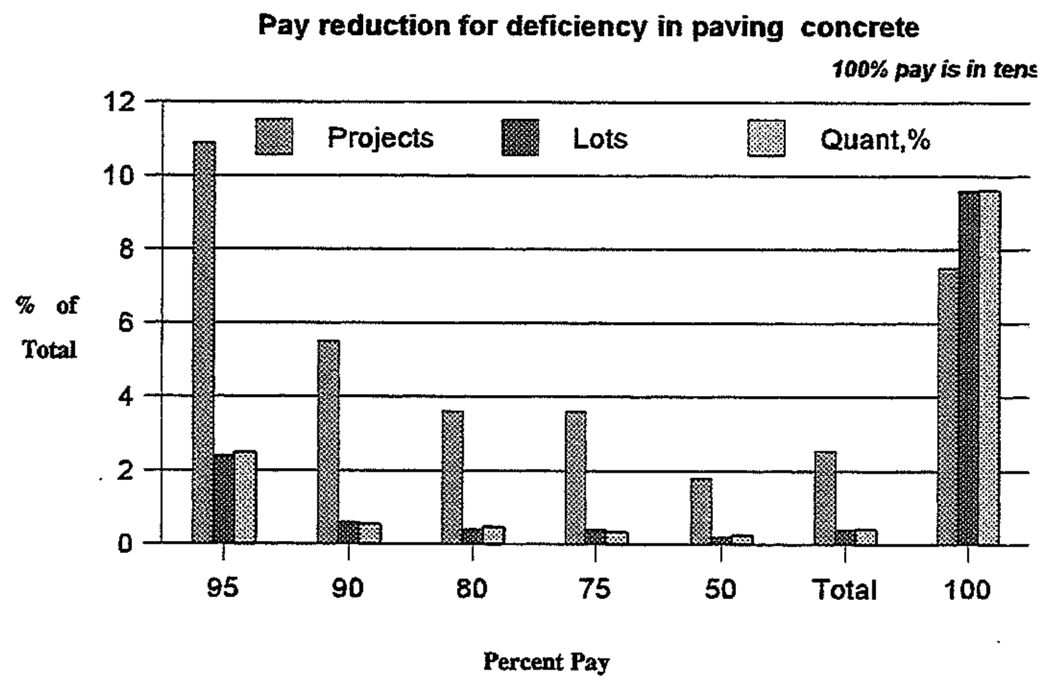


Figure 7.4: Distribution of price reduction for paving concrete

The overall reduction as a result of these deficiencies was 4% of the total quantity with more than half at the 95% level.

The low number of lots (three) with strength deficiency can be attributed to the age of concrete cores at testing time which in most cases exceed the specified minimum curing age of 28 days by as much as 10 to 15 times. In a number of cases, this age was recorded in excess of 200 days. This generally results in higher strengths than would otherwise be indicated at or around the specified curing period.

There were some lots with missing pay values (shown as asterisks under percent pay column). Once again, no valid reason could be determined from individual reports. However, these were included as being paid 100%.

In the 1979 evaluation, 97% of the concrete (Type B) had 100% pay. The three percent that received reduced pay was due to non-conforming thickness. The evaluation was based on 1.69 million square yard concrete distributed over 73 projects.

3. Paving Concrete - Profile Testing

Overview of Acceptance Criteria -

Acceptance of pavement is on lot basis with lot defined as for strength and thickness acceptance criteria. Using an approved profilograph, the profile index is determined longitudinally in each wheel path of each travel lane to determine the smoothness of pavement. Lots not meeting the specified tolerance for smoothness, after corrections are made, are paid at reduced price. The schedule of payment for non conforming lots is summarized in Appendix A.

Overall price reduction -

Table 7.5 is an overview of pay assessment for lots not meeting the stated requirements for smoothness criteria. Figure 7.5 is a chart of the tabled data. Only six of the 368 lots did not meet the requirement for 100% pay. In terms of quantity, this amounts to about 4%. No comparative data from the 1979 evaluation is available.

One of the reasons for such low number of non conforming lots is that the contractor, during quality control testing, is required to correct deficiencies in excess of specified values before submission for acceptance testing.

Table 7.5: Summary of pay reduction for deficiency in Profile Index

Percent Pay	No of Projects (%)	No of Lots (%)	Quantity, sq yd (%)
98	2 *(5.0)*	3 *(0.8)*	9671 *(0.85)*
95	2 *(5.0)*	2 *(0.5)*	3573 *(0.31)*
80	1 *(2.5)*	1 *(0.3)*	2315 *(0..20)*
50	0 *(0.0)*	0 *(0.0)*	0 *(0.)*
****	8 *(20.0)*	25 *(6.8)*	59,788 *(5.25)*)a/
Total with reduced pay	5 *(12.5)*	6 *(1.6)*	15,559 *(1.40)*
Total with 100% Pay	35 *(87.5)*	362 *(98.4)*	1,122,570 *(98.6)*
Total constructed	40	368	1,138,129

a/ included in 100% pay   1 sq yd=0.836 sq m

Summary of Price Adjustments -

The discussion presented in the preceding sections can be summarized in the following statements:

- On the basis of total quantity of structural concrete, the average reduction in final pay was 0.2%, or an average payment per project of 99.8%. This substantiates the average pay of 99.7% for the 1979 projects.

- Compared to the 1979 data evaluation, there has been an increase in the quantity of structural concrete receiving 100% pay. In terms of reduced pay (less than 100%), only 1.4% of the total quantity used in structures was subjected to reduction in price. This reduction was 4.9% for the 1979 data.

- Because of the large volume of concrete used in Class AA and A, 72% (7005 cu yds) of the total concrete that received reduced pay (9731 cu yds) was for this class of concrete. For the 1979 data, the reduction for this class was 92% (21,741 cu yds) of the total of 23,435 cu yds.

- Of the total concrete that had pay reduction, about 15% was at the 50% level compared to 2.6% for the 1979 data.

- The average price reduction in final pay for paving concrete was 0.5%, or an average payment of 99.5% per project. The average payment for the 1979 projects was 99.9%.

- Most of deficiency in paving concrete stems from non-conforming thickness. Furthermore, because of extended curing period allowed before testing for strength, practically none of the concrete showed deficiency in strength requirement. Similar trend was noticed in the 1979 evaluation. The overall reduction was 4% of the total square yards laid with more than half at the 95% reduction level.

- Four percent of the pavement tested for surface smoothness showed profile index exceeding the stated requirements.

8. VARIABILITY OF DATA

In Section 5, it was shown that for a normally distributed property, about 95% of the data can be expected to fall between $\pm 2\sigma$ limits from the mean, and almost 100% of values would be included within $\pm 3\sigma$ from the mean. On the basis of this property of the normal distribution, there exists a definite relationship between specifications and statistical parameters. If the specification tolerances were developed from some known standards of the mean and the standard deviation, any deviation on the process control from this known standard is likely to change the probability of acceptance and/or rejection of the product.

This section discusses the variability of the various criteria defined for control and acceptance of concrete construction, and comparison of this variability to known standards defined by the governing specifications. In the tables that follow, N represent total number of observations and Nlot, number of lots.

1. ***Structural Concrete Strength Variability*** -

Statewide Variability by Class of Concrete

Tables 8.1 and 8.1a show the variability of compressive strength of different classes of concrete. The data represents values pooled over all projects and lots for that class. The tabled data on variability are plotted in Figures 8.1 through 8.3. The plots are for the most commonly used concrete class.

Most of the data follow normal distribution as indicated by the skewness values of less than absolute one. The closeness to the normal distribution is also indicated by the frequency distribution plots of strengths by class of concrete. These distributions are shown in Appendix C.

Based on the ACI rating standards of Table 5.5, the coefficient of variation indicates that the level of production and field control was good for most classes of concrete. This measure of variability is useful in comparing data from multiple sets of measurements with different units or widely differing means. Three classes of concrete, 428, 429 and 431 show fair level of control and class R concrete, poor. The large magnitude of the coefficient of variation for class R concrete is due to the minimal inspection exercised over its production and field control.

Strength variability on projects that were let under the Metric system of specifications is shown in

Table 8.1: Statewide overall & lot variability in compressive strength of different classes of structure concrete (EU)

Concrete Class (MATT Code)	N *NLot*	Quant, cu. yd	Mean, psi	Std Dev, psi	CV	Min, psi	Max, psi	Range, psi	Skewness	Kurtosis
AA (401)	23,861	208,076	5285	738	14.0	1510	8610	7100	0.4	0.8
	4,411		*5294*	*709*	*13.4*	*2398*	*8233*	*5835*	*0.4*	*0.8*
A (402)	36,193	179,240	5358	779	14.5	31	9405	9374	0.4	1.0
	7083		*5350*	*753*	*14.1*	*33*	*9143*	*9110*	*0.4*	*1.1*
D (403)	99	4,298	5040	559	11.1	3340	5860	2520	-0.8	0.3
	17		*5027*	*509*	*10.1*	*4120*	*5755*	*1635*	*-0.3*	*-1.1*
P (404)	87	221	5313	765	14.4	4050	7350	3300	0.6	0.0
	15		*5354*	*770*	*14.4*	*4249*	*6993*	*2744*	*0.7*	*0.3*
S (406)	1416	19,949	5770	758	13.1	3463	9400	5937	0.4	1.5
	259		*5727*	*725*	*12.7*	*3623*	*8805*	*5182*	*0.4*	*1.3*
R (414)	1305	17,709	3208	1002	31.2	1130	8341	7211	1.3	2.3
minor	*403*		*3170*	*972*	*30.7*	*1463*	*8105*	*6642*	*1.3*	*2.5*
AAM (421)	113	996	5305	577	10.9	3700	6950	3250	-0.3	0.6
	23		*5313*	*618*	*11.6*	*3757*	*6440*	*2683*	*-0.3*	*0.8*
AM (422)	297	1,900	5757	476	8.3	4471	7120	2649	0.1	0.1
	65		*5710*	*438*	*7.7*	*4507*	*7043*	*2536*	*0.1*	*0.8*
PM (424)	81	212	6944	882	12.7	3554	9022	5468	-1.2	3.1
	27		*6944*	*859*	*12.4*	*4132*	*8659*	*4527*	*-1.3*	*3.6*
Pvt-air (428)	3240	54,701	5525	903	16.3	2620	9035	6415	0.1	0.3
	757		*5508*	*887*	*16.1*	*2640*	*8237*	*5597*	*-0.0*	*0.3*
Pvt-no air (429)	198	19,878	5114	947	18.5	3428	7860	4432	0.7	-0.2
	52		*4984*	*867*	*17.4*	*3535*	*7318*	*3783*	*0.8*	*0.1*
M (431)	10,285	130,754	4990	825	16.5	354	8738	8384	0.3	0.7
	3220		*4987*	*803*	*16.1*	*2332*	*7996*	*5664*	*0.3*	*0.5*
F (432)	366	3,083	4593	612	13.3	2844	5897	3053	-0.4	-0.2
	109		*4629*	*571*	*12.3*	*3188*	*5840*	*2652*	*-0.4*	*-0.1*
No pile (434)	24	134	5402	433	8.0	4804	6306	1502	0.7	-0.8
	4		*5402*	*476*	*8.8*	*4981*	*6057*	*1076*	*1.2*	*0.9*
(460)	225	18,210	5924	463	7.8	4878	7526	2648	0.6	0.8
	38		*5925*	*425*	*7.2*	*5081*	*7089*	*2008*	*0.6*	*0.9*

1 psi=6.89kPa

Table 8.1a. Class AA and A fall in the fair category with class R showing poor level as was indicated under the English system. According to charts 8.1 through 8.3, the values for different measures of

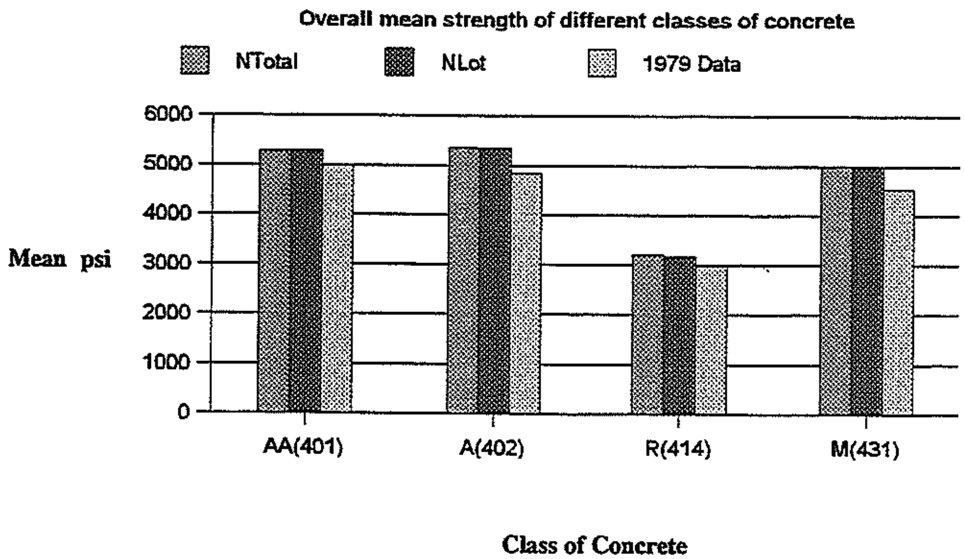


Figure 8.1: Overall mean strength of different classes of concrete

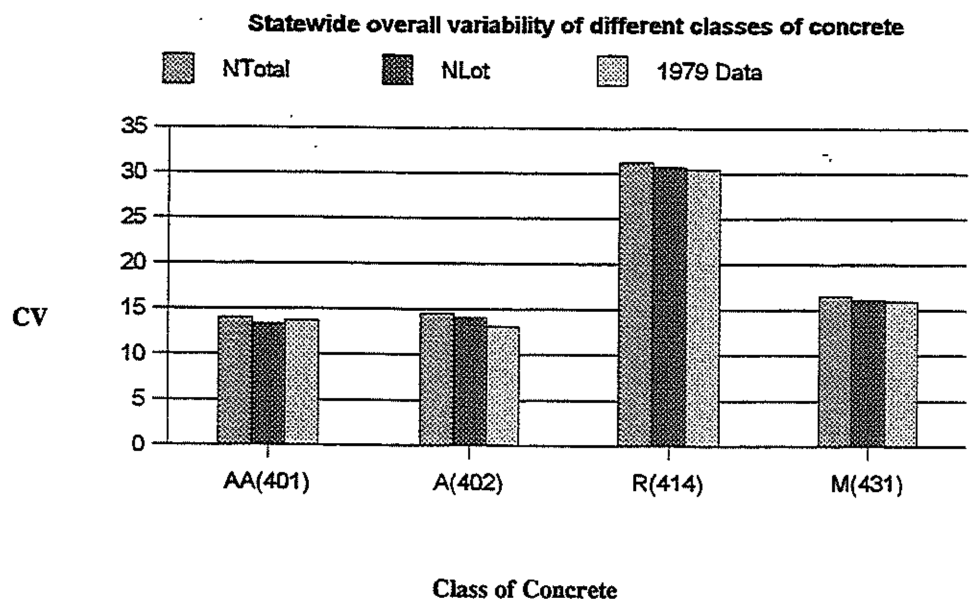


Figure 8.2: Overall coefficient of variation of different classes of concrete

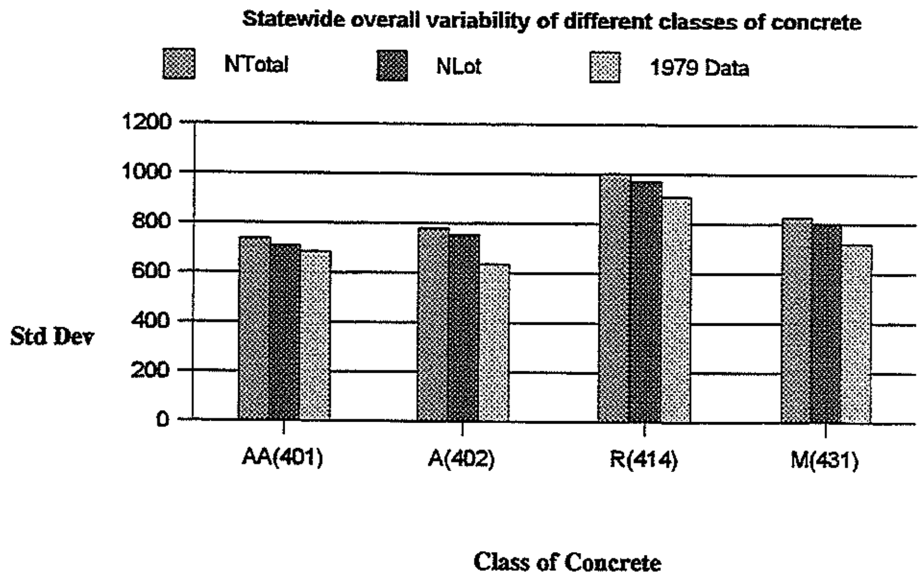


Figure 8.3: Overall standard deviation of different classes of concrete

variability are higher than those indicated by the projects evaluated in 1979. There is an increase in the mean strength across all classes of concrete with the corresponding increase in standard deviation also. This trend (increase variability with increase in the mean) is not uncommon although less desirable. Sometimes the influence of time (lengthy production periods lasting from few days to several months) as a source of variation contributes to the overall variation. This results in a constant change in process control which is reflected in the variability of the measurements. As was mentioned before, any deviation in the process control from the known standard is likely to change the probability of acceptance and/or rejection of the product. To determine the effect of this deviation (increase in the standard deviation and the mean), Table 8.2 was prepared.

The table shows actual number of samples versus predicted number of non-conforming samples for the four classes of concrete. The predicted numbers were calculated using the variability data of Table 8.1 and the theoretical area under the normal curve. The values are for the individual and average strength requirements defined in the specifications for the class of concrete and shown in column 2. There is a close agreement between the predicted and actual number of measurements indicating adequate level of standard maintained with respect to the mean and standard deviation.

Table 8.1a: Statewide overall & lot variability in compressive strength of different classes of structure concrete (MU)

Conc Class (MATT Code)	N *NLot*	Quant, cu m	Mean, MPa	Std Dev, MPa	CV	Min, MPa	Max, MPa	Range, MPa	Skewness	Kurtosis
AA (501)	657 *129*	2308	35.1 *34.6*	6.6 *6.1*	18.7 *17.5*	19.9 *21.9*	55.6 *51.2*	35.7 *30.3*	0.8 *1.0*	0.5 *1.0*
A (502)	2,466 *507*	7996	37.1 *36.8*	5.7 *5.6*	15.4 *15.2*	17.7 *18.3*	73.3 *55.8*	55.6 *27.5*	0.7 *0.7*	1.2 *0.9*
P (504)	38 *13*	134	40.4 *41.6*	4.7 *4.7*	11.7 *11.4*	30.4 *31.6*	49.2 *48.0*	18.8 *16.4*	-0.2 *-0.9*	-0.6 *0.5*
S(506)	39 *7*	184	41.2 *41.1*	2.6 *2.3*	6.3 *5.5*	35.3 *36.6*	45.2 *43.5*	9.9 *6.9*	-0.6 *-1.4*	-0.4 *2.6*
R(514)	36 *11*	194	18.7 *18.1*	5.6 *5.6*	30.1 *31.1*	9.7 *9.9*	29.9 *29.1*	20.2 *19.2*	0.3 *0.5*	-0.9 *-0.1*
Pvt air(528)	578 *126*	6046	42.9 *42.1*	7.0 *6.5*	16.4 *15.4*	28.5 *30.6*	62.0 *58.2*	33.5 *27.6*	0.3 *0.4*	-0.7 *-0.6*
Pvt noair(529)	12 *4*	154	34.8 *34.8*	3.1 *3.3*	9.0 *9.6*	29.2 *29.9*	38.0 *37.2*	8.8 *7.3*	-1.1 *-1.6*	-0.2 *3.3*
M(531)	429 *144*	4250	32.7 *32.7*	5.7 *5.6*	17.3 *17.1*	18.0 *18.7*	56.6 *54.9*	38.6 *36.2*	0.7 *0.8*	1.7 *1.8*

Table 8.2: Predicted versus actual number of samples outside the limits for compressive strength of Structural Concrete

Concrete Class (MATT Code)	PSI's less than	Actual number (%) less than indicated PSI	Predicted number (%) based on Mean and Std Dev (from Table 8.1)
AA(401)	3200	40 (0.17)	57 (0.24)
	4200	*181 (4.10)*	*271(6.16)*
A(402)	3000	47 (0.13)	47 (0.13)
	3800	*82 (1.16)*	*142 (2.0)*
R(414) minor	1800	31 (2.38)	105 (8.0)
	1800	*9 (2.21)*	*32 (7.93)*
M(431) minor	3000	61(0.59)	82(0.80)
	3000	*16((0.50)*	*22(0.68)*

District wide Variability by Class of Concrete

Table 8.3 is listing of statistical parameters detailed according to district and class. Figures 8.4 through 8.7 are graphical representation of the tabled data. The data follow the same trend as for statewide variability - increase mean with associated increase in standard deviation. However, based on the ACI rating of Table 5.5, most of the districts show good field control for all classes of concrete except class R which, as before, indicate poor control.

Although the standard deviation shows an increase from the 1979 data in most cases, the contractor was able to maintain the process mean much higher than the minimum required for 100%. As a result, the percentage of expected failure was much higher than the actual failure for some of the districts that had high percentage of quantity with reduced pay (02, 04, 06, and 08). For these districts, the expected failure was between 1.5% to 2.0% compared to actual pay reduction of less than one percent.

District wide Within-test variability

Variation in concrete occurs from two sources: batch-to-batch variation due to concrete materials (mixture) and within-test sources of variation. The data in Table 8.4 and Figure 8.8 show this within-test variability for the nine districts. ACI has developed variability standards that can be expected for compressive strength tests on projects subject to different degrees of control. Referring to Table 5.5, it is seen that the coefficient of variation in excess of 6.0 relative to field control indicates poor testing control. Based on these standards, none of the districts fall in that category with majority showing very good control and two showing excellent control. District 4 seems to have excellent control regardless of the class of concrete. With the exception of one district, similar trend was indicated in the 1979 data. Well maintained equipment with periodic calibration and well defined sampling and testing procedures are prerequisites to maintaining good test standards.

Table 8.3: Districtwide overall & lot variability in compressive strength of Class A , AA & R (minor) structure concrete

Dist	Concrete Class (MATT Code)															
	AA (401)				A (402)				R (Minor) (414)				A (Minor) (431)			
	N *NLot*	Mean, psi	Std	CV	N *NLot*	Mean, psi	Std	CV	N *NLot*	Mean, psi	Std	CV	N *NLot*	Mean, psi	Std	CV
01	2714 *531*	5630 *5611*	669 *652*	11.9 *11.6*	4132 *781*	5744 *5732*	619 *597*	10.8 *10.4*	148 *46*	2917 *2837*	1007 *1034*	34.5 *35.2*	1514 *493*	5432 *5444*	894 *855*	16.5 *15.7*
02	4907 *958*	5477 *5487*	788 *755*	14.4 *13.8*	5236 *998*	5480 *5464*	761 *736*	13.9 *13.5*	57 *19*	3148 *3148*	619 *622*	19.7 *19.8*	1043 *341*	4946 *4936*	762 *741*	15.4 *15.0*
03	984 *189*	5104 *5069*	677 *660*	13.3 *13.0*	4112 *924*	5422 *5414*	771 *766*	14.2 *14.1*	273 *88*	3113 *3033*	934 *791*	30.0 *26.1*	985 *284*	4990 *5035*	695 *673*	13.9 *13.4*
04	1629 *272*	4681 *4681*	515 *489*	11.0 *10.4*	4909 *896*	4845 *4867*	556 *538*	11.5 *11.0*	227 *73*	3691 *3653*	1002 *1002*	27.2 *27.4*	1173 *370*	4562 *4571*	628 *616*	13.8 *13.5*
05	1553 *282*	5777 *5750*	891 *852*	15.4 *14.8*	1547 *293*	6121 *6106*	735 *725*	12.0 *11.9*	15 *5*	3155 *3155*	1081 *1164*	34.3 *36.9*	1262 *341*	5559 *5557*	847 *837*	15.2 *15.1*
06	6472 *1206*	5191 *5201*	578 *547*	11.1 *10.5*	6860 *1403*	5338 *5319*	543 *519*	10.2 *9.7*	177 *58*	3212 *3227*	1045 *1049*	32.5 *32.5*	557 *184*	4894 *4887*	669 *664*	13.7 *13.6*
07	1758 *294*	4848 *4846*	498 *478*	10.3 *9.9*	2590 *452*	4877 *4890*	570 *597*	11.7 *12.2*	120 *27*	3363 *3332*	889 *848*	26.4 *25.4*	207 *60*	4765 *4818*	699 *677*	14.7 *14.0*
08	1380 *260*	5175 *5172*	737 *708*	14.2 *13.7*	2937 *613*	5096 *5084*	768 *746*	15.1 *14.7*	138 *39*	2870 *2749*	986 *981*	34.3 *35.7*	2661 *862*	4722 *4723*	720 *701*	15.2 *14.8*
09	2464 *419*	5308 *5304*	747 *705*	14.1 *13.3*	3870 *722*	5617 *5566*	1018 *974*	18.1 *17.5*	150 *48*	3149 *3099*	1007 *981*	32.0 *31.6*	883 *285*	4955 *4967*	743 *729*	15.0 *14.7*

1 psi-6.89 kPa

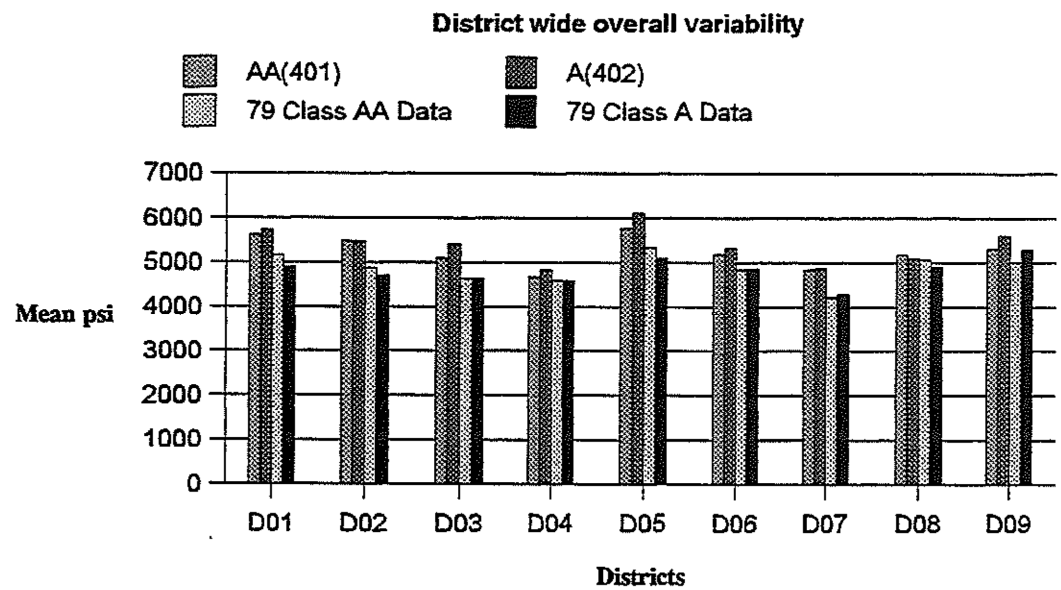


Figure 8.4: District wide mean strength of class A & AA concrete

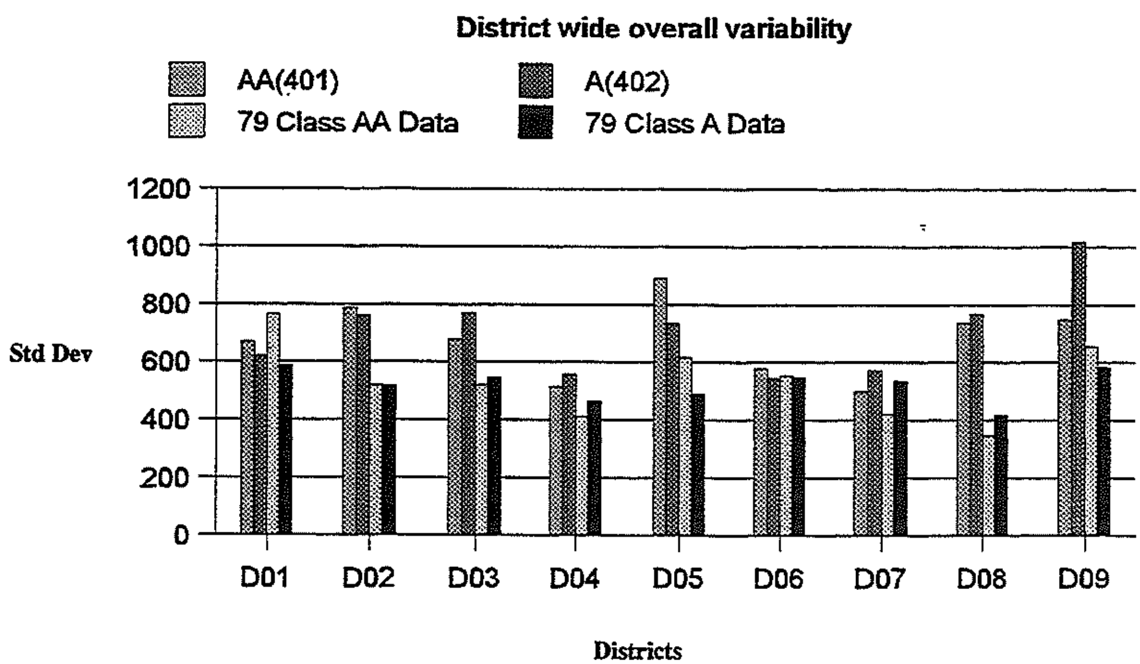


Figure 8.5: District wide standard deviation of class A & AA concrete

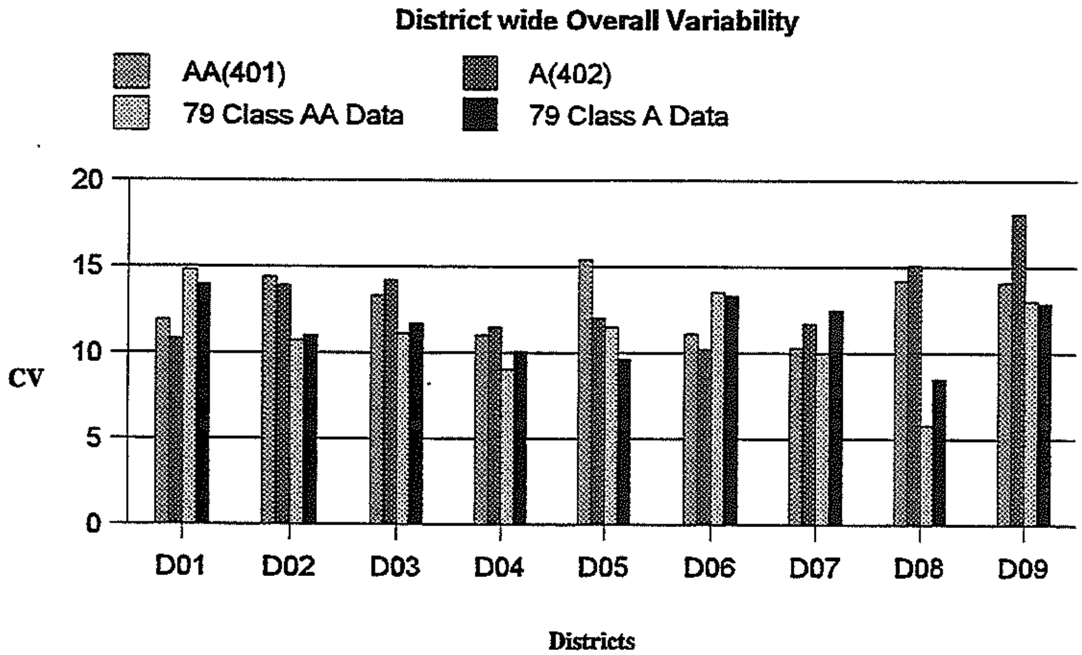


Figure 8.6: District wide coefficient of variation of class A & AA concrete

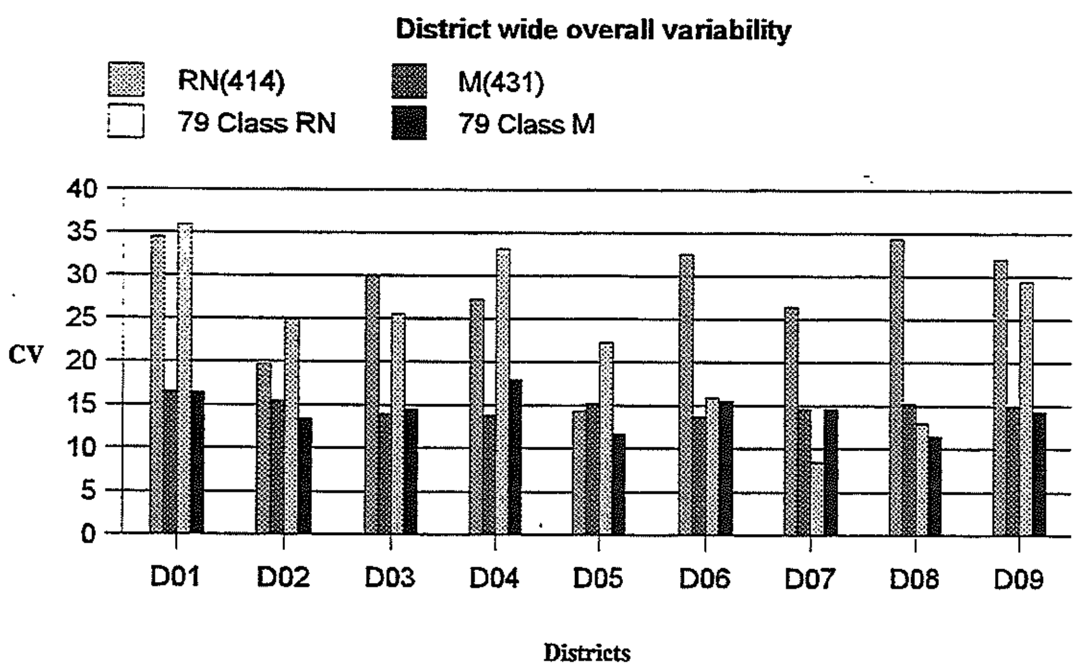


Figure 8.7: District wide coefficient of variation for minor concrete

Table 8.4: District wide test variability in compressive strength of Class A , AA & R (minor) structure concrete

Dist	Concrete Class (MATT Code)											
	AA(401)				A (402)				R (Minor)(414)			
	NLot	Mean psi	Mean Range, psi	CV a/	NLot	Mean	Mean Range	CV	NLot	Mean	Mean Range	CV
01	531	5613	372	3.9	788	5728	331	3.4	47	2933	182	3.7
02	958	5498	295	3.1	998	5471	301	3.2	19	3148	185	3.5
03	189	5081	276	3.2	924	5420	296	3.2	88	3036	155	3.0
04	272	4690	200	2.5	896	4871	140	1.6	73	3651	117	1.9
05	282	5752	334	3.4	293	6103	335	3.2	5	3155	194	3.6
06	1206	5213	246	2.8	1404	5324	197	2.2	58	3226	194	3.6
07	294	4844	198	2.4	452	4884	186	2.3	27	3361	222	3.9
08	260	5163	357	4.1	613	5074	318	3.7	39	2752	181	3.9
09	419	5311	308	3.4	723	5569	311	3.3	48	3101	159	3.0

1 psi = 6.89kPa   a/ - mean range/(1.69)(mean psi)

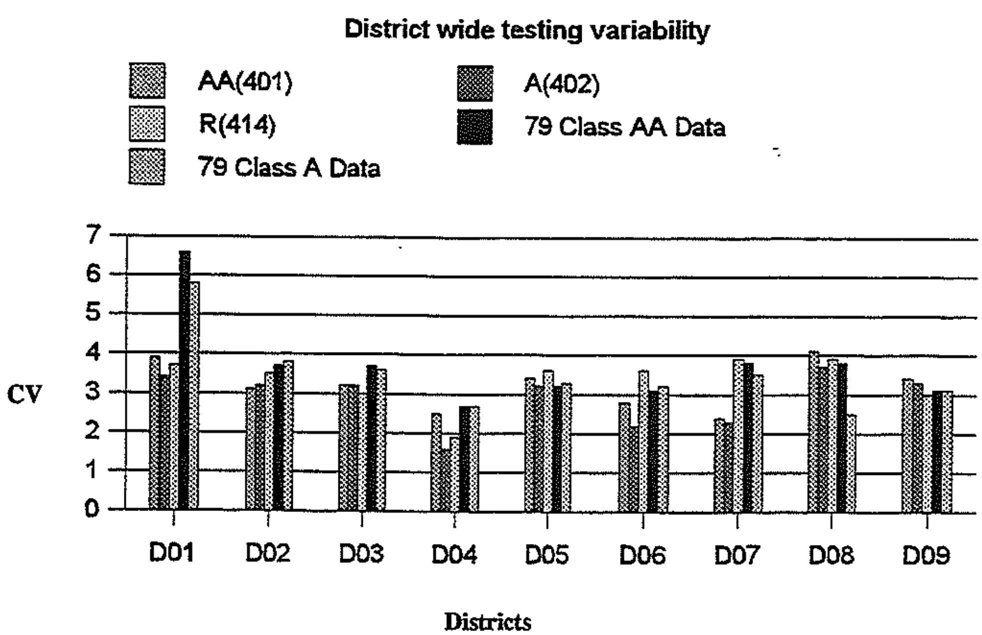


Figure:8.8: District wide within-test variability for different classes of concrete

2. *Paving Concrete Variability*

Statewide Variability of Strength of Roadway Cores

Table 8.5 shows overall variability of compressive strength of roadway cores. The data are from 488 lots representing over 1.7 million square yards of concrete distributed over 55 projects. Figures 8.9 and 8.10 show this data in graphical form for the mean and coefficient of variation, respectively. With the exception of data for Type D concrete, most of the data follow normal distribution as indicated by the skewness values and the near shape of the frequency distribution of this data as shown in Appendix D.

The variability presented as coefficient of variation is in line with the 1979 data. However, this is somewhat higher than data reviewed from some national studies (see Table 5.4). The lengthy construction periods for some of these paving projects and the long curing period, more than 10 to 15 times the required minimum of 28 days, before testing also contributes to this variability. However, because of the high level at which the mean was maintained, very few lots (only 3) failed to meet the minimum requirement for 100% pay. This is shown in Table 8.6 which compares the predicted versus actual number of samples outside the stated limits for individual and mean strength.

Table 8.5: Statewide overall & lot variability in compressive strength of roadway cores

Concrete Type (MATT Code)		N *NLot*	Quant, sq yd	Mean, psi	Std Dev, psi	CV	Min, psi	Max, psi	Range, psi	Skewness
B(451)	Air	764 *158*	521889	6057 *6091*	1114 *967*	18.4 *15.9*	3280 *3904*	9940 *8806*	6660 *4902*	0.43 *0.66*
	No Air	390 *78*	260487	6679 *6681*	1200 *1047*	18.0 *15.7*	3660 *4322*	9656 *8955*	5996 *4633*	0.06 *0.06*
A(452) a/	Air	95 *19*	66872	5376 *5353*	1031 *786*	19.2 *14.7*	2980 *3827*	8800 *6506*	5820 *2679*	-0.20 *-0.42*
	No Air	85 *17*	40364	5921 *5921*	1036 *650*	17.5 *11.0*	3531 *4886*	8894 *6971*	5363 *2085*	0.41 *0.02.*
D(454)	Air	1038 *210*	785272	5434 *5431*	1341 *1232*	24.7 *22.7*	2400 *3364*	10559 *9617*	8159 *6253*	1.34 *1.62*
	No Air	75 *15*	46028	5759 *5759*	667 *441*	11.6 *7.7*	3906 *5066*	7193 *6722*	3287 *1656*	-0.13 *0.38*

1 sq yd=0.836 sq m

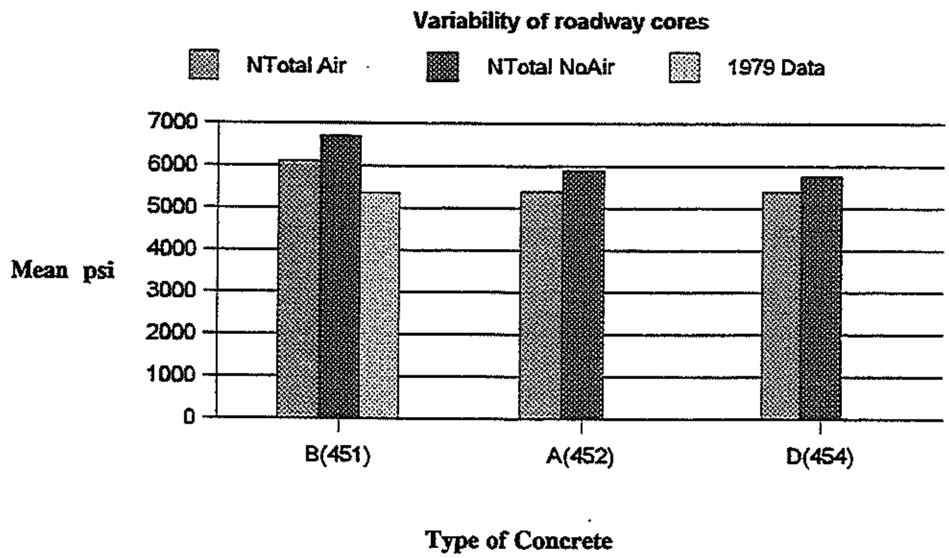


Figure 8.9: Overall mean strength of roadway cores

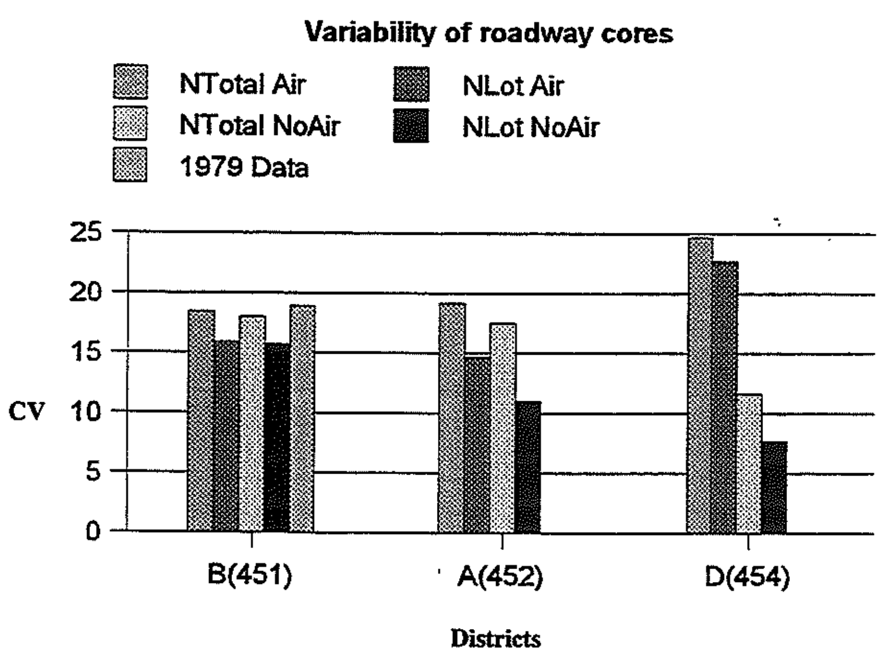


Figure 8.10: Overall coefficient of variation of strength of roadway cores

Table 8.6: Predicted versus actual number of samples outside the limits for compressive strength of roadway cores

Concrete Type (MATT Code)		PSI's less than	Actual number (%) less than indicated PSI	Predicted number (%) based on Mean and Std Dev (from Table 8.5)
B(451)	air	3600	0	10 (1.4)
	no air	*4000*	*0*	*5 (1.3)*
A(452) a/	air	3600	0	4 (4.3)
	no air	*4000*	*0*	*3 (3.2)*
D(454)	air	3600	3 (0.3)	88 (8.5)
	no air	*4000*	*0*	*0 (0.4)*

1 psi=6.89 kPa

To see if there is a relationship between curing period and strength, Figure 8.11 was prepared. The plot is for individuals core strengths of type B paving concrete without air entrainment. As seen, there is too much scatter to indicate any discernable trends.

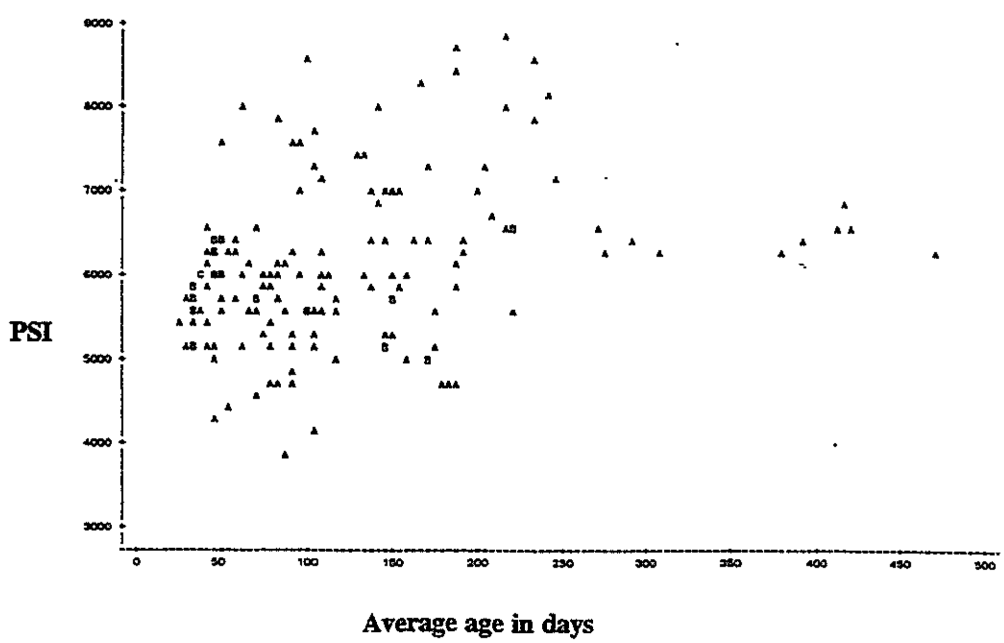


Figure 8.11: Scatter of age versus compressive strength of cores

Statewide Variability of Thickness of Roadway Cores

Figures 8.12 and 8.13 show standard deviation and mean, respectively, of data listed in Table 8.7 for roadway thickness. The thickness represent values measured on the same roadway cores tested for strength.

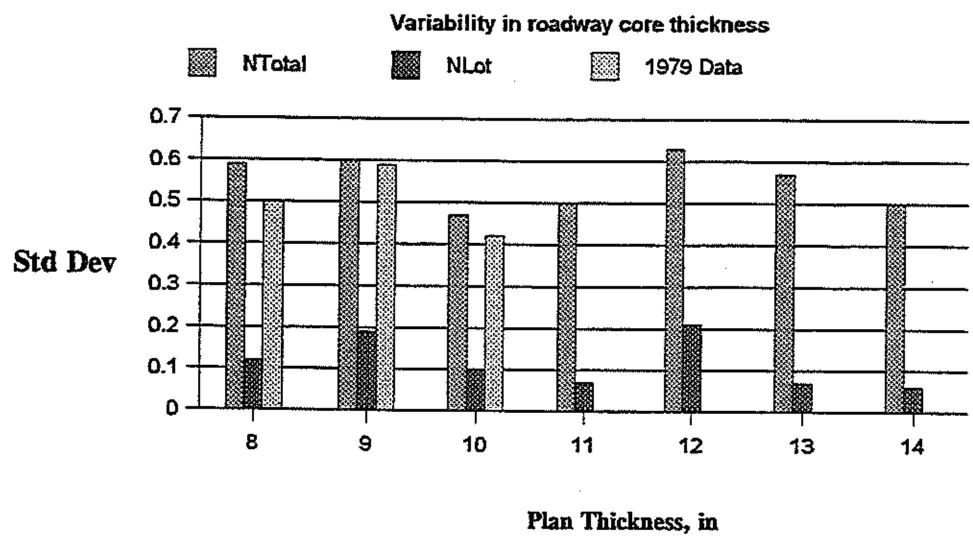


Figure 8.12: Standard deviation of roadway thickness

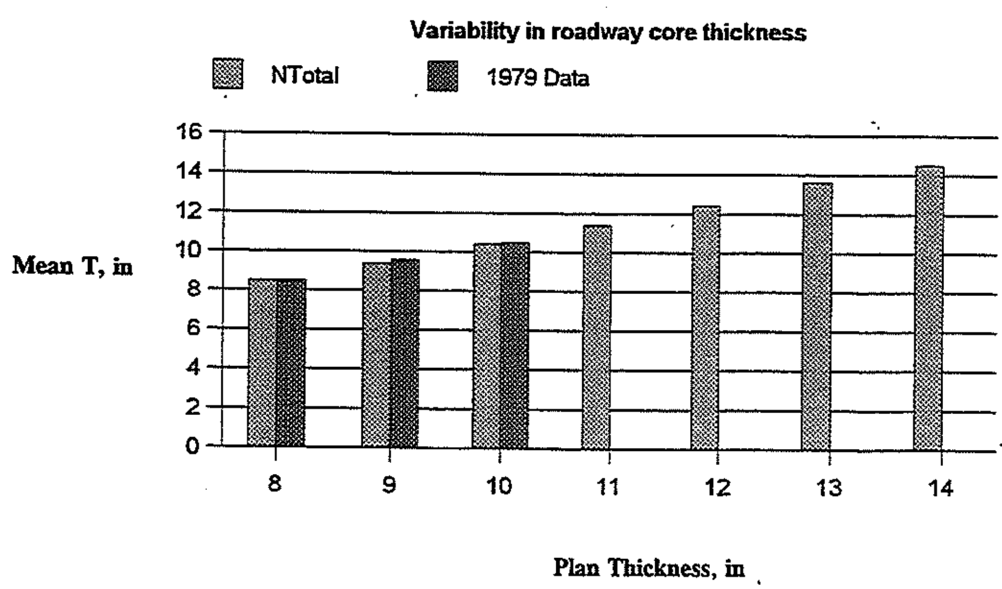


Figure 8.13: Mean thickness of roadway cores

Although the mean value of thickness for the 8-, 9-, and 10-inch plan thickness has remained the same, the variability has increased by almost 0.1 inch from the 1979 data. The norm as reported by some states (Table 5.6) is around 0.25 to 0.35 inches. Further, the lot mean thickness is so close to the plan thickness that some lots are likely to fail the tolerance requirement for acceptance.

Table 8.7: Statewide overall and lot variability in thickness of roadway cores

Plan T	N *NLot*	Quant, sq yd	Mean T, in	Std Dev	CV	Min	Max	Range	Skewness
8	524 *106*	365,543	8.5 *8.1*	0.59 *0.12*	7.0 *1.4*	7.0 *7.8*	11.7 *8.3*	4.7 *0.5*	1.4 *-1.1*
9	451 *91*	322,468	9.4 *9.1*	0.60 *0.19*	6.4 *2.1*	7.2 *7.9*	12.0 *9.3*	4.8 *1.4*	0.8 *-3.3*
10	496 *100*	343,207	10.4 *10.1*	0.47 *0.10*	4.6 *1.0*	9.1 *9.8*	12.9 *10.3*	3.8 *0.5*	1.4 *-1.1*
11	149 *33*	82,977	11.4 *11.2*	0.50 *0.07*	4.3 *0.6*	10.5 *11.0*	13.5 *11.3*	3.0 *0.3*	1.6 *-0.9*
12	35 *7*	18,914	12.4 *12.1*	0.63 *0.21*	5.1 *1.7*	10.5 *11.7*	13.8 *12.3*	3.3 *0.6*	-0.7 *-2.2*
13	355 *71*	266,622	13.6 *13.2*	0.57 *0.07*	4.2 *0.5*	11.3 *13.0*	15.4 *13.3*	4.1 *0.3*	0.3 *-1.5*
14	372 *76*	290,383	14.5 *14.2*	0.50 *0.06*	3.5 *0.4*	13.2 *14.0*	16.6 *14.3*	3.4 *0.3*	1.34 *-1.3*

1 in = 25.4 mm , 1 sq yd = 0.836 sq m

Recall that of the 20 lots that had failed to meet the minimum requirement for 100% pay (Table 7.4), 17 were for the lots with thickness deficiency and 16 of these were for lots with 8 and 9 inch plan thickness. Based on the mean and standard deviation of the lots with these plan thicknesses, about 18% would be the expected number to fail the minimum requirement for 8-inch thickness. The observed number was six. Similar numbers for 9-inch thickness are 25 expected versus 10 observed. The point that is being made here is the importance of maintaining the mean and standard deviation at a level that would minimize nonconformance.

The variation in materials and construction has significant effect on performance. As variation in strength and thickness (and some other properties) increase along a given lot, the variation in distress over time may increase. This would result in increased maintenance and rehabilitation costs.

Pavement Smoothness Variability

Data on smoothness is measured by the 25-ft California type Profilograph over each wheel path of each lane. Acceptance requirements are based on design speed and roadway classification, whether urban or rural. The results are reported as Average Profile Index, or API, in inches per mile per lot. Appendix A lists the specification tolerances for this criteria. The variability data on API is shown in Table 8.8. Also shown is the International Roughness Index (IRI). Frequency distribution is shown in Appendix E.

Table 8.8: Statewide variability of average profile index (API)

Categ	Type	NLot	Mean, in/mi	Std Dev	CV	Min	Max	Range	Skewness
none	API	131	7.9	6.3	78.6	0.1	25.9	25.8	0.73
	IRI	153	31.9	57.0	178.7	-	158.3	158.3	1.26
1	API	65	1.9	2.6	134.7	0	14.6	14.6	2.91
	IRI	67	102.9	29.6	28.7	-	153.7	153.7	-2.40
2	API	7	7.3	4.2	58.0	1.8	12.8	11.0	-0.19
	IRI	7	132.1	11.7	8.8	117.9	149.9	32.0	0.09
3	API	30	10.6	5.5	51.7	0	21.8	21.8	0.07
	IRI	34	47.4	63.0	133.1	-	164.3	164.3	0.83

1 in=25.4 mm   1 mile=1.609 km

No comparative data is available to judge how well the level of control is maintained on this measurement. However a Texas study (*14*) showed a standard deviation between 0.8 to 1.2 in/mile for the average of two results from the same profilograph. The report states that the overall variability is influenced by the operator variability and the interpreter variability. Review of individual project data show the variability to vary from less than one to 6.9 in/mile. In light of this Texas study, the overall variability may be somewhat higher. Future such evaluation may be necessary to develop standard for control on variability.

Quality Control Tests

Slump and air content are two properties that are traditionally measured as screening tests to determine the consistency and durability. The results of these tests are required to be plotted on control charts by the contractor. Table 8.9 and 8.10 show variability data for the two control tests for structure concrete and paving concrete, respectively. Figure 8.14 and 8.15 show graphical representation of the data.

Table 8.9: Statewide overall & lot variability in slump and air content of different classes of structure concrete

Concrete Class (MATT Code)	N *NLot*	Mean	Std Dev	CV	Min	Max	Range	Skewness
SLUMP, in								
AA(401)	7185	3.55	0.82	23.1	0.5	9.0	8.5	-1.4
	4280	*3.56*	*0.78*	*22.9*	*0.5*	*9.0*	*8.5*	*-1.6*
A(402)	10065	3.58	0.86	20.1	0.5	9.0	8.5	0.9
	6335	*3.57*	*0.69*	*19.3*	*0.8*	*9.0*	*8.2*	*0.8*
R(414) minor	319	3.55	0.71	19.9	1.0	5.0	4.0	-0.8
	296	*3.55*	*0.71*	*20.0*	*1.0*	*5.0*	*4.0*	*-0.9*
M(431)	2530	3.27	0.89	27.4	0.5	8.0	7.5	-0.5
	2426	*3.26*	*0.89*	*27.3*	*0.5*	*8.0*	*7.5*	*-0.5*
AIR, %								
AA(401)	6989	4.75	0.57	11.6	0.5	7.0	7.0	0.1
	4152	*4.75*	*0.52*	*10.9*	*2.5*	*7.0*	*7.0*	*0.1*
A(402)	956	4.70	0.62	14.4	1.0	7.0	7.0	-1.2
	651	*4.70*	*0.60*	*56.3*	*1.0*	*7.0*	*7.0*	*-1.4*
R(414) minor	24	4.77	0.66	12.7	3.0	6.0	6.0	-1.3
	17	*4.70*	*0.65*	*59.8*	*3.0*	*6.0*	*6.0*	*-0.8*
M(431)	664	4.84	0.70	15.4	0.5	7.0	7.0	-1.4
	651	*4.80*	*0.67*	*26.0*	*0.5*	*6.5*	*6.5*	*-1.5*

1 in= 25.4 mm

The mean and standard deviation of slump data is substantiated by the 1966 data from field studies for both structure and paving concrete *(3)*. The skewness indicates most of the data to follow normal distribution with the exception of class 401. This happens when there is a frequent shift in the mix design which results in more than one peak in the distribution. The frequency distribution of slump measurements can be found in Appendices C and D.

Previous studies have indicated the variability in slump measurements in the 0.5- to 0.8-inch range and the air content to vary between 0.70 to 1.60 percent *(11,14)*. The present data show somewhat higher

Table 8.10: Statewide overall & lot variability in slump and air content of different types of paving concrete

Concrete Type (MATT Code)	N *NLot*	Mean	Std Dev	CV	Min	Max	Range	Skewness
SLUMP, in								
B(451)	678	2.24	0.98	43.8	1.0	4.5	3.5	0.6
	171	*2.25*	*0.92*	*41.0*	*1.0*	*4.0*	*3.0*	*0.7*
A(452) a/	71	3.05	1.18	38.7	1.0	6.0	5.0	-0.3
	26	*3.27*	*1.09*	*33.4*	*1.0*	*5.6*	*4.6*	*-0.5*
D(454)	366	2.14	0.97	45.5	1.0	4.5	3.5	0.96
	117	*2.13*	*0.91*	*42.6*	*1.2*	*4.0*	*2.8*	*1.0*
AIR , %								
B(451)	579	4.69	0.92	19.6	0.0	7.0	7.0	-1.5
	146	*4.69*	*0.77*	*16.4*	*0.0*	*6.1*	*6.1*	*-3.0*
A(452)	23	4.65	0.65	13.9	3.5	5.5	2.0	0.1
	7	*4.73*	*0.50*	*10.6*	*4.1*	*5.3*	*1.2*	*-0.4*
D(454)	346	4.75	0.82	17.3	3.0	6.5	3.5	-0.1
	109	*4.81*	*0.70*	*14.7*	*3.3*	*6.1*	*2.8*	*-0.3*

1 in=25.4 mm

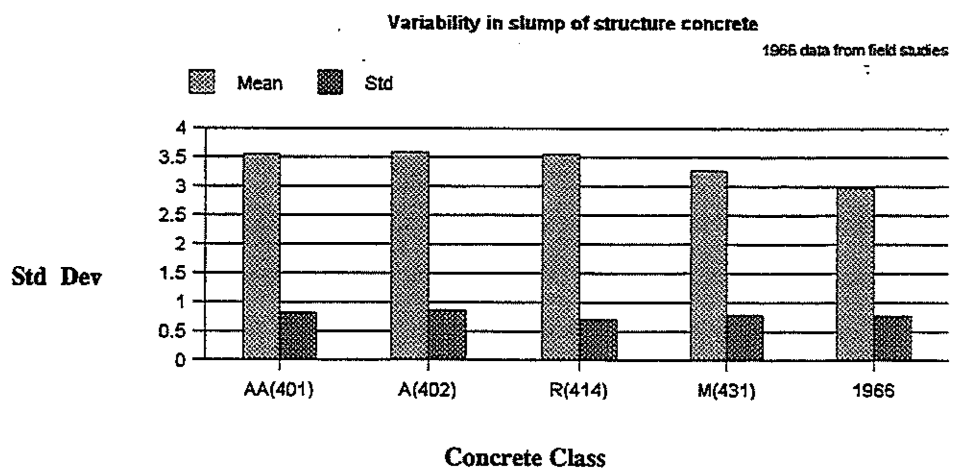


Figure 8.14: Statewide variability in slump of structure concrete

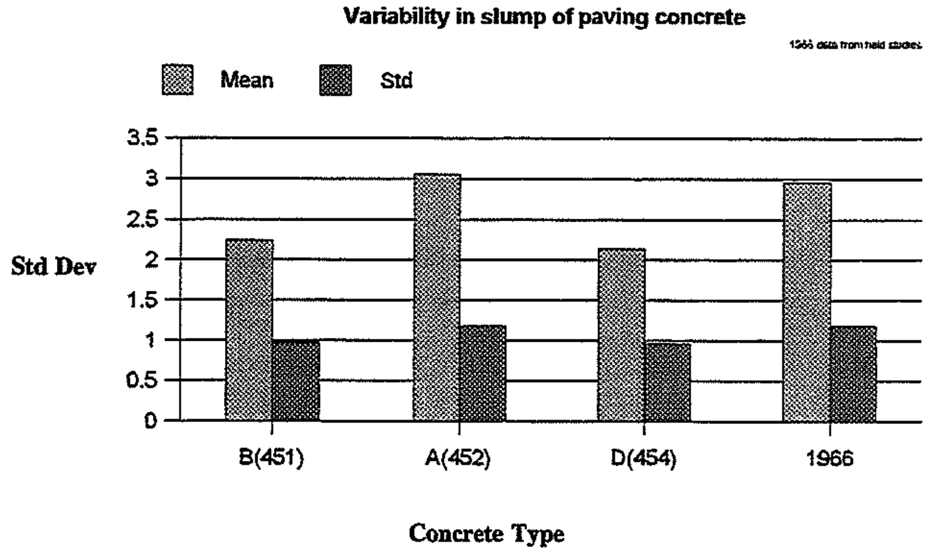


Figure 8.15: Statewide variability in slump of paving concrete

variability than indicated by these references. However in many test results, much of the measured variation could be attributed to sampling and testing methods and procedures, and therefore the real variation may not be as large as results indicate (3).

Summary of Variability Analysis -

Variation of what is considered good construction has been shown by the research summarized here. Based on this analysis, the following observations can be made:

- Most of the data on measured characteristic follow normal distribution.
- Since the first evaluation of the statistically-based specifications in 1979, there has been an increase in the magnitude of the overall mean and the standard deviation for each class of structure concrete. Such higher variability is generally associated with higher mean value of the measured characteristic.
- Since the average strength is maintained at a level well above the minimum requirement for the concrete, the actual number of nonconforming concrete is well below the predicted number based on the mean and standard deviation.

- Based on the ACI standards for field quality control, almost all classes of concrete indicated good control. For within-test variability control, most of the districts fall in the good to excellent category.

- For type B paving concrete, there has been an increase in the magnitude of the mean core strength compared to the 1979 data . However, the magnitude of variation has remained somewhat same.

- The magnitude of statewide variability in thickness, including within lot variability, show an increase from the 1979 data. The overall mean thickness for each plan thickness has remained the same.

- The overall variability in profilograph measurements (API) is higher than some of the values reported elsewhere.

- The variability of the quality control tests, slump and air content, are within the norm reported in previous studies.

9. Operating Characteristic (OC) Curves

OC Curve for Variability Known Sampling Plan-

As was defined in section 4, the Operating Characteristic (OC) curve is nothing more than a graphical presentation of a sampling plan which shows the relationship between the quality of a lot and the probability of its acceptance or rejection. The OC curve indicates how well a given plan discriminates between acceptable and non acceptable lots. In this section, OC curves for current acceptance plan for paving concrete core strength and thickness are presented.

OC Curve for Core Compressive Strength -

To develop an OC curve for the present acceptance plan, it is necessary to assign values to AQL and RQL (see section 4 for definition of these two terms)

AQL=98% - this is the acceptable quality level that should be accepted almost all of the time it is submitted
RQL=95% - this the rejectable quality level that should be rejected almost all of the time it is submitted
Mean=6057 psi (for type B concrete with air from Table 8.5)
Standard deviation σ=1114 psi
n=5
K, the acceptance value=Mean - 0.92σ (see reference 2 for determination of K), or
K =5032 psi or 5000 psi

To see how this plan operates on lots of other means, an OC curve is constructed from data in Table 9.1. Because of the mathematical relationship between AQL, RQL and n, any change in n will change the OC curve.

The OC curve for the above plan indicates that lots with 28-day compressive strength of 5000 psi are submitted, about 50% of the lots would be accepted and 50% would be rejected. On the other hand, if the lots submitted have 6000 psi or more, almost all would be accepted. The plan is based on known sigma scheme which in essence assumes that the sigma will remain constant. This is not always the case and any change in sigma upwards will have a greater risk of accepting poor material. Increasing sample size n increases the slope of the curve thereby making the curve more discriminating. However, more samples means more cost. A balance should be in terms of cost and protection. Such curves can be developed for other types of paving concrete.

Table 9.1: Calculation of OC Curve for core strength

Mean $\overline{X}$, psi	$t=(k-\overline{X})\sqrt{n}/\sigma$	Probability of acceptance
3500	3.049	.0011
3750	2.541	0.0065
4000	2.032	0.0212
4250	1.5246	.0640
4500	1.0164	0.1539
4750	.5082	0.2810
5000	0.0	.5000
5250	.5082	.7190
5500	1.0164	.8461
5750	1.5246	.9360
6000	2.032	.9788
6250	2.541	.9945

1 psi=6.89 kPa   t in the formula is 't' distribution

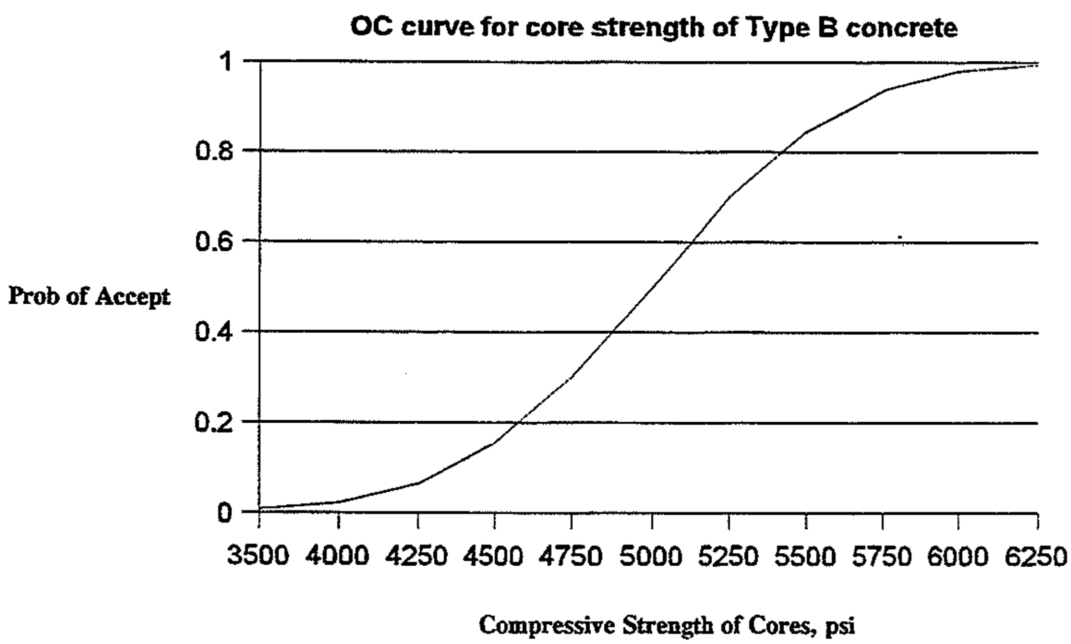


Figure 9.1: OC Curve for compressive strength of Type B paving concrete

OC Curve for Thickness of Paving Concrete

An existing acceptance plan for pavement thickness requires that n = 5 cores be taken at random location from each 4000 sq yd of pavement. Following is the OC curve for 9-inch plan thickness of pavement. Using the same risks for AQL and RQL and the statewide mean and standard deviation from Table 8.7, the OC curve for this plan would be:

AQL=98% - this is the acceptable quality level that should be accepted almost all of the time it is submitted
RQL=95% - this the rejectable quality level that should be rejected almost all of the time it is submitted
Mean=9.4 in (for 9-in thickness from Table 8.5)
Standard deviation σ=0.60
n=5
K, the acceptance value=Mean - 0.92σ (see reference 2 for determination of K), or K =8.85 in.

Table 9.2: Calculation of OC Curve for core thickness

Mean $\overline{X}$, in	$t=(k-\overline{X})\sqrt{n}/\sigma$	Probability of acceptance
8.2	2.422	.0078
8.3	2.049	.0202
8.4	1.6771	.0465
8.5	1.3044	.0968
8.6	.9317	.1762
8.7	.5590	.2877
8.8	.1863	.4286
8.85	.5000	.5000
8.9	.1863	.5714
9.0	.5590	.7123
9.1	.9317	.8238
9.2	1.3044	.9032
9.3	1.6771	.9535
9.4	2.049	.9798

1 in=25.4 mm   t in the formula is 't' distribution

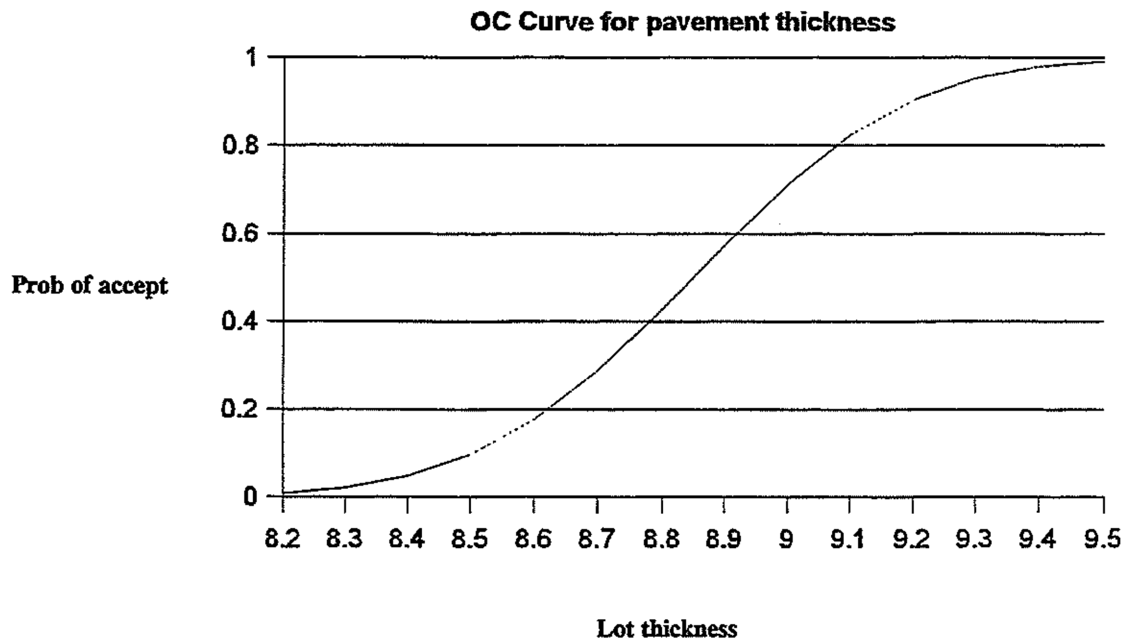


Figure 9.2: OC Curve for thickness of paving concrete cores

In the development of the above OC curve, it was assumed that the standard deviation and the arithmetic mean of the population is known. When the lot standard deviation is unknown the procedure is much the same, except that a sample estimate of σ is substituted for population σ.

From the above curve it can be said that if a lot with a thickness of 8.6 inches is submitted to this plan the probability of accepting this lot is about 20%. It should be mentioned that the above relationship between compressive strength or thickness and probability of acceptance has some meaning when several lots are considered. Essentially what is being interpreted here is that if a number of lots of 8.6 inch thickness are submitted to this plan, approximately 20% of them will be accepted and 80% will be rejected.

The DOTD's present plan of accept/reject is similar to the one illustrated here except that the decision to accept or reject is based on the magnitude of deviation of mean thickness of the lot from the plan thickness. Two characteristics of the OC curves are worth mentioning again. First, increasing n increases the slope of the curve thereby making it more discriminating (better protection). Second, increasing K, the acceptance number, displaces the OC curve to the right and results in accepting more material.

Variability Unknown Sampling Plan (Sigma Unknown) - PWL Specifications

The PWL specifications are based on criteria in which the decision is based on the sample average in combination with a sample variability. As was mentioned before, such plans are referred to as ***unknown-sigma*** plan. The current DOTD acceptance plan for concrete is based on ***known-sigma***. In such plans acceptance is based on the sample average.

Unknown sigma plans are generally employed when inspection and acceptance of some new product is necessary and there is no basis for estimating the variability of this new product. The DOTD specifications on Superpave falls in that category. As more data becomes available and proper statistical control is indicated (either through ***Sigma*** or ***Range*** chart), it may make sense to switch to a known-sigma plan. An incidental advantage of using known-sigma plan is a reduction in sample size. Likewise, **if the statistical control of the dispersion of the measured characteristic shows lack of control, a switch to unknown sigma plan may be the choice to induce tighter control on the variability**. However, for better estimate of sigma, this plan requires larger sample size for making decision on acceptance.

Briefly, the unknown sigma acceptance plan is based on quality level analysis which involves determination of two statistics - the mean and standard deviation of a lot of certain sample size n. From these two statistics and the governing specification limit(s) for the test property, Quality Level Indices (Q_U for upper quality index and Q_L for lower quality index) are calculated. The resulting values are checked against tabled values for the sample size to determine ***Percent Within Limits*** or ***PWL***. The lot, represented by the sample, is considered in conformance to the specifications if the ***PWL*** exceeds some preset value.

Although the present DOTD acceptance plan for variables (sigma known) is adequate in that it is able to discriminate between acceptable and rejectable material, the sigma unknown type plan may be an alternative if it is felt that the magnitude of variation may be high and that better control is needed to minimize this variability. Such plans are particularly suited for acceptance of tests on completed pavement such as compaction, compressive strength of roadway cores, thickness, etc. To see how such a plan would work if applied to present data, all paving concrete projects were simulated using quality level analysis for strength and thickness. The major purpose of this simulation was to show the sensitivity of such a plan to large changes in variability.

For these projects, Q_L (since only lower tolerance is specified) was calculated to determine PWL from the tabled values. For the lot to be considered acceptable (100% pay), the value of Q_L should be greater than 1.20. Negative values of Q_L means the measured value was less than the lower tolerance specified for that measurement. The results of this simulation is presented in Appendix F. The last two columns in the table show a '1' for accept and a '0' for reject.

Application of PWL concept increased the number of lots deficient in strength requirement from three, under the present (variability known) acceptance plan, to 26 under this PWL plan. Likewise, 31 lots were found to be unacceptable under this plan versus 17 under the current plan for thickness requirement.

Some lots with average strength as high as 5500 psi would have received reduced pay because of large magnitude of variability. In some cases, the range in psi values within a lot has been as high as 4000 psi. In the case of thickness, a range as large as 3.5 inches has been observed within a lot. Such wide ranges within a segment of pavement can result in weak areas resulting in less than desired pavement life. The PWL concept induces the contractor to control his variability to a level that would minimize reduction in pay, and provide more uniform and longer lasting product.

10. Summary, Conclusions and Recommendations

Summary -

This study evaluated the extent of variability in the test properties of structural and paving concrete materials and construction. This evaluation was based on over 25,000 lots distributed over some 900 projects during a period of seven years - 1992 to 1999. The major thrust of this evaluation was to determine how well concrete construction, both structure and paving, is controlled on various acceptance criteria and the assessment of specifications in terms of price adjustments. The data for the study was collected from the DOTD's MATT system files. The analysis and evaluation can be summarized as follows:

Assessment of Price Reduction

1. On the basis of total quantity of concrete used on the projects, the overall average reduction in price due to deficiency in acceptance criteria was 0.2% for structure concrete and 0.5% for paving concrete. This substantiates the results from such previous evaluation of 1979.

2. Seventy two percent of the reduction was for class AA and A concrete and most of this occurred at a level one scale below the 100% level (95 or 98%). Fifteen percent was at the 50% level.

3. For paving concrete 85% of the reduction was due to nonconforming thickness measurements. The overall reduction was 4% of total square yard laid with more than half at the 95% level

4. Only 4% of the pavement tested for surface smoothness failed the stated requirement.

5. All in all, the price reduction has been minimal and within the expected frequency.

Assessment of Variability

Most of the price reduction discussed above can be traced to the level of control maintained during production and/or construction process. Because of the definite relationship between specification and statistical parameters, failure to maintain adequate control on the mean and standard deviation will necessarily increase the failure ratio for fixed process variability. Results of the variability analysis are summarized below:

1. Most of the data on measured characteristics for the acceptance and control criteria follow normal distribution.

2. Based on the ACI standards of concrete control, good field control is indicated by all concrete except minor Class R concrete. This substantiates the 1979 evaluation.

3. All districts showed good to excellent control proficiency in the testing phase of concrete control.

4. The strength of all classes of structure concrete is maintained at a higher level than was noted soon after implementation of the statistically based specifications in 1973. However, there is some decline in the level of control on variability.

5. As a result of longer than specified minimum curing period for strength testing, there has been an increase in the magnitude of the average core strength. However, there has also been an increase in the within lot variability.

6. There is a decline in the thickness variability as measured by the cores. Likewise, the within lot variability also show lack of control.

7. Adequate control is maintained on the slump and air content tests.

8. The OC curves for the present variability known acceptance plan for paving concrete tests are able to distinguish acceptable and unacceptable concrete.

<u>Recommendations</u> -

Based on the above statements, the following recommendations are offered for consideration:

- To provide continuous feedback on the level of control maintained at all level of concrete production, increase the frequency of evaluation such as the one conducted here on a routine basis. The MATT system is geared towards satisfying this feedback requirements. Such a feedback would provide, to those responsible for monitoring the project, information relative to the level of control maintained on the mean and variability of the process, the failure ratio, and, as a guideline, the level at which the process control should be maintained to improve the product and reduce the risk of pay reduction.

- To monitor the process on routine basis, develop analysis modules, such as the ones developed in this study, using SAS system package. The modules can be used by the districts and/or project engineers to routinely monitor the level of control on regular (daily, weekly) basis. There are no tools available to do this on routine basis.

- Because of the large within-lot variability in strength and thickness measurements, consideration should be given to developing a variability unknown type acceptance plan for paving concrete criteria, similar to the present plan for Superpave. Such a plan induces the seller to maintain better control on the variability of his product.

- Another approach to reducing the within-lot variation would be to require either a range or standard deviation control chart. This may be a better alternative since the charts give early warning on the process that is about to go out-of-control. Corrective measures can then be taken to get back in control.

- During the development of data base for analysis, anomalies were observed in the MATT system. Considerable time was spent to create a database free of invalid data. A major type of 'noise' in the data was the presence of zero(0) in the strength slump and air content fields. When air is not used, the field has to be left blank rather than the value '0'. To minimize such invalid entry, data entry into the MATT system should be constrained with more edit checks. Likewise, provision should be made to identify concrete specified versus its use, similar to the provision in the MATT system for asphaltic concrete.

10. LIST OF REFERENCES

Eighteen references were cited in the report as follows:

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

2. Shah, S. C., "Quality Control Analysis, Part II - Soil and Aggregate Base Course," Louisiana Department of Highways, Research Report No. 23, July, 1966.

3. Shah, S. C., "Quality Control Analysis, Part III - Concrete and Concrete Aggregates," Louisiana Department of Highways, Research Report No. 24, November, 1966.

4. Shah, S. C., "Quality Control Analysis, Part IV - Simulation of Asphaltic Concrete Specifications," Louisiana Department of Highways, Research Report No. 36, February, 1969.

5. Shah, S. C., and Yoches, Veto, "Quality Control Analysis, Part V - Review of Data Generated by Statistical Specifications on Asphaltic Concrete," Louisiana Department of Transportation & Development (LaDOTD), Research Report No. 94, December, 1975.

6. Shah, S. C., "Evaluation of Data Generated by Statistically-Oriented End-Result Specification on Asphaltic Concrete & Concrete," Louisiana Department of Transportation & Development, Research Report No. 125, January 1979.

7. Shah, S. C., & Yoches, Veto, "Procedural Research for Reporting Material Test System Data Using Computer Systems," Volumes I & II, LaDOTD, Research Report No. 128, Aug,1978.

8. Metcalf, J. B., et al, " Evaluation of Louisiana's Statistically Based Quality and Acceptance Specifications for Asphaltic Concrete," LaDOTD, Project No. 95-2B, November 1996.

9. ACI Committee 214-89, "Recommended Practice for Evaluation of Compression Test Results of Field Concrete," American Concrete Institute, 1989.

10. "Recommended Practice for Acceptance Sampling Plans for Highway Construction," AASHTO, 1996.

11. McMahon, T. F., et al, Quality Assurance in Highway Construction, FHWA Report No. FHWA-TS-89-038, Public Roads, Vol 35, No. 6-11, Washington, D.C., Reprinted in October 1990.

12. Quality Assurance, NCHRP Synthesis Report No. 65, Transportation Research Board, October,1979.

13. Pooled Fund Study, FHWA Contract DTFH61-98-C-0069, Optimal Acceptance for Statistical Construction Specifications, 1998.

14. Variability in Highway Pavement Construction, NCHRP Synthesis Report No. 232, 1996, Transportation Research Board, 1996.

15. Hughes, C. S., et al, Measurement and Specification of Construction Quality, Vol I, FHWA-RD-98-077, Final Report, May 1998.

16. "LA Standard Specifications for Roads & Bridges," LaDOTD, 1992.

17. "MATT System Field Handbook," LaDOTD, 1995.

18.. "SAS Procedures Guide, Version 6, 3rd Edition", SAS Institute, Cary N.C.

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Material Testing System
Specifications File Values for Structural Concrete

Code	100%	98%	95%	90%	80%	50%	Description
401	4200	3800		3200		0	COMPRESSIVE STRENGTH FOR CLASS 'AA'
402	3800	3400		3000		0	COMPRESSIVE STRENGTH FOR CLASS 'A'
403	3300	3000		2500		0	COMPRESSIVE STRENGTH FOR CLASS 'D'
404	5000						COMPRESSIVE STRENGTH FOR CLASS 'P'
406	3800	3400		3000		0	COMPRESSIVE STRENGTH FOR CLASS 'S'
408	3800	3400		3000		0	COMPRESSIVE STRENGTH FOR CLASS 'X'
414	1800					0	COMPRESSIVE STRENGTH FOR CLASS 'R'(MINOR)
418	3000					0	COMPRESSIVE STRENGTH FOR CLASS 'Y'(MINOR)
421	4400	4000		3600		0	COMPRESSIVE STRENGTH FOR CLASS 'AA'(M)
422	4400	4000		3600		0	COMPRESSIVE STRENGTH FOR CLASS 'A'(M)
424	6000						COMPRESSIVE STRENGTH FOR CLASS 'P'(M)
428	4000		3500		3000	0	COMP. STR. FOR PAVT. CONCRETE (WITHOUT AIR ENTRAINMENT)
429	3600		3150		3000	0	COMP. STR. FOR PAVMENT CONCRETE (WITH AIR ENTRAINMENT)
431	3000					0	COMPRESSIVE STRENGTH FOR CLASS 'M'(MINOR)
432	3400					0	COMPRESSIVE STRENGTH FOR CLASS 'F'
433	4200	3800		3200		0	COMPRESSIVE STR.FOR APPROACH SLABS (PILE SUPPORTED)
434	3800	3400		3000		0	COMPRESSIVE STR.FOR APPROACH SLABS (NON-PILE SUPPORTED)
435	4000						COMPRESSIVE STRENGTH FOR CLASS 'M' (PRECAST MINOR)
501	28	26		24		0	COMPRESSIVE STRENGTH FOR CLASS 'AA'
502	26	23		22		0	COMPRESSIVE STRENGTH FOR CLASS 'A'
503	24	21		18		0	COMPRESSIVE STRENGTH FOR CLASS 'D'
504	40						COMPRESSIVE STRENGTH FOR CLASS 'P'
506	26	23		22		0	COMPRESSIVE STRENGTH FOR CLASS 'S'
508	26	23		22		0	COMPRESSIVE STRENGTH FOR CLASS 'X'
514	12					0	COMPRESSIVE STRENGTH FOR CLASS 'R' (MINOR)
518	20					0	COMPRESSIVE STRENGTH FOR CLASS 'Y' (MINOR)
521	30	28		26		0	COMPRESSIVE STRENGTH FOR CLASS 'AA'(M)
522	30	28		26		0	COMPRESSIVE STRENGTH FOR CLASS 'A'(M)
524	45						COMPRESSIVE STRENGTH FOR CLASS 'P(M)'
528	28		25		22	0	COMP.STR.FOR PAVEMENT CONCRETE -WITHOUT AIR ENTRAINMENT
529	26		24		22	0	COMP.STR.FOR PAVEMENT CONCRETE - WITH AIR ENTRAINMENT
531	20					0	COMPRESSIVE STRENGTH FOR CLASS 'M' (MINOR)
532	24					0	COMPRESSIVE STRENGTH FOR CLASS 'F'
533	28	26		24		0	COMPRESSIVE STRENGTH FOR APPROACH SLAB (PILE SUPPORTED)
534	26	23		22		0	COMPRESSIVE STR. FOR APPROACH SLAB (NON-PILE SUPPORTED)
535	28						COMPRESSIVE STRENGTH FOR CLASS 'M' (PRECAST MINOR)

STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Material Testing System
Specifications File Values for Concrete Cores

Material Code - 451 Description - TYPE B PAVING CONCRETE

Test Name	100%	95%	80%	50%
Different Thickness	0.10	0.25	0.50	1.00
Strength	04000	03500	03000	00000
Strength Air Ent	03600	03150	03000	00000

Material Code - 452 Description - CLASS A CONCRETE (FOR PAVING)

Test Name	100%	95%	80%	50%
Different Thickness	0.10	0.25	0.50	1.00
Strength	04000	03500	03000	00000
Strength Air Ent	03600	03150	03000	00000

Material Code - 453 Description - TYPE C PAVING CONCRETE

Test Name	100%	95%	80%	50%
Different Thickness	0.10	0.25	0.50	1.00
Strength	04000	03500	03000	00000
Strength Air Ent	03600	03150	03000	00000

Material Code - 454 Description - TYPE D PAVING CONCRETE

Test Name	100%	95%	80%	50%
Different Thickness	0.10	0.25	0.50	1.00
Strength	04000	03500	03000	00000
Strength Air Ent	03600	03150	03000	00000

Matt542I — Material Testing System — Page 2 — 05-30-2000

Specifications File Values for Concrete Cores

Material Code - 551 Description - TYPE B PAVING CONCRETE

Test Name	100%	95%	80%	50%
Different Thickness				
Strength				
Strength Air Ent				

Material Code - 552 Description - CLASS A CONCRETE (FOR PAVING)

Test Name	100%	95%	80%	50%
Different Thickness				
Strength				
Strength Air Ent				

Material Code - 553 Description - TYPE C PAVING CONCRETE

Test Name	100%	95%	80%	50%
Different Thickness				
Strength				
Strength Air Ent				

Material Code - 554 Description - TYPE D PAVING CONCRETE

Test Name	100%	95%	80%	50%
Different Thickness				
Strength				
Strength Air Ent				

STD2

Matt542N — Material Testing System — Page 1 — 05-30-2000

Specifications File Values for Concrete Pavement

Code	Category	API 100%	98%	95%	80%	50%	Description
451	Cat.I	6.0	7.0	8.0			SURFACE TOLERANCE FOR TYPE B PAVING CONCRETE
	Cat.II	12.0	13.0	14.0			
	Cat.III	20.0	22.0	24.0	26.0		
452	Cat.I	6.0	7.0	8.0			SURFACE TOLERANCE FOR CLASS A CONCRETE (FOR PAVING)
	Cat.II	12.0	13.0	14.0			
	Cat.III	20.0	22.0	24.0	26.0		
453	Cat.I	6.0	7.0	8.0			SURFACE TOLERANCE FOR TYPE C PAVING CONCRETE
	Cat.II	12.0	13.0	14.0			
	Cat.III	20.0	22.0	24.0	26.0		
454	Cat.I	6.0	7.0	8.0			SURFACE TOLERANCE FOR TYPE D PAVING CONCRETE
	Cat.II	12.0	13.0	14.0			
	Cat.III	20.0	22.0	24.0	26.0		
551	Cat.I	94.5	110.0	126.0			SURFACE TOLERANCE FOR TYPE B PAVING CONCRETE
	Cat.II	189.0	205.0	220.5			
	Cat.III	315.5	347.0	378.5	410.0		
552	Cat.I	94.5	110.0	126.0			SURFACE TOLERANCE FOR CLASS A CONCRETE (FOR PAVING)
	Cat.II	189.0	205.0	220.5			
	Cat.III	315.5	347.0	378.5	410.0		
553	Cat.I	94.5	110.0	126.0			SURFACE TOLERANCE FOR TYPE C PAVING CONCRETE
	Cat.II	189.0	205.0	220.5			
	Cat.III	315.5	347.0	378.5	410.0		
554	Cat.I	94.5	110.0	126.0			SURFACE TOLERANCE FOR TYPE D PAVING CONCRETE
	Cat.II	189.0	205.0	220.5			
	Cat.III	315.5	347.0	378.5	410.0		

APPENDIX B

Test Forms, Record Layout & Material Codes

DOTD 03-22-07
Metric / English
Rev. 7/98

Louisiana Department of Transportation and Development

STRUCTURAL CONCRETE TESTS

(DOTD TR 226 & TR 230)

Metric / English ___ (M or E) *Located on MATT Menu*

Project No. ___ **Material Code** ___ **Lot No.** ___

Date Sampled ___ **Submitted By** ___ **Quantity** ___

Purpose Code ___ **Plant Code** C___ **Spec Code** ___

1. Qual. Cont.
2. Verification
3. Acceptance
4. Check
5. Resample
6. Source Appr.
7. Design
8. Indep. Assur.
9. Pre. Source Test

Mix Design No. ___ Date Rec'd.(lab) ___

Admixture: *Y = Yes* *N = No* **Air** ___ **WR-NS** ___ **WR-SR** ___

Remarks 1 ___

Item No. ___

Cylinders Made By ___ Acceptance Tests By ___

Batch Number ___

Date Tested ___

Acceptance Tests

Slump (TR 207), mm (in) ___ Air Content (TR 202), % ___

Sample No.	Laboratory No.	Cond.	Break	Age Days	Diam. mm (in)	Area mm^2 (in^2)	Max. Load kN(lb)	Strength MPa (PSI)

Time Made: ___ Critical Strength: Low ___ High ___ Batch Avg. ___

Batch Number ___

Date Tested ___

Acceptance Tests

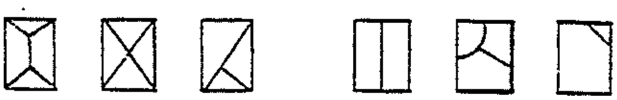
Slump (TR 207), mm (in) ___ Air Content (TR 202), % ___

Sample No.	Laboratory No.	Cond.	Break	Age Days	Diam. mm (in)	Area mm^2 (in^2)	Max. Load kN(lb)	Strength MPa (PSI)

Time Made: ___ Critical Strength: Low ___ High ___ Batch Avg. ___

Break Codes:

1 = Satisfactory 2 = Unsatisfactory



Cond. Codes:

1 = Good
2 = Improperly Made
3 = Damaged
4 = Frozen

Average Strength for Lot ___

Tested By: ___

Checked By: ___

% Pay ___

Remarks 2 ___

Approved By ___

MATERIAL CODES FOR STRUCTURAL CONCRETE

1992 Specifications

Material Code	Material Description
401	COMPRESSIVE STRENGTH FOR CLASS 'AA'
402	COMPRESSIVE STRENGTH FOR CLASS 'A'
403	COMPRESSIVE STRENGTH FOR CLASS 'D'
404	COMPRESSIVE STRENGTH FOR CLASS 'P'
406	COMPRESSIVE STRENGTH FOR CLASS 'S'
408	COMPRESSIVE STRENGTH FOR CLASS 'X'
414	COMPRESSIVE STRENGTH FOR CLASS 'R' (MINOR)
418	COMPRESSIVE STRENGTH FOR CLASS 'Y' (MINOR)
421	COMPRESSIVE STRENGTH FOR CLASS 'AA(M)'
422	COMPRESSIVE STRENGTH FOR CLASS 'A(M)'
424	COMPRESSIVE STRENGTH FOR CLASS 'P(M)'
428	COMPRESSIVE STRENGTH FOR PAVEMENT CONCRETE
431	COMPRESSIVE STRENGTH FOR CLASS 'M' (MINOR)
432	COMPRESSIVE STRENGTH FOR CLASS 'F'
433	COMPRESSIVE STR. FOR APPROACH SLAB (PILE SUPPORTED)
434	COMPRESSIVE STR. FOR APPROACH SLAB (NON-PILE SUPPORTED)
435	COMPRESSIVE STRENGTH FOR CLASS 'M' (PRECAST MINOR)

1982 Specifications

Material Code	Material Description
301	COMPRESSIVE STRENGTH FOR CLASS 'AA'
302	COMPRESSIVE STRENGTH FOR CLASS 'A'
303	COMPRESSIVE STRENGTH FOR CLASS 'D'
304	COMPRESSIVE STRENGTH FOR CLASS 'P'
306	COMPRESSIVE STRENGTH FOR CLASS 'S'
308	COMPRESSIVE STRENGTH FOR CLASS 'X'
311	COMPRESSIVE STRENGTH FOR CLASS 'A' (MINOR)
314	COMPRESSIVE STRENGTH FOR CLASS 'R' (MINOR)
319	COMPRESSIVE STRENGTH FOR CLASS 'A' (APPROACH SLAB)
321	COMPRESSIVE STRENGTH FOR CLASS 'AA(M)'
322	COMPRESSIVE STRENGTH FOR CLASS 'A(M)'
323	COMPRESSIVE STRENGTH FOR CLASS 'A' RAYCRETE 800 CONCRETE
324	COMPRESSIVE STRENGTH FOR CLASS 'P(M)'
326	COMPRESSIVE STRENGTH FOR CLASS 'A' (PRECAST-MINOR)
327	COMPRESSIVE STRENGTH FOR CLASS 'P(M)' (7000 PSI)
328	COMPRESSIVE STRENGTH FOR PAVEMENT CONCRETE (4000 PSI)
329	COMPRESSIVE STRENGTH FOR CLASS 'P(M)' (8500 PSI)
330	COMPRESSIVE STRENGTH FOR CONCRETE (3450 PSI)

See Structural Concrete Notes on the following page.

```
                                                              START   LENG
*****************************
* CHANGED STRENGTH AND SLUMP SO ENGLISH AND METRIC ARE THE SAME
* SIZE          ........BEN 8/03/1999
*****************************
    02  MTTESTA-REC.                                              1    389
        03  MTTESTA-KEY.                                          1     35
            04  MTTESTA-PROJ-NO        PIC X(16).                 1     16
            04  MTTESTA-MATT-ID        PIC X.                    17      1
            04  MTTESTA-MATERIAL-CD    PIC 9(3).                 18      3
            04  MTTESTA-LOT-NO         PIC 9(3).                 21      3
            04  FILLER                 PIC X(12).                24     12
        03  MTTESTA-PROCESS-DATE       PIC 9(5) COMP-3.          36      3
        03  MTTESTA-DATE-SAMP          PIC 9(6) COMP-3.          39      4
        03  MTTESTA-SUBMIT-BY          PIC X(4).                 43      4
        03  MTTESTA-QUANTITY-X.                                  47      3
            04  MTTESTA-QUANTITY       PIC 9999V9 COMP-3.        47      3
        03  MTTESTA-PURP-CD            PIC 9.                    50      1
        03  MTTESTA-SOURCE-CD          PIC X(4).                 51      4
        03  MTTESTA-SPEC-CD            PIC X.                    55      1
        03  MTTESTA-ADMIX-AIR          PIC X.                    56      1
        03  MTTESTA-ADMIX-WR-NS        PIC X.                    57      1
        03  MTTESTA-ADMIX-WR-SR        PIC X.                    58      1
        03  MTTESTA-ITEM-NO            PIC X(51).                59     51
        03  MTTESTA-MIX-DESIGN         PIC XXX.                 110      3
        03  MTTESTA-REMARKS1           PIC X(54).               113     54
        03  MTTESTA-DATE-TEST1         PIC 9(6) COMP-3.         167      4
        03  MTTESTA-SLUMP1-X.                                   171      3
            04  MTTESTA-SLUMP1         PIC S999V99 COMP-3.      171      3
        03  MTTESTA-SLUMP1-M-X   REDEFINES MTTESTA-SLUMP1-X.    171      3
            04  MTTESTA-SLUMP1-M       PIC 999V99 COMP-3.       171      3
        03  MTTESTA-AIR-CONT1-X.                                174      2
            05  MTTESTA-AIR-CONT1      PIC S9V9.                174      2
        03  MTTESTA-SAMPLE1-DATA OCCURS 3.                      176     22
            04  MTTESTA-SAMPLE1        PIC X(5).                176      5
            04  MTTESTA-LAB-NO1        PIC X(9).                181      9
            04  MTTESTA-COND1-X.                                190      1
                05  MTTESTA-COND1      PIC S9.                  190      1
            04  MTTESTA-BREAK1-X.                               191      1
                05  MTTESTA-BREAK1     PIC S9.                  191      1
            04  MTTESTA-AGE1-X.                                 192      2
                05  MTTESTA-AGE1       PIC S99.                 192      2
            04  MTTESTA-STRENGTH1-X.                            194      4
                05  MTTESTA-STRENGTH1  PIC S9(5)V9 COMP-3.      194      4
            04  MTTESTA-STRENGTH1-M-X REDEFINES                 194      4
                MTTESTA-STRENGTH1-X.
                05  MTTESTA-STRENGTH1-M  PIC S9(5)V9 COMP-3.    194      4
        03  MTTESTA-DATE-TEST2-X.                               242      4
            04  MTTESTA-DATE-TEST2     PIC 9(6) COMP-3.         242      4
        03  MTTESTA-SLUMP2-X.                                   246      3
            04  MTTESTA-SLUMP2         PIC S999V99 COMP-3.      246      3
        03  MTTESTA-SLUMP2-M-X   REDEFINES MTTESTA-SLUMP2-X.    246      3
            04  MTTESTA-SLUMP2-M       PIC 999V99   COMP-3.     246      3
        03  MTTESTA-AIR-CONT2-X.                                249      2
            05  MTTESTA-AIR-CONT2      PIC S9V9.                249      2
```

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                                                              START  LENG
03 MTTESTA-SAMPLE2-DATA OCCURS 3.                              251    22
   04 MTTESTA-SAMPLE2          PIC X(5).                       251     5
   04 MTTESTA-LAB-NO2          PIC X(9).                       256     9
   04 MTTESTA-COND2-X.                                         265     1
      05 MTTESTA-COND2         PIC S9.                         265     1
   04 MTTESTA-BREAK2-X.                                        266     1
      05 MTTESTA-BREAK2        PIC S9.                         266     1
   04 MTTESTA-AGE2-X.                                          267     2
      05 MTTESTA-AGE2          PIC S99.                        267     2
   04 MTTESTA-STRENGTH2-X.                                     269     4
      05 MTTESTA-STRENGTH2     PIC S9(5)V9 COMP-3.             269     4
   04 MTTESTA-STRENGTH2-M-X REDEFINES                          269     4
      MTTESTA-STRENGTH2-X.
      05 MTTESTA-STRENGTH2-M   PIC S9(5)V9 COMP-3.             269     4
03 MTTESTA-PRCT-PAY-X.                                         317     2
   04 MTTESTA-PRCT-PAY         PIC 9(3) COMP-3.                317     2
03 MTTESTA-REMARKS2            PIC X(54).                      319    54
03 MTTESTA-PAY-CALC-X.                                         373     2
   04 MTTESTA-PAY-CALC         PIC 9(3) COMP-3.                373     2
03 MTTESTA-PASS-FAIL           PIC X.                          375     1
03 MTTESTA-DATE-ENTER          PIC 9(5) COMP-3.                376     3
03 MTTESTA-TIME-ENTER          PIC 9(7) COMP-3.                379     4
03 MTTESTA-USERID-LAST-UPDT    PIC X(7).                       383     7
03 FILLER REDEFINES MTTESTA-USERID-LAST-UPDT.                  383     7
   04 MTTESTA-TERMINAL-ID      PIC X(4).                       383     4
   04 MTTESTA-DATE-DELETED     PIC 9(5)    COMP-3.             387     3
```

MATT MENU SELECTION - 10

Louisiana Department of Transportation and Development

DOTD 03-22-0736
Metric / English
Rev. 2/98

DRILLED PAVING CONCRETE CORES

(DOTD TR 225 and TR 230)

Metric/English ___ (M or E) *Located on MATT Menu*

Project No. ___ **Material Code** ___ **Lot Number** ___

Lab. No. ___ **Spec Code** ___ **Submitted By** ___

Purpose Code ___ Air *(Y=Yes N=No)* ___

Plan Thickness, mm (in) ___ Section Length, m (ft) ___

Section Width, m (ft) ___ Approx. Area, m^2 (yd^2) ___

From Station ___ + ___ To Station ___ + ___

Remarks 1 ___

___

Item No. ___

	Core Ident	Station	Position	Date Poured
1.		+		- - 19
2.		+		- - 19
3.		+		- - 19
4.		+		- - 19
5.		+		- - 19

	Re-Cored *Y = Yes OR Blank*	Date Cored	Nominal Core Dia. mm (in)	Date Tested	Thickness mm (in)	Strength MPa (psi)
1.		- - 19		- - 19		
2.		- - 19		- - 19		
3.		- - 19		- - 19		
4.		- - 19		- - 19		
5.		- - 19		- - 19		

Specification Lot Averages ___ ___

Remarks 2 ___

___

Percent Pay ___

Sampled By: ___

APPROVED BY: ___ **Date:** ___

MATERIAL CODES - - 1992 Specification	
Metric	
Code	Description
551	Surface Tolerance for Type B Paving Concrete
552	Surface Tolerance for Class A Concrete (for Paving)
553	Surface Tolerance for Type C Paving Concrete
554	Surface Tolerance for Type D Paving Concrete
English	
Code	Description
451	Surface Tolerance for Type B Paving Concrete
452	Surface Tolerance for Class A Concrete (for Paving)
453	Surface Tolerance for Type C Paving Concrete
454	Surface Tolerance for Type D Paving Concrete

TEST METHOD CODES FOR PCC SURFACE TOLERANCE

Code	Description
2	Profilograph
3	Static Straightedge

PAVEMENT CODES FOR PCC SURFACE TOLERANCE

Code	Description
3	Associated Pavement
5	Travel Lanes, Greater than 45 MPH
6	Urban Areas, Continuous Paving, 45 MPH or Less
7	Urban Areas, Non-Continuous Paving, 45 MPH or Less
8	Tie-in Areas, Shoulders, Turnouts or Crossovers *(1992 Specs)*

```
                                                                START  LENG
 02  CONCRETE-CORE-TESTS.                                           1   650
     03  CONCRETE-CORE-KEY.                                         1    35
         04  PROJ-NO                 PIC     X(16).                 1    16
         04  MATT-ID                 PIC     X.                    17     1
         04  MATERIAL-CD             PIC     9(3).                 18     3
         04  LOT-NO                  PIC     9(3).                 21     3
         04  LAB-NO                  PIC     X(9).                 24     9
         04  FILLER                  PIC     X(3).                 33     3
     03  PROCESS-DATE                PIC     9(5) COMP-3.          36     3
     03  SPEC-CD                     PIC     X.                    39     1
     03  SUBMIT-BY                   PIC     9(4).                 40     4
     03  PLAN-THICKNESS-X.                                         44     5
         04  PLAN-THICKNESS          PIC     S999V99.              44     5
     03  SECTION-LENGTH-X.                                         49     4
         04  SECTION-LENGTH          PIC     S9(4).                49     4
     03  SECTION-WIDTH-X.                                          53     5
         04  SECTION-WIDTH           PIC     S9(4)V9.              53     5
     03  APPROX-AREA-X.                                            58     5
         04  APPROX-AREA             PIC     S9(5).                58     5
     03  TO-STATION                  PIC     X(7).                 63     7
     03  FROM-STATION                PIC     X(7).                 70     7
     03  PURP-CD                     PIC     9.                    77     1
     03  AIR-ENT-ADMIX               PIC     X.                    78     1
     03  REMARKS1                    PIC     X(54).                79    54
     03  ITEM-NO                     PIC     X(30).               133    30
     03  MTTESTI-ENTRY-DISTRICT      PIC     XX.                  163     2
     03  FILLER                      PIC     X(6).                165     6
     03  CONCRETE-CORE-TABLE OCCURS 5 TIMES.                      171    59
         04  CORE-ID                 PIC     X(5).                171     5
         04  STATION                 PIC     X(7).                176     7
         04  FPOSITION               PIC     X(4).                183     4
         04  DATE-POURED-X.                                       187     8
             05  DATE-POURED         PIC     9(8).                187     8
         04  DATE-CORED-X.                                        195     8
             05  DATE-CORED          PIC     9(8).                195     8
         04  DATE-TESTED-X.                                       203     8
             05  DATE-TESTED         PIC     9(8).                203     8
         04  AGE-X.                                               211     4
             05  AGE                 PIC     S9(4).               211     4
         04  THICKNESS-X.                                         215     5
             05  THICKNESS           PIC     S999V99.             215     5
         04  STRENGTH-X.                                          220     6
             05  STRENGTH            PIC     S9(5)V9.             220     6
         04  RECORED                 PIC     X.                   226     1
         04  NOMINAL-CORE-X.                                      227     3
             05  NOMINAL-CORE        PIC      9(3).               227     3
     03  AVG-THICKNESS-X.                                         466     5
         04  AVG-THICKNESS           PIC     S999V99.             466     5
     03  AVG-STRENGTH-X.                                          471     6
         04  AVG-STRENGTH            PIC     S9(5)V9.             471     6
     03  REMARKS2                    PIC     X(54).               477    54
     03  PRCT-PAY-X.                                              531     3
         04  PRCT-PAY                  PIC     S9(3).             531     3
     03  PAY-CALC-X.                                              534     3
```

			START	LENG
	04 PAY-CALC	PIC S9(3).	534	3
03	PASS-FAIL	PIC X.	537	1
03	DATE-ENTER-X.		538	8
	04 DATE-ENTER	PIC 9(8).	538	8
03	TIME-ENTER	PIC 9(7).	546	7
03	MTTESTI-USERID-LAST-UPDT	PIC X(8).	553	8
03	MTTESTI-TERMINAL-ID	PIC X(4).	561	4
03	MTTESTI-DATE-UPDATED	PIC 9(8).	565	8
03	MTTESTI-TIME-UPDATED	PIC 9(6).	573	6
03	MTTESTI-DATE-DELETED	PIC 9(8).	579	8
03	FILLER	PIC X(64).	587	64

DOTD 03-22-4035
Metric/English
Rev. 8/98

Department of Transportation and Development

PORTLAND CEMENT CONCRETE PAVEMENT REPORT

etric/English ☐ *(Located on MATT Menu)*

Project No. ☐ **Material Code** ☐ **Lot No.** ☐ **Category** ☐ *(Spec. Cat. = I, II, III)*

ubmitter ☐ **Plant Code** C ☐ **Mix Design No.** ☐ **Spec Code** ☐ **Purp. Code** ☐

onst. Method ☐ *1 = Slip Form 2 = Form 3 = Split Slab 4 = Contin. Reinforced 5 = Other* Joints: Spacing ☐ Configuration ☐ *1 = Transverse 2 = Skewed*

ate ☐ **Item No.** ☐ **Lot Complete** ☐ *Y = Yes N = No*

emarks 1 ☐

Sta: ☐ + ☐ To Sta: ☐ + ☐ | Sta: ☐ + ☐ To Sta: ☐ + ☐

Location ☐ Width ☐ m (ft) | Location ☐ Width ☐ m (ft)

Thick. ☐ mm (in) Area ☐ m^2 (yd^2) | Thick. ☐ mm (in) Area ☐ m^2 (yd^2)

PREVIOUS ________ m^2 (yd^2) + CURRENT, m^2 (yd^2) ☐ = Total to Date ________ m^2 (yd^2)

URRENT ☐ m^3 (yd^3) Theoret.Yield ☐ m^2/m^3 (yd^2/yd^3) Actual Yield ☐ m^2/m^3 (yd^2/yd^3)

Air ☐ ☐ ☐ ☐ Slump, mm (in) ☐ ☐ ☐ ☐

Joint Materials

Load Transfer Device: Materials ☐ Source ☐ ________

Adhesive Lubricant: Materials ☐ Source ☐ ________

Filler: Materials ☐ Source ☐ ________

Sealer: Materials ☐ Source ☐ ________

Curing

uring Method: ☐ *1 = Burlap 2 = Paper 3 = Poly Sheeting 4 = Burlap & Poly Sheeting 5 = Curing Membrane*

Curing Membrane Rate ☐ m^2/L (ft^2/gal)

Surface Texture

pplied By: ☐ *1 = Manual 2 = Mechanical* *[Record Measurement to Nearest mm (1/32 in)]*

tation: ☐ + ☐ Location: ☐ | Station: ☐ + ☐ Location: ☐

_____ 2. _____ 3. _____ 4. _____ 5. _____ | 1. _____ 2. _____ 3. _____ 4. _____ 5. _____

Average: ☐ mm (1/32 in) | Average: ☐ mm (1/32 in)

Surface Tolerance

Test Method: ☐ *(Codes listed on back)* Pavement Code: ☐ *(Codes listed on back)*

Measured ☐ lin m (lin ft) IRI Std ☐ mm/km (in/mi) Avg.Prof. Ind. ☐ mm/km (in/mi)

Remarks 2 ☐

% Pay ☐

________________________ ________________________

Laboratory Authorized Evaluator **Department's Certified Inspector**

________________________ ________________________

District Laboratory Engineer **Project Engineer**

MATERIAL CODES - - 1992 Specification

Metric

Code	Description
551	Surface Tolerance for Type B Paving Concrete
552	Surface Tolerance for Class A Concrete (for Paving)
553	Surface Tolerance for Type C Paving Concrete
554	Surface Tolerance for Type D Paving Concrete

English

Code	Description
451	Surface Tolerance for Type B Paving Concrete
452	Surface Tolerance for Class A Concrete (for Paving)
453	Surface Tolerance for Type C Paving Concrete
454	Surface Tolerance for Type D Paving Concrete

TEST METHOD CODES
FOR PCC SURFACE TOLERANCE

Code	Description
2	Profilograph
3	Static Straightedge

PAVEMENT CODES
FOR PCC SURFACE TOLERANCE

Code	Description
3	Associated Pavement
5	Travel Lanes, Greater than 45 MPH
6	Urban Areas, Continuous Paving, 45 MPH or Less
7	Urban Areas, Non-Continuous Paving, 45 MPH or Less
8	Tie-in Areas, Shoulders, Turnouts or Crossovers *(1992 Specs)*

```
                                                                     START   LENG
******************************************************************
* MTTESTN     PORTLAND CONCRETE CEMENT RECORD LAYOUT             *
*    OLD LENGTH WAS 311 BYTES..... NEW WAS 408, NOW 484 BYTES    *
*    PUT INTO PRODUCTION 9/02/1998 B.NICHOLS   (METRIC)          *
******************************************************************
    02  MTTESTN-REC.                                                   1    484
        03  MTTESTN-KEY.                                               1     35
            04  MTTESTN-PROJECT           PIC X(16).                   1     16
            04  MTTESTN-MATT-ID           PIC X.                      17      1
            04  MTTESTN-MATERIAL-CD       PIC 9(3).                   18      3
            04  MTTESTN-LOT-NO            PIC X(4).                   21      4
            04  MTTESTN-FILLER            PIC X(11).                  25     11
        03  MTTESTN-PROCESS-DATE          PIC 9(5)  COMP-3.           36      3
        03  MTTESTN-PAY-CALC-X.                                       39      3
            04  MTTESTN-PAY-CALC          PIC S9(3).                  39      3
        03  MTTESTN-ENTRY-DISTRICT        PIC XX.                     42      2
        03  MTTESTN-SPEC-CD               PIC 9.                      44      1
        03  MTTESTN-SUBMIT-BY             PIC X(4).                   45      4
        03  MTTESTN-PLANT                 PIC X(4).                   49      4
        03  MTTESTN-MIX-DES-X.                                        53      3
            04  MTTESTN-MIX-DES           PIC 999.                    53      3
        03  MTTESTN-PURP-CD               PIC 9.                      56      1
        03  MTTESTN-CONST-METHOD          PIC X.                      57      1
        03  MTTESTN-JOINTS-SPACE          PIC X(2).                   58      2
        03  MTTESTN-JOINT-CONFIG          PIC X.                      60      1
        03  MTTESTN-DATE-SAMP             PIC 9(8).                   61      8
        03  MTTESTN-ITEM-NO               PIC X(16).                  69     16
        03  FILLER                        PIC X.                      85      1
        03  MTTESTN-FROM-STA1             PIC X(7).                   86      7
        03  MTTESTN-TO-STA1               PIC X(7).                   93      7
        03  MTTESTN-LOC1                  PIC X(4).                  100      4
        03  MTTESTN-WIDTH1-X.                                        104      5
            04  MTTESTN-WIDTH1            PIC 9(4)V9.                104      5
        03  MTTESTN-THICK1-X.                                        109      5
            04  MTTESTN-THICK1            PIC S999V99.               109      5
        03  MTTESTN-SY1-X.                                           114      5
            04  MTTESTN-SY1               PIC S9999V9.               114      5
        03  MTTESTN-FROM-STA2             PIC X(7).                  119      7
        03  MTTESTN-TO-STA2               PIC X(7).                  126      7
        03  MTTESTN-LOC2                  PIC X(4).                  133      4
        03  MTTESTN-WIDTH2-X.                                        137      5
            04  MTTESTN-WIDTH2            PIC 9(4)V9.                137      5
        03  MTTESTN-THICK2-X.                                        142      5
            04  MTTESTN-THICK2            PIC S999V99.               142      5
        03  MTTESTN-SY2-X.                                           147      5
            04  MTTESTN-SY2               PIC S9999V9.               147      5
        03  MTTESTN-SY-CURRENT-X.                                    152      5
            04  MTTESTN-SY-CURRENT        PIC S9999V9.               152      5
        03  MTTESTN-CY-CURRENT-X.                                    157      4
            04  MTTESTN-CY-CURRENT        PIC S9(4).                 157      4
        03  MTTESTN-THEO-YIELD-X.                                    161      4
            04  MTTESTN-THEO-YIELD        PIC S99V99.                161      4
        03  MTTESTN-ACTUAL-YIELD-X.                                  165      4
            04  MTTESTN-ACTUAL-YIELD      PIC S99V99.                165      4
```

```
                                                              START   LENG
03  MTTESTN-AIR-TABLE OCCURS 4 TIMES.                           169      2
    04  MTTESTN-PCT-AIR-X.                                      169      2
        05  MTTESTN-PCT-AIR            PIC S9V9.                169      2
03  MTTESTN-SLUMP-TABLE OCCURS 4 TIMES.                         177      5
    04  MTTESTN-SLUMP-X.                                        177      5
        05  MTTESTN-SLUMP              PIC S999V99.             177      5
03  MTTESTN-JOINT-MATERIALS.                                    197     28
    04  MTTESTN-LOAD-TRANS             PIC X(3).                197      3
    04  MTTESTN-LOAD-TRANS-SOURCE      PIC X(4).                200      4
    04  MTTESTN-LUB-ADHES              PIC X(3).                204      3
    04  MTTESTN-LUB-ADHES-SOURCE       PIC X(4).                207      4
    04  MTTESTN-FILLER-MATERIAL        PIC X(3).                211      3
    04  MTTESTN-FILLER-SOURCE          PIC X(4).                214      4
    04  MTTESTN-SEALER                 PIC X(3).                218      3
    04  MTTESTN-SEALER-SOURCE          PIC X(4).                221      4
03  MTTESTN-CURING-METHOD              PIC X.                   225      1
03  MTTESTN-CURING-MEMBRANE-X.                                  226      3
    04  MTTESTN-CURING-MEMBRANE        PIC S9(3).               226      3
03  MTTESTN-SURFACE-TEXTURE.                                    229     27
    04  MTTESTN-APPLIED-BY             PIC X.                   229      1
    04  MTTESTN-TEXT-STA1              PIC X(7).                230      7
    04  MTTESTN-TEXT-LOC1              PIC X(4).                237      4
    04  MTTESTN-TEXT-AVG1-X.                                    241      2
        05  MTTESTN-TEXT-AVG1          PIC S99.                 241      2
    04  MTTESTN-TEXT-STA2              PIC X(7).                243      7
    04  MTTESTN-TEXT-LOC2              PIC X(4).                250      4
    04  MTTESTN-TEXT-AVG2-X.                                    254      2
        05  MTTESTN-TEXT-AVG2          PIC S99.                 254      2
03  MTTESTN-SURFACE-TOLERANCE.                                  256      9
    04  MTTESTN-FT-MEAS-X.                                      256      4
        05  MTTESTN-FT-MEAS            PIC S9(4).               256      4
    04  MTTESTN-AVG-PROFILE-IND-X.                              260      4
        05  MTTESTN-AVG-PROFILE-IND    PIC S999V9.              260      4
    04  MTTESTN-TEST-METHOD            PIC X.                   264      1
03  MTTESTN-REMARKS1                   PIC X(54).               265     54
03  MTTESTN-PAVEMENTS                  PIC X.                   319      1
03  MTTESTN-LOT-COMP                   PIC X.                   320      1
03  MTTESTN-IRI-STD-X.                                          321      5
    04  MTTESTN-IRI-STD                PIC S9999V9.             321      5
03  MTTESTN-DATE-ENTER                 PIC  9(8).               326      8
03  MTTESTN-TIME-ENTER                 PIC  9(6).               334      6
03  MTTESTN-USERID-LAST-UPDT           PIC X(8).                340      8
03  MTTESTN-TERMINAL-ID                PIC X(4).                348      4
03  MTTESTN-DATE-UPDATED               PIC  9(8).               352      8
03  MTTESTN-TIME-UPDATED               PIC  9(6).               360      6
03  MTTESTN-DATE-DELETED               PIC  9(8).               366      8
03  MTTESTN-CATEGORY                   PIC X.                   374      1
03  MTTESTN-REMARKS2                   PIC X(54).               375     54
03  MTTESTN-PASS-FAIL                  PIC X.                   429      1
03  MTTESTN-PASS-FAIL-CR               PIC X.                   430      1
03  FILLER                             PIC X(54).               431     54
```

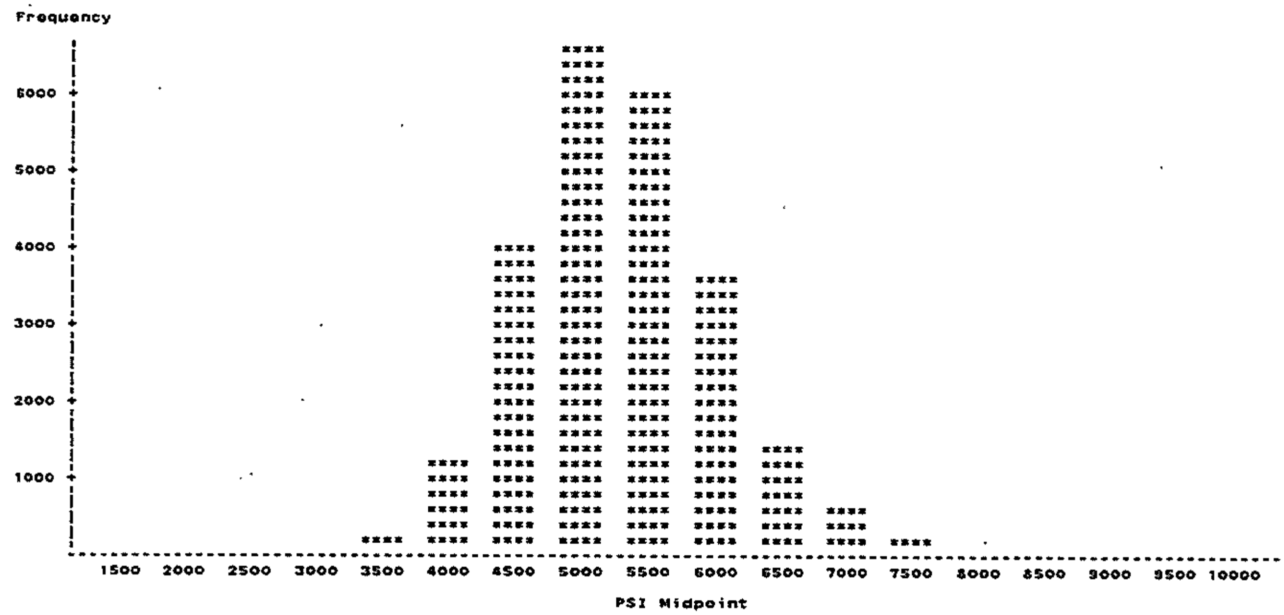
APPENDIX C

Frequency Distribution of Structure Concrete Data

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 10:32 Thursday, May 25, 2000 5

MATT_CD=401

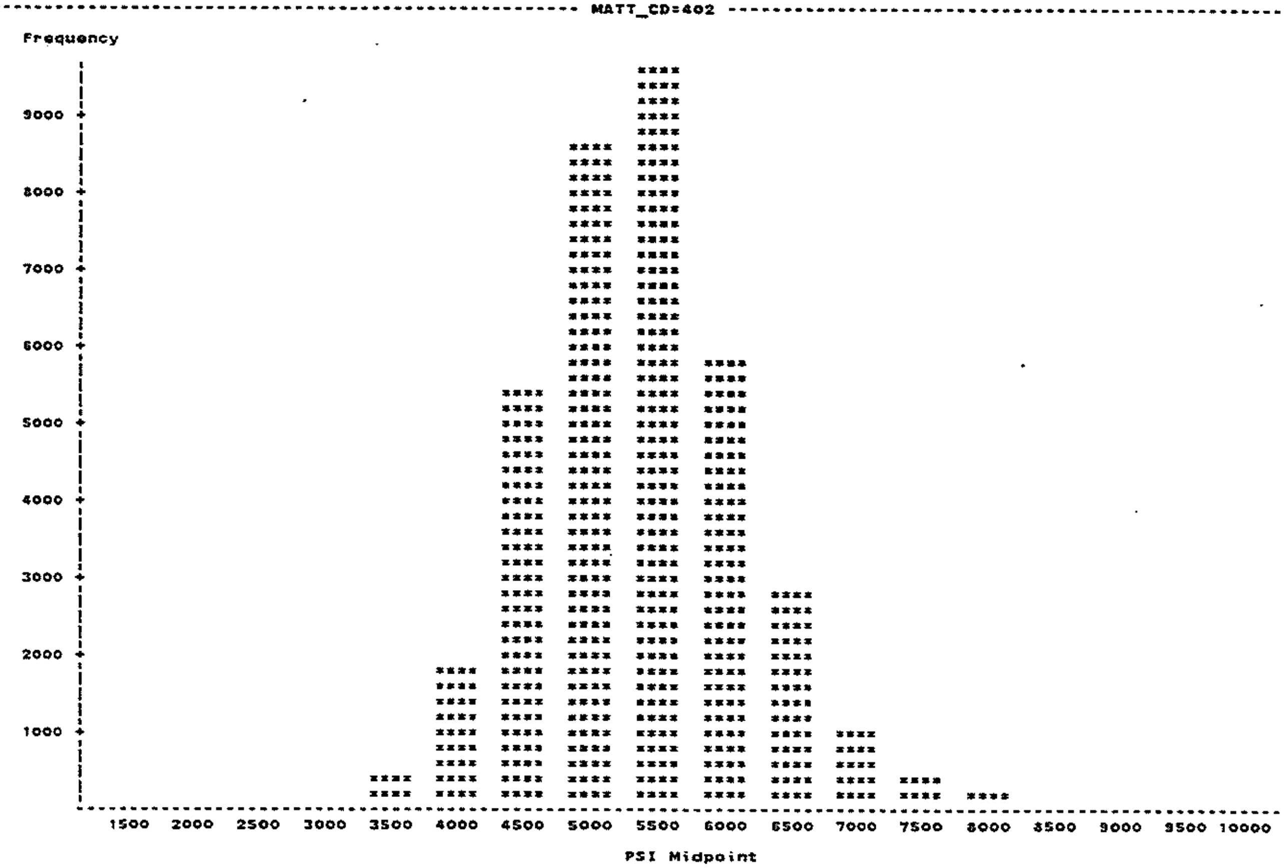


STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 10:32 Thursday, May 25, 2000 6

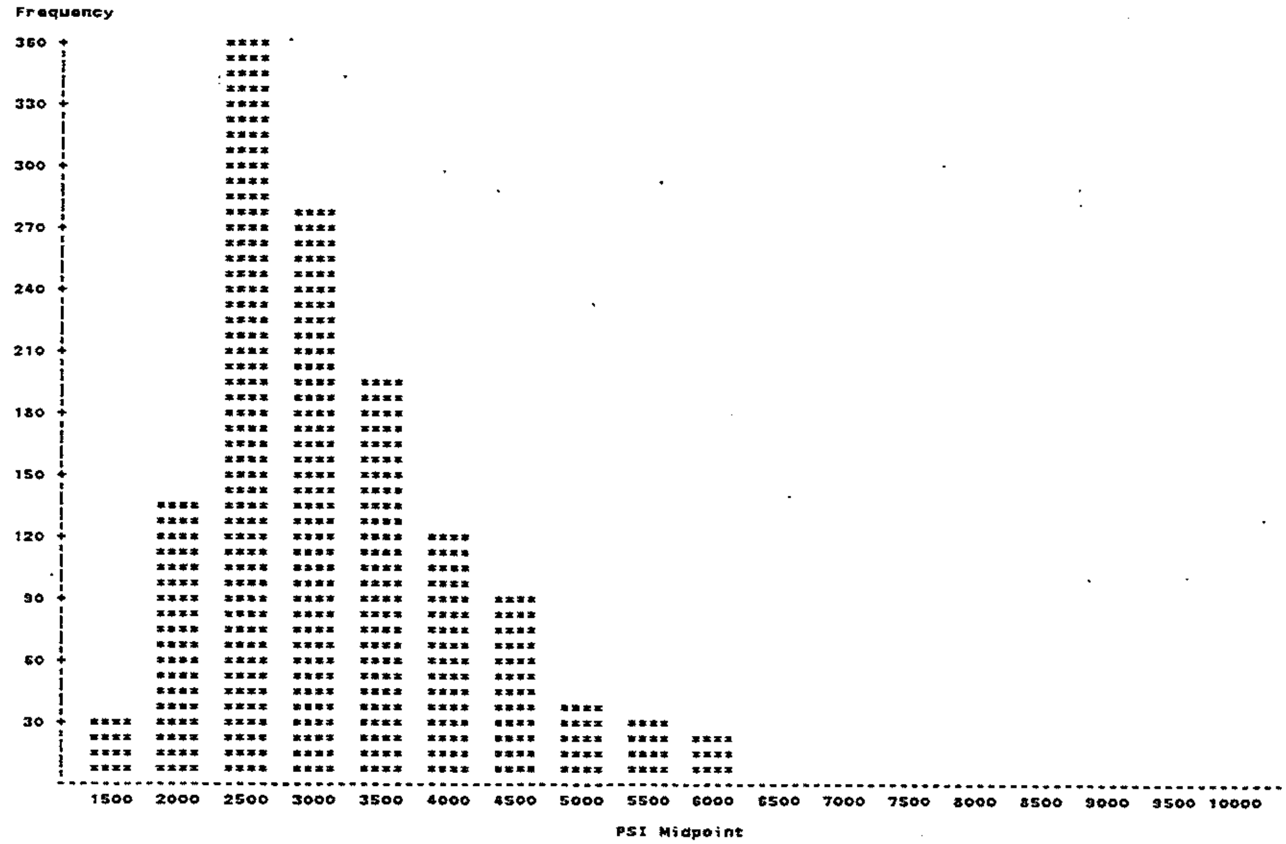
MATT_CD=402



LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 10:32 Thursday, May 25, 2000 7

MATT_CD=414



STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 10:32 Thursday, May 25, 2000 8

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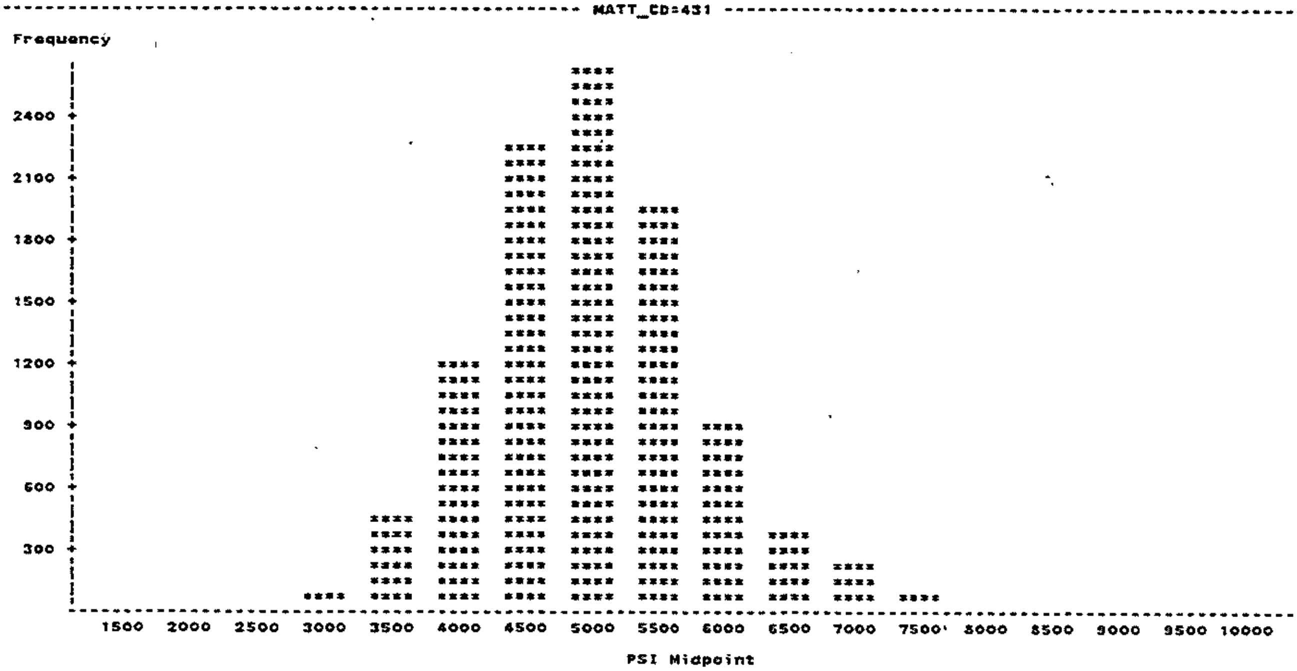

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

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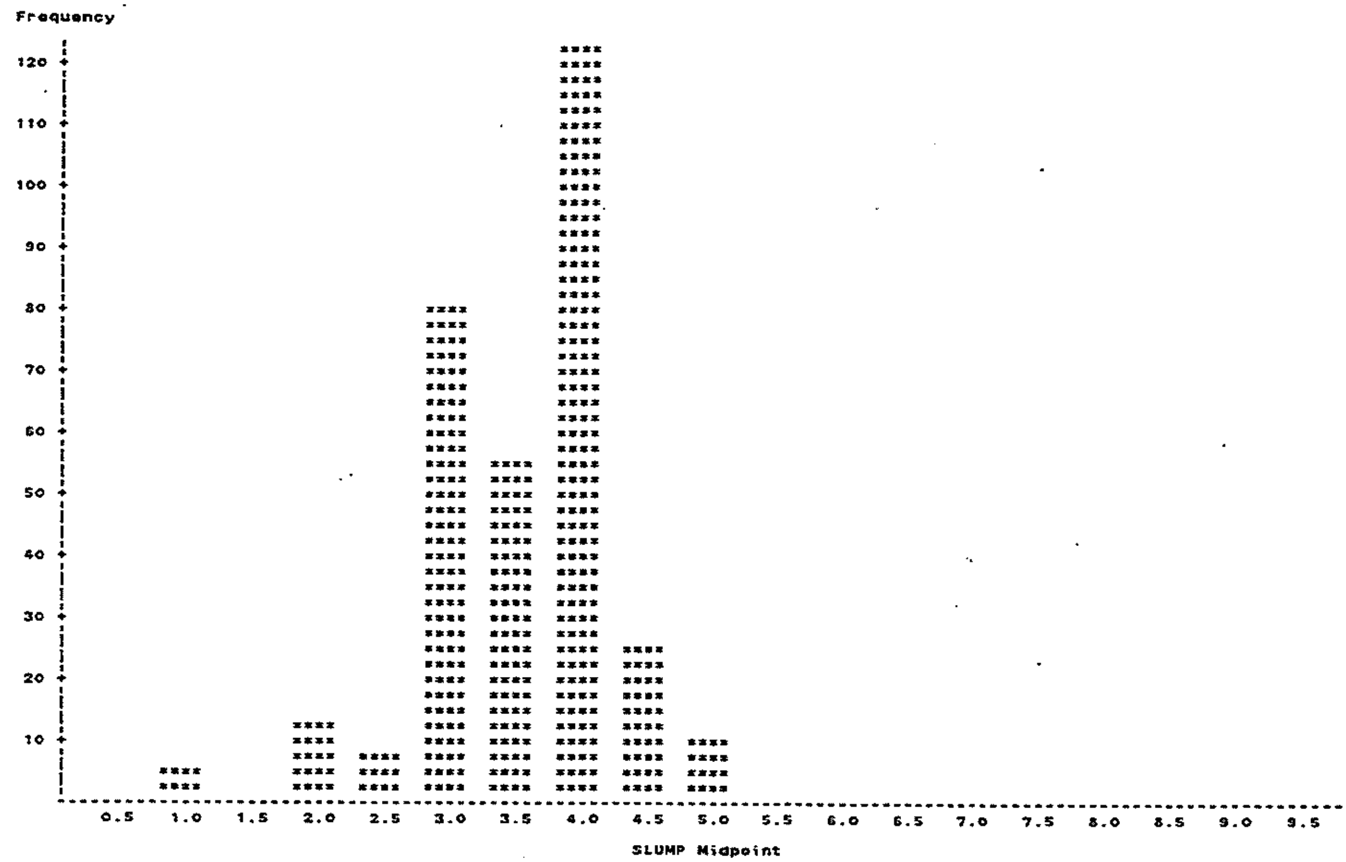

STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

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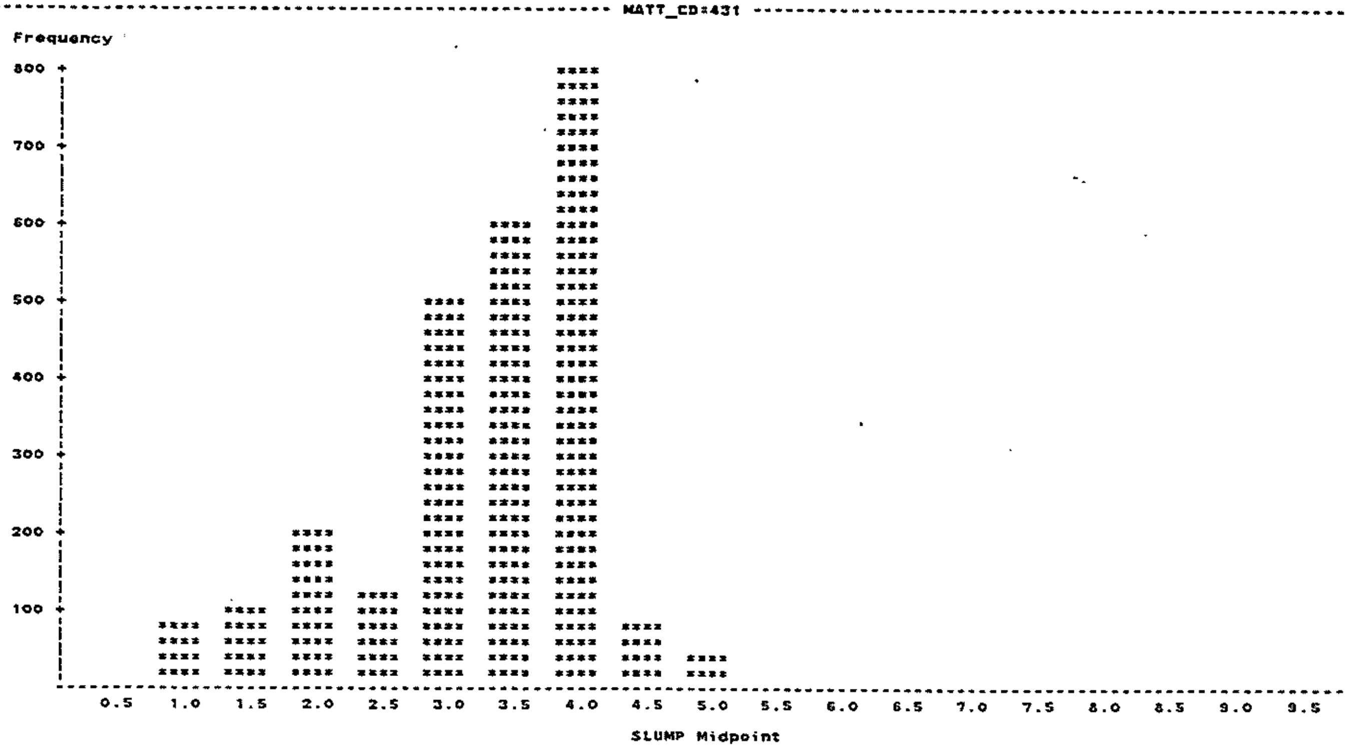

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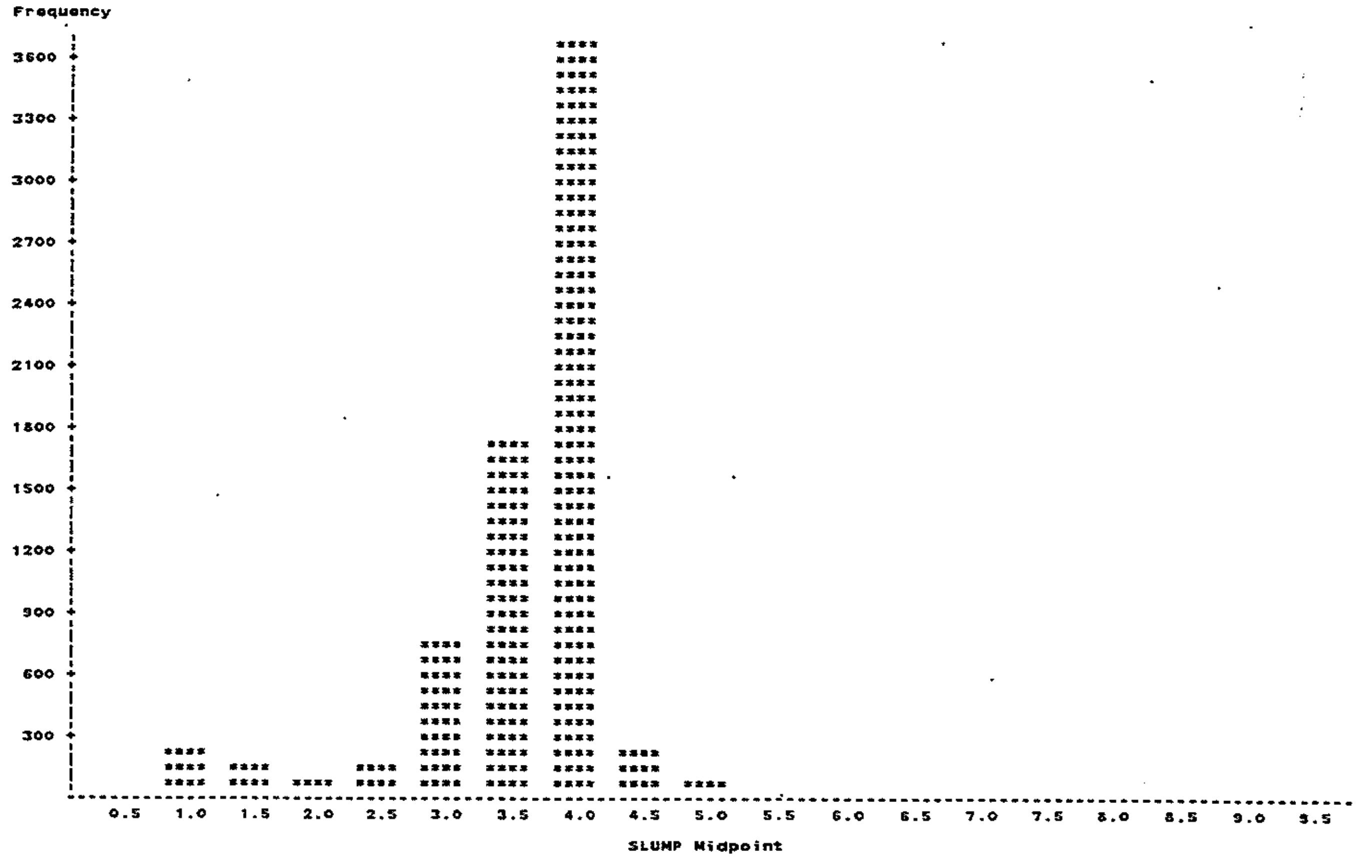
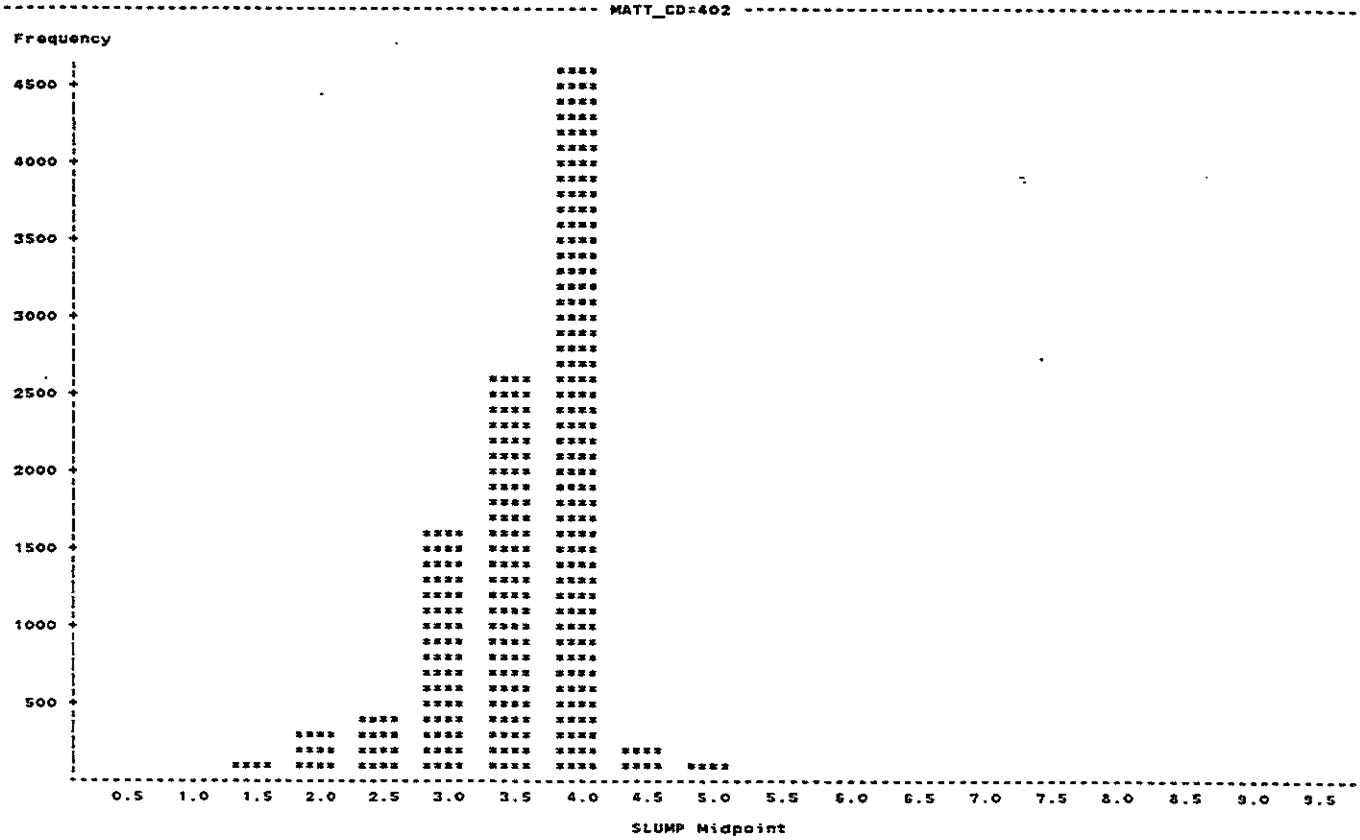


STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 10:32 Thursday, May 25, 2000 2

MATT_CD=402



Analysis Variable : PCTAIR

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MATT_CD=402

N	Mean	Std Dev	CV	Minimum	Maximum	Range	Skewness
747	4.7	0.7	14.4	1.0	7.0	6.0	-1.2

MATT_CD=414

N	Mean	Std Dev	CV	Minimum	Maximum	Range	Skewness
19	4.8	0.6	12.7	3.0	6.0	3.0	-1.3

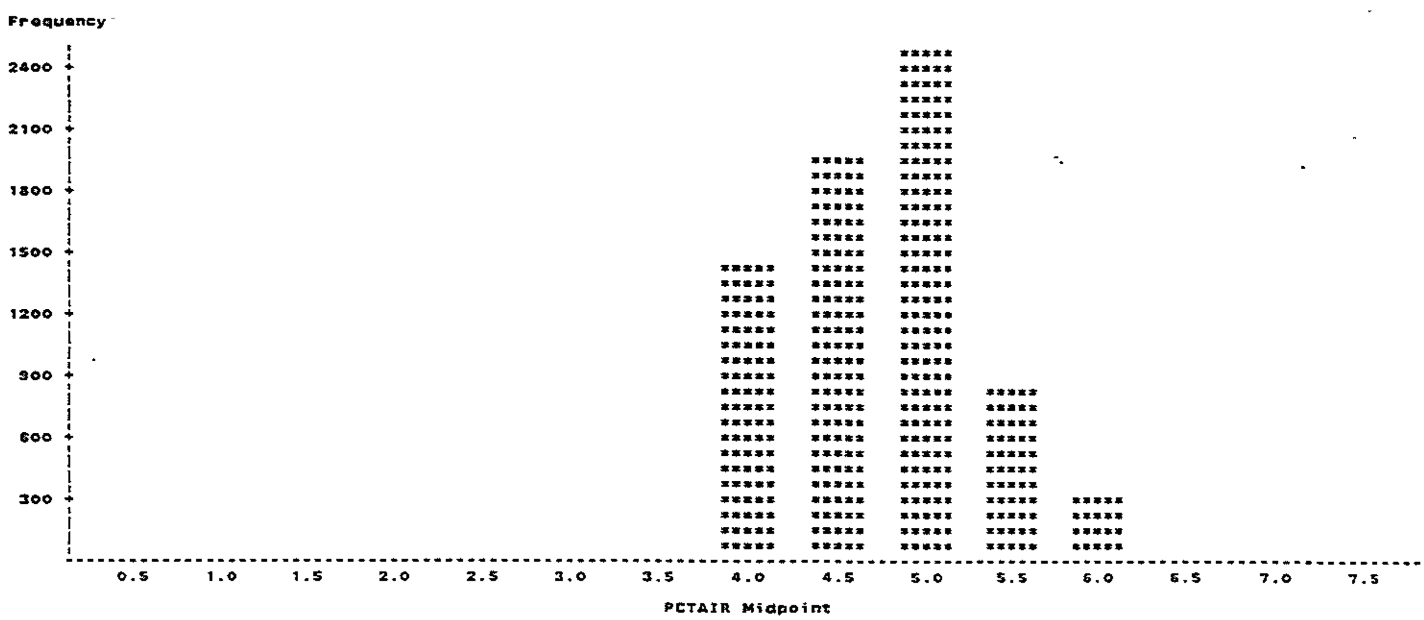
MATT_CD=431

N	Mean	Std Dev	CV	Minimum	Maximum	Range	Skewness
637	4.8	0.7	15.4	0.5	7.0	6.5	-1.4

STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

MATT_CD=401



LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 09:56 Tuesday, May 30, 2000 7

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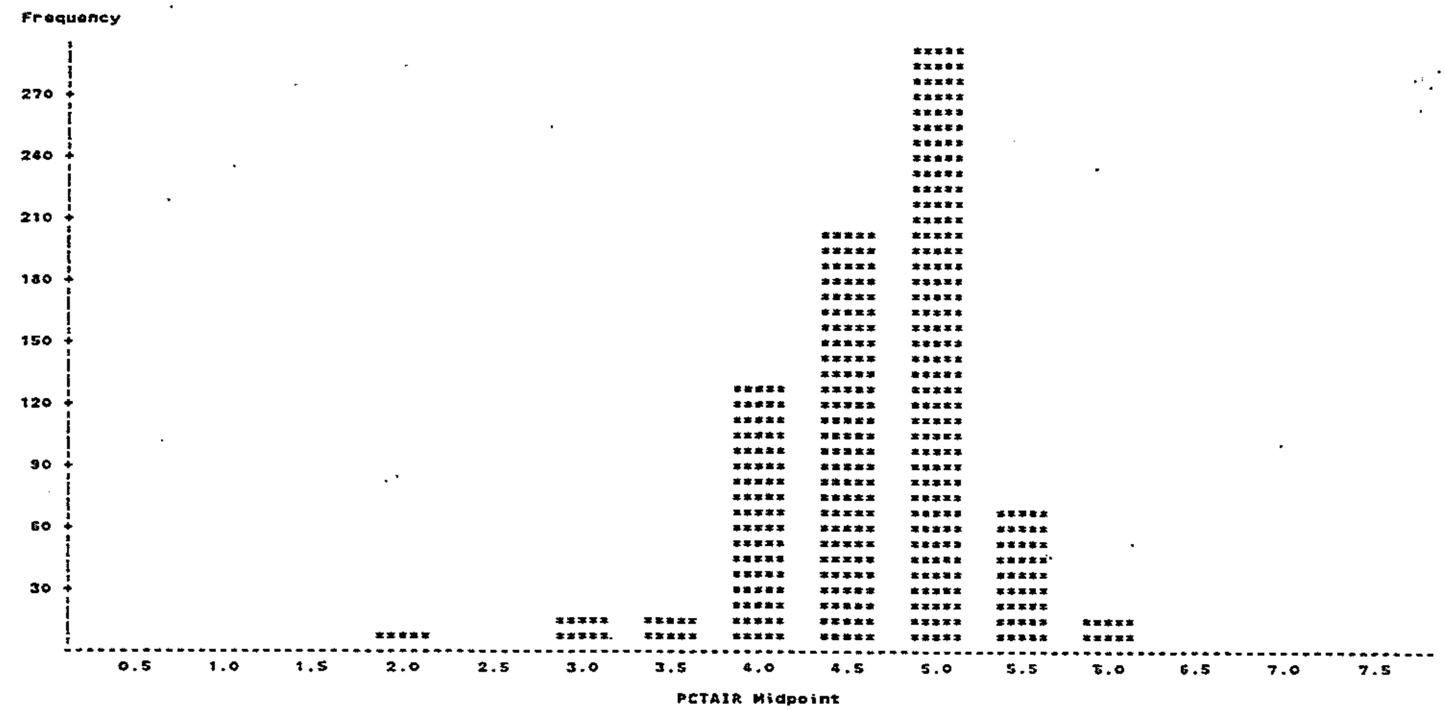

STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 09:56 Tuesday, May 30, 2000 8

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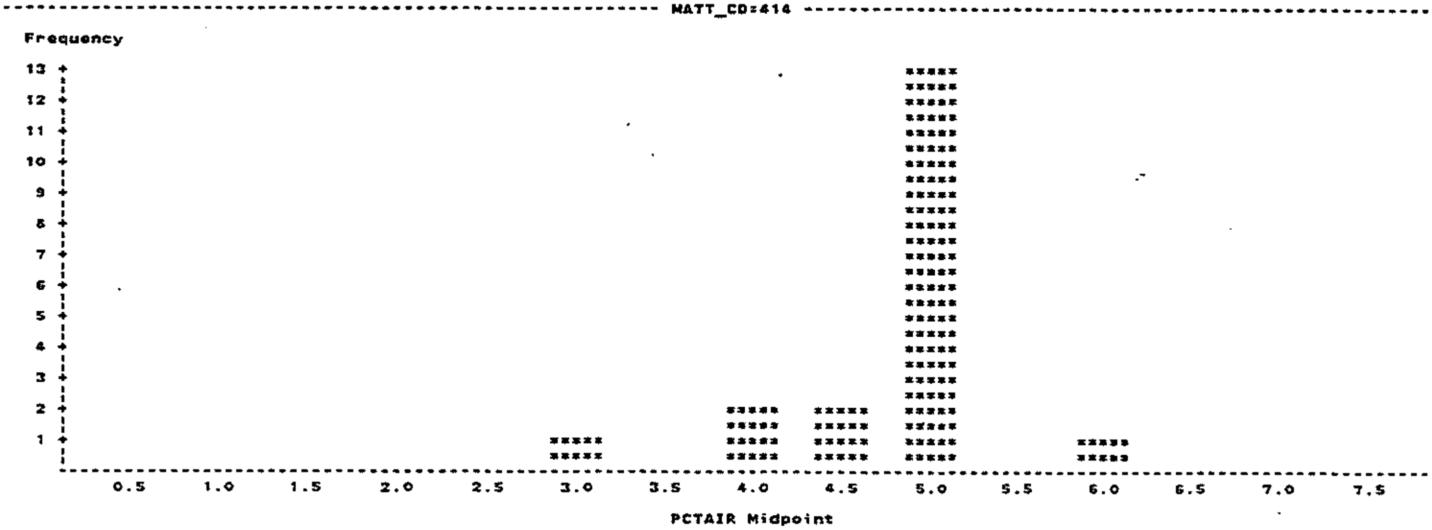
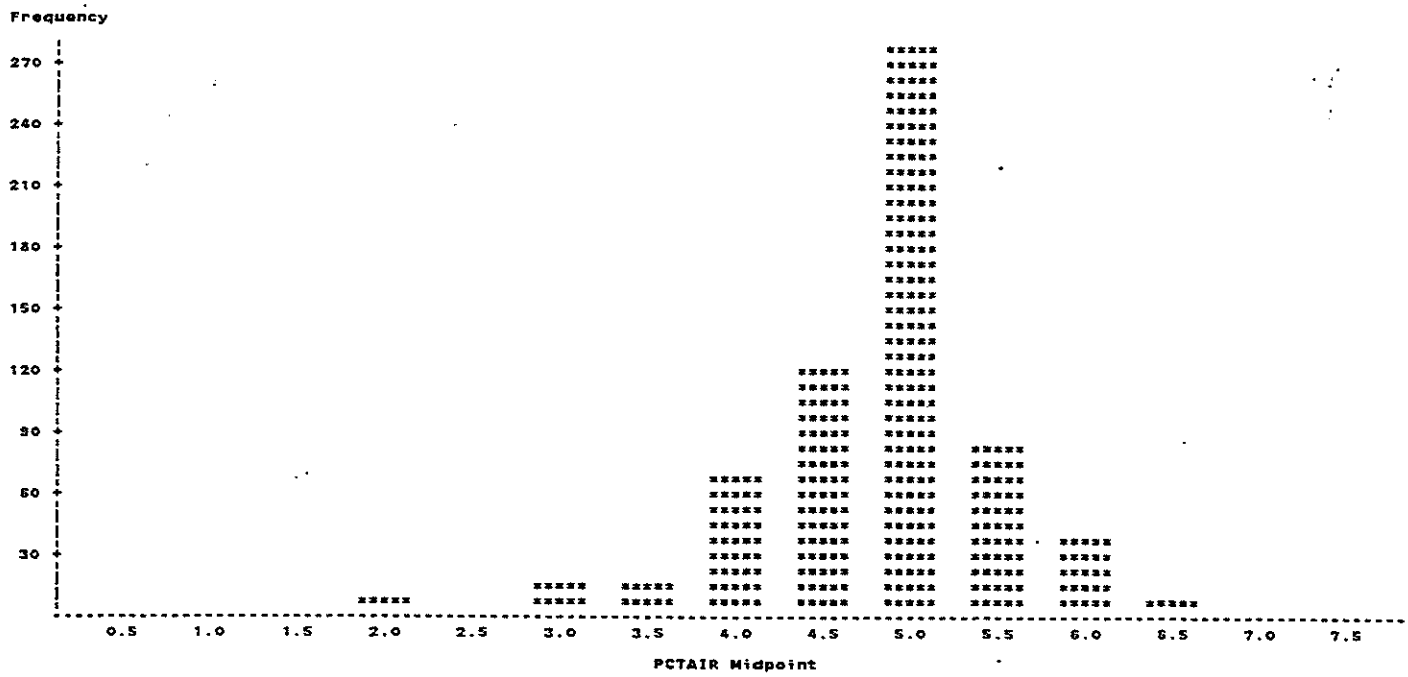


LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

MATT_CD=431



STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

APPENDIX D

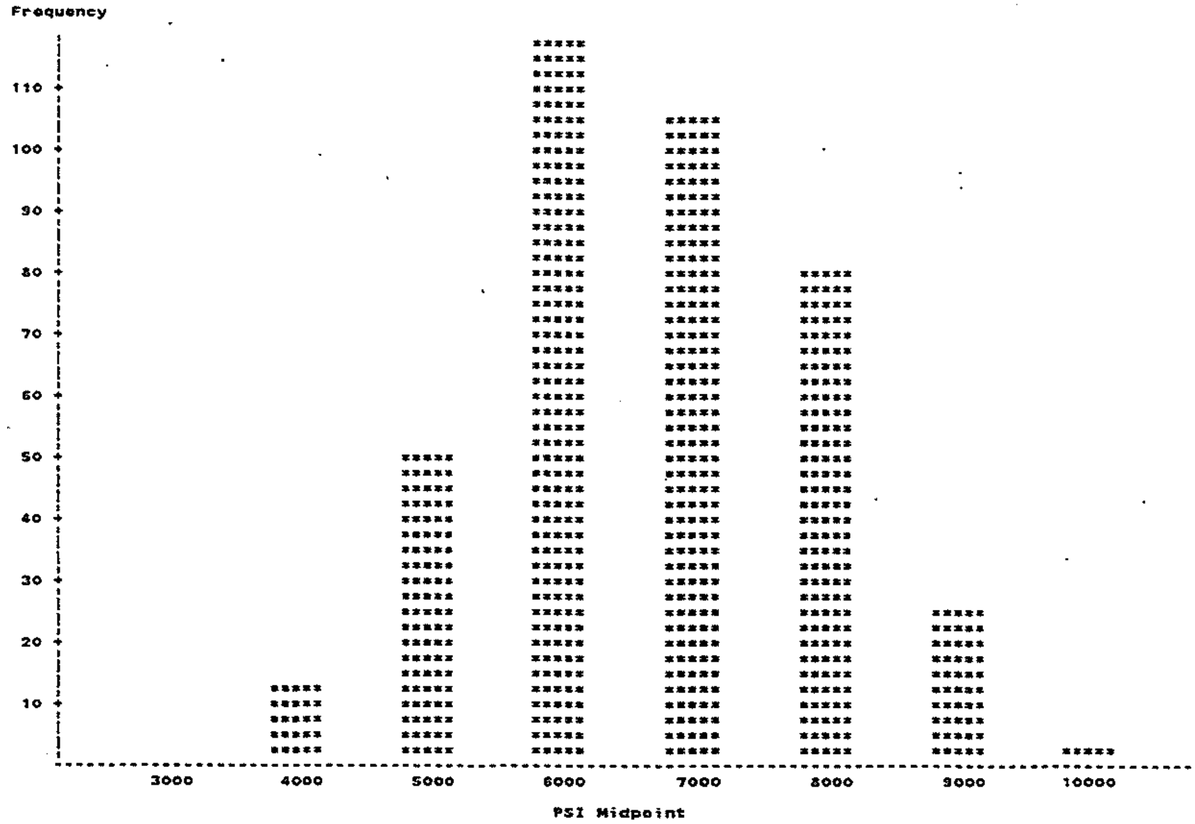
Frequency Distribution of Paving Concrete Data

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Compressive Strength Frequency Distribution For

10:30 Thursday, May 25, 2000 1

AIR=N Matt Code=451



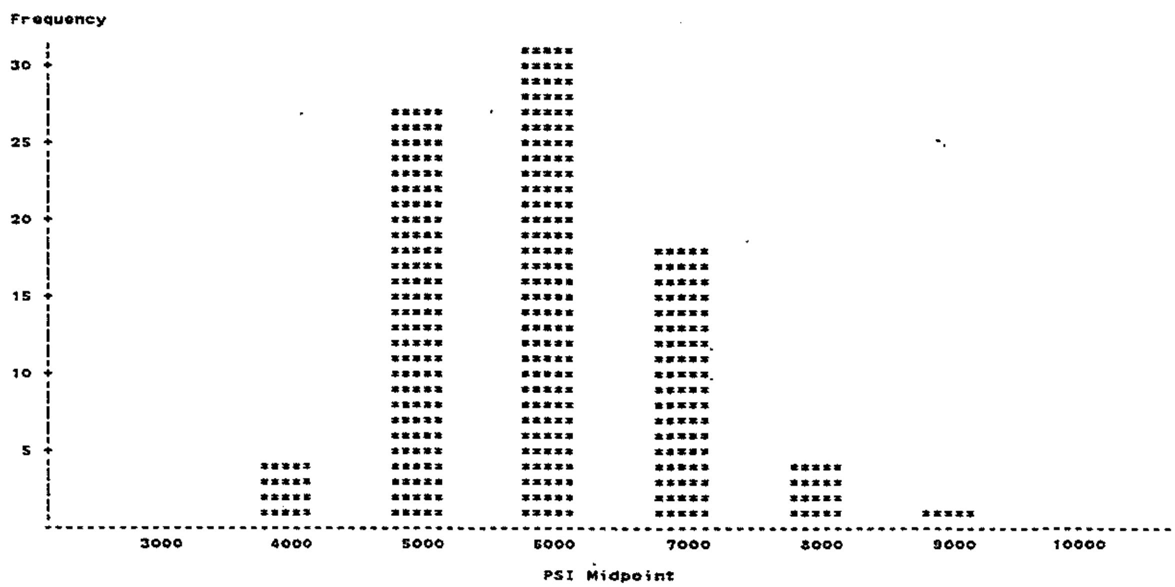
STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Compressive Strength Frequency Distribution For

10:30 Thursday, May 25, 2000 2

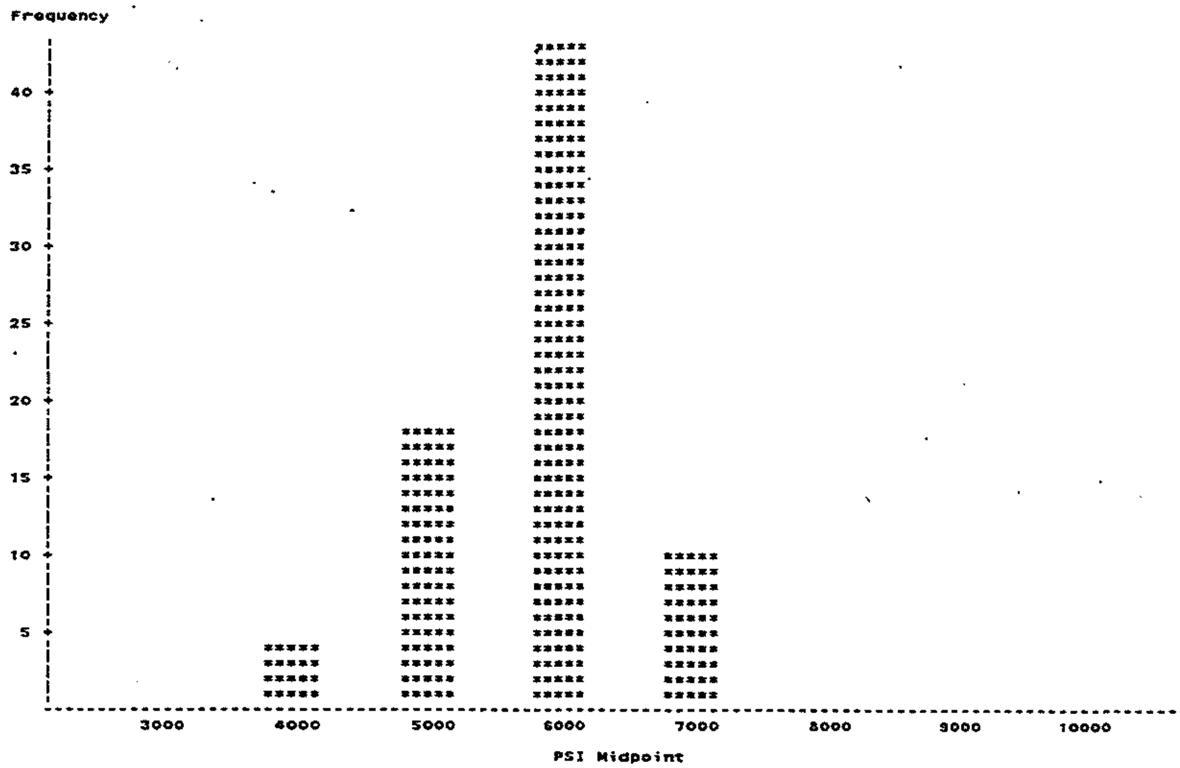
AIR=N Matt Code=452



LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Compressive Strength Frequency Distribution For

AIR=N Matt Code=454

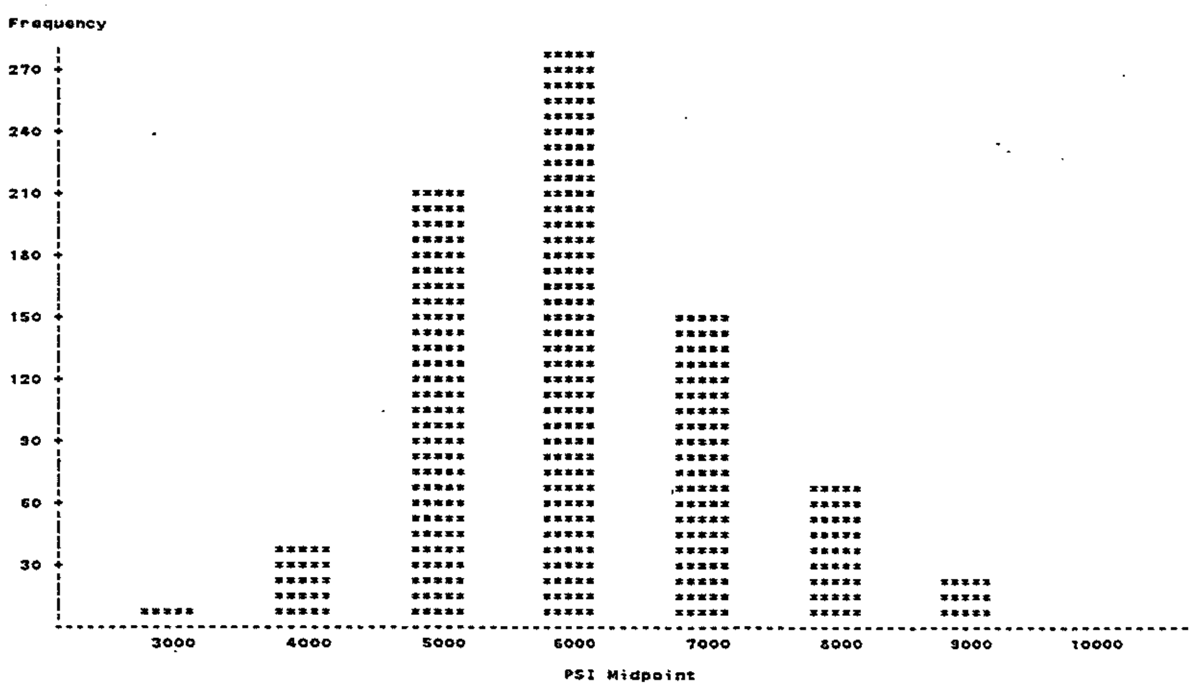


STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Compressive Strength Frequency Distribution For

AIR=Y Matt Code=451

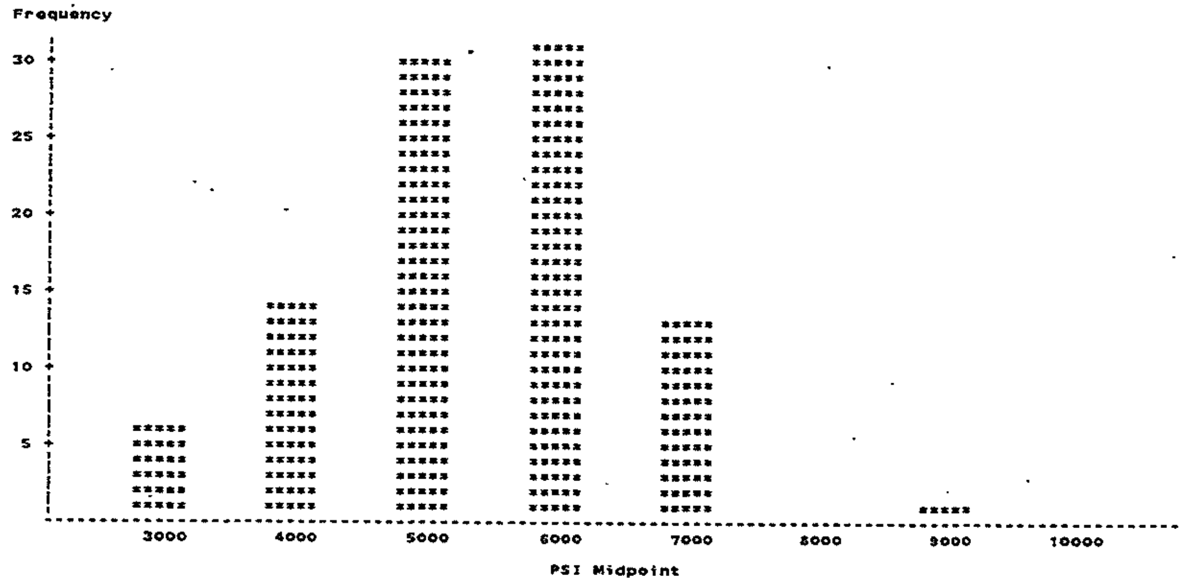


LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Compressive Strength Frequency Distribution For

10:30 Thursday, May 25, 2000 5

----- AIR=Y Matt Code=452 -----



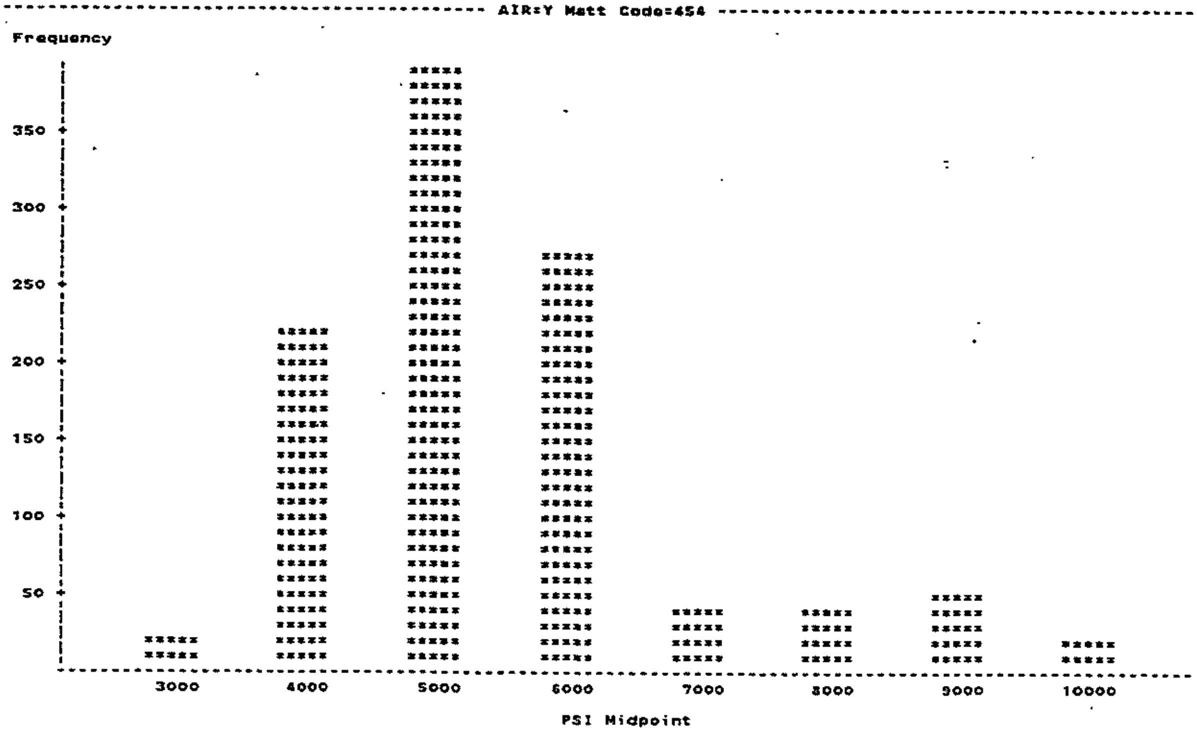
STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Compressive Strength Frequency Distribution For

10:30 Thursday, May 25, 2000 6

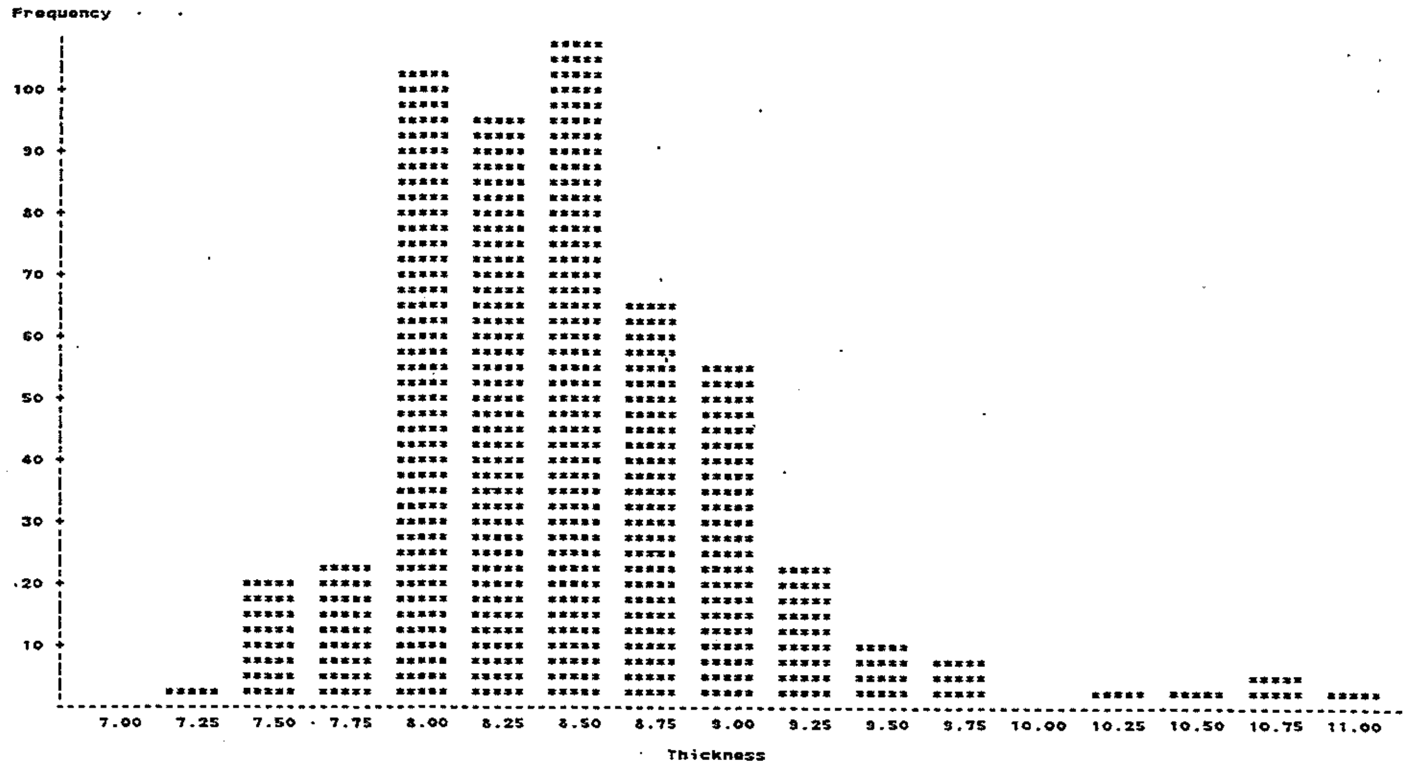
----- AIR=Y Matt Code=454 -----



LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores 10:30 Thursday, May 25, 2000 7
Thickness Frequency Distribution For

Plan Thichness=8

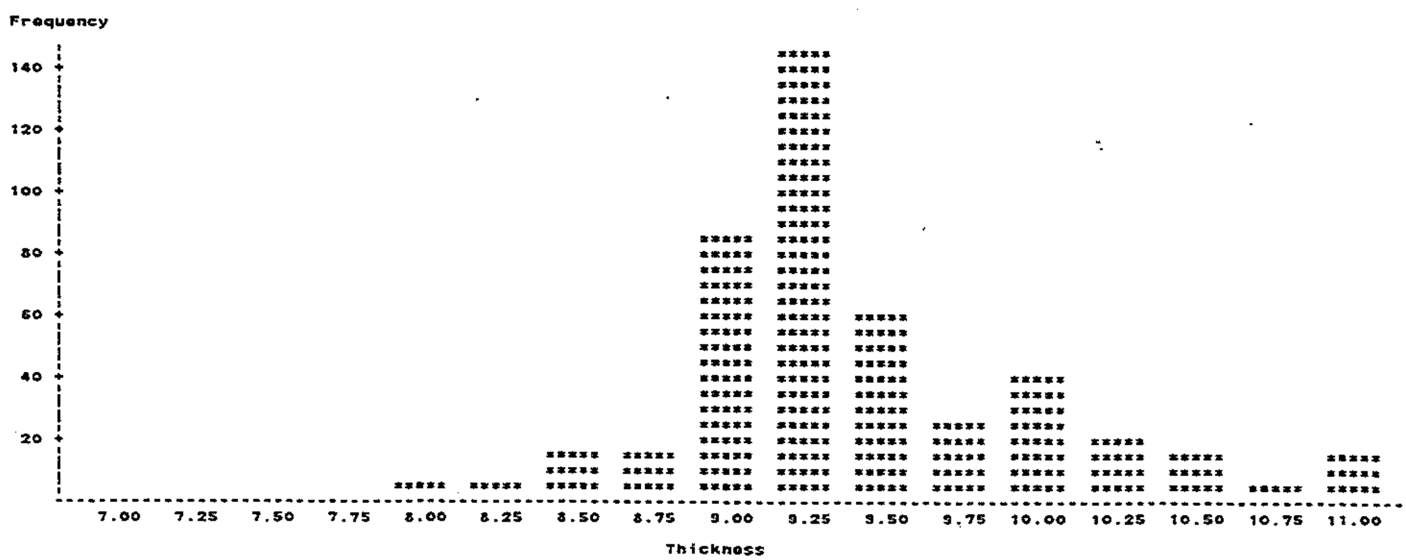


STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores 10:30 Thursday, May 25, 2000 8
Thickness Frequency Distribution For

Plan Thichness=9

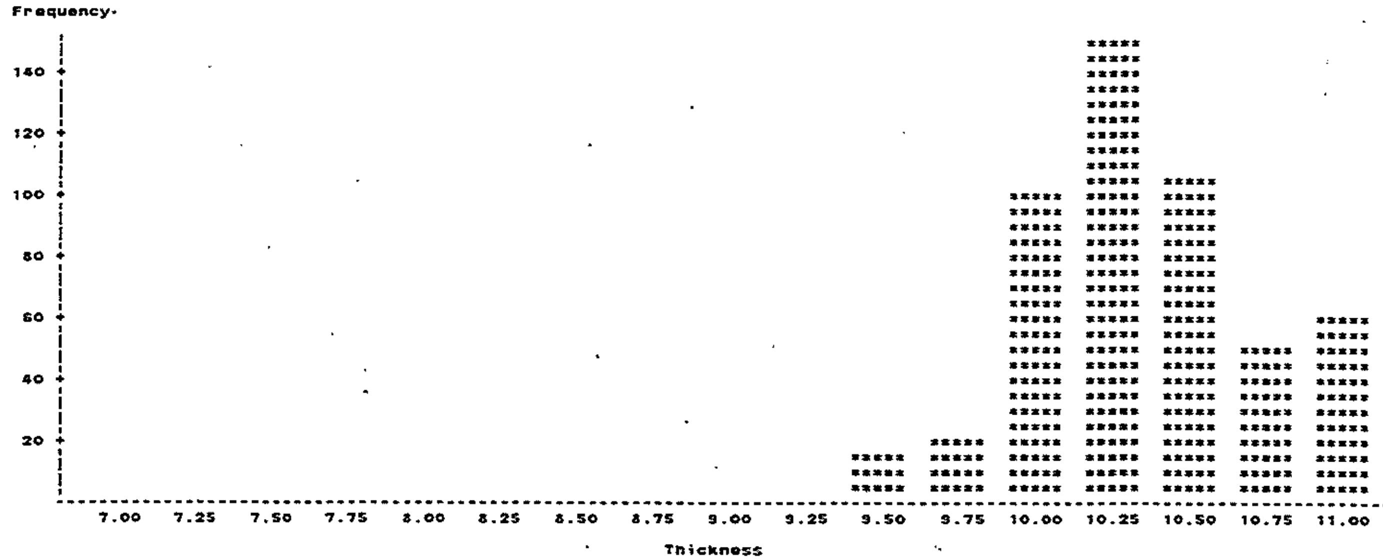


LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Thickness Frequency Distribution For

10:30 Thursday, May 25, 2000 9

Plan Thichness=10



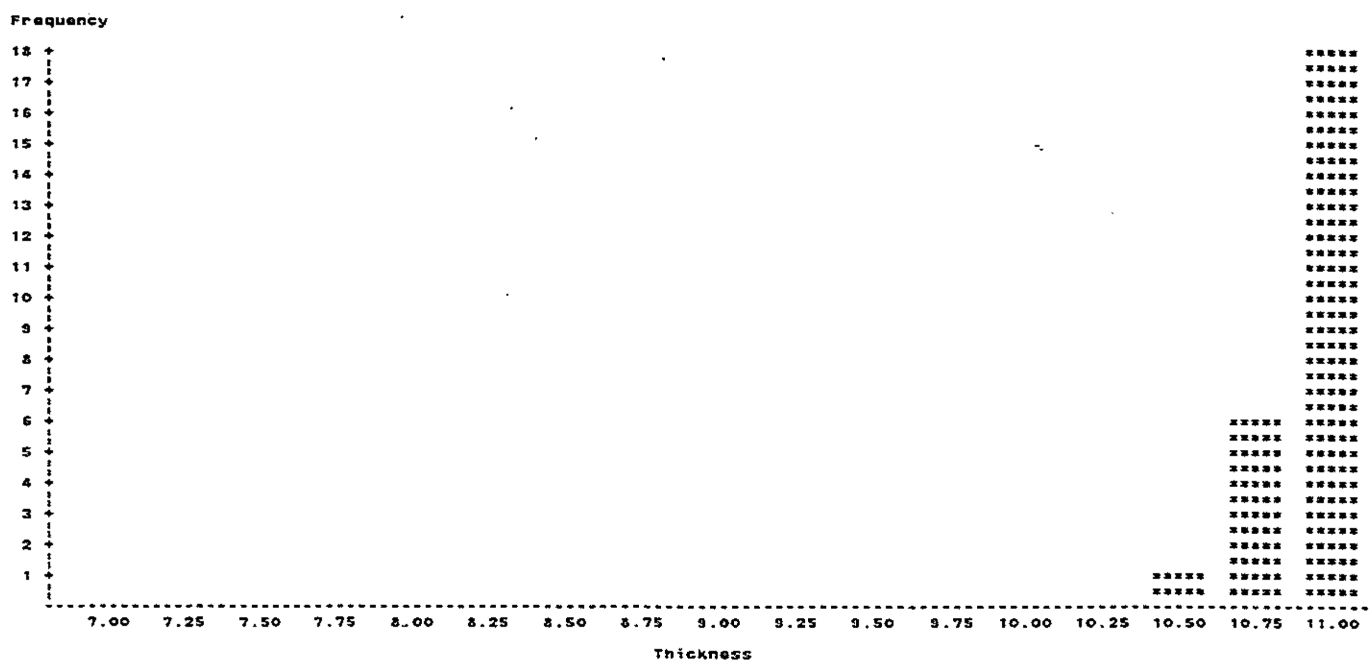
ST02

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Thickness Frequency Distribution For

10:30 Thursday, May 25, 2000 10

Plan Thichness=10.5



ST02

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Thickness Frequency Distribution For

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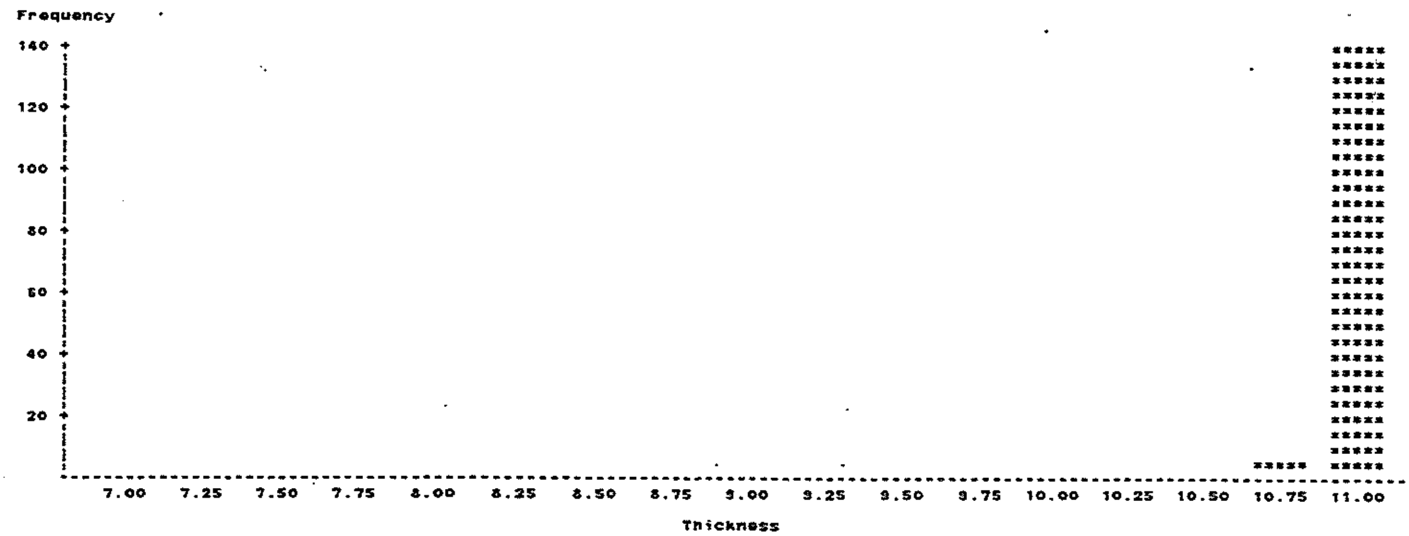
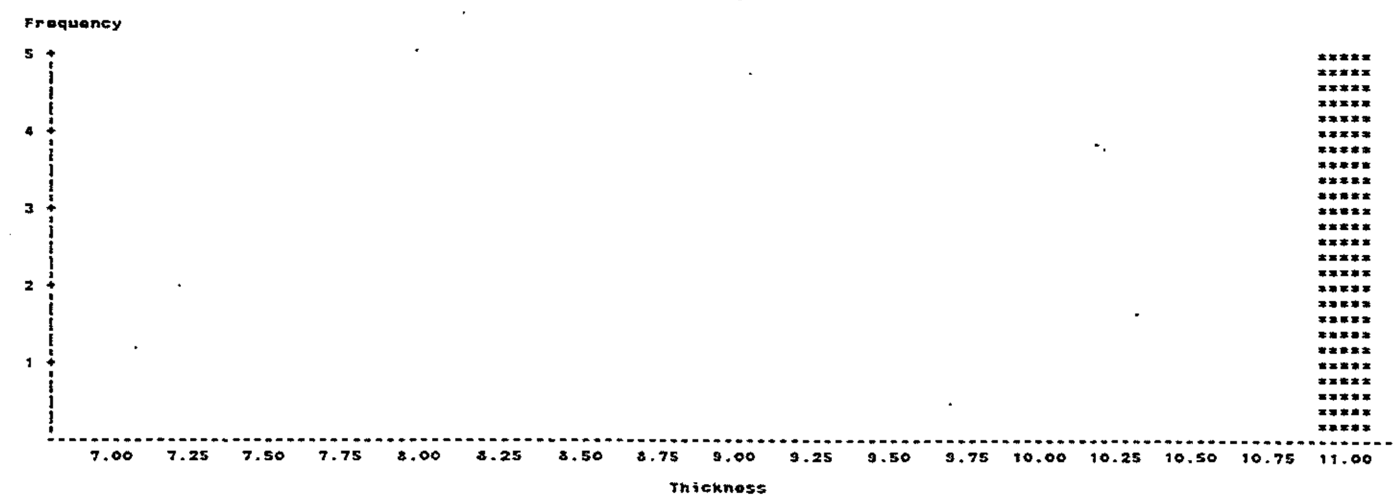


STO2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Thickness Frequency Distribution For

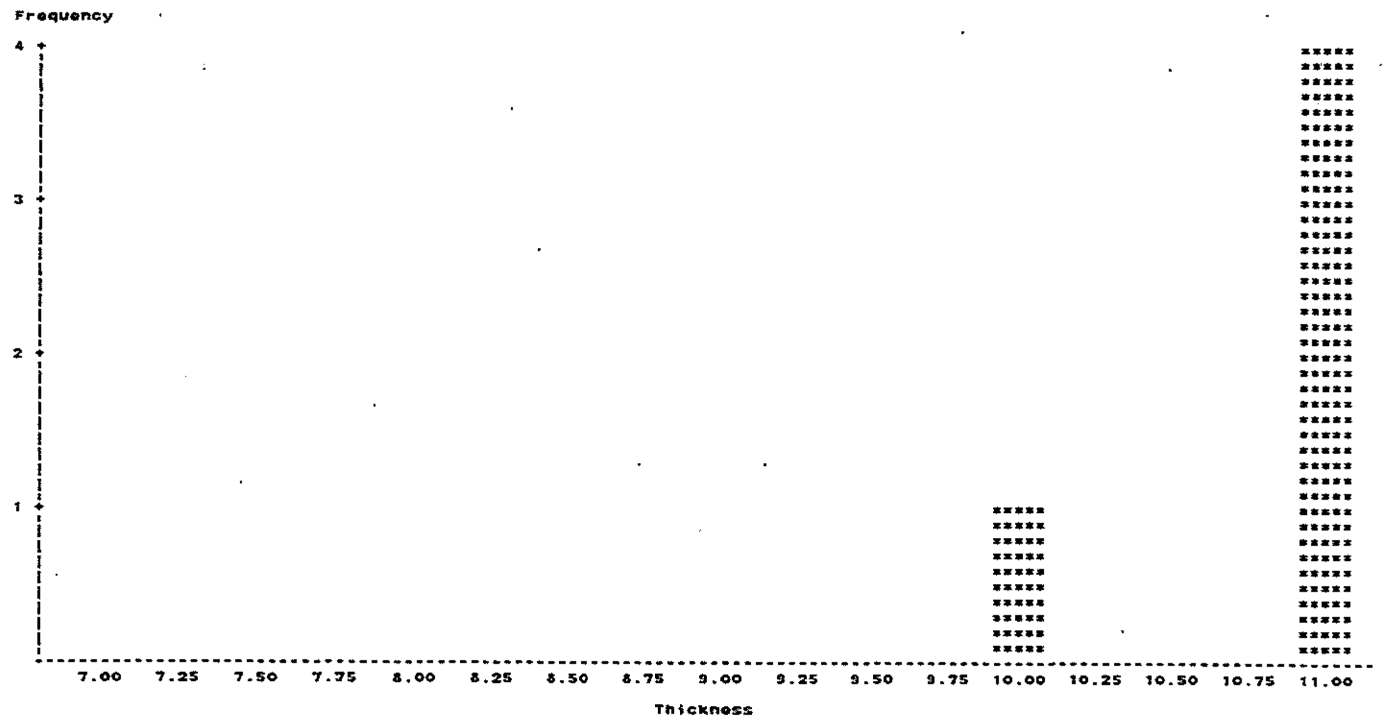
Plan Thichness=11.25



LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Thickness Frequency Distribution For

Plan Thichness=11.75

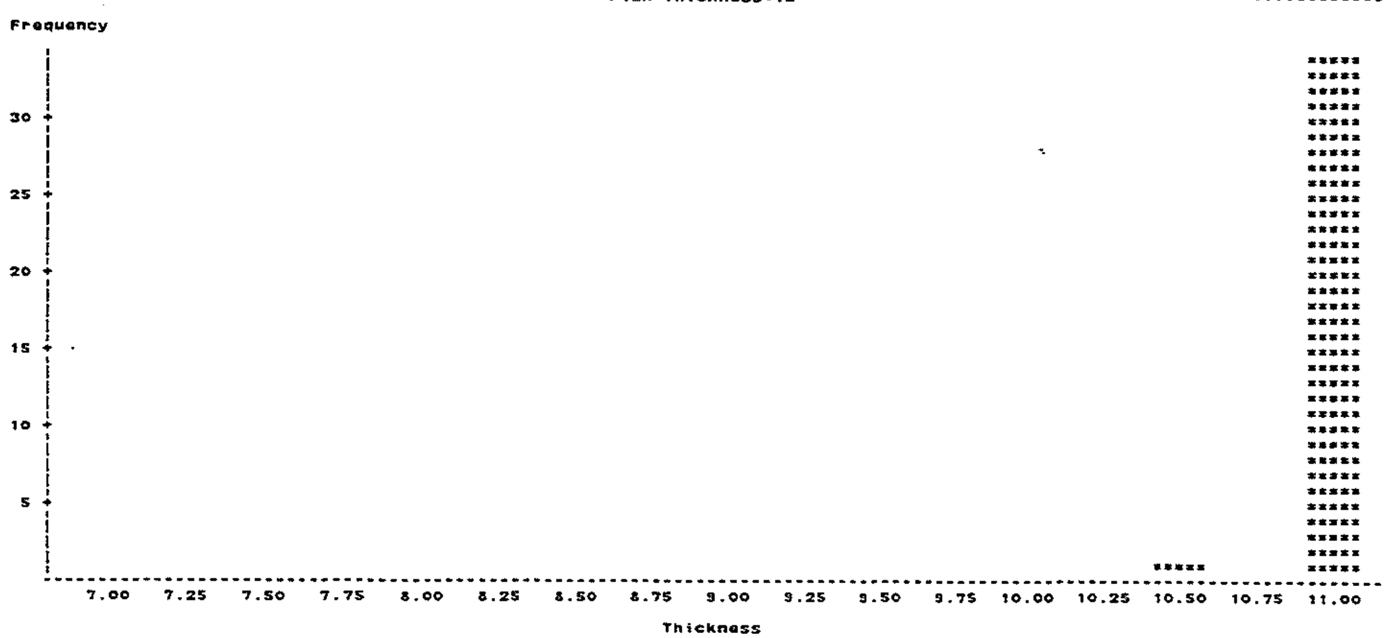


STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Thickness Frequency Distribution For

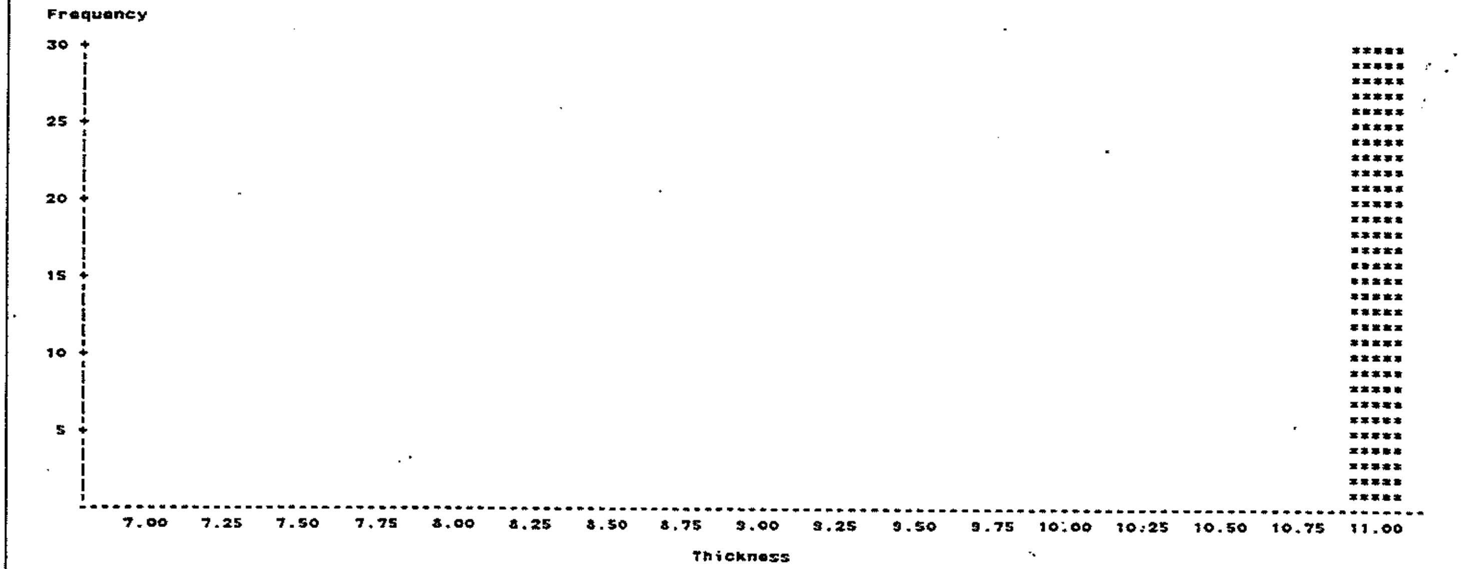
Plan Thichness=12



LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores 10:30 Thursday, May 25, 2000 15
Thickness Frequency Distribution For .

Plan Thichness=12.5

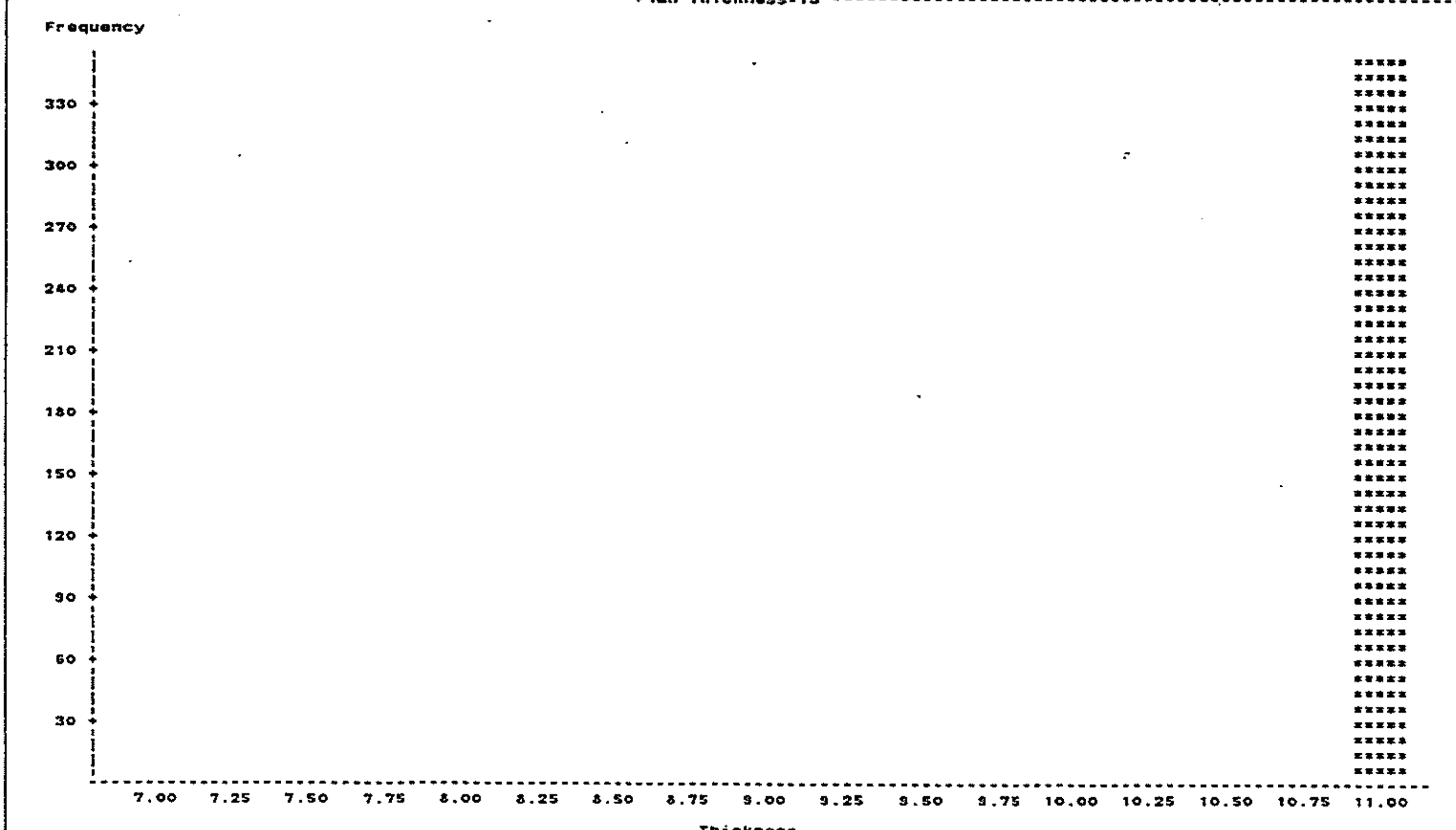


STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores 10:30 Thursday, May 25, 2000 16
Thickness Frequency Distribution For

Plan Thichness=13

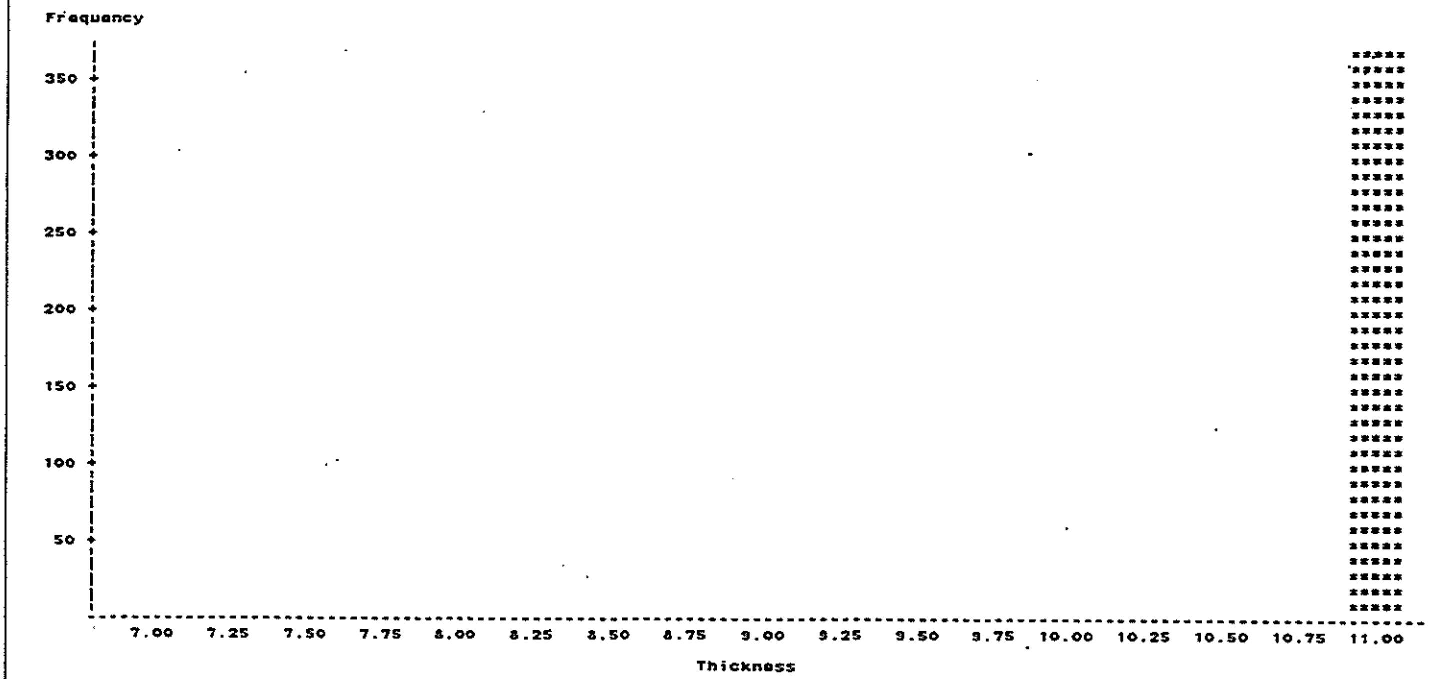


LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

Drilled Paving Concrete Cores
Thickness Frequency Distribution For

10:30 Thursday, May 25, 2000 17

Plan Thickness=14



STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

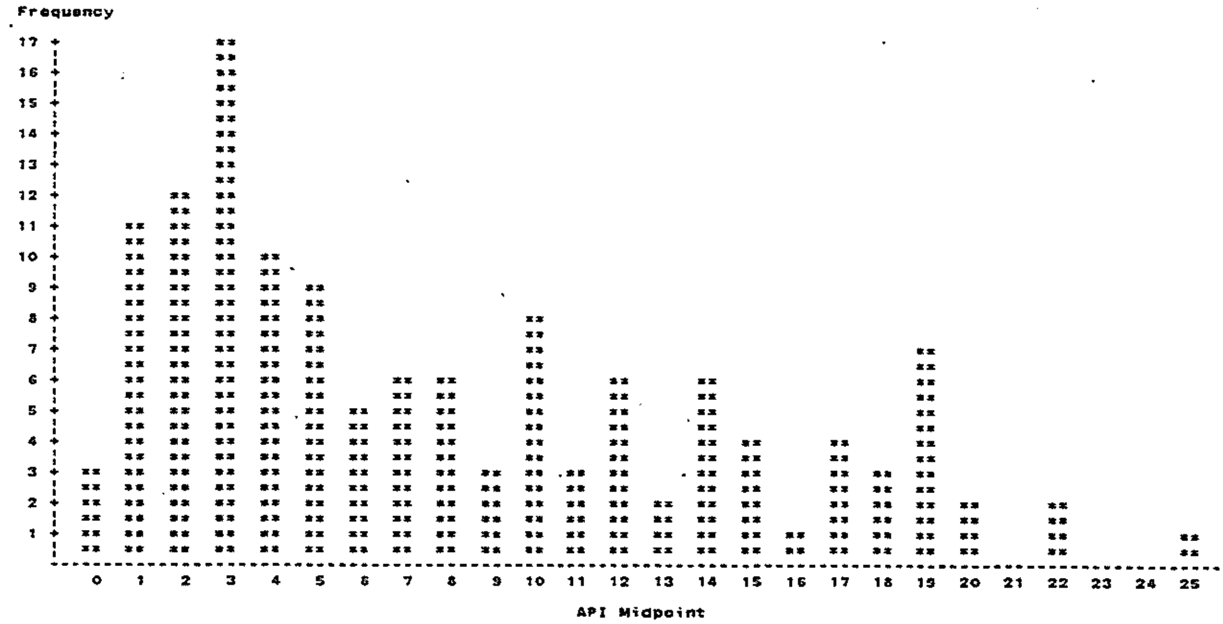
APPENDIX E

Frequency Distribution of Profile Index & IRI

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 09:07 Tuesday, May 30, 2000 1

CATG=' '



STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 09:07 Tuesday, May 30, 2000 2

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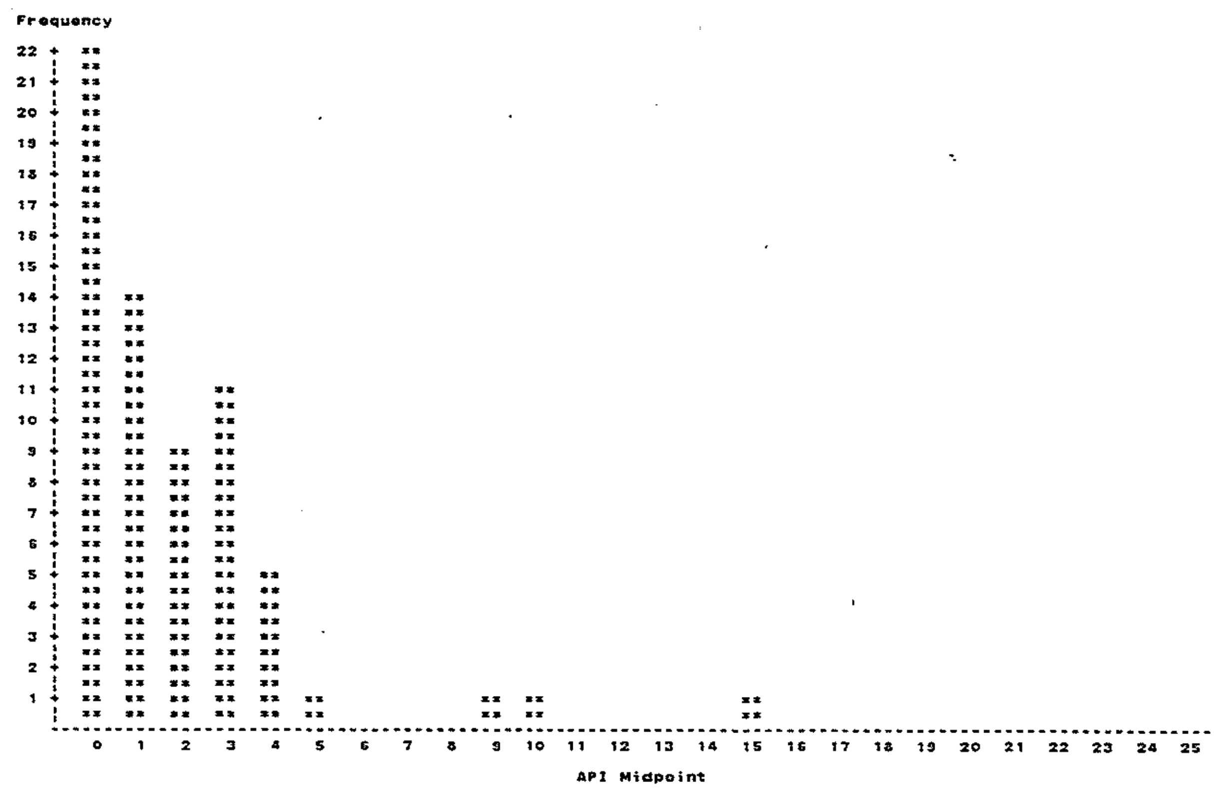

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

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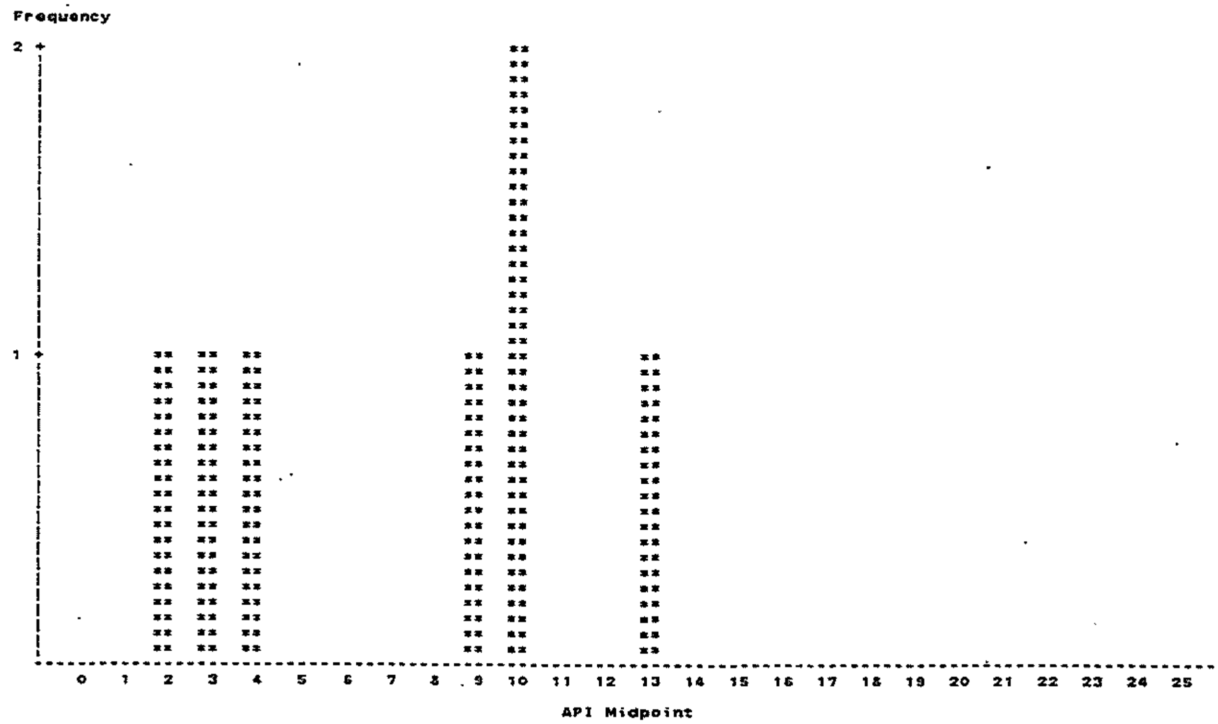

STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

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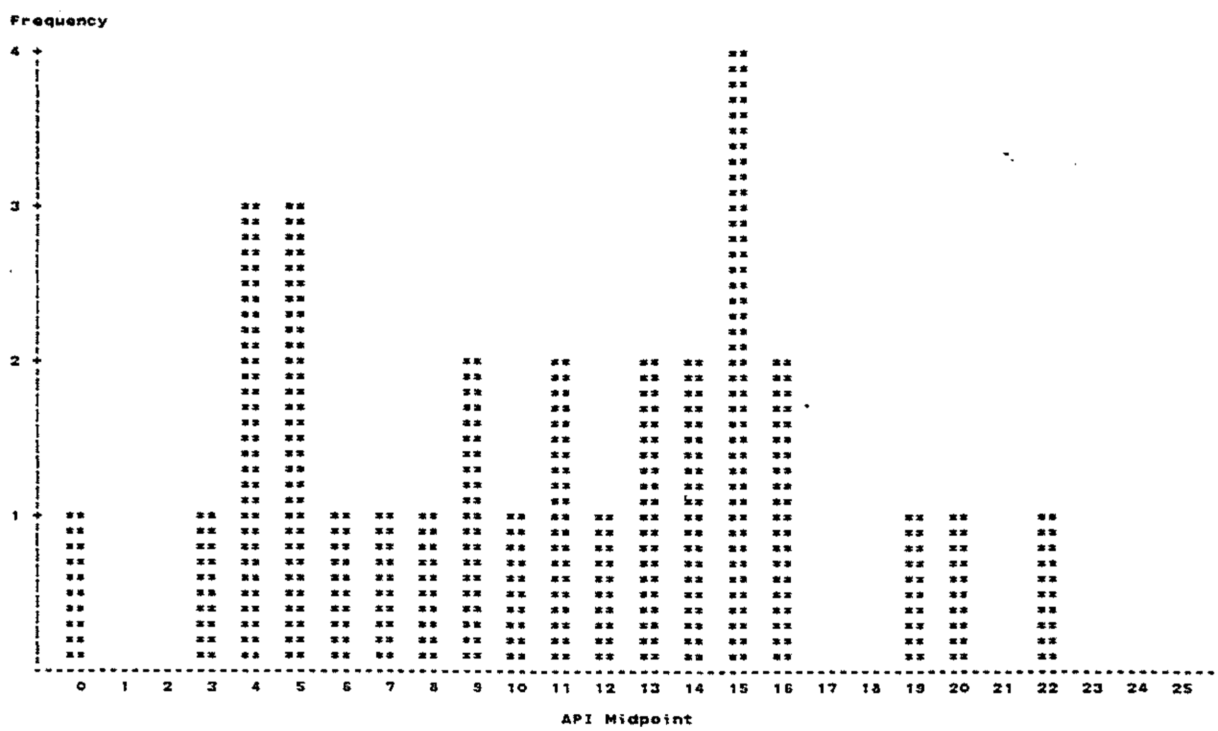
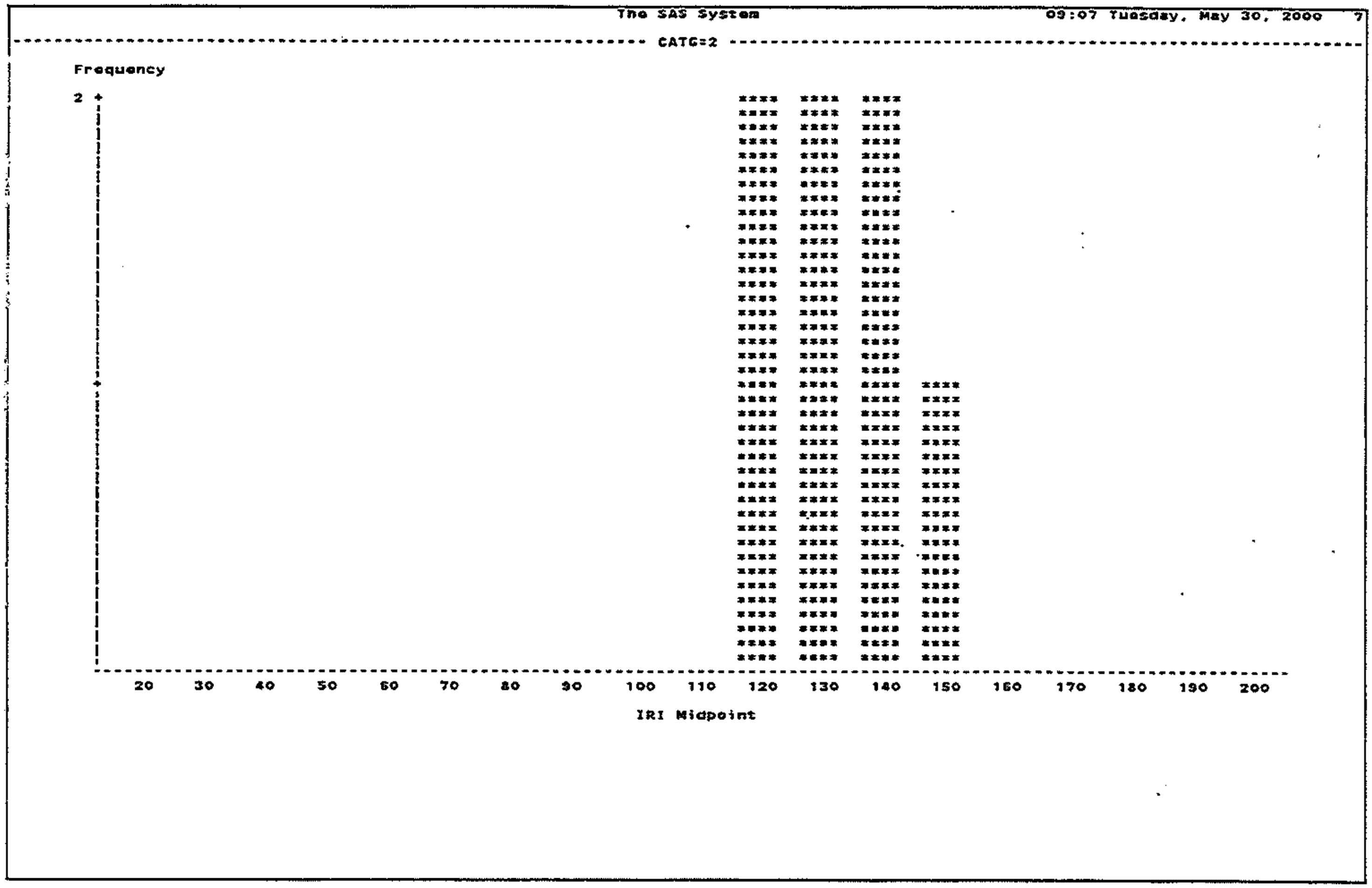
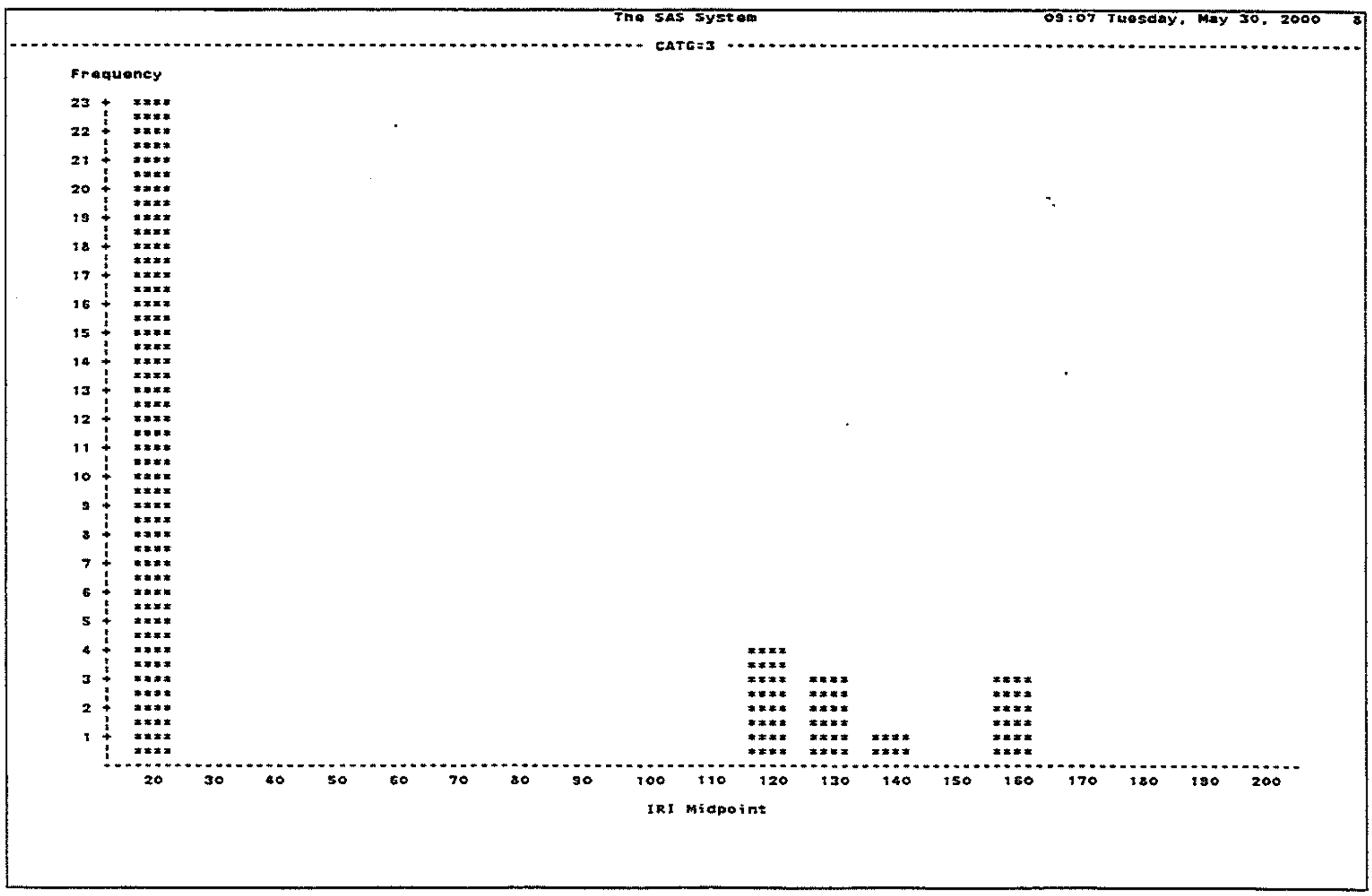


LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER



STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER



LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 09:07 Tuesday, May 30, 2000 5

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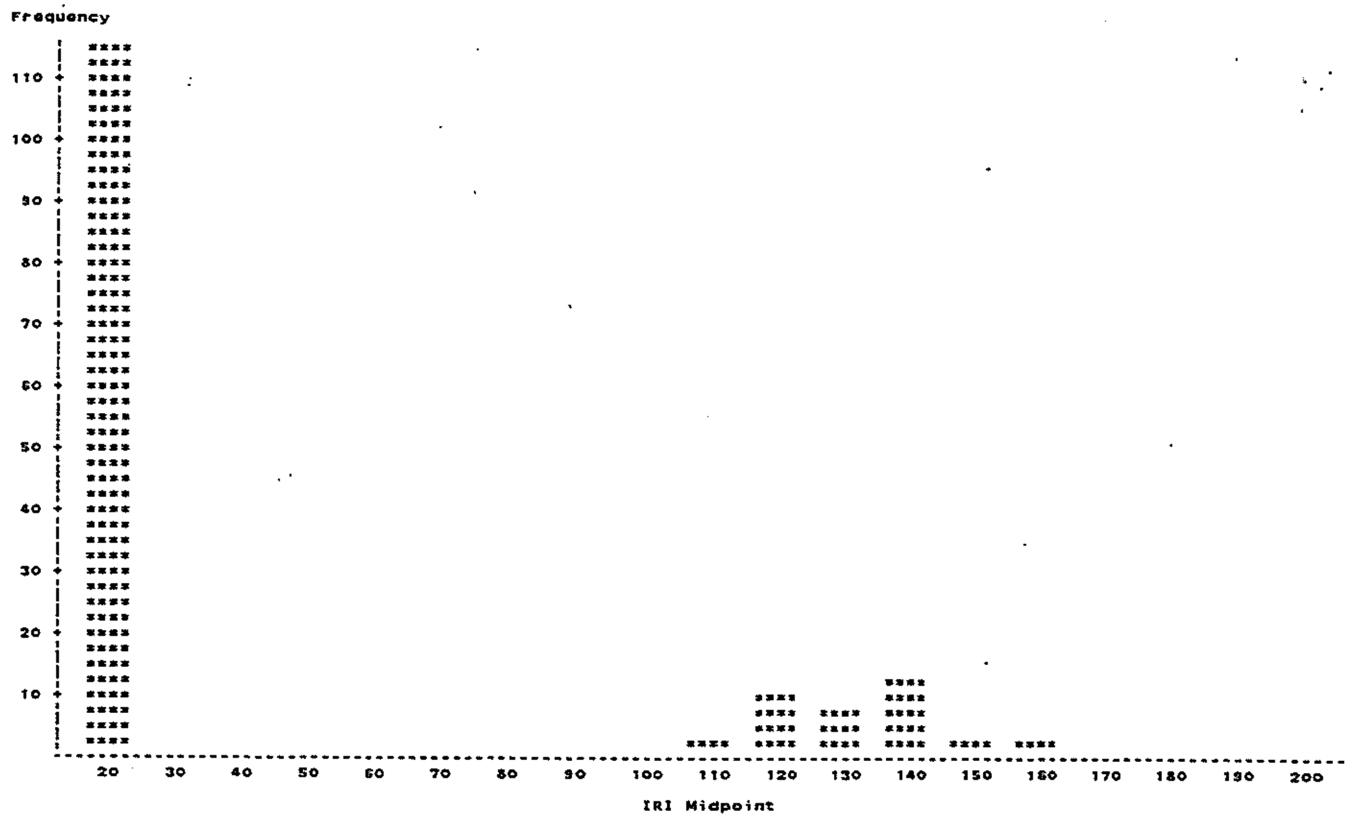
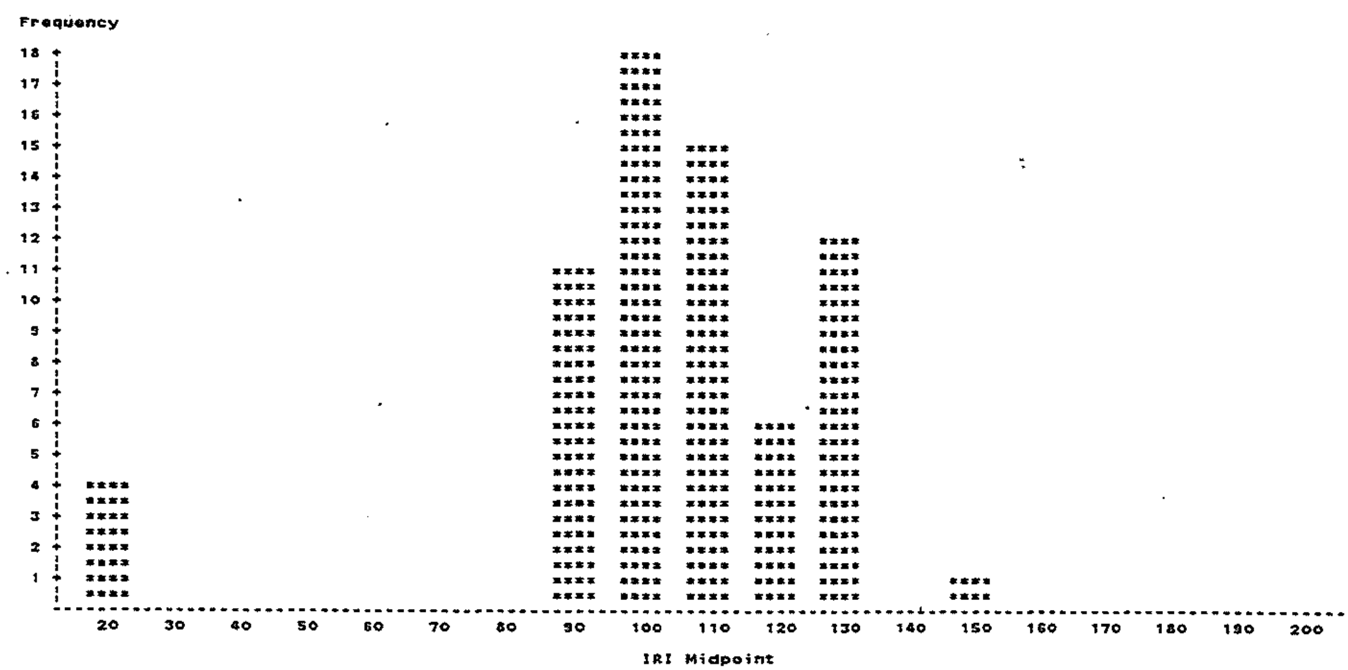


STD2

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

The SAS System 09:07 Tuesday, May 30, 2000 6

CATG=1



APPENDIX F
Simulation of PWL Specification

PROJ_NO=001-01-0026 AIR=N MATT_CD=452

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	4899	709	303.334	2.96373	10	0.19	10.19	1.51	0.61800	0.30744	.	1	1

N = 1

PROJ_NO=020-08-0015 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	6494.0	2870	1111.18	2.60443	11	0.12	11.12	1.0	0.36469	0.32905	100	1	1
002	5	5934.0	1720	773.74	3.01650	11	0.25	11.25	0.7	0.32711	0.76427	100	1	1
003	5	5764.0	2770	1045.62	2.06958	11	0.14	11.14	1.5	0.56391	0.24826	100	1	1
005	5	6484.0	1590	703.51	4.09943	11	0.25	11.25	0.4	0.19494	1.28247	100	1	1
006	3	5823.3	930	465.44	4.77678	11	0.25	11.25	0.8	0.43589	0.57354	100	1	1
007	5	5016.0	1400	571.56	2.47743	11	0.19	11.19	1.6	0.70711	0.26870	100	1	1
008	5	5500.0	1500	605.68	3.13696	11	0.03	11.03	2.0	0.90664	0.03309	100	1	1

N = 7

PROJ_NO=023-01-0037 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	5160	1540	602.20	2.59048	10	0.25	10.25	0.4	0.16733	1.49404	100	1	1
002	5	5554	970	369.30	5.29114	10	0.24	10.24	1.2	0.49193	0.48787	100	1	1
003	5	5102	1090	440.48	3.40994	10	0.25	10.25	0.8	0.31305	0.79860	100	1	1
004	5	5290	930	352.49	4.79445	10	0.25	10.25	0.9	0.42778	0.58441	100	1	1
005	5	5560	1660	668.62	2.93142	10	0.17	10.17	0.8	0.32094	0.52970	100	1	1
007	5	4163	2360	1133.57	0.49686	10	0.20	10.20	0.8	0.34641	0.57735	100	0	1
008	5	5733	730	300.22	7.10487	10	-0.10	9.90	0.7	0.27749	-0.36037	100	1	0

N = 7

PROJ_NO=031-05-0016 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	6932	2110	866.07	3.3854	8	0.19	8.19	0.4	0.20000	0.95000	100	1	1
002	5	6898	1000	375.59	7.7158	8	-0.10	7.90	0.6	0.22361	-0.44721	100	1	0
003	5	7468	1150	543.11	6.3854	8	-0.16	7.84	0.7	0.28810	-0.55537	100	1	0
004	5	7096	2290	962.64	3.2161	8	0.08	8.08	0.7	0.28810	0.27768	100	1	1
005	5	6690	2220	1056.67	2.5457	8	-0.05	7.95	0.6	0.21909	-0.22822	100	1	0
006	5	7256	1650	720.12	4.5214	8	0.13	8.13	0.9	0.34928	0.37219	100	1	1
007	5	7262	2540	994.85	3.2789	8	0.08	8.08	0.9	0.35355	0.22627	100	1	1
008	5	7134	920	380.04	8.2465	8	0.25	8.25	0.9	0.39115	0.63914	100	1	1
009	5	6480	1160	496.34	4.9966	8	0.25	8.25	0.4	0.15166	1.64845	100	1	1
010	5	6046	550	199.57	10.2518	8	0.19	8.19	0.3	0.10954	1.73445	100	1	1
011	5	6524	1050	470.14	5.3686	8	0.07	8.07	0.3	0.13038	0.53688	100	1	1
012	5	7090	2240	888.62	3.4773	8	0.06	8.06	0.7	0.36742	0.16330	100	1	1
013	5	7244	1430	586.71	5.5291	8	-0.07	7.93	1.0	0.35637	-0.19642	100	1	0

STD

PROJ_NO=031-05-0016 AIR=N MATT_CD=451
(continued)

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
014	5	6760	1630	683.776	4.03641	8	-0.06	7.94	1.0	0.48683	-0.12325	100	1	1
015	5	6502	1440	610.590	4.09768	8	0.23	8.23	0.6	0.24900	0.92370	100	1	1

N = 15

PROJ_NO=034-30-0019 AIR=N MATT_CD=452

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	5216	1107	464.34	2.61877	10	0.20	10.20	1.04	0.42176	0.47421	100	1	1
002	5	5425	1556	670.56	2.12509	10	0.24	10.24	1.88	0.83362	0.28790	100	1	1
003	5	4886	2418	1009.34	0.87780	10	-0.01	9.99	2.15	0.83260	-0.01201	100	0	1

N = 3

PROJ_NO=053-04-0030 AIR=Y MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	5734	1210	588.838	3.6241	9	0.10	9.10	0.25	0.13693	0.73030	100	1	1
002	5	5386	970	399.412	4.4716	9	0.19	9.19	0.25	0.10840	1.75281	100	1	1
003	5	5672	470	178.802	11.5883	9	0.18	9.18	0.25	0.10368	1.73607	100	1	1
004	5	5674	660	267.451	7.7547	9	0.23	9.23	0.05	0.02739	8.39841	100	1	1
005	5	5448	1440	684.558	2.6996	9	0.17	9.17	0.25	0.09747	1.74416	100	1	1
006	5	5966	490	200.075	11.8256	9	0.21	9.21	0.15	0.06519	3.22125	100	1	1
007	5	5590	840	353.765	5.6252	9	0.20	9.20	0.25	0.11180	1.78885	100	1	1

N = 7

PROJ_NO=055-06-0048 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	6038	1700	708.60	3.4406	9	0.24	9.24	0.5	0.19494	1.23117	100	1	1
002	5	6362	2790	1191.69	2.3177	9	0.25	9.25	0.1	0.05477	4.56435	100	1	1
003	5	6888	2500	1020.82	3.2209	9	0.20	9.20	0.6	0.21679	0.92253	100	1	1
008	5	7012	1660	680.27	5.0156	9	0.15	9.15	0.5	0.21679	0.69190	100	1	1
009	5	7424	630	257.74	14.8366	9	0.17	9.17	0.6	0.23022	0.73843	100	1	1
013	5	6138	2190	833.56	3.0448	9	0.23	9.23	0.2	0.08367	2.74903	100	1	1
014	5	6352	1190	462.41	5.9515	9	0.18	9.18	0.3	0.12247	1.46969	100	1	1

N = 7

PROJ_NO=056-07-0010 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	8386	1160	481.280	9.9443	8	0.19	8.19	0.7	0.27019	0.70322	100	1	1
002	5	8052	850	317.758	14.0107	8	0.21	8.21	0.1	0.04472	4.69574	100	1	1
003	5	7246	1700	739.919	4.9276	8	0.25	8.25	0.8	0.31623	0.79057	100	1	1
004	5	7630	1570	632.337	6.3732	8	0.20	8.20	1.2	0.46690	0.42835	100	1	1
005	5	8528	330	138.094	35.6858	8	0.17	8.17	1.1	0.51478	0.33024	100	1	1
006	5	7724	1310	554.464	7.4378	8	0.25	8.25	1.3	0.52631	0.47501	100	1	1
007	5	7488	1630	670.276	5.8006	8	0.20	8.20	1.0	0.40988	0.48795	100	1	1
008	5	7172	1800	702.617	5.0839	8	0.25	8.25	0.5	0.24083	1.03807	100	1	1
009	5	7032	830	345.934	9.9210	8	0.22	8.22	0.6	0.22361	0.98387	100	1	1

N = 9

PROJ_NO=062-03-0007 AIR=Y MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	8768	1038	383.951	13.4600	10	-0.03	9.97	0.75	0.27477	-0.10918	.	1	1
002	5	8822	2089	920.184	5.6750	10	0.14	10.14	0.39	0.15421	0.90787	.	1	1
003	5	9351	1910	745.665	7.7126	10	0.03	10.03	1.10	0.46583	0.06440	.	1	1
004	5	9617	1964	880.706	6.8320	10	-0.09	9.91	1.20	0.44497	-0.20226	.	1	0
005	5	9130	1973	843.508	6.5560	10	0.03	10.03	0.71	0.28005	0.10712	.	1	1
006	5	8887	867	350.907	15.0667	10	-0.08	9.92	0.53	0.20157	-0.39689	.	1	0
007	5	8734	1493	575.293	8.9241	10	0.23	10.23	0.23	0.09633	2.38756	.	1	1
008	5	8584	1815	796.078	6.2607	10	-0.04	9.96	0.58	0.22616	-0.17686	.	1	0
009	5	8793	1795	868.831	5.9770	10	0.01	10.01	0.66	0.31109	0.03214	.	1	1
010	5	8781	1306	494.079	10.4862	10	0.20	10.20	0.65	0.27835	0.71851	.	1	1
011	5	8645	1036	427.158	11.8106	10	-0.18	9.82	0.50	0.18363	-0.98023	.	1	0
012	5	8468	1577	735.745	6.6164	10	0.12	10.12	0.80	0.30252	0.39666	.	1	1
013	5	8272	737	334.670	13.9600	10	0.14	10.14	0.80	0.30008	0.46654	.	1	1
014	5	8016	1933	742.242	5.9495	10	0.25	10.25	0.38	0.13686	1.82672	.	1	1
015	5	8025	1285	636.876	6.9480	10	0.14	10.14	0.89	0.35676	0.39242	.	1	1
016	5	7716	1790	888.107	4.6346	10	0.25	10.25	0.48	0.22332	1.11949	.	1	1
017	5	8342	864	339.732	13.9581	10	0.17	10.17	0.78	0.31236	0.54424	.	1	1
018	5	8484	1602	777.531	6.2814	10	0.13	10.13	1.00	0.41300	0.31477	.	1	1
019	5	7765	1850	763.664	5.4540	10	0.24	10.24	1.16	0.47290	0.50751	.	1	1
020	5	8044	2459	880.118	5.0493	10	0.24	10.24	1.15	0.45158	0.53147	.	1	1
021	5	9567	1850	867.377	6.8794	10	0.24	10.24	0.84	0.37672	0.63707	.	1	1

N = 21

PROJ_NO=077-04-0015 AIR=Y MATT_CD=452

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	5034	1230	500.43	2.86554	8	0.20	8.20	0.8	0.32094	0.62318	100	1	1
002	5	5592	660	276.08	7.21531	8	0.11	8.11	1.0	0.43359	0.25370	100	1	1
003	5	4886	2080	904.12	1.42238	8	0.11	8.11	1.4	0.65727	0.16736	100	1	1
004	5	4270	2480	1049.64	0.63631	8	0.25	8.25	0.9	0.40249	0.62113	100	0	1
005	5	6228	640	265.08	9.91381	8	0.25	8.25	0.6	0.22804	1.09632	100	1	1
006	5	6276	1920	717.27	3.73080	8	0.19	8.19	0.7	0.36742	0.51711	100	1	1

STD2

PROJ_NO=077-04-0015 AIR=Y MATT_CD=452
(continued)

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
007	5	5648	2130	786.75	2.60313	8	0.25	8.25	0.7	0.30000	0.83333	100	1	1
008	5	5542	4610	1891.39	1,02676	8	0.18	8.18	2.5	0.93113	0.19331	100	0	1
009	5	5494	1810	740.16	2.55892	8	0.25	8.25	0.5	0.18708	1.33631	100	1	1
010	5	4900	1120	530.94	2.44848	8	0.25	8.25	0.5	0.19235	1.29969	100	1	1
011	5	4708	3560	1279.03	0.86628	8	0.25	8.25	0.7	0.26458	0.94491	100	0	1
012	5	3988	3000	1169.15	0.33186	8	0.25	8.25	1.2	0.45056	0.55487	90	0	1
013	5	3827	2740	1040.18	0.21823	8	0.20	8.20	3.6	1.57702	0:12682	100	0	1

N = 13

PROJ_NO=102-01-0029 AIR=Y MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	5158.4	1110	502.912	3.09875	9	0.25	9.25	1.00	0.41079	0.60858	100	1	1
002	5	5521.6	949	384.702	4.99504	9	0.15	9.15	1.25	0.57009	0.26312	100	1	1
003	5	5197.4	1089	444.083	3.59707	9	0.10	9.10	0.75	0.28504	0.35082	100	1	1
004	5	5177.8	1690	676.155	2.33349	9	0.25	9.25	0.50	0.22361	1.11803	100	1	1
005	5	5051.2	1319	518.476	2.79897	9	0.20	9.20	0.50	0.20917	0.95618	100	1	1
006	5	5825.4	1418	555.848	4.00361	9	-0.20	8.80	0.75	0.32596	-0.61357	95	1	0
007	5	5666.0	763	289.559	7:13498	9	0.25	9.25	0.50	0.22361	1.11803	100	1	1
008	5	5024.2	937	390.223	3.64971	9	0.10	9.10	1.00	0.43301	0.23094	100	1	1
009	5	5974.0	782	310.004	7.65796	9	0.05	9.05	1.25	0.48088	0.10398	100	1	1
010	5	5999.4	894	345.703	6.94065	9	0.25	9.25	1.00	0.48734	0.51299	100	1	1
011	5	5892.4	1334	479.436	4.78145	9	0.25	9.25	0.75	0.28504	0.87706	100	1	1
012	5	5647.0	773	331.820	6.16901	9	0.20	9.20	1.00	0.37914	0.52750	100	1	1
013	5	5572.2	2109	824.190	2.39289	9	-0.15	8.85	3.25	1.17260	-0.12792	90	1	1
014	5	5433.2	792	293.543	6.24509	9	0.20	9.20	2.00	0.81777	0.24457	100	1	1
015	5	5291.6	1589	669.151	2.52798	9	0.05	9.05	1.25	0.68465	0.07303	100	1	1
016	5	4481.4	1496	721.974	1.22082	9	0.25	9.25	1.75	0.77055	0.32444	100	1	1
018	5	5533.8	947	345.637	5.59488	9	0.00	9.00	0.00	0.00000	.	100	1	0

N = 17

PROJ_NO=102-02-0020 AIR=N MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	6091.0	1460	603.872	3.46265	9	0.25	9.25	0.00	0.00000	.	100	1	0
002	5	5066.0	2332	930.192	1.14600	9	0.20	9.20	0.25	0.11180	1.78885	100	0	1
003	5	5254.6	1229	557.596	2.25001	9	0.20	9.20	1.50	0.58630	0.34112	100	1	1
004	5	5973.4	1501	592.729	3.32935	9	0.15	9.15	2.00	1.05475	0.14221	100	1	1
005	5	5713.2	684	262.450	6.52771	9	0.15	9.15	1.00	0.51235	0.29277	100	1	1
006	5	6091.0	1460	603.872	3.46265	9	0.25	9.25	0.00	0.00000	.	100	1	0
007	5	6721.6	1361	526.670	5.16756	9	0.25	9.25	1.00	0.37914	0.65938	100	1	1

N = 7

PROJ_NO=450-10-0099 AIR=Y MATT_CD=454
(continued)

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
068	5	4768	1010	406.10	2.87611	14.0	0.25	14.25	0.40	0.17321	1.4434	100	1	1
069	5	5270	840	369.26	4.52261	14.0	0.25	14.25	0.90	0.35637	0.7015	100	1	1
070	5	5172	1590	584.95	2.68740	14.0	0.25	14.25	0.30	0.10954	2.2822	100	1	1
071	5	5224	760	272.91	5.95067	14.0	0.25	14.25	1.10	0.45826	0.5455	100	1	1
072	5	4856	800	347.68	3.61254	14.0	0.24	14.24	1.70	0.69857	0.3436	100	1	1
073	5	4774	1520	548.62	2.13993	14.0	0.24	14.24	1.80	0.76942	0.3119	100	1	1
074	5	4834	1950	773.97	1.59438	14.0	0.20	14.20	1.80	0.66483	0.3008	100	1	1
075	5	5286	1750	685.51	2.45947	14.0	0.25	14.25	0.60	0.24083	1.0381	100	1	1
076	5	5472	890	411.30	4.55139	14.0	0.25	14.25	1.30	0.51672	0.4838	100	1	1
077	5	5458	1430	662.17	2.80592	14.0	0.14	14.14	0.70	0.29665	0.4719	100	1	1
081	5	5260	1100	479.43	3.46247	12.5	0.24	12.74	1.60	0.60581	0.3962	100	1	1
082	5	5014	1100	403.71	3.50253	14.0	0.04	14.04	1.05	0.46957	0.0852	100	1	1
084	5	5338	1430	675.33	2.57356	14.0	0.24	14.24	0.05	0.02236	10.7331	100	1	1
087	5	5102	1910	747.58	2.00916	14.0	0.24	14.24	0.80	0.37417	0.6414	100	1	1
088	5	5140	3140	1179.30	1.30586	14.0	0.25	14.25	0.30	0.12247	2.0412	100	1	1
089	5	5016	1530	630.82	2.24471	14.0	0.18	14.18	0.35	0.15652	1.1500	100	1	1
090	5	5086	1440	588.29	2.52598	14.0	0.24	14.24	2.10	0.79561	0.3017	100	1	1
092	5	5434	1320	519.69	3.52901	12.5	0.25	12.75	1.30	0.66858	0.3739	100	1	1

N = 77

PROJ_NO=450-11-0034 AIR=Y MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
037	5	5218.0	1530	667.47	2.4241	9	0.12	9.12	1.6	0.69498	0.17267	100	1	1
038	5	4796.0	2110	749.92	1.5948	9	0.25	9.25	0.9	0.35071	0.71283	100	1	1
039	5	4974.0	1610	574.31	2.3924	9	0.25	9.25	1.1	0.44944	0.55624	100	1	1
040	5	5270.0	1180	449.67	3.7139	9	0.25	9.25	2.2	0.88204	0.28343	100	1	1
041	5	5528.0	410	174.56	11.0451	9	0.25	9.25	0.8	0.33912	0.73721	100	1	1
042	5	5022.0	3080	1229.85	1.1562	9	0.24	9.24	1.8	0.68411	0.35082	100	0	1
043	5	5306.0	2630	1104.64	1.5444	9	0.25	9.25	1.1	0.46152	0.54169	100	1	1
044	5	6442.0	1290	620.62	4.5793	9	0.25	9.25	1.1	0.45056	0.55487	100	1	1
045	5	5724.0	1360	600.61	3.5364	9	0.25	9.25	0.8	0.33615	0.74371	100	1	1
046	5	5866.0	740	352.46	6.7128	9	0.24	9.24	1.8	0.80747	0.29723	100	1	1
047	5	4634.0	1000	382.20	2.7054	9	-0.20	8.80	1.6	0.75033	-0.26655	95	1	0
048	5	5036.0	1290	509.74	2.8171	9	-0.12	8.88	0.5	0.19235	-0.62385	95	1	0
049	5	4656.0	1690	688.17	1.5345	9	-0.26	8.74	1.1	0.54129	-0.48033	80	1	0
050	5	4760.0	820	350.14	3.3129	9	-1.06	7.94	1.2	0.51769	-2.04757	50	1	0
051	5	4578.0	790	405.18	2.4137	9	-0.40	8.60	0.9	0.33912	-1.17954	80	1	0
052	5	4522.0	1550	593.86	1.5526	9	-0.25	8.75	1.0	0.44497	-0.56183	95	1	0
053	5	5048.0	820	356.33	4.0637	9	-0.05	8.95	0.8	0.30332	-0.16485	100	1	0
054	5	5272.0	860	358.98	4.6576	9	-0.06	8.94	0.9	0.38341	-0.15649	100	1	0
055	5	5770.0	1690	625.82	3.4675	9	-0.06	8.94	1.4	0.57619	-0.10413	100	1	1
056	5	4870.0	2210	952.58	1.3332	9	0.25	9.25	0.7	0.33166	0.75378	100	1	1
059	4	5252.5	1010	413.31	3.3982	14	0.19	14.19	2.0	0.89069	0.21332	100	1	1
060	5	6318.0	1190	485.97	5.5929	9	0.12	9.12	2.9	1.11669	0.10746	100	1	1
061	5	5398.0	810	302.27	5.9482	9	-0.24	8.76	0.5	0.20736	-1.15738	95	1	0

N = 23

PROJ_NO=450-15-0092 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
004	5	5894.2	915	436.025	4.34425	14	0.03	14.03	0.58	0.27608	0.10866	.	1	1

N = 1

PROJ_NO=450-30-0035 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	6410	890	462.115	5.21516	8	0.25	8.25	0.8	0.37815	0.66111	100	1	1
002	5	6366	870	373.537	6.33404	8	0.13	8.13	1.8	0.90664	0.14339	100	1	1

N = 2

PROJ_NO=450-91-0077 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	5943.6	453	199.19	11.7656	13	0.25	13.25	0.40	0.16733	1.49404	100	1	1
002	5	5959.8	1364	627.98	3.7577	13	0.09	13.09	1.00	0.45607	0.19734	100	1	1
003	5	6263.4	1349	618.74	4.3045	13	0.20	13.20	1.70	0.69642	0.28718	100	1	1
004	5	6408.0	2410	1116.23	2.5156	13	-0.05	12.95	1.70	0.61400	-0.08143	100	1	1
005	5	5942.0	830	345.86	6.7715	13	0.10	13.10	1.00	0.47223	0.21176	100	1	1
006	5	5862.0	320	123.77	18.2752	13	0.20	13.20	1.30	0.55045	0.36334	100	1	1
007	5	6134.0	1440	511.20	4.9569	13	0.24	13.24	1.10	0.42190	0.56885	100	1	1
008	5	5732.0	870	358.85	5.9413	13	0.24	13.24	1.10	0.42190	0.56885	100	1	1
009	5	4660.0	1400	521.87	2.0312	13	0.22	13.22	0.20	0.08944	2.45967	100	1	1
010	5	5090.0	2780	1114.83	1.3365	13	0.14	13.14	0.80	0.36332	0.38534	100	1	1
012	5	5780.0	670	240.73	9.0559	13	0.20	13.20	0.90	0.35355	0.56569	100	1	1
015	5	5158.0	620	230.37	6.7631	13	0.17	13.17	0.60	0.21909	0.77594	100	1	1
019	5	5378.0	600	233.07	7.6287	13	0.20	13.20	1.40	0.53666	0.37268	100	1	1
020	5	6256.4	1062	439.62	6.0424	13	0.25	13.25	1.90	0.84735	0.29504	100	1	1
021	5	6312.0	2480	1128.13	2.4040	13	0.25	13.25	0.80	0.38079	0.65653	100	1	1
031	5	5760.0	1390	588.68	3.6692	13	0.25	13.25	0.00	0.00000	.	100	1	0
042	5	5234.0	1030	388.37	4.2073	13	0.15	13.15	0.25	0.13693	1.09545	100	1	1

N = 17

PROJ_NO=451-01-0083 AIR=N MATT_CD=452

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	6660.4	2772	991.40	2.68348	12	0.15	12.15	1.00	0.41833	0.35857	100	1	1
002	5	6329.6	4285	1691.48	1.37726	12	-0.35	11.65	2.50	1.02164	-0.34259	74	1	0
003	5	5388.6	929	364.26	3.81211	14	0.10	14.10	1.00	0.44721	0.22361	100	1	1
004	5	6185.6	2965	1200.47	1.82062	14	0.15	14.15	0.50	0.20917	0.71714	100	1	1
006	5	5718.0	2634	1016.67	1.68984	9	0.20	9.20	1.00	0.37081	0.53936	95	1	1
007	5	5712.2	1611	632.20	2.70831	9	0.20	9.20	1.00	0.37914	0.52750	100	1	1
008	5	5644.2	605	219.26	7.49888	12	0.25	12.25	1.00	0.37914	0.65938	100	1	1
009	5	6731.8	3160	1227.79	2.22498	12	0.20	12.20	1.75	0.69372	0.28830	100	1	1

PROJ_NO=451-01-0083 AIR=N MATT_CD=452
(continued)

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
011	5	6239.4	2315	952.109	2.35204	12	0.1	12.1	1.5	0.65192	0.15339	100	1	1

N = 9

PROJ_NO=451-01-0098 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	5951	1134	481.103	4.88669	10	0.03	10.03	1.77	0.69125	0.04340	100	1	1
002	5	5413	1470	540.666	3.35327	10	0.25	10.25	1.90	0.73992	0.33787	100	1	1

N = 2

PROJ_NO=454-03-0028 AIR=Y MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	4860	560	271.293	4.64442	13	0.25	13.25	1.00	0.38987	0.64124	100	1	1
002	5	4912	980	359.819	3.64627	13	0.25	13.25	0.90	0.40866	0.61176	100	1	1
003	5	4250	420	199.123	3.26431	13	0.25	13.25	1.50	0.62450	0.40032	100	1	1
004	5	4232	1210	469.649	1.34569	13	0.25	13.25	1.40	0.52915	0.47246	100	1	1
005	5	4618	2170	803,785	1.26651	13	0.13	13.13	1.80	0.75366	0.17249	100	1	1
006	5	4606	510	218.929	4.59509	13	0.20	13.20	0.80	0.29496	0.67806	100	1	1
007	5	4556	940	384.877	2.48391	13	0.25	13.25	0.70	0.27928	0.89514	100	1	1
008	5	4650	420	173.925	6.03708	13	0.20	13.20	1.20	0.50299	0.39762	100	1	1
009	5	4856	1720	620.750	2.02336	13	0.24	13.24	1.00	0.40866	0.58729	100	1	1
010	5	4600	1180	490.051	2.04060	13	0.25	13.25	1.40	0.54589	0.45796	100	1	1
011	5	4964	1720	630.777	2.16241	13	0.20	13.20	1.60	0.63482	0.31505	100	1	1
012	5	5390	2220	807.991	2.21537	13	0.24	13.24	1.20	0.44721	0.53666	100	1	1
013	5	5478	1930	777.348	2.41591	13	0.25	13.25	1.20	0.43818	0.57054	100	1	1
014	5	6012	670	256.262	9.41226	13	0.25	13.25	1.00	0.42778	0.58441	100	1	1
015	5	6088	1220	508.940	4.88859	13	0.25	13.25	0.50	0.22804	1.09632	100	1	1
016	5	3562	580	220.952	-0.17198	13	-0.02	12.98	3.20	1.21367	-0.01648	95	0	1
017	5	4196	790	292.797	2.03554	13	0.22	13.22	1.10	0.39623	0.55523	100	1	1
018	5	4016	1040	381.746	1.08973	13	0.25	13.25	0.80	0.34351	0.72778	100	0	1
019	5	3834	810	291.084	0.80389	13	0.22	13.22	0.79	0.29903	0.73571	100	0	1
020	5	3530	460	207.605	-0.33718	13	0.19	13.19	0.60	0.22804	0.83321	95	0	1
021	5	4326	600	243.269	2.98435	13	0.13	13.13	0.50	0.20494	0.63434	100	1	1
022	5	4100	890	407.308	1.22757	13	0.25	13.25	0.40	0.14832	1.68550	100	1	1
023	5	4568	550	224.878	4.30456	13	0.17	13.17	1.00	0.47958	0.35447	100	1	1
024	5	4368	1240	449.244	1.70954	13	0.14	13.14	0.80	0.33466	0.41833	100	1	1
025	5	4214	1230	455.335	1.34846	13	0.24	13.24	0.50	0.18166	1.32116	100	1	1
026	5	4220	870	367.287	1.68805	13	0.12	13.12	0.70	0.29496	0.40684	100	1	1
027	5	3836	750	316.670	1.06104	13	0.13	13.13	0.30	0.13416	0.96896	100	0	1
028	5	4192	750	364.513	1.62408	13	0.23	13.23	0.60	0.24900	0.92370	100	1	1
029	5	4338	960	459.260	1.60693	13	0.12	13.12	0.20	0.10954	1.09545	100	1	1
030	5	4506	540	197.307	4.59183	13	0.21	13.21	1.00	0.39749	0.52831	100	1	1
031	5	4160	470	198.368	2.82303	13	0.25	13.25	2.00	0.75631	0.33055	100	1	1
032	5	3364	670	269.870	-0.87449	13	0.12	13.12	1.70	0.63482	0.18903	95	0	1

STD2

PROJ_NO=454-03-0028 AIR=Y MATT_CD=454
(continued)

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
033	5	6064	2680	1024.93	2.4041	13	0.19	13.19	0.4	0.20494	0.92711	100	1	1
034	5	5902	2130	778.28	2.9578	13	0.25	13.25	0.4	0.21909	1.14109	100	1	1
035	5	5526	520	211.61	9.1015	13	0.25	13.25	1.2	0.49800	0.50201	100	1	1
036	5	5724	1250	524.00	4.0534	13	0.24	13.24	1.1	0.41473	0.57869	100	1	1
037	5	6176	540	212.91	12.0991	13	0.23	13.23	1.3	0.57271	0.40160	100	1	1
038	5	5944	940	412.83	5.6779	13	0.25	13.25	0.9	0.37014	0.67543	100	1	1
039	5	4080	70	25.50	18.8271	13	0.08	13.08	1.7	0.65955	0.12130	100	1	1
040	5	3800	580	240.21	0.8326	13	0.20	13.20	1.2	0.46368	0.43133	100	0	1
041	5	4244	290	115.24	5.5884	13	0.09	13.09	0.3	0.14142	0.63640	100	1	1
042	5	4342	2190	877.82	0.8453	13	0.25	13.25	0.5	0.20736	1.20561	100	0	1
043	5	4472	2100	844.85	1.0321	13	0.20	13.20	1.4	0.53572	0.37333	100	0	1
044	5	4806	320	153.39	7.8621	13	0.14	13.14	0.6	0.27928	0.50128	100	1	1
045	5	4272	1460	609.98	1.1017	13	0.14	13.14	0.6	0.27019	0.51816	100	0	1
046	5	3918	1020	488.49	0.6510	13	0.15	13.15	1.0	0.45607	0.32890	100	0	1
115	5	6168	570	211.94	12.1164	13	0.25	13.25	1.4	0.58310	0.42875	100	1	1
116	5	4342	1060	411.91	1.8014	13	0.15	13.15	1.5	0.69498	0.21583	100	1	1
132	5	4672	1860	770.66	1.3910	13	0.20	13.20	0.6	0.23875	0.83771	100	1	1

N = 49

PROJ_NO=455-05-0059 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
001	5	5544	1830	693.888	2.80161	9	0.15	9.15	1.0	0.46904	0.31980	100	1	1
002	5	6134	1700	665.192	3.80943	9	0.22	9.22	0.8	0.31937	0.68885	100	1	1
003	5	6398	1220	467.729	5.98210	9	0.08	9.08	1.2	0.50200	0.15936	100	1	1
004	5	5820	1160	487.975	4.54941	9	-0.03	8.97	0.4	0.15166	-0.19781	100	1	0
005	5	5984	1700	738.372	3.02395	9	0.17	9.17	1.6	0.64265	0.26453	100	1	1
006	5	5186	1540	650.138	2.43948	9	0.22	9.22	0.4	0.19494	1.12858	100	1	1
007	5	5032	1990	816.927	1.75291	9	0.08	9.08	1.6	0.66858	0.11966	100	1	1

N = 7

PROJ_NO=578-09-0005 AIR=N MATT_CD=452

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TQL1	PAY	PSIPWL	TPWL
002	5	5775	2339	963.56	1.84213	10.5	0.25	10.75	0.59	0.26048	0.95977	.	1	1
003	5	6971	1419	598.70	4.96244	10.5	0.25	10.75	0.75	0.29821	0.83833	.	1	1
004	5	6799	2005	820.52	3.41126	10.5	0.23	10.73	0.87	0.33447	0.68766	.	1	1
005	5	6071	2769	1015.72	2.03896	10.5	0.18	10.68	1.83	0.67789	0.26553	.	1	1

N = 4

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
BATON ROUGE
COMPUTER CENTER

PROJ_NO=578-09-0005 AIR=Y MATT_CD=452

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	8506	323	124.325	23.3742	10.5	0.23	10.73	0.68	0.25344	0.90753	.	1	1

N = 1

PROJ_NO=578-61-0011 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6296	1240	548.480	4.18612	10	0.08	10.08	0.8	0.33912	0.23591	100	1	1
002	5	5212	1660	690.051	1.75639	10	0.16	10.16	1.8	0.67305	0.23772	100	1	1
003	5	5573	1330	595.172	2.64293	10	0.07	10.07	1.4	0.53385	0.13112	100	1	1
004	5	5756	880	366.101	4.79649	10	-0.01	9.99	2.3	0.90719	-0.01102	100	1	1

N = 4

PROJ_NO=742-05-0046 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
004	5	8247	1219	477.619	8.8920	10	0.23	10.23	1.11	0.43949	0.52334	.	1	1
005	5	8074	882	353.271	11.5322	10	0.25	10.25	0.39	0.15723	1.59007	.	1	1

N = 2

PROJ_NO=742-06-0069 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	7779	526	203.339	18.5847	8	0.25	8.25	1.13	0.46623	0.53622	.	1	1
002	5	8955	949	418.509	11.8396	8	0.19	8.19	1.16	0.46160	0.41162	.	1	1
003	5	8779	1863	832.478	5.7407	8	0.25	8.25	1.52	0.68606	0.36440	.	1	1
004	5	8761	1203	615.445	7.7359	8	0.23	8.23	0.86	0.38460	0.59802	.	1	1
005	5	8208	1641	711.102	5.9176	8	0.05	8.05	1.46	0.59007	0.08474	.	1	1
006	5	7655	1327	540.671	6.7601	8	0.25	8.25	0.60	0.28041	0.89155	.	1	1
007	5	8121	871	349.713	11.7839	8	0.17	8.17	1.57	0.60454	0.28121	.	1	1

N = 7

PROJ_NO=742-06-0074 AIR=N MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	5964	1960	724.210	2.71192	8	0.25	8.25	0.6	0.23452	1.06600	100	1	1
002	5	5302	1000	394.360	3.30155	8	0.24	8.24	0.6	0.25495	0.94136	100	1	1
003	5	5554	650	253.041	6.14129	8	0.20	8.20	1.5	0.55408	0.36096	100	1	1
004	5	5310	1140	466.154	2.81023	8	0.13	8.13	1.3	0.54498	0.23854	100	1	1

N = 4

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
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PROJ_NO=742-06-0098 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6053	645	237.055	8.6604	8	0.15	8.15	0.50	0.20917	0.71714	100	1	1
002	5	5774	1400	555.365	3.1943	8	0.10	8.10	1.25	0.51841	0.19290	100	1	1
003	5	5831	1015	402.933	4.5442	8	0.00	8.00	1.20	0.43646	0.00000	100	1	1
004	5	5764	1440	578.515	3.0492	8	-0.20	7.80	1.00	0.44721	-0.44721	100	1	0
005	5	5820	270	137.659	13.2211	8	0.05	8.05	0.50	0.22361	0.22361	100	1	1
006	5	5872	340	160.530	11.6613	8	0.10	8.10	0.50	0.27386	0.36515	100	1	1
007	5	5236	1040	493.386	2.5051	8	0.00	8.00	1.00	0.37081	0.00000	100	1	1

N = 7

PROJ_NO=742-07-0044 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	7032.6	909	416.23	7.28590	8	0.13	8.13	0.47	0.20354	0.63868	.	1	1
002	5	5772.8	2816	1048.92	1.69011	8	0.13	8.13	0.61	0.27172	0.47844	.	1	1
003	5	7033.2	1068	443.30	6.84237	8	0.07	8.07	0.74	0.32081	0.21820	.	1	1

N = 3

PROJ_NO=742-07-0047 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	5422	3288	1213.14	1.17217	8	0.15	8.15	1	0.41833	0.35857	.	0	1
002	5	5480	1001	396.47	3.73298	8	0.10	8.10	1	0.44721	0.22361	.	1	1

N = 2

PROJ_NO=742-07-0049 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6946	1210	566.154	5.2035	8	0.06	8.06	1.3	0.50299	0.11929	100	1	1
002	5	7074	790	304.023	10.1111	8	-0.21	7.79	0.8	0.34641	-0.60622	95	1	0
003	5	6270	1670	704.166	3.2237	8	0.25	8.25	0.7	0.35777	0.69877	100	1	1
004	5	7228	1390	544.582	5.9275	8	0.09	8.09	1.4	0.59414	0.15148	100	1	1

N = 4

PROJ_NO=742-07-0095 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	7798	1670	676.365	5.6153	8	0.06	8.06	0.8	0.25495	0.23534	100	1	1
002	5	7322	2120	860.070	3.8625	8	0.00	8.00	1.2	0.46690	0.00000	100	1	1
003	5	8304	690	283.249	15.1951	8	0.24	8.24	0.5	0.18708	1.28285	100	1	1
004	5	8224	1840	695.615	6.0723	8	0.25	8.25	0.3	0.13038	1.91741	100	1	1

PROJ_NO=742-07-0095 AIR=N MATT_CD=451 (continued)

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
005	5	8094	1510	705.18	5.80560	8	0.00	8.00	1.6	0.61237	0.00000	100	1	1
006	5	6818	3360	1382.90	2.03774	8	0.24	8.24	1.1	0.40373	0.59445	100	1	1
007	5	7394	1730	707.34	4.79826	8	0.25	8.25	0.9	0.34351	0.72778	100	1	1
008	5	7334	1300	481.54	6.92363	8	-0.01	7.99	1.2	0.43818	-0.02282	100	1	1

N = 8

PROJ_NO=742-07-0117 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	8262.2	1576	637.156	6.68941	8	0.25	8.25	1.11	0.44144	0.56633	.	1	1

N = 1

PROJ_NO=742-17-0009 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	4678	1680	671.729	1.00934	8	0.00	8.00	1.6	0.58992	0.000000	100	0	1
002	5	4716	1710	704.152	1.01683	8	-0.03	7.97	1.8	0.66558	-0.045073	100	0	1

N = 2

PROJ_NO=742-17-0117 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6366	1530	579.422	4.77372	9	0.13	9.13	0.45	0.18574	0.69990	100	1	1
002	5	5050	790	331.738	4.37092	9	0.25	9.25	0.00	0.00000	.	100	1	0
003	5	6294	1610	722.586	3.72828	9	0.15	9.15	0.25	0.13693	1.09545	100	1	1
004	5	5594	1580	630.658	3.16178	9	0.06	9.06	0.45	0.19170	0.31298	100	1	1

N = 4

PROJ_NO=742-36-0002 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	3	8569.7	587	293.50	16.9325	11	0.02	11.02	0.37	0.19858	0.1007	.	1	1
002	3	7241.0	1684	842.00	4.3242	11	0.24	11.24	0.02	0.01155	20.7846	.	1	1
003	3	8346.3	481	240.50	19.7351	11	0.24	11.24	0.02	0.01155	20.7846	.	1	1
004	3	7927.0	480	240.00	18.0292	11	0.25	11.25	0.00	0.00000	.	.	1	0
005	3	8806.0	238	127.86	40.7166	11	0.17	11.17	0.15	0.07550	2.2517	.	1	1
006	3	7944.0	217	110.64	39.2628	11	0.23	11.23	0.06	0.03464	6.6395	.	1	1
007	5	7245.0	3823	1381.81	2.6378	11	0.16	11.16	0.33	0.14342	1.1156	.	1	1
008	5	8676.0	1307	539.61	9.4067	11	0.21	11.21	0.21	0.09391	2.2361	.	1	1

STD2

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PROJ_NO=742-36-0002 AIR=Y MATT_CD=451 (continued)

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
009	3	7598	627	338.362	11.8157	11	0.23	11.23	0.07	0.040415	5.69102	.	1	1

N = 9

PROJ_NO=742-36-0106 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6206.8	1577	606.98	3.63569	11	0.20	11.20	0.16	0.070569	2.83410	100	1	1
002	5	7094.2	2448	1018.64	3.03758	9	0.25	9.25	0.00	0.000000	.	100	1	0
003	5	5829.8	1970	728.17	2.51287	9	0.25	9.25	0.00	0.000000	.	100	1	0

N = 3

PROJ_NO=808-07-0035 AIR=N MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
007	5	5521.8	2075	957.714	1.58899	10	0.1	10.1	2	0.79057	0.12649	100	1	1

N = 1

PROJ_NO=808-07-0035 AIR=Y MATT_CD=454

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	5405.0	943	398.77	4.52636	10	0.10	10.10	2.00	0.72024	0.13884	100	1	1
002	5	6262.8	1341	580.83	4.58445	10	0.25	10.25	0.75	0.28504	0.87706	100	1	1
003	5	6594.0	2089	807.86	3.70607	10	0.20	10.20	0.75	0.33541	0.59628	100	1	1
004	5	6113.6	2089	830.80	3.02550	10	0.25	10.25	1.75	0.68465	0.36515	100	1	1
005	3	5454.3	2141	1181.63	1.56928	10	0.08	10.08	1.25	0.62915	0.12716	100	1	1
006	5	5397.2	2308	836.34	2.14888	10	0.10	10.10	2.50	0.94538	0.10578	100	1	1

N = 6

PROJ_NO=810-30-0002 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	5504	1640	603.515	3.15485	10	0.24	10.24	1.0	0.35777	0.67082	100	1	1
002	5	5124	1780	646.243	2.35825	10	0.18	10.18	0.6	0.24495	0.73485	100	1	1
003	5	4958	1520	631.799	2.14942	10	0.17	10.17	2.3	0.89275	0.19042	100	1	1
004	5	5408	1770	692.077	2.61243	10	0.19	10.19	0.9	0.34928	0.54397	100	1	1
005	5	5870	720	311.769	7.28103	10	0.21	10.21	0.4	0.18166	1.15601	100	1	1
006	5	5684	670	269.221	7.74085	10	0.24	10.24	0.5	0.20736	1.15738	100	1	1
007	5	5164	1710	652.403	2.39729	10	0.24	10.24	0.3	0.13038	1.84072	100	1	1
008	5	5150	900	348.784	4.44402	10	0.23	10.23	0.4	0.18166	1.26611	100	1	1

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PROJ_NO=810-30-0002 AIR=Y MATT_CD=451
(continued)

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
009	5	6424	1470	706.56	3.99682	10	0.14	10.14	0.1	0.05477	2.55604	100	1	1
010	5	6296	3840	1530.24	1.76182	10	0.22	10.22	0.1	0.05477	4.01663	100	1	1
011	5	6460	1800	790.76	3.61678	10	0.20	10.20	0.0	0.00000	.	100	1	0
012	5	6384	1280	493.84	5.63743	10	0.22	10.22	0.4	0.16733	1.31475	100	1	1
013	5	5986	2620	983.63	2.42571	10	0.21	10.21	0.5	0.18708	1.12250	100	1	1
014	5	6220	1250	511.96	5.11762	10	0.04	10.04	0.3	0.11402	0.35082	100	1	1
015	5	5988	2740	1036.11	2.30478	10	0.00	10.00	0.4	0.14142	0.00000	100	1	1
016	5	5668	1080	416.56	4.96450	10	0.17	10.17	0.3	0.10954	1.55188	100	1	1
017	5	5680	1140	568.46	3.65899	10	0.12	10.12	0.3	0.15166	0.79126	100	1	1
018	5	5524	1140	494.25	3.89279	10	0.04	10.04	0.2	0.08944	0.44721	100	1	1
019	5	5514	1290	666.77	2.87056	10	0.22	10.22	0.2	0.08944	2.45967	100	1	1
020	5	6956	970	386.43	8.68457	10	0.10	10.10	2.1	0.89722	0.11146	100	1	1

N = 20

PROJ_NO=817-40-0004 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	5538	570	249.14	7.7788	10	0.24	10.24	0.3	0.12247	1.95959	100	1	1
002	5	5946	2220	963.78	2.4342	10	0.17	10.17	0.5	0.19494	0.87208	100	1	1
003	5	5230	2580	1009.13	1.6152	10	0.25	10.25	0.9	0.34928	0.71575	100	1	1
004	5	6526	680	280.86	10.4182	10	0.22	10.22	1.1	0.42661	0.51569	100	1	1
005	5	5508	1640	634.25	3.0083	10	0.16	10.16	0.9	0.35637	0.44897	100	1	1
006	5	5348	1260	473.62	3.6907	10	0.24	10.24	0.2	0.08944	2.68328	100	1	1
007	5	5518	710	290.90	6.5934	10	-0.07	9.93	1.3	0.47223	-0.14823	100	1	0
008	5	6272	1420	510.36	5.2355	10	0.25	10.25	0.2	0.08367	2.98807	100	1	1
009	5	5832	1060	425.70	5.2431	10	0.19	10.19	0.3	0.10954	1.73445	100	1	1
010	5	5744	1880	670.25	3.1988	10	0.24	10.24	0.4	0.15811	1.51789	100	1	1
011	5	6076	2210	839.96	2.9478	10	0.24	10.24	0.3	0.11402	2.10494	100	1	1
012	5	5118	1510	584.78	2.5558	10	0.22	10.22	0.9	0.33615	0.65446	100	1	1
013	5	4668	1490	637.86	1.6743	10	0.25	10.25	0.6	0.28810	0.86776	100	1	1
014	5	3904	1200	478.00	0.6360	12	0.13	12.13	1.1	0.47223	0.27529	100	0	1
015	5	4693	3200	1341.33	0.8149	10	0.02	10.02	3.1	1.46697	0.01363	100	0	1

N = 15

PROJ_NO=828-36-0018 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6626	1500	651.022	4.03366	9	0.25	9.25	1.1	0.43012	0.58124	100	1	1
002	5	5576	1040	418.903	3.76220	9	0.20	9.20	1.3	0.52726	0.37932	100	1	1
003	5	5446	1020	365.418	3.95712	9	0.25	9.25	0.3	0.13038	1.91741	100	1	1
004	5	5620	1090	426.487	3.79838	9	0.24	9.24	0.7	0.31145	0.77059	100	1	1
005	5	5500	2470	972.548	1.54234	9	0.25	9.25	0.7	0.26458	0.94491	100	1	1

N = 5

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PROJ_NO=828-39-0021 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6676	2050	743.19	4.13892	11	0.17	11.17	2.2	0.92087	0.18461	100	1	1
002	5	6518	1000	413.36	7.05915	11	0.24	11.24	1.4	0.59161	0.40567	100	1	1
003	5	6538	1660	707.47	4.15280	11	0.22	11.22	0.3	0.14142	1.55563	100	1	1
004	5	6560	1670	690.83	4.28468	11	0.10	11.10	0.2	0.10000	1.00000	100	1	1
005	5	6314	2120	911.20	2.97850	11	0.22	11.22	1.3	0.48477	0.45383	100	1	1
006	5	5826	930	410.52	5.42234	11	0.12	11.12	1.0	0.42426	0.28284	100	1	1
007	5	5992	1510	567.51	4.21489	11	0.12	11.12	0.6	0.25495	0.47068	100	1	1
008	5	6172	1230	472.73	5.44078	11	0.16	11.16	0.5	0.19235	0.83180	100	1	1
009	5	6508	1280	526.71	5.52110	11	0.13	11.13	0.8	0.32094	0.40507	100	1	1
010	5	5828	1450	544.77	4.08983	11	0.11	11.11	1.0	0.42190	0.26073	100	1	1
011	5	5828	990	404.07	5.51394	11	0.23	11.23	0.5	0.21679	1.06091	100	1	1
012	5	5964	930	389.72	6.06593	11	0.22	11.22	0.9	0.32711	0.67256	100	1	1
013	5	7518	3610	1358.11	2.88489	11	0.07	11.07	1.3	0.50695	0.13808	100	1	1
014	5	5542	2580	1097.53	1.76943	11	0.25	11.25	1.1	0.47958	0.52129	100	1	1
015	5	6393	1990	1006.97	2.77368	11	0.25	11.25	2.2	0.86023	0.29062	100	1	1
016	5	6300	1480	757.91	3.56245	11	0.25	11.25	2.0	0.84380	0.29628	100	1	1

N = 16

PROJ_NO=832-22-0013 AIR=N MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	4322	1120	458.334	0.70254	8	0.25	8.25	1.0	0.38987	0.64124	100	0	1
002	5	5008	1600	701.156	1.43763	8	0.25	8.25	0.6	0.30000	0.83333	100	1	1
003	5	5306	560	201.445	6.48317	8	0.24	8.24	2.5	0.97108	0.24715	100	1	1

N = 3

PROJ_NO=840-22-0017 AIR=Y MATT_CD=452

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6128	910	364.376	6.93788	8	0.24	8.24	1.3	0.54129	0.44338	100	1	1
002	5	5472	1080	443.080	4.22497	8	0.13	8.13	2.4	0.99146	0.13112	100	1	1
003	5	6376	750	304.680	9.11119	8	0.22	8.22	0.9	0.36332	0.60553	100	1	1

N = 3

PROJ_NO=840-44-0002 AIR=Y MATT_CD=451

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIQL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	6836.0	1920	782.100	4.1376	8	0.25	8.25	0.50	0.25100	0.99602	100	1	1
002	5	6578.0	780	331.089	8.9946	8	0.12	8.12	2.10	0.80436	0.14919	100	1	1
003	5	6612.0	1890	765.748	3.9334	8	0.25	8.25	0.70	0.31145	0.80270	100	1	1
004	5	6216.0	650	241.826	10.8177	9	0.20	9.20	1.30	0.57706	0.34658	100	1	1
005	3	6393.3	340	181.475	15.3922	8	0.25	8.25	1.00	0.52915	0.47246	100	1	1
006	5	6322.0	2050	879.812	3.0938	9	0.05	9.05	0.75	0.32596	0.15339	100	1	1

N = 6

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---------- PROJ_NO=937-01-0007 AIR=N MATT_CD=454 ----------

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
001	5	5642	1130	435.741	3.76830	8	0.25	8.25	0.7	0.27749	0.90094	100	1	1

N = 1

---------- PROJ_NO=937-01-0007 AIR=Y MATT_CD=454 ----------

NLOT	NOBS	AVGPSI	RNGPSI	STDPSI	PSIOL1	PL_T	TDIFF	AVGT	RNGT	STDT	TOL1	PAY	PSIPWL	TPWL
002	5	4326	330	118.448	5.12926	8	0.08	8.08	0.9	0.33615	0.23799	100	1	1
003	5	4864	1100	443.317	2.85123	8	0.09	8.09	1.1	0.40866	0.22023	100	1	1
004	5	6046	950	380.171	6.43395	8	0.24	8.24	0.7	0.31145	0.77059	100	1	1

N = 3

STD2

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