EVALUATION OF DATA GENERATED BY STATISTICALLY ORIENTED END-RESULT SPECIFICATIONS

Final Report

by

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ABSTRACT

This report is concerned with the review of data generated on projects let under the statistically oriented end-result specifications (ERS) on asphaltic concrete and portland cement concrete. The review covered analysis of data for determination of price reduction for deficient material and overall variability of data.

The analysis and evaluation indicated: (1) an overall reduction of less than 0.5 percent in the contract unit price for asphaltic concrete and portland cement concrete; (2) at least 74 percent of all projects meeting the requirements for 100 percent pay; (3) a significant decrease in overall price reduction for asphaltic concrete since the first evaluation of 1975; (4) some increase (from 1975) in non-uniformity in the production phase of asphaltic concrete with little or no difference in the compaction phase; (5) good to excellent control in production and testing of concrete used as critical concrete; and (6) a need for continual evaluation, such as the one presented here, for enhancement of the State's overall quality assurance system.

ACKNOWLEDGEMENTS

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IMPLEMENTATION

The data reported here represent those generated during the seven years of implementation of asphaltic concrete end-result specifications and five years of implementation of portland cement concrete specifications. For asphaltic concrete, this is the second such evaluation since its implementation in 1971.

Evaluation of data as a result of a change in the system should be a continuing effort. The ERS is a new concept in specification development and application to highway materials. Enhancement can only be made from periodic evaluation of data generated by the new system. With the newly implemented computerized system of reporting material and construction test data (MATT System), the Department expects to continue such evaluation for enhancement of the overall quality assurance system.

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1. INTRODUCTION

This report is concerned with the evaluation of data generated on projects let under the statistically oriented End-Result Specifications (ERS) on asphaltic concrete and Portland Cement concrete. This evaluation is a part of a continuing quality assurance program within the Department which had started in the early sixties with the analysis and evaluation of historical data to determine the pattern of variability of different materials (1, 2, 3)*. This initial effort led to the development and subsequent field trial of the statistically oriented ERS (4). Total implementation, after the field trial, came in early 1971 for asphaltic concrete and in late 1973 for Portland Cement concrete. An evaluation similar to the one contained in this report was presented for asphaltic concrete in 1975 (5). For Portland Cement concrete, however, this is the first such evaluation since full adoption of ERS in 1973.

All ERS currently in use in the state are generally formatted to include three basic criteria:

1. Definition of responsibilities for the contractor and the Department for control and/or acceptance of the material.
2. Definition of quality criteria for control and acceptance.
3. Price adjustments for non-conforming materials.

The details of the above three criteria are tabulated in Appendix A and Appendix B (6).

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*Underlined numbers in parentheses refer to list of references.

2. OBJECTIVES

The primary objective of this study was to review the data generated on projects governed by ERS for the control and acceptance of asphaltic concrete and Portland Cement concrete. Specifically, the major objectives can be listed according to their order of importance as follows:

1. To determine the effect of ERS on the final adjusted bid price, and isolate the acceptance criteria contributory to the overall reduction in this bid price.
2. To determine the variability of the product with respect to various quality characteristics, and compare this variability of the data to those from which the statistical limits were developed or any other established standard (e.g., ACI standard for concrete cylinder strengths).
3. To determine standard statistical parameters of the criteria according to material type, use and source.

3. DATA COLLECTION AND ANALYSIS

Data Collection

In order to accomplish the stated objectives, the various districts within the Department were requested to furnish data on the following major materials:

- asphaltic concrete
- structural concrete
- paving concrete

Only information generated by the Department on acceptance criteria was requested from these districts.

Table 3.1 lists the breakdown of tonnage for various types of asphaltic concrete mixes. Table 3.2 shows similar breakdown but according to mix use. The mix codes in Table 3.1 represent mix types as defined in the standard specifications (6). All mixes except mix codes 3 and 4 represent sand-gravel-filler mixes. Mix codes 3 and 4 represent shell mixes. The total tonnage for asphaltic concrete represents 90 percent of all projects constructed between 1975 and 1977,or a total of 218 projects. These projects were distributed throughout the state's nine districts.

Table 3.3 is a breakdown of total structural concrete quantity by districts and different classes of concrete. This quantity was distributed over 561 projects located throughout the state. The basic difference in the various classes of concrete is in the requirements specified for minimum cement content and the 28-day compressive strength.

The paving concrete data was generated by 73 projects representing approximately 1.69 million square yards of concrete.

Table 3.1: Distribution of Tonnage According to Mix Types

MIX CODE	MIX TYPE	NO OF LOTS	TONNAGE
1	1WC	2209	1605668
2	1BC	419	342140
3	2WC	32	21383
4	2BC	28	20199
5	3WC	457	340271
6	3BC	323	300707
7	5A	654	649412
8	5B	495	543336
TOTAL		4617	3823116

Table 3.2: Distribution of Tonnage According to Mix Use

MIX USE	NO OF LOTS	TONNAGE
ROADWAY	3180	2956576
SHOULDER	530	409898
LEVELING	372	324354
PATCHING	248	24841
WIDENING	121	80560
MISC.	166	26887
TOTAL	4617	3823116

Table 3.3: Distribution of Structural Concrete Quantity by Class and District

	CLASS OF CONCRETE, CY				
DISTRICT	AA	A	A(MINOR)*	R(MINOR)*	TOTAL
1	85047	120758	27948	370	234123
2	35830	31786	7749	1831	77196
3	13090	34381	17367	2773	67611
4	5799	3224	8073	1185	18281
5	11060	11228	5870	2258	30416
6	3248	6090	8219	747	18304
7	1995	1601	1832	75	5503
8	617	1121	1125	0	2863
9	8705	6907	7119	492	23223
TOTAL	165391	217096	85302	9731	477520

*In subsequent portions of the report, tables and figures, these concretes may be identified as AN and RN.

Data Analyses

The mass of data collected on each of the materials was punched on computer cards and stored on magnetic tapes. Wherever applicable, standard statistical procedures were used. In the succeeding chapters the results of the various analyses are discussed according to material types. The crux of the evaluation, however, is contained in the next chapter and centers around assessment of price adjustments.

4. ASSESSMENT OF PRICE ADJUSTMENTS

As stated in the first chapter, one of the primary aspects of ERS is the provision for reduction in unit price for materials that do not conform to the stated requirements for 100 percent pay. The schedule of adjustments in unit price for various acceptance criteria for different materials can be found in Appendix A and Appendix B. This chapter discusses the deficiencies, if any, due to materials and/or tests and the effect of such deficiencies on the final adjusted pay. Although the evaluation may indicate reduced payment, it cannot be said with certainty that such assessments were truly applied and that the contractor did receive reduced payment.

Asphaltic Concrete

Table C-1 in Appendix C is a summary of data showing final adjusted payment for each project. The table shows, for each project, the total tons (TOT-TONS), the number of lots (N-LOT), the corresponding number of lots that had reduced payments (N-LOT-P), the tons involved in the reduced payment of 50, 80 and 95 percent pay (TONS-50, TONS-80, TONS-95) as defined in Tables A-3 through A-6 in Appendix A. The last column represents the final percent payment for each project (PPPP).* Thus, in this table there were no adjustments in final pay for the first eight projects (B01 through B08). Project B09 with a total of 10,403 tons distributed over 15 lots had one lot, represented by 877 tons, subjected to 95 percent pay. Because of this reduced payment for that quantity, the final payment (theoretically) on this project should have been 99.578 percent of the unit price or a reduction of 0.422 percent.

Table 4.1 is a frequency distribution of the final pay (PPPP) shown in Table C-1. The listing shows that 82 percent of the projects had received (or should have received) 100 percent pay. Likewise,

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*For computation of this variable see footnote in Appendix Table C-1.

9.6 percent of the projects were qualified to receive between 99.0 and 99.9 percent of unit bid price. In the first evaluation (5) the percentage of projects in the 100 percent pay class was 45. The present data shows an increase of almost two-fold. This significant increase can be attributed to the familiarity gained in the philosophy and application of ERS. Concurrent to this, there has also been a significant decrease in the overall reduction in final pay from that observed in the first evaluation. The data indicates an overall average reduction in pay per project of only 0.4 percent (or a payment of 99.6 percent) as compared to 1.5 percent shown by the 1971-75 data (5).

Table 4.1: Frequency Distribution of Final Pay

PPPP	FREQUENCY	CUM FREQ	PERCENT	CUM PERCENT
83	1	1	0.459	0.459
94	2	3	0.917	1.376
95	1	4	0.459	1.835
96	1	5	0.459	2.294
97	2	7	0.917	3.211
98	12	19	5.505	8.716
99	21	40	9.633	18.349
100	178	218	81.651	100.000

In order to determine the distribution of pay reduction with respect to the various acceptance criteria, Table 4.2 was prepared. The table summarizes the contribution of each of the quality characteristics to the final pay on the basis of total tonnage and tonnage subjected to reduction in pay. Reduction in payment due to gradation deficiency is not shown since only nine projects had this requirement included in the contract as acceptance criteria, and none of these projects had deficiency due to this quality characteristic.

Table 4.2: Distribution of Reduction in Pay According to Acceptance Criteria

		DISTRIBUTION, %			
	PENALTY	ACCEPTANCE CRITERIA			
BASED ON	@	STAB	COMP	SURF TOL	TOTAL
TOTAL TONS (3823116)	50	.09	.07	.01	.17
	80	.67	.99	.25	1.91
	95	1.30	3.07	.17	4.55
	TOTAL	2.06	4.13	.43	6.63
TONS PENALIZED (253296)	50	1.32	1.10	.16	2.58
	80	10.14	14.93	3.72	28.79
	95	19.66	46.32	2.65	68.63
	TOTAL	31.12	62.35	6.53	100.00

In the above table it is seen that about two-thirds of the reduction in pay was due to deficiency in roadway compaction and 75 percent of this had occurred at 95 percent pay. Figure 4.1 is a comparative evaluation of this data with the 1975 data (5). There has been a significant decrease in the reduction in pay due to surface tolerance criteria. Improved procedure for calibration and testing of the rolling straight edge could have resulted in this decrease in reduced payment. On the other hand, deficiency due to stability criteria has increased to a significant level from the 1975 data.

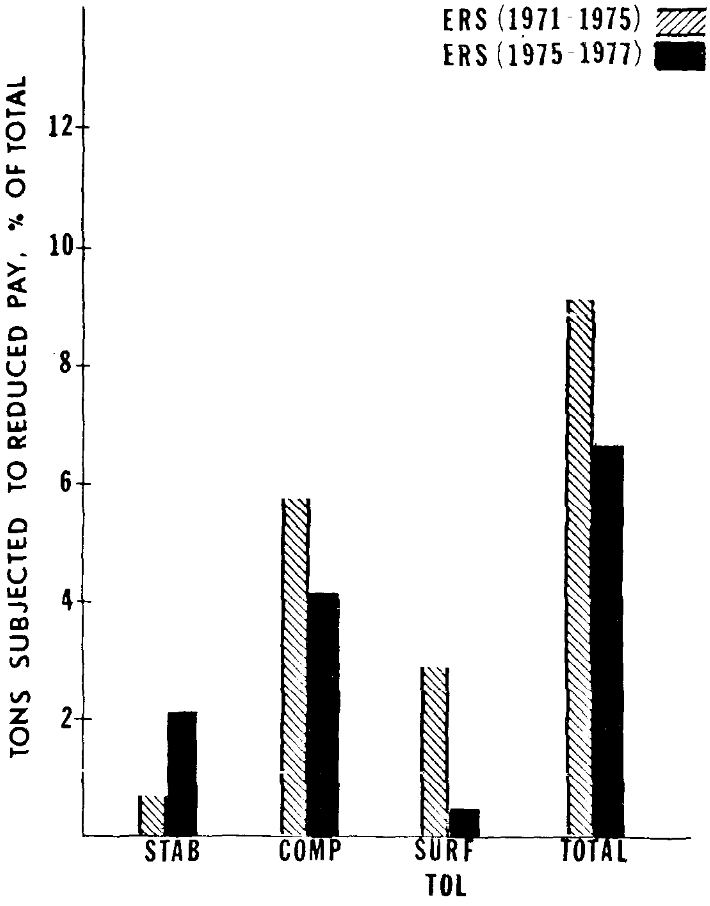


Figure 4.1: Comparison of Reduction in Pay Due to Acceptance Criteria

Most of the above deficiency in stability had occurred for mixes designated by codes 5 and 7 (mix types 3WC and 5A base course, respectively). This is shown in Table 4.3, which is a listing of the distribution of reduction in pay according to mix types and acceptance criteria. Likewise, deficiency due to roadway compaction criteria was predominantly confined to mix types 1WC, 3WC and 5B (mix codes 1, 5 and 8, respectively). Such high percentage of non-conforming material generally occurs as a result of the producer's inability or failure to maintain his production process at a specified level. This is discussed in detail in the next chapter.

Table 4.3: Distribution of Reduction in Pay According to Mix Types and Acceptance Criteria

MIX	MARSHALL STABILITY	ROADWAY COMPACTION	SURFACE TOLERANCE	TOTAL
1	2.34	13.38	5.77	21.49
2	.93	4.73	0	5.66
3	0	1.37	.08	1.45
4	0	1.23	0	1.23
5	12.79	11.36	.68	24.83
6	1.92	5.11	0	7.03
7	10.52	7.68	0	18.20
8	2.62	17.49	0	20.11
TOTAL	31.12	62.35	6.53	100.00

Of the 298 lots that had reduced payment (column N-LOT-P in Table C-1) 20, or seven percent, had deficiency due to two criteria and no project had deficiency in all three criteria.

The overall effect of ERS on the price adjustments can be summarized as follows:

1. There has been a significant decrease in the overall average reduction in pay since the first evaluation of 1975 (1.5 percent versus 0.4 percent). Likewise, the number of projects qualified for 100 percent pay has almost doubled since that year (45 percent versus 82 percent).

2. Roadway compaction continues to contribute the most to the total reduction in pay. This is followed by Marshall stability and surface tolerance.

3. Less than 0.2 percent of the total mix was deficient at the 50 percent pay level. Deficiency at the 80 and 95 percent level was 1.9 and 4.6 percent, respectively. These figures represent a significant decrease from the 1975 data which were 0.4, 3.4 and 5.4 at 50, 80 and 95 percent pay scale, respectively.

4. Type 3, wearing course mix (mix code 5), showed the largest deficiency which was distributed evenly between stability and compaction.

Structural Concrete

Structural concrete is accepted on the basis of 28-day compressive strength of cylinders fabricated at the job site by the Department inspectors and tested in the district laboratory. A table, similar to the one presented for asphaltic concrete (C-1), was prepared to determine the reduction in unit price due to strength deficiency. This table appears as C-2 in Appendix C. The data is listed by class of concrete and district. In this table, the numbers appearing in the column identified as PROJ are assigned project numbers. The quantity of concrete used on the project is shown as TOT-QTY followed by the number of lots (N-LOT) generated by the quantity. The remaining columns define the number of lots that had reduced payments and the quantity of concrete that was deficient at the various pay levels. The last column shows the final percent pay for each project.

According to Table C-2 there is an overall average reduction in final pay of only 0.3 percent, or an average payment per project of 99.7 percent. Of further interest is the frequency distribution of final percent pay per project (PPPP). This is shown in Table 4.4. Approximately 74 percent of the projects received 100 percent payment, with 20 percent receiving between 99 and 99.9 percent payment.

Table 4.4: Frequency Distribution of Final Pay

PPPP	Frequency	Cum. Freq.	Percent	Cum. %
Below 95	6	6	1.07	1.07
95	4	10	0.71	1.78
96	3	13	0.53	2.31
97	8	21	1.43	3.74
98	15	36	2.67	6.41
99	110	146	19.51	26.02
100	415	561	73.98	100.00

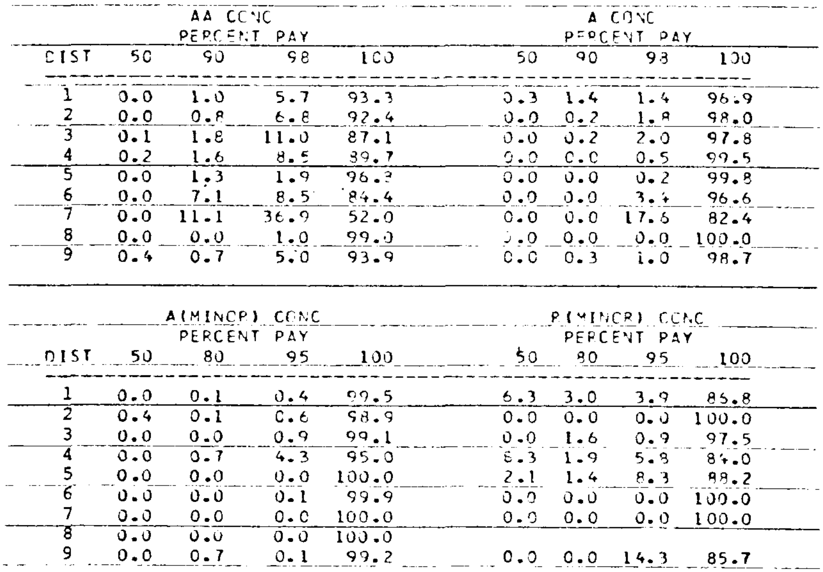
Table 4.5: Distribution of Reduction in Pay by Class of Concrete

CLASS	PAY	QUANTITY cy	% FOR CLASS
AA	50	58	0.04
AA	90	2155	1.30
AA	98	11511	6.96
AA	100	151667	91.70
AC	50	356	0.16
AC	90	2476	1.14
AC	98	5185	2.39
AC	100	209079	96.31
AN	50	26	0.03
AN	80	131	0.15
AN	95	894	1.05
AN	100	84251	98.77
RN	50	170	1.75
RN	80	108	1.11
RN	95	365	3.75
RN	100	9088	93.39

Table 4.5 is a breakdown of payment for different classes of concrete. This data is further categorized by districts in Table 4.6. These two tables indicate the difficulties the producers have in meeting the stated requirements for 100 percent pay for class AA and class R concrete (Tables B-3 and B-4 in Appendix B). To reduce the number of non-conforming lots, the producers need to maintain the mean and/or variability of the cylinder strengths at a specified level. This is evident in the case of District 7, which had an unusually high percentage of non-conforming lots. An evaluation of the mean and standard deviation of the concrete strengths revealed these two parameters to be far removed from the desired level necessary for 100 percent conformance. More on this in the next chapter. Designing concrete at an absolute minimum cement content specified by the Department could also contribute to lower strengths than those required for 100 percent pay. The high percentage of deficiency in class R concrete should be attributed to the relaxed inspection procedures exercised over

its production. This class is used in non-critical work such as curbs, sidewalks, fence posts and other incidental work.

Table 4.6: Distribution of Reduction in Pay by Class and Districts



	AA CONC				A CONC			
	PERCENT PAY				PERCENT PAY			
DIST	50	90	98	100	50	90	98	100
1	0.0	1.0	5.7	93.3	0.3	1.4	1.4	96.9
2	0.0	0.8	6.8	92.4	0.0	0.2	1.8	98.0
3	0.1	1.8	11.0	87.1	0.0	0.2	2.0	97.8
4	0.2	1.6	8.5	89.7	0.0	0.0	0.5	99.5
5	0.0	1.3	1.9	96.8	0.0	0.0	0.2	99.8
6	0.0	7.1	8.5	84.4	0.0	0.0	3.4	96.6
7	0.0	11.1	36.9	52.0	0.0	0.0	17.6	82.4
8	0.0	0.0	1.0	99.0	0.0	0.0	0.0	100.0
9	0.4	0.7	5.0	93.9	0.0	0.3	1.0	98.7

	A(MINOR) CONC				B(MINOR) CONC			
	PERCENT PAY				PERCENT PAY			
DIST	50	80	95	100	50	80	95	100
1	0.0	0.1	0.4	99.5	6.3	3.0	3.9	86.8
2	0.4	0.1	0.6	98.9	0.0	0.0	0.0	100.0
3	0.0	0.0	0.9	99.1	0.0	1.6	0.9	97.5
4	0.0	0.7	4.3	95.0	8.3	1.9	5.8	84.0
5	0.0	0.0	0.0	100.0	2.1	1.4	8.3	88.2
6	0.0	0.0	0.1	99.9	0.0	0.0	0.0	100.0
7	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0
8	0.0	0.0	0.0	100.0				
9	0.0	0.7	0.1	99.2	0.0	0.0	14.3	85.7

Paving Concrete

Paving concrete is accepted on the basis of 28-day compressive strength and pavement thickness. The schedule of payments for non-conforming concrete is given in Tables B-5 and B-6 of Appendix B. Table C-3 in Appendix C is a summary of data showing final adjusted payment for each project. The format and definition of each column heading in this table parallels Table C-2. Of the total number of projects evaluated, only two, 27 and 31, show a reduction in final payment. This reduced payment was due to deficiency in thickness. In both cases, this deficiency was at the 95 percent level and, consequently, the contractor was qualified to receive 99.3 and 99.8 percent, respectively, of the contract price.

The low number of non-conforming lots for this concrete should be attributed to the fact that the contractor generally tends to maintain his thickness level on the high side of the required plan thickness. Furthermore, the age of concrete cores at testing time normally exceeds the minimum age of 28-days specified for strength measurements by as much as 100 percent. This generally results in strengths higher than would be indicated at or around the specified curing period.

No data is available on deficiency due to surface smoothness since the contractor is required to correct this deficiency prior to sampling for strength and thickness measurements.*

The discussion presented in the preceding paragraphs for Portland Cement concrete can be summarized in the following statements:

1. Seventy-four percent of the structural concrete and 97 percent of the paving concrete met the requirements for 100 percent pay.
2. On the basis of total quantity of each type of concrete, there was an overall average price reduction of 0.3 percent for structural concrete and less than 0.1 percent for paving concrete.
3. Only 0.13 percent of the structural concrete showed deficiency at the 50 percent or remove scale of the pay schedule.
4. Class AA and class R concrete seemed to have more trouble in meeting the requirements for 100 percent pay.

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*Not more than four percent of the lot should exceed 1/4 inch of surface deviation for CRCP. For jointed pavement, not more than eight percent of each lot should exceed 1/4 inch. When greater percentage occurs, corrections are required with approved grinding tools.

5. VARIABILITY OF DATA

The specification limits tabulated in Appendix Tables A and B were developed from known process levels with respect to the mean and variability of the material and/or test. These levels were determined from historical sources. Therefore, there exists a definite relationship between specifications and statistical parameters of the various criteria discussed in the previous section. In order to minimize the reduced payment risks due to deficiency on any of the acceptance criteria, the contractor should maintain his process at the specified mean level and concurrently attempt to reduce his variability. Failure to maintain the process at the specified level will necessarily increase the percentage of non-conforming product. This is theoretically illustrated below.

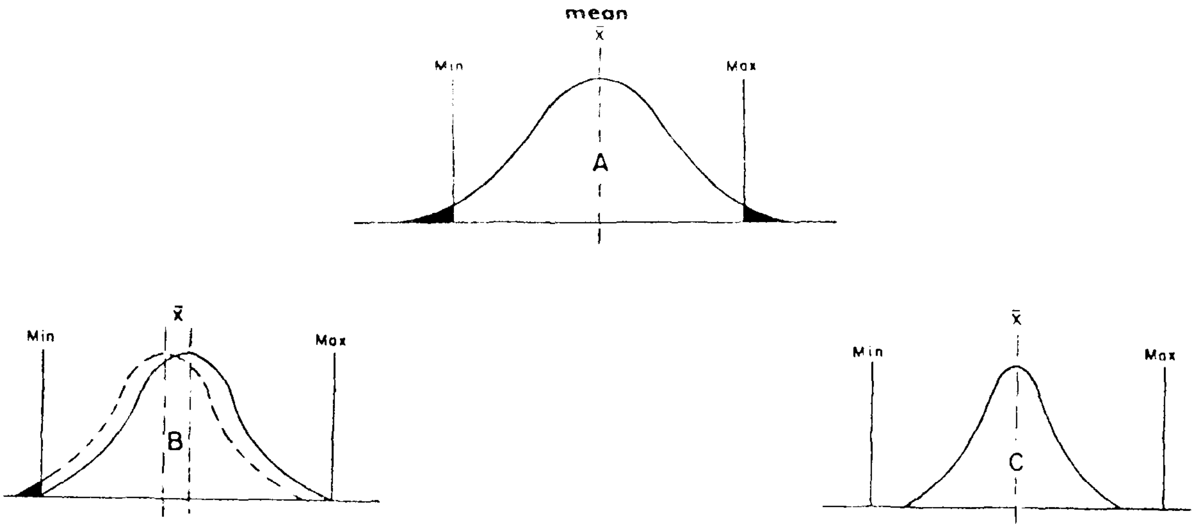

Figure 5.1: Some Distributional Aspects of Specifications

Curve A symbolizes a relationship between specification tolerance limits and statistical parameters (mean and standard deviation) using an idealized normal distribution curve. This situation is untenable, and the contractor has to reduce the magnitude of variation or sacrifice a percentage of his product, as shown by the shaded portion of the curve.

Curve B shows a situation where the curve just clears the inside limits. Although this might seem perfect at first, there is no allowance for operating tolerance. The dotted curve shows how the measurements would fall outside the limits with only a slight shift in the mean.

The most comfortable situation is illustrated in Curve C, where some leeway for sampling, testing, or material variation is allowed. Under this condition adequate conformance with specification tolerance can be expected.

The preceding idealized illustration can be applied to explain the occurrence of some of the deficiencies that were discussed in Chapter 4. This chapter discusses the variability of the materials and comparison of this variability to known standards.

Asphaltic Concrete

Table 5.1 is a summary of statistical parameters for acceptance and control criteria. Data were pooled over projects with similar mix types to determine the listed parameters. The number of pooled observations is listed under the column heading "N." It should be noted that the values of the listed statistics represent those derived from data pooled over projects with similar mix types and not the values of the pooled statistics. Such an approach provides a valid comparison with the previously established parameters used in specification development. Referring to Table 4.3 of the previous chapter, 12.79 percent of mix 5 had failed to meet the 100 percent requirements for Marshall stability. This occurrence can be related to the mean and standard deviation listed for this criteria under mix 5 in Table 5.1. The mean value of 1888 lbs. (8362 N) is too close to the requirement of 1700 lbs. (7562 N) for 100 percent pay. In order to reduce the percent of deficient material, the contractor should maintain his mean level at or around 2100 lbs. (9786 N) and his variability at 250 lbs. (1112 N). Theoretically, on the basis of the observed mean and standard deviation, approximately 11 percent of the stabilities should be below 1700 lbs. (7562 N). This theoretical value agrees with the observed percentage of 12.79 shown in Table 4.3. Similar reasoning can be applied to data for mix 7. The mean for this mix is too close to the 1200 lbs. (5338 N) required for 100 percent pay. This mean should have been no less than 1600 lbs. (7117 N), assuming no shift in the variability. These examples are based on population parameters and not project parameters. However, similar reasoning can be applied to individual projects to determine the proportion of values expected to be outside the limits.

Table 5.1: Statistical Parameters According to Mix Types

VARIABLE		MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
MIX=1						
STABILITY	7356	1553.28	289.96	345.00	3364.0	18.67
COMPACTION	10031	96.36	1.64	86.30	103.90	1.70
1 INCH	2783	100.00	0.09	99.00	100.00	0.02
3/4 INCH	3820	99.72	0.89	85.00	100.00	0.89
1/2 INCH	3814	91.90	4.37	71.00	100.00	4.75
NO. 4	3816	55.98	5.11	35.00	77.00	9.14
NO. 10	3816	41.88	4.56	21.00	61.00	10.89
NO. 40	3816	24.58	3.49	9.00	38.00	14.21
NO. 80	3816	11.53	2.39	4.00	23.00	20.72
NO. 200	3815	6.43	1.55	2.00	18.00	24.13
A.C., %	3816	5.06	0.39	3.00	7.10	7.68
MIX=2						
STABILITY	1413	1624.69	313.85	324.00	3148.00	19.32
COMPACTION	1984	96.32	1.56	87.00	101.30	1.62
1 INCH	554	99.90	0.62	94.00	100.00	0.62
3/4 INCH	734	98.52	2.36	84.00	100.00	2.40
1/2 INCH	734	86.67	5.05	61.00	99.00	5.83
NO. 4	734	51.86	4.83	35.00	71.00	9.31
NO. 10	734	39.22	4.34	23.00	56.00	11.06
NO. 40	734	23.37	3.49	14.00	35.00	14.94
NO. 80	734	10.29	2.44	3.00	20.00	23.67
NO. 200	734	5.89	1.47	1.60	15.00	24.97
A.C., %	734	4.62	0.40	3.70	6.60	8.59
MIX=3						
STABILITY	107	1926.45	409.33	1146.00	3042.00	21.25
COMPACTION	160	93.82	2.35	88.30	98.70	2.50
1 INCH	52	100.00	0.00	100.00	100.00	0.00
3/4 INCH	54	99.76	0.67	96.00	100.00	0.67
1/2 INCH	54	92.11	3.79	82.00	99.00	4.12
NO. 4	54	66.22	3.46	58.00	74.00	5.22
NO. 10	54	50.89	3.98	40.00	58.00	7.83
NO. 40	54	31.94	3.86	22.00	38.00	12.09
NO. 80	54	11.50	1.51	9.00	16.00	13.17
NO. 200	54	6.35	1.58	4.00	11.60	23.78
A.C., %	54	6.03	0.38	5.30	6.36	6.29

Table 5.1 (Continued)

MIX=4

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
STABILITY	85	2134.94	253.36	1346.00	2628.00	11.87
COMPACTION	140	92.56	1.69	88.30	96.50	1.82
1 INCH	45	100.00	0.00	100.00	100.00	0.00
3/4 INCH	45	99.58	0.75	97.00	100.00	0.00
1/2 INCH	45	94.18	2.62	89.00	99.00	2.78
NO. 4	45	68.24	2.90	63.00	76.00	4.25
NO. 10	45	51.00	3.49	44.00	63.00	6.84
NO. 40	45	30.60	3.49	25.00	44.00	11.42
NO. 80	45	10.89	1.09	9.00	16.00	10.03
NO. 200	45	6.69	1.47	3.90	12.20	21.91
A.C., %	45	6.15	0.32	5.60	6.80	5.18

MIX=5

STABILITY	1410	1898.40	303.27	671.00	2968.00	16.06
COMPACTION	1978	96.14	1.52	89.90	100.00	1.59
1 INCH	552	100.00	0.00	100.00	100.00	0.00
3/4 INCH	730	99.80	0.73	93.00	100.00	0.71
1/2 INCH	732	92.71	3.61	59.00	99.00	3.89
NO. 4	732	55.70	4.98	30.00	70.00	8.94
NO. 10	732	39.74	3.66	25.00	54.00	9.22
NO. 40	732	23.31	2.79	14.00	35.00	11.95
NO. 80	722	11.85	2.14	5.00	19.00	18.09
NO. 200	732	6.68	1.43	3.00	11.90	21.45
A.C., %	732	5.10	0.38	4.00	7.10	7.44
% CRUSHED	711	83.69	6.53	61.00	99.00	7.80

MIX=6

STABILITY	1004	1755.82	300.25	944.00	3481.00	17.10
COMPACTION	1510	96.34	1.35	91.20	100.00	1.41
1 INCH	452	99.98	0.31	95.00	100.00	0.31
3/4 INCH	521	99.75	1.85	92.00	100.00	1.87
1/2 INCH	521	87.56	4.83	68.00	99.00	5.52
NO. 4	521	51.33	5.38	36.00	66.00	10.47
NO. 10	521	37.17	4.14	24.00	50.00	11.14
NO. 40	521	22.57	2.80	12.00	33.00	12.39
NO. 80	521	10.65	1.96	4.00	18.00	19.41
NO. 200	521	6.22	1.52	2.00	11.00	24.48
A.C., %	519	4.64	0.41	3.50	6.90	8.82
% CRUSHED	516	74.69	8.99	44.00	98.00	12.00

MIX=7

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
STABILITY	2210	1393.60	255.61	556.00	2499.00	18.34
COMPACTION	3226	96.49	1.43	88.10	103.40	1.59
1 INCH	1106	99.36	1.69	90.00	100.00	1.70
3/4 INCH	668	93.50	5.04	76.00	100.00	5.39
1/2 INCH	668	79.68	5.84	63.00	98.00	7.33
NO. 4	1145	49.30	6.23	32.00	67.00	12.64
N/. 10	668	35.86	4.80	23.00	54.00	13.38
NO. 40	1143	22.65	3.53	9.00	36.00	15.58
NO. 80	668	9.93	1.94	4.00	17.00	19.57
NO. 200	1145	5.89	1.44	2.00	11.00	24.39
A.C., %	1144	4.22	0.37	3.10	6.10	8.75

MIX=8

STABILITY	1731	1350.53	401.09	464.00	2754.00	29.70
COMPACTION	2503	96.19	1.57	89.60	101.70	1.63
1 INCH	881	96.77	3.84	80.00	100.00	3.97
3/4 INCH	191	95.45	5.03	79.00	100.00	5.27
1/2 INCH	189	80.67	9.39	60.00	99.00	11.65
NO. 4	881	49.10	8.59	31.00	72.00	17.50
NO. 10	189	39.84	5.52	28.00	52.00	13.87
NO. 40	879	27.61	3.75	14.00	46.00	13.57
NO. 80	189	11.75	2.70	7.00	23.00	22.97
NO. 200	879	6.38	1.53	1.00	12.10	23.95
A.C., %	878	4.60	0.65	3.40	7.30	14.16

The variability data for roadway compaction tells the same story. The high percentage of non-conforming data for mixes 1, 5 and 8 can be attributed to the low process mean. The specification requirement of 95 percent for 100 percent pay is based on the known standard of 97.3 percent for the mean and 1.6 percent for the standard deviation. A shift in either of these parameters will increase the proportion of data that will fall below the 95 percent requirements. This was illustrated by curve B of Figure 5.1.

The data presented in Table 5.1 for mix type 1 was evaluated for variability according to its use in roadway construction. Table 5.2 is a summary of the various statistics according to P, S, W, R, L and M representing patching, shoulder, widening, roadway, leveling and miscellaneous, respectively. The data shows that production control is independent of the mix usage. This is indicated by the coefficient of variation for the mixes being close to the 18 percent indicated in Table 5.1 for mix type 1. Mixes used for widening, however, show better uniformity than other mixes. On the other hand, the level of control exercised during compaction may be associated to mix use. This is evident from the differing coefficient of variations for each mix use. Mixes used for roadway show better uniformity in compaction than those used for other purposes. Also, notice the high variability associated with patching mixes.

A continuous shift in the process level generally results in poor uniformity. The within lot variation for stability, expressed as range, has been shown to be in excess of three times the standard deviation of the process (5). Figure 5.2 represents the scatter of the morning stability average versus the difference in stabilities between the afternoon average and the morning average. A positive difference, therefore, would signify high afternoon average and a negative difference would be indicative of low afternoon average. Thus, whenever low stabilities were indicated during the morning

Table 5.2: Statistical Parameters According to Mix Use (Mix Type 1)

USE=P

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	C.V.
STAB	645	1527.27596399	273.37882073	744.00000000	2270.00000000	17.900
COMP	560	97.60214286	2.03137177	90.40000000	103.90000000	2.081
P1	282	100.00000000	0.00000000	100.00000000	100.00000000	0.000
P34	359	99.89136490	0.56123176	96.00000000	100.00000000	0.562
P12	357	92.43137255	4.38382132	77.00000000	99.00000000	4.743
N4	359	56.24512535	5.47274327	36.00000000	75.00000000	9.730
N10	359	41.48746518	4.46078335	26.00000000	54.00000000	10.752
N40	359	24.65738162	3.49415231	9.00000000	38.00000000	14.171
N80	359	11.44289694	2.44639707	5.00000000	19.00000000	21.379
N200	358	6.43826816	1.46779215	2.00000000	11.00000000	22.798
AC	359	5.06406685	0.40453595	4.10000000	7.00000000	7.988
USE=S						
STAB	894	1370.94407159	249.88290472	652.00000000	2643.00000000	18.227
COMP	1446	96.29730290	1.61436876	90.60000000	100.90000000	1.676
P1	287	100.00000000	0.00000000	100.00000000	100.00000000	0.000
P34	450	99.47333333	1.18845598	92.00000000	100.00000000	1.195
P12	449	90.38752784	4.39779017	76.00000000	99.00000000	4.865
N4	449	54.82182628	4.96140148	39.00000000	68.00000000	9.050
N10	449	41.30289532	4.16961967	29.00000000	55.00000000	10.095
N40	449	24.59020045	3.16883431	13.00000000	34.00000000	12.887
N80	449	12.19144766	2.16078150	6.00000000	21.00000000	17.732
N200	449	7.03118040	1.72725233	3.00000000	18.00000000	24.566
AC	449	5.43563474	0.45249764	4.30000000	7.10000000	8.325
USE=W						
STAB	76	1568.22368421	167.56217542	1195.00000000	1929.00000000	10.685
COMP	116	94.03189655	1.89656895	90.60000000	98.70000000	2.017
P1	26	100.00000000	0.00000000	100.00000000	100.00000000	0.000
P34	42	99.80952381	0.55163152	98.00000000	100.00000000	0.553
P12	42	94.45238095	4.19175952	83.00000000	99.00000000	4.438
N4	42	57.90476190	3.51171922	49.00000000	65.00000000	6.065
N10	42	42.23809524	3.46979668	34.00000000	48.00000000	8.215
N40	42	25.19047619	2.54939537	20.00000000	34.00000000	10.120
N80	42	11.78571429	1.63103610	9.00000000	16.00000000	13.839
N200	42	5.47380952	1.21134032	2.00000000	8.00000000	22.130
AC	42	4.92857143	0.21331954	4.50000000	5.40000000	4.328
USE=R						
STAB	4550	1585.16153846	284.62887726	345.00000000	3364.00000000	17.956
COMP	6656	96.36452825	1.49387908	88.60000000	102.20000000	1.550
P1	1734	99.99942330	0.02401461	99.00000000	100.00000000	0.024
P34	2327	99.71809196	0.86417878	85.00000000	100.00000000	0.867
P12	2324	91.83648881	4.29897853	71.00000000	100.00000000	4.681
N4	2324	55.78614458	4.98092417	35.00000000	70.00000000	8.929
N10	2324	41.91566265	4.51493239	21.00000000	57.00000000	10.771
N40	2324	24.60714285	3.56818591	9.00000000	37.00000000	14.501
N80	2324	11.46471601	2.46578888	4.00000000	23.00000000	21.508
N200	2324	6.32947504	1.50388186	2.00000000	14.00000000	23.839
AC	2325	5.01453763	0.33074567	4.00000000	6.40000000	6.596
USE=L						
STAB	974	1576.34804928	291.58334239	690.00000000	3033.00000000	18.497
COMP	1049	96.05719733	1.85427301	86.30000000	100.90000000	1.930
P1	330	100.00000000	0.00000000	100.00000000	100.00000000	0.000
P34	502	99.82071713	0.85689005	91.00000000	100.00000000	0.858
P12	502	93.03784861	3.79364972	74.00000000	99.00000000	4.078
N4	502	57.27888446	5.09358780	39.00000000	74.00000000	8.887
N10	502	42.02788845	4.92531235	26.00000000	54.00000000	11.719
N40	502	24.04980080	3.14003032	14.00000000	34.00000000	13.056
N80	502	11.19123506	2.12936949	6.00000000	21.00000000	19.027
N200	502	6.42171315	1.55392320	2.00000000	12.00000000	24.198
AC	501	4.97145709	0.38450445	3.90000000	6.30000000	7.734
USE=M						
STAB	217	1604.44700461	341.76666315	681.00000000	2760.00000000	21.301
COMP	204	96.24264705	1.47016130	91.00000000	101.30000000	1.528
P1	124	100.00000000	0.00000000	100.00000000	100.00000000	0.000
P34	140	99.75000000	0.82344250	94.00000000	100.00000000	0.826
P12	140	91.70000000	5.58221740	77.00000000	99.00000000	6.087
N4	140	56.66428571	6.03301554	43.00000000	77.00000000	10.647
N10	140	43.52857143	5.29482285	30.00000000	61.00000000	12.164
N40	140	25.62142857	4.33401779	15.00000000	38.00000000	16.916
N80	140	12.00714286	2.34596371	7.00000000	19.00000000	19.538
N200	140	6.52428571	1.46321177	3.20000000	12.00000000	22.427
AC	140	5.09142857	0.41837055	4.30000000	6.90000000	8.217

run, a shift would be made to a higher level in the afternoon in order for the daily average to be within the requirements for 100 percent pay. The somewhat negative trend indicated by the scatter also means that the shift in the afternoon level also occurs even if the morning average is sufficiently high to provide the daily average within the tolerance limit. Whether such shifts occur as a result of chance causes or otherwise cannot be determined with certainty. However, it would seem that the technological sohpistication in production equipment would minimize such chance occurrences and maintain the process at a constant level.

Process variations of the magnitude discussed above generally result in loss of uniformity of the quality characteristics. A comparison of the uniformity of the product in terms of the quality indicators is presented in Figure 5.3. The plots represent standard deviation of the various quality criteria for conventional and end-result specifications. The middle solid bars represent data from the first evaluation (5). This comparison clearly shows the loss in uniformity over the time period. Although the data for conventional specifications were derived from historical sources, and therefore subject to bias, the magnitude of variability reflected by the ERS data cannot be ignored on the basis of this argument. One of the primary reasons for such decay in uniformity is the failure on the part of the producer to exercise adequate control over the process, as was pointed out by Figure 5.2. A much closer day-to-day monitoring is essential in order to improve the process uniformity and also decrease the probability of rejection rate of deficient materials.

The present specifications define gradation as an acceptance criteria with reduction in pay for out-of-tolerance material. This provision was introduced after the 1975 evaluation, which had indicated a significant loss in uniformity as is shown in Figure 5.3. Prior to this, gradation was defined as control criteria with

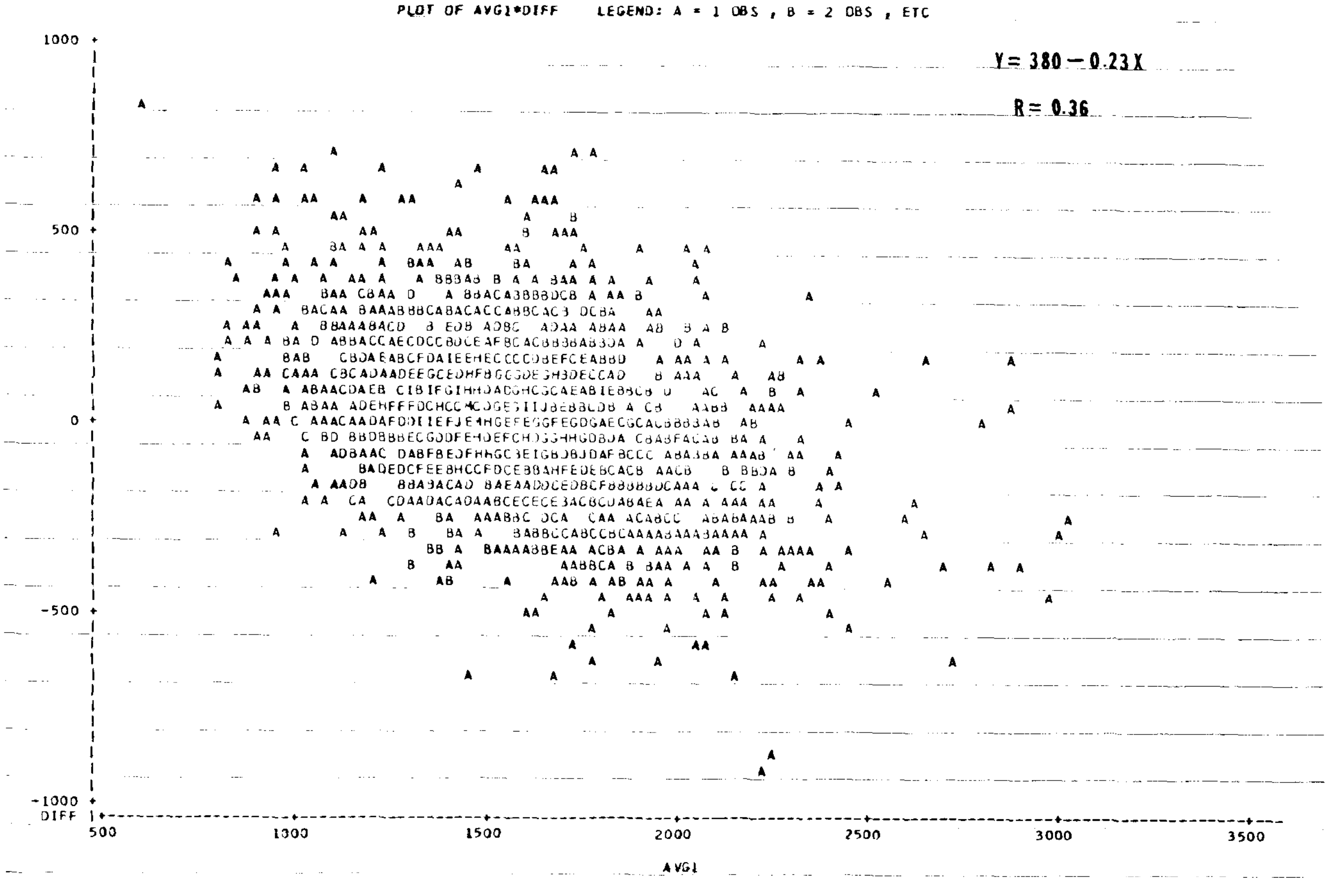

Figure 5.2: Shift in Process Level Within Day (Lot) for Marshall Stability

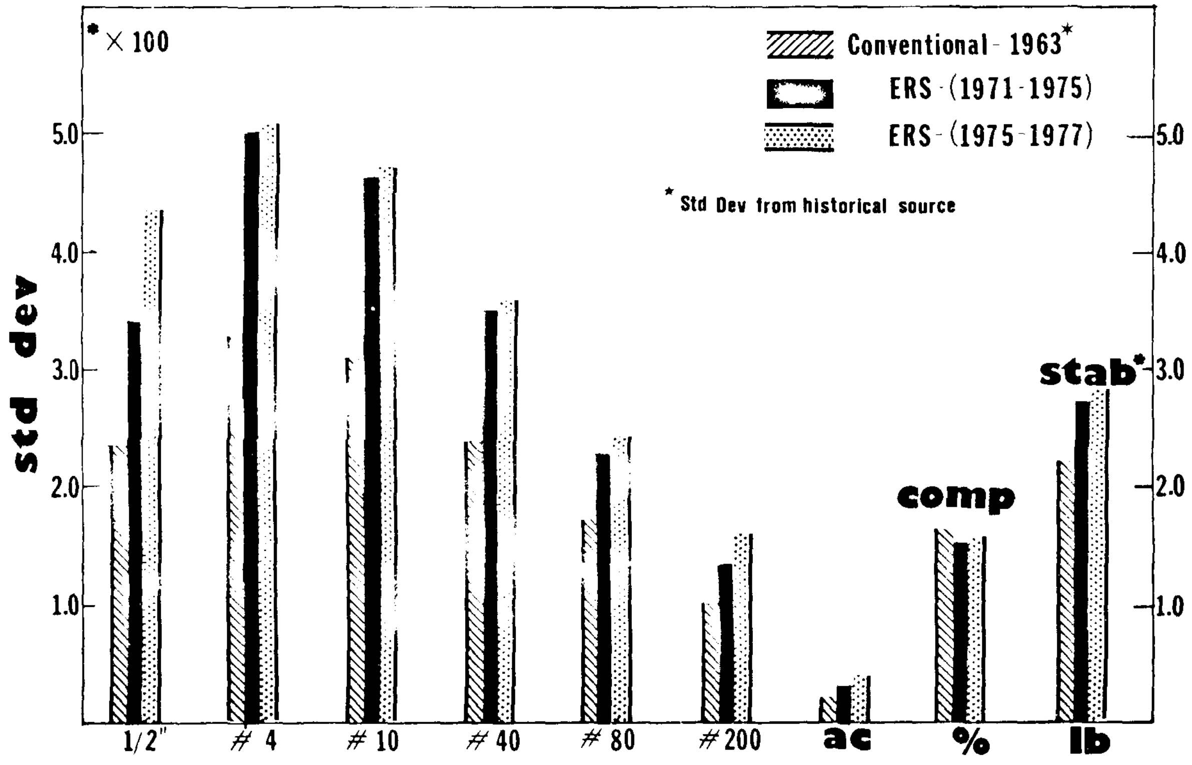

Figure 5.3: Comparison of Variability Between Conventional and End-Result Specification Asphaltic Concrete (Mix Type 1)

no pay reduction for out-of-tolerance material. Whether this change from control to acceptance criteria with pay reduction has had any effect on the gradation uniformity remains to be determined when sufficient data is available on projects let under this provision. The nine-project data available in this data set are too few to draw any logical inference.

Structural Concrete

End-result specifications for Portland Cement concrete structures and pavement have been in effect since the latter part of 1973. The specification requirements for the various classes of concrete are given in Appendix B.

Table 5.3 shows the variability in compressive strength of different classes of concrete. The data represent values pooled over all projects. The last column is the coefficient of variation and, according to ACI standard, is indicative of the control exercised on the production process (7). The coefficient of variation is the standard deviation expressed as percent of the mean of the measured characteristic. This measure of variability is useful in comparing data from multiple sets of measurements with different units or with widely differing means. Table 5.4, which was extracted from reference 7, is a summary of rating standards developed by the ACI for judging the control exercised in overall concrete production. According to this table, the control of production of class AA and class A concrete should be rated good and that of class AN and class RN for minor structures, fair and poor, respectively. The large magnitude of the coefficient of variation for class R concrete is due to the minimal inspection exercised over its production.

Table 5.3: Variability of Different Classes of Concrete

```
CLASS    NUM_CYL     AVG_CYL     STD_CYL     MIN_CYL     MAX_CYL     CV_CYL

 AA       19628       4979         684        1950        9530        13.7
 A        24135       4842         635        1910        9050        13.1
 AN       11610       4531         719        1550        7280        15.9
 RN        1178       2982         908         743        6010        30.4
```

Table 5.4: ACI Standards of Concrete Control

Class of operation	Coefficients of variation for different control standards			
	Excellent	Good	Fair	Poor
Over-all variations: General construction	Below 10.0	10.0 to 15.0	15.0 to 20.0	Above 20.0
Within-test variations: Field control	Below 4.0	4.0 to 5.0	5.0 to 6.0	Above 6.0

Note: These standards represent the average for 28-day cylinders computed from a large number of tests. Different values for other than average concretes can be expected.

Table 5.5 is a listing of the statistical parameters listed in Table 5.3 but detailed according to districts and class. Figure 5.4 is a graphical representation of this data. Again, based on the ACI rating of Table 5.4, class AA and A concrete control is from good to excellent. Fair to good control is indicated for class AN concrete and practically all districts indicate poor control on class RN concrete. Although both AN and RN concrete are noncritical concrete for minor structures, the latter shows twice as much coefficient of variation as the former. In spite of the usage of class RN concrete, a much closer control on inspection and testing is necessary to reduce this poor uniformity. Failure to reduce this nonuniformity will diminish the economic returns as is discussed in the next paragraph.

Table 5.5: Variability of Concrete Data by Class and Districts

DISTRICT	CLASS	NUM_CYL	AVG_CYL	STD_CYL	MIN_CYL	MAX_CYL	CV_CYL
1	AA	8137	5155	765	2560	7770	14.9
1	A	9634	4802	585	2140	7470	14.0
1	A N	3387	4650	762	1550	7280	16.4
1	R N	98	3024	1115	940	5010	35.9
2	AA	4643	4865	520	2300	6190	10.7
2	A	4392	4704	517	1910	5780	11.0
2	A N	1809	4528	605	1650	5890	13.4
2	R N	84	3577	890	2100	5580	24.9
3	AA	1554	4632	513	1750	9580	11.1
3	A	3545	4655	545	2330	6220	11.7
3	A N	1911	4236	613	1330	5100	14.5
3	R N	390	3222	823	1560	5310	25.6
4	AA	1670	4596	412	3060	5750	9.0
4	A	1092	4593	465	3300	5340	10.1
4	A N	1210	4205	752	2030	5650	17.9
4	R N	234	2588	855	743	4530	33.1
5	AA	1542	5332	615	3180	7070	11.5
5	A	1773	5103	490	2810	6730	9.6
5	A N	933	4892	574	3020	6870	11.7
5	R N	210	2430	539	1100	5480	22.2
6	AA	660	4847	552	3110	5800	13.5
6	A	1674	4870	649	2410	9050	13.3
6	A N	943	4849	752	2510	6930	15.5
6	R N	87	3619	571	2400	4700	15.8
7	AA	300	4219	421	2900	5510	10.0
7	A	246	4284	534	3250	5310	12.5
7	A N	261	4397	646	3320	6470	14.7
7	R N	18	4253	368	2630	5050	8.6
8	AA	90	5071	347	4030	5300	5.9
8	A	281	4913	417	3640	5300	8.5
8	A N	312	4759	551	2790	5300	11.6
9	AA	1032	5012	653	2970	6800	13.0
9	A	1448	5302	594	3150	7170	12.2
9	A N	844	4392	630	2300	6150	14.3
9	R N	57	2656	780	1750	4520	29.4

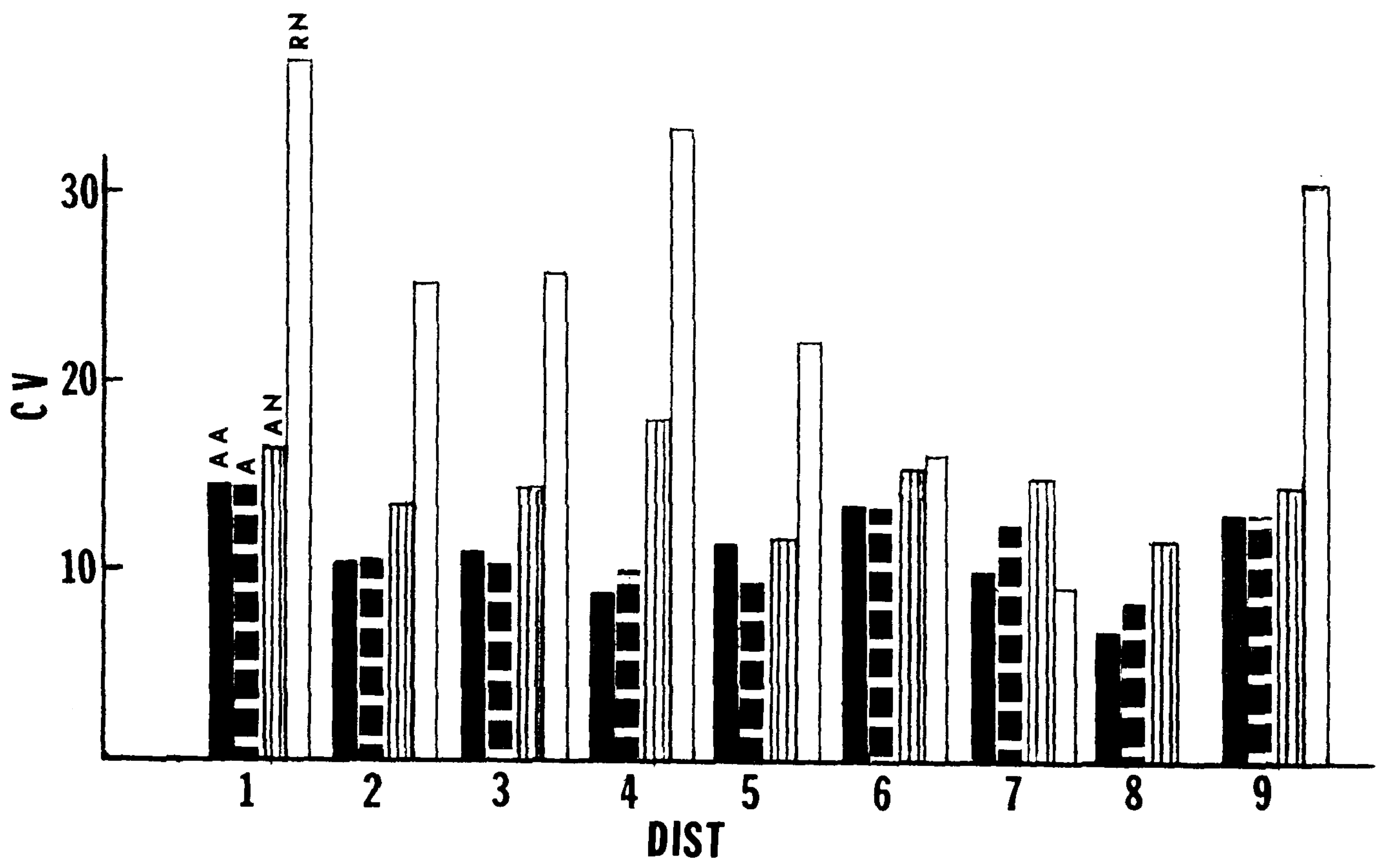

Figure 5.4: Overall Variability of Different Classes of Concrete by Districts

Tables 5.3 and 5.5 attempt to provide some explanation for the failure ratio discussed in Tables 4.5 and 4.6. Referring to Table 5.5, it is seen that in a majority of the cases the mean compressive strength, listed under the column heading AVG-CYL, was maintained too close to the minimum specification requirement for that concrete. The 48 percent failures shown in Table 4.6 for District 7 should be attributed to the overall mean of 4218 psi (29082 kPa) being too close to the stated requirement of 4200 psi (28958 kPa) for 100 percent pay. This 48 percent is in line with the theoretical calculated value of 48 percent. Similarly, the 17.6 percent of failing class A concrete in the same district parallels with the 15 percent theoretical value. Notice that this district was able to exercise good control on concrete according to ACI standards of Table 5.4; yet the failure ratio was quite high. This emphasizes the fact that the production process should be maintained at a level compatible to the specification requirements.

Variations in strength of concrete can be traced to two different sources: (1) properties of the concrete mixture, and (2) discrepancies in testing methods. Referring to Table 5.4, it is seen that the coefficient of variation in excess of 6.0 indicates poor testing procedures. Based on these standards, District 1, in Figure 5.5, shows poor testing control for both class AA and class A concrete. The rest of the districts project good to excellent testing control. Table 5.6 is a detailed listing of the testing variation for all classes of concrete.

Discrepancies in sampling, fabrication, curing and testing of specimens contribute to such excessive variation in testing. The importance of using accurate testing machines and other laboratory equipment should not be overemphasized since test results can be no more accurate than the equipment. Periodic calibration of equipment, therefore, should be considered as a standard for good testing procedure.

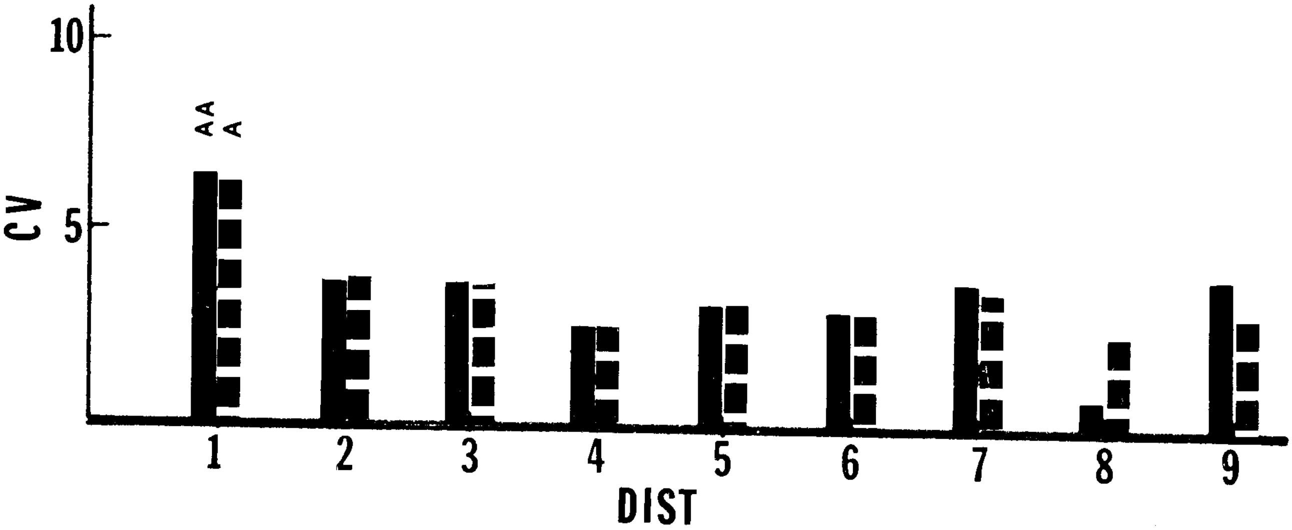

Figure 5.5: Testing Variance by Districts for Class AA and Class A Concrete

Table 5.6: Testing Variance by Districts for Different Classes of Concrete

DISTRICT	CLASS	STD DEV	NUM	AVG_MEAN	CV
1	AA	340	2597	5156	6.6
1	A	331	3206	4393	5.8
1	A N	333	1120	4650	7.2
1	B N	212	32	3032	7.0
2	AA	179	1543	4867	3.7
2	A	181	1453	4705	3.8
2	A N	173	599	4531	3.8
2	B N	128	28	3577	3.6
3	AA	171	518	4532	3.7
3	A	167	1179	4655	3.6
3	A N	176	537	4236	4.1
3	B N	129	130	3222	4.0
4	AA	123	556	4596	2.7
4	A	123	354	4593	2.7
4	A N	108	402	4204	2.6
4	B N	81	78	2589	3.1
5	AA	173	514	5332	3.2
5	A	171	591	5103	3.3
5	A N	156	311	4992	3.4
5	B N	71	70	2430	2.9
6	AA	150	220	4847	3.1
6	A	158	558	4870	3.2
6	A N	159	313	4853	3.3
6	B N	101	29	3519	2.8
7	AA	162	100	4213	3.8
7	A	151	82	4284	3.5
7	A N	157	87	4397	3.6
7	B N	232	6	4253	5.5
8	AA	43	30	5071	0.8
8	A	124	93	4914	2.5
8	A N	88	104	4759	1.9
9	AA	199	344	5012	4.0
9	A	166	481	5304	3.1
9	A N	122	230	4393	2.8
9	B N	106	19	2656	4.0

Paving Concrete

Table 5.7 is a comparison of the standard statistics generated by conventional specification and the ERS. The data do not project any change in the quality of concrete with respect to the strength characteristic. However, comparison of the present thickness data to those obtained from conventional specifications shows an increase in variability. This is evident in Figure 5.6, which shows almost a two-fold increase in standard deviation at all thickness levels.

Table 5.7: Comparison of Variability in Strengths for Conventional and End-Result Specification Concrete

Statistic	Conventional	ERS
Mean, psi	5231	5353
Std. Dev., psi	1060	1013
C.V., %	20.4	18.9

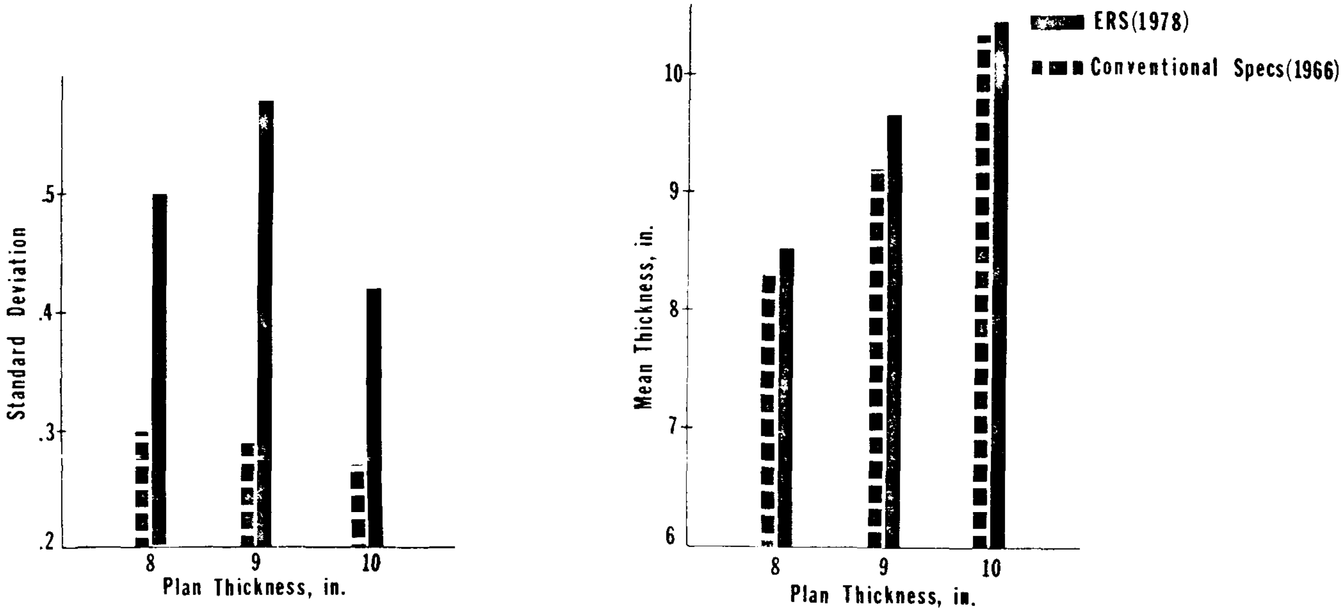

Figure 5.6: Comparison of Variability in Thicknesses for Conventional and End-Result Specifications

6. SUMMARY

Price Reduction

One of the primary provisions in all statistically oriented end-result specifications is the reduction in price of the product that fails to satisfy the requirements set forth in the specifications for 100 percent pay. Chapter 4 discussed in detail the price reductions at different levels defined in the pay schedules for the materials (Appendix A and Appendix B). The following is a summary of statements based on that discussion.

1. The overall average reduction in price is less than half of one percent for all materials evaluated here. This means an average final pay per project of more than 99.5 percent of the unit price.
2. At least 74 percent of the projects let under ERS received 100 percent pay.
3. Most of the deficiency occurred at a level one scale below the 100 percent level (95 or 98 percent). Correspondingly, less than 0.2 percent of the material evaluated was deficient at the 50 percent or remove scale.

Variability

Most of the price reduction can be traced to the level of control maintained during the production or construction process. In other words, a definite relationship exists between the mean and variability of the process and the corresponding specification limits. Thus, operating at a level too close to the specification limit will necessarily increase the failure ratio assuming fixed process variability. The discussion and data presented in Chapter 5 can be summed up in the following statements:

1. The level of uniformity in the production phase of asphaltic concrete shows some decline from the first evaluation. Overall, the ERS data project a significant increase in non-uniformity from the conventional data. However, the level

of uniformity projected by the roadway compaction data generated by ERS shows inconsequential improvement over the conventional specification data.

2. Deficiency in the product and subsequent price reduction can be attributed to the contractor's failure to maintain his process control at a level that would provide leeway in the event of a shift in the mean or variability of the process.

3. Based on the ACI standards of concrete control, good to excellent control was indicated by class AA and class A concrete. However, class RN concrete, which is used as incidental concrete, indicated poor control according to this ACI standard.

4. Eight of the nine districts showed from good to excellent proficiency in the testing phase of concrete control. Frequent inspection of all phases of concrete testing should be made an integral part of overall concrete inspection.

Quality Assurance and ERS

A decade or so of analysis and evaluation of historical data has provided a set of guidelines that we have acclimatized ourselves to identify as "statistically oriented end-result specifications." These are "statistical" indeed since statistical or probability concepts were used in their development as opposed to the conventional type, which specified absolute conformance and yet left much gray area for disposition of the deficient product. But are they really end-result oriented? Not if one looks at the list of quality criteria specified for control and/or acceptance of the final product. Furthermore, these so-called "quality indicators" raise serious doubts as to their ability to relate to performance. What are considered quality indicators are truly "uniformity indicators." Will the present decline in gradation uniformity of asphaltic concrete result in poor performance? The question is highly debatable. Along the same lines, is there a need to specify requirements for the production phase of the asphaltic concrete? What good will a 100 percent plant conformance mix be if it fails to provide the desired roadway characteristics because of poor control during the compaction and finishing phase?

A quality assurance program is a closed-looped system. For this system to work effectively, a well-documented and continuous feedback of data on materials, tests, performance and specifications must be a necessary requirement. Through such a feedback, the Department and the contractor can keep a close and constant vigilance on the level of inspection and control necessary to obtain the desired end product. The Department's newly implemented MATT System, an acronym for MATerial Test Data Reporting System, is geared towards satisfying these feedback requirements. Such a feedback would provide, to those responsible for monitoring the project, information relative to 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.

The concept of end-result specification is here to stay. However, for realistic application of such specifications, it is of paramount importance to:

- define quality in terms of fundamental true indicators of quality;
- accelerate development and use of rapid nondestructive testing of construction materials;
- relax restrictive equipment specifications and provide flexibility in the use of newly developed tools;
- provide a constant feedback of information relative to process variability so that timely and corrective measures can be taken if deemed necessary.

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APPENDIX A

SPECIFICATIONS FOR ASPHALTIC CONCRETE

Table A-1: Delegation of Responsibility for Control and Acceptance of Asphaltic Concrete

Control Sampling & Testing for:	Delegated to:
Mix Design	Contractor
Job-Mix Formula	Contractor Proposes
Job-Mix Formula	Department Approves
Have Certified Technician	Contractor & Department
Plant Operation	Contractor
Gradation & Bitumen Content	Contractor
Acceptance Sampling & Testing for:	
Gradation of Extracted Aggregate	Contractor's Data
Stability	Department
Pavement Sampling	Contractor
Pavement Testing	Department
Smoothness	Department

Table A-2: Sampling Plan for Control and Acceptance of Asphaltic Concrete

Requirements for	Lot Size	Sample Size	Frequency	Basis of Randomness
Control:				
Bitumen Content and Gradation	Day's Production	2	One in AM One in PM	Time
Temperature	Day's Production	10	Five in AM Five in PM	None
Acceptance:				
Gradation		Same as for Control		
Stability	Day's Production	4*	Two in AM Two in PM	Time
Roadway Compaction	Day's Production	5	One from each of five equally divided segments	Pavement surface area
Surface Tolerance	Day's Production	day's length	total length	Transverse distance

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*Reduction in sample size allowed if the plant does not operate the full day.

Table A-3: Adjustment in Contract Price Per Unit of Measurement for Marshall Stability

Type 1,2,4 WC, BC Type 5A Base AC-40	**Type 1,2,4 WC, BC Type 5A Base AC-20**	**Type 3 Binder AC-40**	**Type 3 Wearing AC-40**	**Type 5B AC-20**	**Shoulder Mix AC-20**	**Payment Percent of Contract Unit Price/Lot)**
A	Average of Four Marshall Stability Results					
1200 & higher	1100 & higher	1400 & higher	1700 & higher	800 & higher	1000 & higher	100%
1100 to 1199	1000 to 1099	1300 to 1399	1550 to 1699	750 to 799	950 to 999	95%
1000 to 1099	900 to 999	1150 to 1299	1350 to 1549	700 to 749	900 to 949	80%
Below 1000	Below 900	Below 1150	Below 1350	Below 700	Below 900	50% or Remove
B	Average of Three Marshall Stability Results					
1150 & higher	1050 & higher	1350 & higher	1600 & higher	750 & higher	950 & higher	100%
1100 to 1149	1000 to 1049	1300 to 1349	1525 to 1599	700 to 749	900 to 949	95%
1000 to 1099	900 to 999	1150 to 1299	1350 to 1524	650 to 699	850 to 899	80%
Below 1000	Below 900	Below 1150	Below 1350	Below 650	Below 850	50% or Remove
C	Average of Two Marshall Stability Results					
1050 & higher	1000 & higher	1250 & higher	1500 & higher	700 & higher	900 & higher	100%
1000 to 1049	950 to 999	1200 to 1249	1425 to 1499	650 to 699	850 to 899	95%
900 to 999	800 to 949	1050 to 1199	1250 to 1424	600 to 649	800 to 849	80%
Below 900	Below 800	Below 1050	Below 1250	Below 600	Below 800	50% or Remove
D	One Marshall Stability Test Result					
900 & higher	800 & higher	1050 & higher	1250 & higher	600 & higher	800 & higher	100 %
Below 900	Below 800	Below 1050	Below 1250	Below 600	Below 800	50% or Remove

Table A-4: Adjustment in Contract Price Per Unit of Measurement for Roadway Density

Average of Five Roadway Samples Minimum Density Requirement (% of Laboratory Density)				Payment (Percent of Contract Unit Price/Lot)
95%	94%	93%	92%	
95 & higher	94 & higher	93 & higher	92 & higher	100%
94 to 94.9	93 to 93.9	91 to 92.9	90 to 91.9	95%
92 to 93.9	91 to 92.9	90 to 90.9	89 to 89.9	80%
Below 92	Below 91	Below 90	Below 89	50% or Remove

Table A-5: Adjustment in Contract Price Per Unit of Measurement for Surface Tolerance

Linear Percent of Roadway Exceeding Surface Tolerance		Payment (Percent of Contract Unit Price/Lot)
1/8" Tolerance*	3/16" Tolerance*	
0.0 to 1.0	0.0 to 0.50	100%
1.1 to 1.5	0.51 to 0.75	95%
1.6 to 2.5	0.76 to 1.5	80%
2.6 or More	1.6 or More	50% or Remove

*The individual surface tolerance requirements for various types of mixes are given in Subsection 501.21.

Table A-6: Adjustment in Contract Price Per Unit of Measurement for Extracted Gradation Deviations

U.S. Sieve Size			Percent of Contract Unit Price/Lot
No. 4	No. 40	No. 80	
A Average of the deviations of two tests			
0 to 1.0	0 to 1.0	0 to 1.0	100% Payment
1.1 to 4.0	1.1 to 3.0	1.1 to 3.0	98% Payment
More than 4.0	More than 3.0	More than 3.0	95% Payment
B Deviation for One Test			
0 to 2.0	0 to 2.0	0 to 2.0	100% Payment
2.1 to 5.0	2.1 to 4.0	2.1 to 4.0	98% Payment
More than 5.0	More than 4.0	More than 4.0	95% Payment

Note: The lowest percentage of contract price will be used for final adjustment in unit price for mixes deficient in any of the above listed accepted criteria.

APPENDIX B

SPECIFICATIONS FOR PORTLAND CEMENT CONCRETE

Table B-1: Delegation of Responsibilities for Control and Acceptance of Portland Cement Concrete

Control Sampling & Testing for:		Delegated to:
Mix Design		Contractor Proposes Department Approves
Gradation		Contractor
Slump	(Control Chart)	Contractor
Air Content		Contractor
Temperature		Contractor
Acceptance Sampling & Testing for:		
Compressive Strength		Department
Smoothness		Department
Thickness of Pavement Cores		Department

Table B-2: Sampling Plan for Control and Acceptance of Portland Cement Concrete

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Requirements for	Lot Size	Sample Size	Frequency	Basis of Randomness
Control:				
Gradation	Day's Pour	2 Paving 1 Structure	1 AM, 1 PM AM or PM	Time Time
Slump and Air	Paving:			
	3000', 1-lane Pour 1500', 2-lane Pour 1000', 3-lane Pour	4	2 in AM 2 in PM	Trucks
	Structure:			
	200 cu yd	2	Variable	Trucks
Acceptance:				
Compressive Strength	Paving:			
	Same as for Slump and Air	5	One from each of five equal segments	Surface Area
	Structure:			
	200 cu yd	2 batches 3 cylinders per batch	Variable	Trucks

Table B-3: Adjustment in Unit Price Per Unit of Measurement for Structural Concrete Compressive Strength

Average Compressive Strength per Lot, psi (28 to 31 days)					
Class A	**Class AA**	**Class A(M)or Class AA(M)**	**Class D**	**Class S**	**Percent Contract Price**
3800 & above	4200 & above	4400 & above	3300 & above	3800 & above	100
3400 - 3799	3800 - 4199	4000 - 4399	3000 - 3299	3400 - 3799	98
3000 - 3399	3200 - 3799	3600 - 3999	2500 - 2999	3000 - 3399	90
below 3000	below 3200	below 3600	below 2500	below 3000	50 or remove and replace

Table B-4: Adjustment in Unit Price Per Unit of Measurement for Minor Structure Concrete Compressive Strength

Average Compressive Strength, psi (28 to 31 days)		
Class A	**Class R**	**Percent Contract Price**
3,000 & above	2,000 & above	100
2,500 - 2,999	1,750 - 1,999	95
2,000 - 2,499	1,500 - 1,749	80
under 2,000	under 1,500	50 or remove and replace

Table B-5: Adjustment in Unit Price Per Unit of Measurement for Paving Concrete Compressive Strength

Average Compressive Strength of 5 Cores Per Lot (psi) (Minimum of 28 days)		Percent of Contract Unit Price Per Lot
Without Air Entrainment	**With Air Entrainment**	
4,000 and above	3,600 and above	100% Payment
3,500—3,999	3,150—3,599	95% Payment
3,000—3,499	3,000—3,149	80% Payment
below 3,000	below 3,000	50% Payment or Remove

Table B-6: Adjustment in Unit Price Per Unit of Measurement for Paving Concrete Thickness Deficiency

Deficiency in the Average Thickness of 5 Cores Per Lot Inches	Percent of Contract Price Per Lot
0— .10	100% Payment
.11— .25	95% Payment
.26— .50	80% Payment
.51—1.00	50% Payment
more than 1.00	Remove

Note: For paving concrete, when both price adjustments apply, only the greater of the two reductions will govern final payment.

APPENDIX C

COMPREHENSIVE TEST DATA

Table C-1: *Summary of Pay Reduction on Projects with Deficiency in Asphaltic Concrete Acceptance Criteria*

AVERAGE PERCENT PAY FOR PROJECTS WITH END-RESULT SPECIFICATIONS

PROJ	TOT_TONS	N_LOT	N_LOT_P	TONS_50	TONS_80	TONS_95	PPPP *
B01	5186	11	0	0	0	0	100.000
B02	35761	37	0	0	0	0	100.000
B03	4802	5	0	0	0	0	100.000
B04	8030	22	0	0	0	0	100.000
B05	7020	11	0	0	0	0	100.000
B06	13143	10	0	0	0	0	100.000
B07	15625	16	0	0	0	0	100.000
B08	5299	11	0	0	0	0	100.000
B09	10403	15	1	0	0	877	99.578
B10	13111	32	1	110	0	0	99.581
B11	10357	11	0	0	0	0	100.000
B12	6373	13	3	0	0	1811	98.579
B13	10499	25	1	0	0	571	99.728
B14	6798	5	0	0	0	0	100.000
B15	9527	17	1	0	0	1142	99.401
B16	19314	26	4	0	1932	1239	97.679
B17	5450	5	0	0	0	0	100.000
B18	7521	14	0	0	0	0	100.000
B19	8391	15	3	0	380	960	98.522
B20	14127	16	0	0	0	0	100.000
B21	3583	4	0	0	0	0	100.000
B22	49448	58	0	0	0	0	100.000
B23	61785	42	6	0	3555	2353	98.658
B24	212708	179	17	115	5010	14342	99.165
B25	233258	210	32	2560	9794	21159	98.137
B26	430313	418	59	240	17627	32992	98.760
B27	150134	179	18	196	2163	8218	99.373
B28	2193	5	0	0	0	0	100.000
B29	2779	8	0	0	0	0	100.000
B30	4086	8	0	0	0	0	100.000
B31	6234	6	0	0	0	0	100.000
B32	4337	4	0	0	0	0	100.000
B33	4671	8	0	0	0	0	100.000
B34	9060	16	0	0	0	0	100.000
B35	8866	7	0	0	0	0	100.000
B36	7213	11	0	0	0	0	100.000
B37	9526	12	1	0	0	827	99.566
B38	18049	26	0	0	0	0	100.000
B39	525	2	0	0	0	0	100.000
B40	1396	3	0	0	0	0	100.000
B41	3030	4	0	0	0	0	100.000
B42	9330	9	0	0	0	0	100.000
B43	9569	5	0	0	0	0	100.000
B44	6798	14	0	0	0	0	100.000
B47	4770	8	6	304	1782	1408	87.845
B48	8251	9	0	0	0	0	100.000
B50	3798	6	0	0	0	0	100.000
B51	3229	8	0	0	0	0	100.000
B52	2834	6	0	0	0	0	100.000
B53	330	1	0	0	0	0	100.000
B54	1731	6	1	0	502	0	94.200
B55	14213	20	0	0	0	0	100.000
B56	11295	19	1	0	0	676	99.701

AVERAGE PERCENT PAY FOR PROJECTS WITH END-RESULT SPECIFICATIONS

PROJ	TOT_TONS	N_LOT	N_LOT_P	TONS_50	TONS_80	TONS_95	PPPP
B57	5516	13	1	0	296	0	98.927
B58	83044	66	7	0	873	10923	99.132
B59	12106	15	0	0	0	0	100.000
B60	25687	37	0	0	0	0	100.000
B61	12715	30	1	260	0	0	98.978
B62	22171	21	1	0	0	68	99.985
B63	4459	10	0	0	0	0	100.000
B64	8129	22	1	0	672	0	98.347
B65	6904	6	1	0	0	834	99.396
B66	9065	10	0	0	0	0	100.000
B67	7664	9	0	0	0	0	100.000
B68	4751	8	0	0	0	0	100.000
B69	7715	8	0	0	0	0	100.000
B70	3207	5	0	0	0	0	100.000
B71	1525	6	2	0	0	960	96.852
B72	7569	5	0	0	0	0	100.000
B73	24337	25	0	0	0	0	100.000
B74	23908	24	0	0	0	0	100.000
B75	38138	73	3	0	331	2103	99.551
B76	6156	15	0	0	0	0	100.000
B77	3276	6	1	201	0	0	96.932
B78	1680	4	0	0	0	0	100.000
B79	1480	6	0	0	0	0	100.000
B80	55234	63	13	0	1937	7388	98.656
B81	3866	12	0	0	0	0	100.000
B82	7129	8	0	0	0	0	100.000
B83	7460	4	0	0	0	0	100.000
B84	12985	13	4	0	942	1971	97.790
B85	23654	31	0	0	0	0	100.000
B86	7840	15	1	0	0	57	99.964
B87	14331	18	0	0	0	0	100.000
B88	23946	28	2	0	1767	0	98.524
B89	3540	6	0	0	0	0	100.000
B90	71650	135	2	183	0	0	99.672
B91	19482	45	0	0	0	0	100.000
B92	19597	29	1	0	0	456	99.884
B93	28377	37	1	0	189	0	99.867
B94	12347	16	2	0	0	1766	99.285
B95	55215	64	1	0	125	0	99.955
B96	5053	12	2	0	0	630	99.377
B97	40658	50	0	0	0	0	100.000
B98	29252	30	0	0	0	0	100.000
B99	1917	3	0	0	0	0	100.000
C01	9737	26	0	0	0	0	100.000
C02	16604	18	3	0	0	3153	99.051
C03	23325	43	0	0	0	0	100.000
C04	6486	11	0	0	0	0	100.000
C05	26378	40	5	0	1320	1883	98.641
C06	3293	11	0	0	0	0	100.000
C07	22908	19	0	0	0	0	100.000
C08	210	2	0	0	0	0	100.000
C09	7463	6	0	0	0	0	100.000
C10	89	1	0	0	0	0	100.000

*PPPP = TOT_TONS - (0.05 x TONS_95) - (0.20 x TONS_80) - (0.50 x TONS_50) ÷ TOT_TONS

Table C-1 (Continued)

AVERAGE PERCENT PAY FOR PROJECTS WITH END-RESULT SPECIFICATIONS

PROJ	TOT_TONS	N_LOT	N_LOT_P	TONS_50	TONS_80	TONS_95	PPPP
C11	2067	2	0	0	0	0	100.000
C12	3697	5	0	0	0	0	100.000
C13	22404	46	0	0	0	0	100.000
C14	8560	12	0	0	0	0	100.000
C15	7495	9	2	0	0	2455	98.362
C16	16008	18	0	0	0	0	100.000
C17	12885	10	0	0	0	0	100.000
C18	12251	11	0	0	0	0	100.000
C19	5915	11	0	0	0	0	100.000
C20	180	2	0	0	0	0	100.000
C21	1838	2	0	0	0	0	100.000
C22	3732	5	0	0	0	0	100.000
C23	15308	22	0	0	0	0	100.000
C24	585	4	0	0	0	0	100.000
C25	15633	34	4	0	675	2674	98.281
C26	17184	14	0	0	0	0	100.000
C27	17023	25	0	0	0	0	100.000
C28	9458	13	2	936	0	70	95.015
C29	1216	2	0	0	0	0	100.000
C30	2916	10	0	0	0	0	100.000
C31	2941	5	0	0	0	0	100.000
C32	17377	20	1	0	0	806	99.768
C33	4021	5	0	0	0	0	100.000
C34	2755	4	0	0	0	0	100.000
C35	12337	10	0	0	0	0	100.000
C36	17143	29	6	0	902	3018	98.067
C37	3249	7	0	0	0	0	100.000
C38	8926	13	0	0	0	0	100.000
C39	11733	13	2	0	912	525	98.222
C40	5271	9	0	0	0	0	100.000
C41	2150	2	0	0	0	0	100.000
C42	21862	20	0	0	0	0	100.000
C43	10568	13	0	0	0	0	100.000
C44	11329	7	0	0	0	0	100.000
C45	9528	10	0	0	0	0	100.000
C46	13159	20	0	0	0	0	100.000
C47	16860	13	0	0	0	0	100.000
C48	6203	7	0	0	0	0	100.000
C49	103039	99	3	0	0	2896	99.859
C50	13439	21	4	0	783	1126	98.422
C51	3656	5	0	0	0	0	100.000
C52	3555	4	0	0	0	0	100.000
C53	898	7	0	0	0	0	100.000
C54	12949	30	1	172	0	0	99.336
C55	1558	6	0	0	0	0	100.000
C56	1400	2	0	0	0	0	100.000
C57	2142	4	0	0	0	0	100.000
C58	14128	21	0	0	0	0	100.000
C59	17671	24	3	0	1314	1957	97.959
C60	11874	16	0	0	0	0	100.000
C61	2626	8	0	0	0	0	100.000
C62	7275	9	3	0	1096	731	96.485
C63	12528	18	0	0	0	0	100.000

AVERAGE PERCENT PAY FOR PROJECTS WITH END-RESULT SPECIFICATIONS

PROJ	TOT_TONS	N_LOT	N_LOT_P	TONS_50	TONS_80	TONS_95	PPPP
C64	25686	28	0	0	0	0	100.000
C65	6306	8	0	0	0	0	100.000
C66	53061	57	1	0	0	840	99.521
C67	4395	6	0	0	0	0	100.000
C68	8192	11	0	0	0	0	100.000
C69	15382	18	0	0	0	0	100.000
C70	66056	56	26	1152	13320	17370	93.780
C71	23321	43	3	0	294	892	99.557
C72	10160	10	0	0	0	0	100.000
C73	16053	19	0	0	0	0	100.000
C74	9123	28	2	0	72	1012	99.288
C75	4286	7	0	0	0	0	100.000
C76	3158	5	0	0	0	0	100.000
C77	2552	7	0	0	0	0	100.000
C78	18929	27	0	0	0	0	100.000
C79	5321	7	0	0	0	0	100.000
C80	5731	9	0	0	0	0	100.000
C81	13706	20	0	0	0	0	100.000
C82	8221	10	1	0	677	0	98.353
C83	12595	11	0	0	0	0	100.000
C84	1365	2	0	0	0	0	100.000
C85	34600	35	1	0	0	743	99.893
C86	3060	15	0	0	0	0	100.000
C87	7783	25	2	0	523	680	98.379
C88	13966	19	1	0	0	1193	99.573
C89	666	1	0	0	0	0	100.000
C90	3794	3	0	0	0	0	100.000
C91	2826	4	0	0	0	0	100.000
C92	45	1	0	0	0	0	100.000
C93	1297	5	0	0	0	0	100.000
C94	2056	4	0	0	0	0	100.000
C95	15384	19	1	0	0	745	99.758
C96	24924	14	1	0	0	2425	99.514
C97	5174	13	1	0	0	659	99.363
C98	6587	6	0	0	0	0	100.000
C99	2806	5	1	0	0	149	99.734
D01	7757	6	0	0	0	0	100.000
D02	4227	7	0	0	0	0	100.000
D03	12090	13	0	0	0	0	100.000
D04	6690	5	0	0	0	0	100.000
D05	6596	14	0	0	0	0	100.000
D06	5550	9	1	0	0	95	99.914
D07	7462	11	0	0	0	0	100.000
D08	11619	14	0	0	0	0	100.000
D09	3159	4	0	0	0	0	100.000
D10	7295	8	0	0	0	0	100.000
D11	29063	43	1	0	0	627	99.892
D12	163	1	0	0	0	0	100.000
D13	1240	2	0	0	0	0	100.000
D14	10636	33	1	0	0	1332	99.35
D15	200945	152	8	0	0	9152	99.772
D16	12982	11	0	0	0	0	100.000
D17	12659	29	0	0	0	0	100.000
D18	15281	12	0	0	0	0	100
D19	21031	26	0	0	0	0	100
D20	7605	13	0	0	0	0	100
D21	23925	38	0	0	0	0	100
D22	370	1	0	0	0	0	100
D23	112	1	0	0	0	0	100

Table C-2: *Summary of Pay Reduction on Projects with Deficiency in Structural Concrete Strength*

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------------------------------------------ CLASS=A    DIST=1 ------------------------------------------

PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98      PPPP

   5       7453       83          0         0         0         0         0         0    100.00
   8         15        1          0         0         0         0         0         0    100.00
  11       4753      109          3         0         0        16         0       119     99.92
  13         25        3          0         0         0         0         0         0    100.00
  14          9        1          0         0         0         0         0         0    100.00
  18        112        7          0         0         0         0         0         0    100.00
  23         98        1          0         0         0         0         0         0    100.00
  73        430       24          0         0         0         0         0         0    100.00
  74          2        1          0         0         0         0         0         0    100.00
  90         11        2          0         0         0         0         0         0    100.00
  91        418        9          3         6         0        16         0        72     98.56
  92        478       21          0         0         0         0         0         0    100.00
  93        430       10          1         0         0         0         0        24     99.89
  97        825       37          0         0         0         0         0         0    100.00
  98         76        2          0         0         0         0         0         0    100.00
 128          7        2          0         0         0         0         0         0    100.00
 129          7        2          0         0         0         0         0         0    100.00
 141       8455      110          1         0         0         0         0       188     99.96
 165         93        3          0         0         0         0         0         0    100.00
 178       1596       67          1         0         0         0         0         3    100.00
 179      10371      168          2         0         0         0         0        21    100.00
 180         50        1          0         0         0         0         0         0    100.00
 184        286        6          0         0         0         0         0         0    100.00
 185       6209      110          1         0         0         0         0        69     99.98
 186       4559      109          3         0         0         0         0        65     99.97
 201          2        1          0         0         0         0         0         0    100.00
 203        342       13          0         0         0         0         0         0    100.00
 204       2222       65          0         0         0         0         0         0    100.00
 211         24        2          0         0         0         0         0         0    100.00
 213       9329      100         40       345         0      1801         0      1898     95.81
 214       6604       45          2         0         0         0         0       214     99.94
 215      25725      202          1         0         0         0         0        57    100.00
 217      17860      202          8         0         0       477         0       446     99.68
 242       3458       75          0         0         0         0         0         0    100.00
 243       1884       51          0         0         0         0         0         0    100.00
 244       2700       86          3         0         0         0         0        95     99.93
 258          9        2          0         0         0         0         0         0    100.00
 288        419       18          0         0         0         0         0         0    100.00
 302         87        1          0         0         0         0         0         0    100.00
 303        246       12          0         0         0         0         0         0    100.00
 309          5        1          0         0         0         0         0         0    100.00
 311         86        8          1         0         0         0         0        10     99.77
 313        529       30          1         0         0         0         0        21     99.92
 318       2419       24          0         0         0         0         0         0    100.00
```

Table C-2 (Continued)

CLASS=A DIST=2

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
24	344	13	0	0	0	0	0	0	100.00
66	107	4	0	0	0	0	0	0	100.00
81	404	17	1	0	0	10	0	0	99.75
82	40	2	0	0	0	0	0	0	100.00
135	73	8	2	0	0	0	0	17	99.53
139	52	3	1	0	0	0	0	17	99.35
157	227	7	1	0	0	0	0	15	99.87
158	189	8	0	0	0	0	0	0	100.00
159	65	4	0	0	0	0	0	0	100.00
161	58	2	0	0	0	0	0	0	100.00
163	98	2	0	0	0	0	0	0	100.00
164	98	2	0	0	0	0	0	0	100.00
170	910	59	1	0	0	0	0	4	99.99
171	894	42	1	0	0	0	0	5	99.99
172	1224	67	12	0	0	39	0	175	99.40
173	224	12	0	0	0	0	0	0	100.00
174	13708	250	0	0	0	0	0	0	100.00
175	6766	102	2	0	0	0	0	32	99.99
176	1633	68	9	0	0	25	0	210	99.59
177	4350	97	2	0	0	0	0	120	99.94
195	24	1	0	0	0	0	0	0	100.00
199	26	2	0	0	0	0	0	0	100.00
250	16	1	0	0	0	0	0	0	100.00
263	76	1	0	0	0	0	0	0	100.00
315	21	1	0	0	0	0	0	0	100.00
319	76	6	0	0	0	0	0	0	100.00
320	21	1	0	0	0	0	0	0	100.00

CLASS=A DIST=3

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
26	54	3	0	0	0	0	0	0	100.00
47	83	4	0	0	0	0	0	0	100.00
49	526	6	0	0	0	0	0	0	100.00
50	657	18	0	0	0	0	0	0	100.00
51	87	9	0	0	0	0	0	0	100.00
52	570	30	0	0	0	0	0	0	100.00
54	161	7	2	0	0	0	0	48	99.40
70	529	25	5	0	0	49	0	76	98.79
77	15	1	0	0	0	0	0	0	100.00
113	3	1	0	0	0	0	0	0	100.00
117	91	2	0	0	0	0	0	0	100.00
181	2013	59	6	0	0	23	0	203	99.68
182	357	20	0	0	0	0	0	0	100.00
219	534	28	1	0	0	0	0	27	99.90
220	320	20	0	0	0	0	0	0	100.00
225	79	3	0	0	0	0	0	0	100.00
236	1700	61	0	0	0	0	0	0	100.00
237	18653	114	0	0	0	0	0	0	100.00
238	1917	76	7	0	0	0	0	114	99.88

Table C-2 (Continued)

```
------------------------------------- CLASS=A      DIST=3 --------------------------------------

  PROJ    TOT_QTY    N_LOT   N_LOT_P   QTY_50   QTY_80   QTY_90   QTY_95   QTY_98     PPPP

   239     1645        37        5        0        0        0        0      221      99.73
   240     3270        89        0        0        0        0        0        0     100.00
   291      559        25        0        0        0        0        0        0     100.00
   292      144        13        1        2        0        0        0        0      99.31

------------------------------------- CLASS=A      DIST=4 --------------------------------------

  PROJ    TOT_QTY    N_LOT   N_LOT_P   QTY_50   QTY_80   QTY_90   QTY_95   QTY_98     PPPP

    30        4         1        0        0        0        0        0        0     100.00
    31      419        26        0        0        0        0        0        0     100.00
    32      112         6        0        0        0        0        0        0     100.00
    40      611        30        0        0        0        0        0        0     100.00
    41      120         5        0        0        0        0        0        0     100.00
    42      206        14        2        0        0        0        0       16      99.84
   104      487        31        0        0        0        0        0        0     100.00
   106      242        17        0        0        0        0        0        0     100.00
   149      127         4        0        0        0        0        0        0     100.00
   151      209        23        0        0        0        0        0        0     100.00
   230       16         1        0        0        0        0        0        0     100.00
   231       32         5        0        0        0        0        0        0     100.00
   234      186         6        0        0        0        0        0        0     100.00
   265       53         3        0        0        0        0        0        0     100.00
   304      148         9        0        0        0        0        0        0     100.00
   305      222        13        0        0        0        0        0        0     100.00

------------------------------------- CLASS=A      DIST=5 --------------------------------------

  PROJ    TOT_QTY    N_LOT   N_LOT_P   QTY_50   QTY_80   QTY_90   QTY_95   QTY_98     PPPP

    60      188        24        0        0        0        0        0        0     100.00
    64      237        14        0        0        0        0        0        0     100.00
   134     5176       104        0        0        0        0        0        0     100.00
   154       44         3        0        0        0        0        0        0     100.00
   188      216         8        0        0        0        0        0        0     100.00
   209     5005       151        2        3        0        0        0       22      99.96
   262       20         2        0        0        0        0        0        0     100.00
   294      292        14        0        0        0        0        0        0     100.00
```

Table C-2 (Continued)

CLASS=A DIST=6

PROJ	TOT_QTY	N_LCT	N_LCT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
25	1479	55	0	0	0	0	0	0	100.00
29	56	2	0	0	0	0	0	0	100.00
36	32	5	2	0	0	0	0	39	99.05
39	60	1	0	0	0	0	0	0	100.00
44	0	1	0	0	0	0	0	0	.
45	465	29	4	0	0	0	0	72	99.69
46	233	11	1	0	0	0	0	4	99.97
62	427	20	2	0	0	0	0	33	99.85
63	267	20	0	0	0	0	0	0	100.00
67	424	14	0	0	0	0	0	0	100.00
107	65	4	0	0	0	0	0	0	100.00
118	85	2	0	0	0	0	0	0	100.00
122	2	1	0	0	0	0	0	0	100.00
125	15	4	0	0	0	0	0	0	100.00
126	10	1	0	0	0	0	0	0	100.00
127	272	15	1	0	0	0	0	13	99.90
130	428	22	1	0	0	0	0	33	99.85
152	71	5	0	0	0	0	0	0	100.00
187	639	41	0	0	0	0	0	0	100.00
306	122	11	0	0	0	0	0	0	100.00
307	35	2	0	0	0	0	0	0	100.00
312	356	15	1	0	0	0	0	12	99.93
321	437	23	0	0	0	0	0	0	100.00

CLASS=A DIST=7

PROJ	TOT_QTY	N_LCT	N_LCT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
38	80	4	0	0	0	0	0	0	100.00
68	255	11	6	0	0	0	0	120	99.06
121	116	4	0	0	0	0	0	0	100.00
123	21	2	0	0	0	0	0	0	100.00
124	35	1	0	0	0	0	0	0	100.00
131	1033	20	2	0	0	0	0	162	99.70
255	11	1	0	0	0	0	0	0	100.00

CLASS=A DIST=8

PROJ	TOT_QTY	N_LCT	N_LCT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
84	518	31	0	0	0	0	0	0	100
142	54	1	0	0	0	0	0	0	100
144	10	4	0	0	0	0	0	0	100
146	264	10	0	0	0	0	0	0	100
207	268	9	0	0	0	0	0	0	100
296	7	1	0	0	0	0	0	0	100

Table C-2 (Continued)

CLASS=A DIST=9

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
35	8	1	0	0	0	0	0	0	100.00
147	180	4	0	0	0	0	0	0	100.00
159	260	13	0	0	0	0	0	0	100.00
241	2493	74	1	0	0	0	0	49	99.96
246	415	19	0	0	0	0	0	0	100.00
247	2011	72	0	0	0	0	0	0	100.00
248	88	5	0	0	0	0	0	0	100.00
249	310	10	0	0	0	0	0	0	100.00
314	397	19	0	0	0	0	0	0	100.00
316	745	27	2	0	0	20	0	24	99.67

CLASS=A N DIST=1

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
5	256	25	0	0	0	0	0	0	100.00
6	3333	71	1	0	0	0	50	0	99.92
7	3	1	0	0	0	0	0	0	100.00
8	73	3	0	0	0	0	0	0	100.00
9	3	1	0	0	0	0	0	0	100.00
10	3	3	0	0	0	0	0	0	100.00
11	1859	63	1	0	14	0	0	0	99.85
12	4	2	0	0	0	0	0	0	100.00
14	13	3	0	0	0	0	0	0	100.00
15	44	5	0	0	0	0	0	0	100.00
16	30	8	0	0	0	0	0	0	100.00
17	2	1	0	0	0	0	0	0	100.00
18	3	2	0	0	0	0	0	0	100.00
19	3	2	0	0	0	0	0	0	100.00
20	22	2	0	0	0	0	0	0	100.00
72	17	1	0	0	0	0	0	0	100.00
74	14	6	1	0	2	0	0	0	97.14
88	2	1	0	0	0	0	0	0	100.00
89	6	1	0	0	0	0	0	0	100.00
90	150	20	1	0	0	0	3	0	99.90
91	353	39	1	0	0	0	3	0	99.96
92	29	2	0	0	0	0	0	0	100.00
94	40	2	0	0	0	0	0	0	100.00
95	20	1	0	0	0	0	0	0	100.00
96	36	2	0	0	0	0	0	0	100.00
97	711	33	2	2	0	0	50	0	99.51
98	50	1	0	0	0	0	0	0	100.00
128	274	38	0	0	0	0	0	0	100.00
129	1613	148	1	0	0	0	0	45	99.94
141	200	4	0	0	0	0	0	0	100.00
148	32	4	0	0	0	0	0	0	100.00
165	95	5	0	0	0	0	0	0	100.00
166	250	5	0	0	0	0	0	0	100.00
167	1622	53	3	0	0	0	100	0	99.69
168	3	1	0	0	0	0	0	0	100.00
178	172	9	0	0	0	0	0	0	100.00

Table C-2 (Continued)

CLASS=A N DIST=1

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
179	623	17	0	0	0	0	0	0	100.00
180	247	10	0	0	0	0	0	0	100.00
183	1	1	0	0	0	0	0	0	100.00
185	629	40	0	0	0	0	0	0	100.00
186	756	23	0	0	0	0	0	0	100.00
200	30	8	0	0	0	0	0	0	100.00
202	4	2	0	0	0	0	0	0	100.00
203	243	11	0	0	0	0	0	0	100.00
204	2121	138	1	0	0	0	4	0	99.99
205	8253	150	0	0	0	0	0	0	100.00
206	60	8	0	0	0	0	0	0	100.00
211	153	8	0	0	0	0	0	0	100.00
212	62	6	0	0	0	0	0	0	100.00
215	39	4	1	0	0	0	13	0	98.33
216	1023	30	0	0	0	0	0	0	100.00
217	410	45	0	0	0	0	0	0	100.00
242	41	2	0	0	0	0	0	0	100.00
245	4	1	0	0	0	0	0	0	100.00
258	27	3	0	0	0	0	0	0	100.00
259	44	2	0	0	0	0	0	0	100.00
261	70	1	0	0	0	0	0	0	100.00
264	431	13	0	0	0	0	0	0	100.00
272	5	1	0	0	0	0	0	0	100.00
274	11	2	0	0	0	0	0	0	100.00
285	15	4	0	0	0	0	0	0	100.00
286	16	4	0	0	0	0	0	0	100.00
287	32	8	2	0	0	0	5	5	98.91
288	1027	56	1	0	0	0	5	0	99.98
289	10	1	0	0	0	0	0	0	100.00
300	7	1	0	0	0	0	0	0	100.00
303	12	1	0	0	0	0	0	0	100.00
308	3	1	0	0	0	0	0	0	100.00
313	16	1	0	0	0	0	0	0	100.00
318	20	1	0	0	0	0	0	0	100.00

CLASS=A N DIST=2

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
4	860	67	0	0	0	0	0	0	100.00
24	1	1	0	0	0	0	0	0	100.00
28	102	2	0	0	0	0	0	0	100.00
81	18	1	0	0	0	0	0	0	100.00
82	536	11	0	0	0	0	0	0	100.00
109	322	31	0	0	0	0	0	0	100.00
110	31	4	1	23	0	0	0	0	62.90
136	81	8	0	0	0	0	0	0	100.00
137	31	3	0	0	0	0	0	0	100.00
138	14	3	0	0	0	0	0	0	100.00
139	5	1	0	0	0	0	0	0	100.00
140	7	1	0	0	0	0	0	0	100.00

Table C-2 (Continued)

CLASS=A N DIST=2

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
153	6	1	0	0	0	0	0	0	100.00
156	7	1	0	0	0	0	0	0	100.00
157	31	3	0	0	0	0	0	0	100.00
160	16	1	0	0	0	0	0	0	100.00
161	38	5	1	0	4	0	0	0	97.89
162	7	1	0	0	0	0	0	0	100.00
163	4	1	0	0	0	0	0	0	100.00
164	2	1	0	0	0	0	0	0	100.00
170	638	12	0	0	0	0	0	0	100.00
171	76	14	1	0	0	0	0	13	99.66
172	11	2	0	0	0	0	0	0	100.00
173	468	31	0	0	0	0	0	0	100.00
174	155	27	0	0	0	0	0	0	100.00
175	432	36	0	0	0	0	0	0	100.00
176	171	28	0	0.	0	0	0	0	100.00
177	126	29	0	0	0	0	0	0	100.00
192	42	8	0	0	0	0	0	0	100.00
193	98	9	0	0	0	0	0	0	100.00
195	439	28	3	0	2	0	41	0	99.44
196	146	5	0	0	0	0	0	0	100.00
197	363	24	0	0	0	0	0	0	100.00
198	201	14	0	0	0	0	0	0	100.00
199	1072	78	0	0	0	0	0	0	100.00
257	20	2	0	0	0	0	0	0	100.00
263	2	1	0	0	0	0	0	0	100.00
271	37	7	0	0	0	0	0	0	100.00
275	29	4	0	0	0	0	0	0	100.00
279	17	5	0	0	0	0	0	0	100.00
301	813	30	0	0	0	0	0	0	100.00
315	1	1	0	0	0	0	0	0	100.00
319	162	29	0	0	0	0	0	0	100.00
320	111	17	0	0	0	0	0	0	100.00

CLASS=A N DIST=3

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
1	4	1	.	.	.	.	.	.	.
50	37	4	0	0	0	0	0	0	100.00
52	44	1	0	0	0	0	0	0	100.00
53	168	18	0	0	0	0	0	0	100.00
54	1644	64	0	0	0	0	0	0	100.00
55	225	11	1	0	0	0	12	0	99.73
56	433	28	1	0	0	0	20	0	99.77
67	5	1	0	0	0	0	0	0	100.00
70	207	18	0	0	0	0	0	0	100.00
76	13	3	0	0	0	0	0	0	100.00
77	139	7	0	0	0	0	0	0	100.00
79	14	5	0	0	0	0	0	0	100.00
108	10	1	0	0	0	0	0	0	100.00
112	49	13	0	0	0	0	0	0	100.00

Table C-2 (Continued)

CLASS=A N DIST=3

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
113	34	28	1	1	0	0	0	0	99.40
114	1	1	0	0	0	0	0	0	100.00
115	74	4	0	0	0	0	0	0	100.00
116	50	1	0	0	0	0	0	0	100.00
117	56	6	0	0	0	0	0	0	100.00
181	2	1	0	0	0	0	0	0	100.00
182	60	5	0	0	0	0	0	0	100.00
218	5109	82	0	0	0	0	0	0	100.00
219	59	2	0	0	0	0	0	0	100.00
221	292	9	0	0	0	0	0	0	100.00
222	483	15	0	0	0	0	0	0	100.00
223	1723	24	0	0	0	0	0	0	100.00
224	252	12	0	0	0	0	0	0	100.00
225	6	1	0	0	0	0	0	0	100.00
226	14	3	0	0	0	0	0	0	100.00
227	31	2	0	0	0	0	0	0	100.00
236	60	10	1	0	0	0	28	0	97.67
237	45	2	0	0	0	0	0	0	100.00
238	1319	38	1	0	0	0	50	0	99.81
239	97	3	0	0	0	0	0	0	100.00
240	127	5	0	0	0	0	0	0	100.00
273	20	2	0	0	0	0	0	0	100.00
280	11	2	0	0	0	0	0	0	100.00
284	1815	70	1	0	0	0	50	0	99.86
290	2575	123	0	0	0	0	0	0	100.00
292	5	2	0	0	0	0	0	0	100.00

CLASS=A N DIST=4

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
2	195	6	0	0	0	0	0	0	100.00
31	551	14	0	0	0	0	0	0	100.00
32	129	5	0	0	0	0	0	0	100.00
33	112	3	0	0	0	0	0	0	100.00
40	2872	168	14	0	43	0	159	0	99.42
42	37	5	0	0	0	0	0	0	100.00
65	27	1	0	0	0	0	0	0	100.00
103	6	1	0	0	0	0	0	0	100.00
104	169	17	1	0	0	0	14	0	99.59
132	3	1	0	0	0	0	0	0	100.00
149	5	2	0	0	0	0	0	0	100.00
150	992	34	6	0	0	0	164	0	99.17
151	4	2	0	0	0	0	0	0	100.00
229	2	1	0	0	0	0	0	0	100.00
230	2235	74	1	0	0	0	9	0	99.98
231	432	35	1	0	11	0	0	0	99.49
232	14	3	0	0	0	0	0	0	100.00
233	5	1	0	0	0	0	0	0	100.00
234	6	1	0	0	0	0	0	0	100.00
235	35	9	1	0	2	0	0	0	97.14

Table C-2 (Continued)

```
------------------------------------ CLASS=A N   DIST=4 ------------------------------------

  PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98    PPPP

   304       112        6         0          0         0         0         0         0      100
   310       130        8         0          0         0         0         0         0      100

------------------------------------ CLASS=A N   DIST=5 ------------------------------------

  PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98    PPPP

     3       182        9         0          0         0         0         0         0      100
    27         7        4         0          0         0         0         0         0      100
    57        51        8         0          0         0         0         0         0      100
    58         7        1         0          0         0         0         0         0      100
    59       260       34         0          0         0         0         0         0      100
    61       203       12         0          0         0         0         0         0      100
   100       200        8         0          0         0         0         0         0      100
   101       121        3         0          0         0         0         0         0      100
   102       181       11         0          0         0         0         0         0      100
   134        48        3         0          0         0         0         0         0      100
   154         4        1         0          0         0         0         0         0      100
   155         7        1         0          0         0         0         0         0      100
   188       110        7         0          0         0         0         0         0      100
   189        84        7         0          0         0         0         0         0      100
   190        25        3         0          0         0         0         0         0      100
   191      1992       46         0          0         0         0         0         0      100
   194       252       11         0          0         0         0         0         0      100
   203        89       11         0          0         0         0         0         0      100
   253         3        1         0          0         0         0         0         0      100
   266         8        2         0          0         0         0         0         0      100
   270        35        4         0          0         0         0         0         0      100
   278        29        5         0          0         0         0         0         0      100
   283        10        2         0          0         0         0         0         0      100
   293       208        7         0          0         0         0         0         0      100
   294      1710       99         0          0         0         0         0         0      100
   297        30        4         0          0         0         0         0         0      100
   298        14        2         0          0         0         0         0         0      100

------------------------------------ CLASS=A N   DIST=6 ------------------------------------

  PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98      PPPP

    25       491       19         0          0         0         0         0         0    100.00
    29       210       20         1          0         0         0         2         0     99.95
    43        83        6         1          0         0         0         0         4     99.90
    44        54        3         0          0         0         0         0         0    100.00
    45       454        8         1          0         0         0         0        32     99.66
    63        11        6         0          0         0         0         0         0    100.00
    69       205       12         0          0         0         0         0         0    100.00
    78         3        2         0          0         0         0         0         0    100.00
   107       435       13         0          0         0         0         0         0    100.00
   113         4        1         0          0         0         0         0         0    100.00
   119       177        8         0          0         0         0         0         0    100.00
```

Table C-2 (Continued)

```
---------------------------------------- CLASS=A N   DIST=6 ----------------------------------------

  PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98      PPPP

   122       807       87        0          0         0         0         0         0       100.00
   125        36        4        0          0         0         0         0         0       100.00
   126      1026       56        0          0         0         0         0         0       100.00
   127       101        5        0          0         0         0         0         0       100.00
   130      1003        7        0          0         0         0         0         0       100.00
   152         8        1        0          0         0         0         0         0       100.00
   187       245        1        0          0         0         0         0         0       100.00
   255       527       15        0          0         0         0         0         0       100.00
   269         9        2        0          0         0         0         0         0       100.00
   312      2030        9        0          0         0         0         0         0       100.00
   321       140       17        1          0         0         0         3         0        99.89

---------------------------------------- CLASS=A N   DIST=7 ----------------------------------------

  PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98      PPPP

    68       978       29        0          0         0         0         0         0        100
   120       148       19        0          0         0         0         0         0        100
   124       505       23        0          0         0         0         0         0        100
   131        83        7        0          0         0         0         0         0        100
   268        26        2        0          0         0         0         0         0        100
   276        42        1        0          0         0         0         0         0        100
   281        35        1        0          0         0         0         0         0        100
   317         5        2        0          0         0         0         0         0        100

---------------------------------------- CLASS=A N   DIST=8 ----------------------------------------

  PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98      PPPP

    22        23        1        0          0         0         0         0         0        100
    84       342       27        0          0         0         0         0         0        100
    85         3        1        0          0         0         0         0         0        100
    86         5        1        0          0         0         0         0         0        100
   143         2        1        0          0         0         0         0         0        100
   145         9        2        0          0         0         0         0         0        100
   146       595       61        0          0         0         0         0         0        100
   210         7        1        0          0         0         0         0         0        100
   256         4        1        0          0         0         0         0         0        100
   267        34        1        0          0         0         0         0         0        100
   299       101        3        0          0         0         0         0         0        100
```

Table C-2 (Continued)

CLASS=A N DIST=9

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
34	2660	63	1	0	0	0	6	0	99.99
35	1594	63	1	0	0	0	3	0	99.99
75	215	15	0	0	0	0	0	0	100.00
169	982	37	0	0	0	0	0	0	100.00
208	484	21	0	0	0	0	0	0	100.00
243	778	63	1	0	0	0	1	0	99.99
251	137	5	0	0	0	0	0	0	100.00
252	114	3	1	0	50	0	0	0	91.23
277	19	3	0	0	0	0	0	0	100.00
282	12	2	0	0	0	0	0	0	100.00
316	74	4	0	0	0	0	0	0	100.00

CLASS=AA DIST=1

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
11	4844	105	5	0	0	16	0	102	99.92
18	440	14	5	0	0	4	0	172	99.13
91	122	6	2	0	0	29	0	27	97.18
92	100	5	1	0	0	0	0	11	99.78
93	1073	29	8	0	0	117	0	235	98.47
99	11	1	0	0	0	0	0	0	100.00
141	2796	52	1	0	0	0	0	24	99.98
173	2683	105	23	0	0	20	3	649	99.44
179	7483	197	37	8	0	241	0	1412	99.25
184	230	5	4	0	0	68	0	155	95.70
185	4922	61	1	0	0	0	0	136	99.94
186	4351	88	19	0	0	236	0	769	99.10
204	1430	29	3	0	0	26	0	149	99.61
215	4390	68	0	0	0	0	0	0	100.00
217	14328	170	5	0	0	2	0	50	99.99
242	11149	189	4	0	0	0	0	240	99.96
243	11598	197	1	0	0	0	0	37	99.99
244	10786	172	8	0	0	46	0	427	99.88
302	75	2	1	0	0	0	0	25	99.33
303	270	13	6	0	0	0	0	116	99.14
311	439	19	1	0	0	0	0	2	99.99
313	1527	44	4	0	0	0	0	30	99.96

CLASS=AA DIST=2

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
24	4758	148	0	0	0	0	0	0	100.00
80	12	2	0	0	0	0	0	0	100.00
81	123	3	1	0	0	0	0	40	99.35
82	172	4	4	0	0	129	0	43	92.00
135	158	4	0	0	0	0	0	0	100.00
161	217	8	0	0	0	0	0	0	100.00
163	10	2	0	0	0	0	0	0	100.00

Table C-2 (Continued)

CLASS=AA DIST=2

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
164	13	2	0	0	0	0	0	0	100.00
170	684	32	1	0	0	0	0	151	99.56
171	2687	59	11	0	0	16	0	162	99.82
172	5353	137	31	0	0	176	0	865	99.35
173	289	10	0	0	0	0	0	0	100.00
174	6867	182	5	0	0	0	0	93	99.97
175	4893	88	18	0	0	12	0	258	99.85
176	4301	66	13	0	0	5	0	489	99.76
177	5116	134	25	0	0	12	0	1007	99.58
263	117	14	0	0	0	0	0	0	100.00

CLASS=AA DIST=3

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
47	283	6	5	0	0	0	0	203	98.57
43	736	24	7	0	0	16	0	323	98.90
51	397	17	4	0	0	0	0	62	99.69
52	1578	61	14	0	0	12	0	220	99.65
70	607	21	8	0	0	102	0	200	98.24
219	297	8	1	0	0	0	0	20	99.87
220	17	2	0	0	0	0	0	0	100.00
226	4	1	0	0	0	0	0	0	100.00
236	41	8	0	0	0	0	0	0	100.00
237	6151	83	3	0	0	0	0	67	99.98
238	204	19	13	4	0	110	0	48	93.16
240	2134	67	10	0	0	0	0	93	99.91
292	441	12	5	0	0	0	0	206	99.07

CLASS=AA DIST=4

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
31	785	40	6	0	0	52	0	132	99.00
40	918	28	0	0	0	0	0	0	100.00
41	101	4	2	0	0	0	0	87	98.28
42	40	5	0	0	0	0	0	0	100.00
104	729	28	1	0	0	0	0	7	99.98
106	783	46	4	0	0	0	0	35	99.91
149	151	10	0	0	0	0	0	0	100.00
151	597	33	1	0	0	0	0	2	99.99
230	3	1	0	0	0	0	0	0	100.00
265	796	39	14	10	0	43	0	128	98.49
304	298	22	5	0	0	0	0	20	99.86
305	578	25	3	0	0	0	0	81	99.72

Table C-2 (Continued)

```
---------------------------------------- CLASS=AA    DIST=5 ----------------------------------------

   PROJ    TOT_QTY     N_LOT    N_LOT_P     QTY_50     QTY_80     QTY_90     QTY_95     QTY_98       PPPP

     64        231         8          0          0          0          0          0          0     100.00
    134       5170        88          0          0          0          0          0          0     100.00
    209       4788       195          3          0          0          0          0          8     100.00
    294        671        32          2          0          0        149          0        199      97.83

---------------------------------------- CLASS=AA    DIST=6 ----------------------------------------

   PROJ    TOT_QTY     N_LOT    N_LOT_P     QTY_50     QTY_80     QTY_90     QTY_95     QTY_98       PPPP

     25        406        18          0          0          0          0          0          0     100.00
     39        396        10          0          0          0          0          0          0     100.00
     45         20         3          2          0          0          6          0          3      96.70
     62        671        20          7          0          0        133          0        175      97.50
    118        233        11          0          0          0          0          0          0     100.00
    127          5         1          0          0          0          0          0          0     100.00
    152        368        11          0          0          0          0          0          0     100.00
    187        457        16          6          0          0         90          0         91      97.63
    306        358        19          0          0          0          0          0          0     100.00
    307        334         8          1          0          0          0          0          8      99.95

---------------------------------------- CLASS=AA    DIST=7 ----------------------------------------

   PROJ    TOT_QTY     N_LOT    N_LOT_P     QTY_50     QTY_80     QTY_90     QTY_95     QTY_98       PPPP

     37        113         5          0          0          0          0          0          0     100.00
     68        652        19         14          0          0        138          0        299      96.97
    121        257         6          0          0          0          0          0          0     100.00
    123          3         1          0          0          0          0          0          0     100.00
    131        970        19         13          0          0         84          0        437      98.23

---------------------------------------- CLASS=AA    DIST=8 ----------------------------------------

   PROJ    TOT_QTY     N_LOT    N_LOT_P     QTY_50     QTY_80     QTY_90     QTY_95     QTY_98       PPPP

     21          4         1          0          0          0          0          0          0     100.00
    146        613        17          1          0          0          0          0          6      99.98

---------------------------------------- CLASS=AA    DIST=9 ----------------------------------------

   PROJ    TOT_QTY     N_LOT    N_LOT_P     QTY_50     QTY_80     QTY_90     QTY_95     QTY_98       PPPP

    147        263        10          0          0          0          0          0          0     100.00
    241       4380        64          4          0          0          0          0         71      99.97
    246       1744        28          4         36          0         26          0        112      98.69
    247        349         7          0          0          0          0          0          0     100.00
    250        231         4          0          0          0          0          0          0     100.00
    314       1590        59          8          0          0         36          0        253      99.46
    316        148         4          0          0          0          0          0          0     100.00
```

Table C-2 (Continued)

CLASS=R N DIST=1

PROJ	TOT_QTY	N_LCT	N_LCT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
143	6	2	0	0	0	0	0	0	100.00
186	190	10	3	23	11	0	6	0	92.63
204	54	7	0	0	0	0	0	0	100.00
207	84	13	1	0	0	0	8	0	99.52
211	9	1	0	0	0	0	0	0	100.00
212	12	1	0	0	0	0	0	0	100.00
217	15	1	0	0	0	0	0	0	100.00

CLASS=R N DIST=2

PROJ	TOT_QTY	N_LCT	N_LCT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
81	11	1	0	0	0	0	0	0	100
135	100	2	0	0	0	0	0	0	100
170	876	15	0	0	0	0	0	0	100
172	789	3	0	0	0	0	0	0	100
173	8	2	0	0	0	0	0	0	100
174	23	6	0	0	0	0	0	0	100
176	24	1	0	0	0	0	0	0	100

CLASS=R N DIST=3

PROJ	TOT_QTY	N_LCT	N_LCT_P	QTY_50	QTY_80	QTY_90	QTY_95	QTY_98	PPPP
55	114	6	0	0	0	0	0	0	100.00
70	184	5	1	0	45	0	0	0	95.11
71	15	1	0	0	0	0	0	0	100.00
111	26	2	0	0	0	0	0	0	100.00
116	150	3	0	0	0	0	0	0	100.00
182	36	3	0	0	0	0	0	0	100.00
219	508	19	0	0	0	0	0	0	100.00
221	60	3	1	0	0	0	24	0	98.00
226	33	2	0	0	0	0	0	0	100.00
236	477	18	0	0	0	0	0	0	100.00
237	234	17	0	0	0	0	0	0	100.00
238	545	20	0	0	0	0	0	0	100.00
239	53	6	0	0	0	0	0	0	100.00
240	333	24	0	0	0	0	0	0	100.00

Table C-2 (Continued)

```
------------------------------------------ CLASS=R N    DIST=4 ------------------------------------------

 PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98      PPPP

  32        64        2         0          0         0         0         0         0       100.00
  40       142       14         2          5        10         0         0         0        96.83
 104       415       34        13         70        12         0        61         0        90.25
 105        86        4         0          0         0         0         0         0       100.00
 106        26        2         1          0         0         0         8         0        98.46
 228       249       15         1         24         0         0         0         0        95.18
 234       191        4         0          0         0         0         0         0       100.00
 304        22        2         0          0         0         0         0         0       100.00

------------------------------------------ CLASS=R N    DIST=5 ------------------------------------------

 PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98      PPPP

 133        26        1         0          0         0         0         0         0       100.00
 138        27        2         0          0         0         0         0         0       100.00
 209      2205       67         8         43        30         0       188         0        93.21

------------------------------------------ CLASS=R N    DIST=6 ------------------------------------------

  PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98     PPPP

   36        64        3         0          0         0         0         0         0        100
   62       155        1         0          0         0         0         0         0        100
  107       310       10         0          0         0         0         0         0        100
  122        49        3         0          0         0         0         0         0        100
  254        66        4         0          0         0         0         0         0        100
  321       103        8         0          0         0         0         0         0        100

------------------------------------------ CLASS=R N    DIST=7 ------------------------------------------

  PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98     PPPP

  120        75        6         0          0         0         0         0         0        100

------------------------------------------ CLASS=R N    DIST=9 ------------------------------------------

 PROJ    TOT_QTY    N_LOT    N_LOT_P    QTY_50    QTY_80    QTY_90    QTY_95    QTY_98      PPPP

  35        57        2         0          0         0         0         0         0       100.00
  83         1        1         0          0         0         0         0         0       100.00
  87        11        1         0          0         0         0         0         0       100.00
 169       365       14         2          0         0         0        70         0        99.04
 314        18        1         0          0         0         0         0         0       100.00
```

Table C-3: Summary of Pay Reduction on Projects with Deficiency in Strength and Thickness of Paving Concrete

PROJ	TOT_QTY	N_LOT	N_LOT_P	QTY_50	QTY_80	QTY_95	PPPD
1	2824	3	0	0	0	0	100.0
2	10478	3	0	0	0	0	100.0
3	342	1	0	0	0	0	100.0
4	71184	20	0	0	0	0	100.0
5	1789	1	0	0	0	0	100.0
6	617	1	0	0	0	0	100.0
7	2490	1	0	0	0	0	100.0
8	704	1	0	0	0	0	100.0
9	1495	1	0	0	0	0	100.0
10	119321	14	0	0	0	0	100.0
11	121410	31	0	0	0	0	100.0
12	50931	14	0	0	0	0	100.0
13	552	1	0	0	0	0	100.0
14	47412	13	0	0	0	0	100.0
15	3799	2	0	0	0	0	100.0
16	6348	2	0	0	0	0	100.0
17	64	1	0	0	0	0	100.0
18	7075	2	0	0	0	0	100.0
19	60000	15	0	0	0	0	100.0
20	27369	8	0	0	0	0	100.0
21	350	1	0	0	0	0	100.0
22	2715	1	0	0	0	0	100.0
23	449	1	0	0	0	0	100.0
24	781	1	0	0	0	0	100.0
25	4800	2	0	0	0	0	100.0
26	25442	8	0	0	0	0	100.0
27	24000	6	1	0	0	3200	99.3
28	74217	18	0	0	0	0	100.0
29	24078	9	0	0	0	0	100.0
30	52000	13	1	0	0	1600	99.8
31	42818	13	0	0	0	0	100.0
32	45090	12	0	0	0	0	100.0
33	1419	1	0	0	0	0	100.0
34	30251	9	0	0	0	0	100.0
35	1879	1	0	0	0	0	100.0
36	20895	6	0	0	0	0	100.0
37	6000	2	0	0	0	0	100.0
38	2806	1	0	0	0	0	100.0
39	57692	19	0	0	0	0	100.0
40	19020	5	0	0	0	0	100.0
41	13838	6	0	0	0	0	100.0
42	18481	4	0	0	0	0	100.0
43	204	1	0	0	0	0	100.0
44	24395	6	0	0	0	0	100.0
45	4338	1	0	0	0	0	100.0
46	470	1	0	0	0	0	100.0
47	79992	24	0	0	0	0	100.0
48	38076	13	0	0	0	0	100.0
49	3251	2	0	0	0	0	100.0
50	622	1	0	0	0	0	100.0
51	292	1	0	0	0	0	100.0
52	791	1	0	0	0	0	100.0
53	706	1	0	0	0	0	100.0
54	346441	88	0	0	0	0	100.0
55	66516	20	0	0	0	0	100.0
56	1913	1	0	0	0	0	100.0
57	1148	1	0	0	0	0	100.0
58	4000	1	0	0	0	0	100.0
59	1642	2	0	0	0	0	100.0
60	15588	5	0	0	0	0	100.0
61	8850	2	0	0	0	0	100.0
62	6691	3	0	0	0	0	100.0
63	31413	8	0	0	0	0	100.0
64	11548	3	0	0	0	0	100.0
65	659	1	0	0	0	0	100.0
66	9746	6	0	0	0	0	100.0
67	870	1	0	0	0	0	100.0
68	681	1	0	0	0	0	100.0
69	21629	8	0	0	0	0	100.0
70	415	1	0	0	0	0	100.0
71	4000	2	0	0	0	0	100.0
72	4322	2	0	0	0	0	100.0
73	13042	4	0	0	0	0	100.0