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HBP PILOT VOID ACCEPTANCE PROJECTS COMPLETED IN 1993-1996

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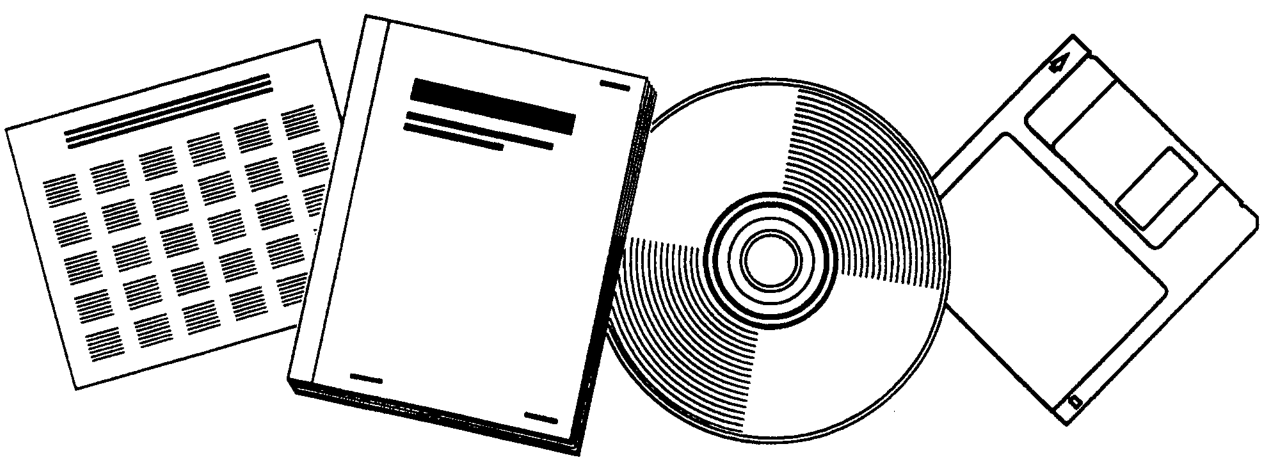

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HBP Pilot Void Acceptance Projects Completed in 1993-1996

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13. ABSTRACT (Maximum 200 words)

In 1993, CDOT recognized that specifying HBP volumetric properties would likely provide superior pavements. A long range goal was set for acceptance to be based on voids properties (VA). Beginning in 1993, a series of VA pilot projects were let to contract; by the end of 1996, nine had been completed. Six had conventional mix designs. The last three were designed using Superpave technology. The data for the nine VA projects is summarized and compared with data from concurrent CDOT projects under Quality Level Analysis (QLA). The quality levels and pay facotrs for VA projects are somewhat to considerably less than for the concurrent QLA projects. This is attributed to (1) changes in specifications, test methods, and test equipment made during the pilot program, (2) large sampling and testing variability associated with voids testing, and (3) contractor unfamiliarity with the new concepts and parameter interactions. The VA projects are expected to perform as well as the QLA projects.

Implementation: The long range goal should not change, but VA implementation should be slowed while test methods are refined. During this time, implement Superpave technology. As soon as practical the QLA and VA technologies should be merged into a single specification.

14. SUBJECT TERMS

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HOT BITUMINOUS PAVEMENT PILOT VOID ACCEPTANCE PROJECTS COMPLETED IN 1993 -1996

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HOT BITUMINOUS PAVEMENT PILOT VOID ACCEPTANCE PROJECTS COMPLETED IN 1993 -1996

BACKGROUND OF VOID ACCEPTANCE PILOT PROJECTS

In the late 1980's the Colorado Department of Transportation (CDOT) was very actively engaged in improving the performance of hot mix asphalt. Rutting was identified as one of the major problems and seemed to be closely related to mixture volumetric properties. By 1990 the Federal Highway Administration was proceeding with Demonstration Project No 74, Field Management of Asphalt Mixes. This project focused on measuring and controlling the volumetric properties of asphalt mixes concurrently with their manufacturing and placement. There are a number of involved test procedures necessary to accomplish volumetric control, but specifying two end result parameters, voids in the mineral aggregate (VMA) and air voids (AV), were selected by CDOT to quantify volumetric properties.

IMPLEMENTATION OF VOID ACCEPTANCE PILOT PROGRAM

In 1991, D'Angelo and Ferragut [1] reported on findings from Project No. 74. Their work showed the importance of field management of asphalt mix volumetric control. In 1993 CDOT took two significant actions towards volumetric end result specifications:

(1) They participated in Demonstration Project No. 74 by doing void control on three hot mix asphalt projects construction. Only one of the three had formal Void Acceptance specifications with provisions for incentive and disincentive payments included. The contractors and CDOT field personnel cooperated in accomplishing routine volumetric testing on the other projects. Aschenbrener , CDOT mix design engineer, reported[2] on this work in January 1994. He concluded that meeting void acceptance (VA) specifications would not ensure that hot mix asphalt would be high in quality, but only that the field mix would match the laboratory design. This initial effort demonstrated the potential for successfully controlling the void properties of asphalt mixtures in Colorado during construction.

(2) They announced their intent to fully implement QC/QA void acceptance specifications. Target date was set as about 1997. Implementation was to be preceded by a series of pilot projects which would be evaluated as they were constructed. This would ensure feasibility of adopting the VA concept and serve as a basis for adjustments in parameters.

By the end of 1996, eleven VA pilot projects had been let to contract, including one that Aschenbrener reported[2] on in 1994. Two of the eleven will not be completed until 1997, leaving nine completed VA projects. An "Explanation of the CDOT Void Acceptance Pilot Program" by Aschenbrener is attached as Exhibit 1. It sets forth a chronological outline of the steps taken by CDOT as they have carefully moved towards VA specification implementation.

SUMMARY REPORT ON THE COMPLETED VA PILOT PROJECTS

This summary report is a compilation of the hot bituminous pavement VA data reported by the field personnel on the nine projects. It is not intended as a thorough study on field control of voids during construction or the potential performance benefits. In 1992, Aschenbrener reported [3] on a comprehensive CDOT investigation of rutting performance of pavements in Colorado. Among other important findings, the report established the need for close volumetric control during construction.

QC/QA Pilot Program for HBP Using Conventional Tests

In 1992, CDOT implemented pilot QC/QA specifications for hot bituminous pavement (HBP). The specifications require field evaluation for materials pay factors (PF) to be done on three elements, in-place density (compaction), asphalt content and aggregate gradation. Quality acceptance (QA) is based on random samples and tests by CDOT on the three elements. The results are evaluated by standard statistical methods and the percent within tolerance, or quality level (QL), is established. PFs are calculated from the QLs and the number of tests in each process to determine incentive/disincentive (I/D) payments. The contractor is required to test the same elements (at a greater frequency) and use the results for quality control (QC). Comprehensive requirements are included in the QC testing schedule.

Under the pilot specifications (QPM 1, the computer software designation), over 3 million tons of HBP were produced during four construction seasons, 1992-1995. The pilot program had been scheduled for completion in 1994, but several projects were held over and completed in 1995. Following collection and analysis of the 1994 data, a revised and updated QC/QA standard special specification (QPM 2) was implemented in 1995. To date there have been four reports on the program; in 1993, 94, 95 and 96 ([4],[5],[6]&[7]). A fifth report[8] is now in progress on the QPM 2 work completed in 1996. The QPM 1 and 2 programs proceeded mostly independent of the VA projects during the same time period. The VA specifications were similar to QPM 1 in format, except that contractors were not required to perform quality control testing. Exhibit 1 provides additional information.

THE VOID ACCEPTANCE PILOT SPECIFICATION

The VA specifications have no field aggregate gradation requirements. Studies have shown that gradation is only subjectively related to performance. Other aggregate characteristics affect mix volumetric properties, and consequently performance, but are difficult to measure or specify. It is expected the contractors will learn to carefully control aggregate characteristics in relation to their motivation by the I/D schedule. As a result, future pavements built under VA specifications are expected to perform in a superior manner to pavements built under conventional specifications. CDOT is selectively evaluating the VA pilot projects for rutting and changes in voids after subjection to traffic. Data is not yet available, but no performance problems have been reported.

The VA pilot specification (special provision) used for the three projects completed 1996 is attached as Exhibit 2. It consists chiefly of revisions to Section 105, Control of Work, and revisions to Section 106, Control of Materials (as pertaining specifically to this Item). The specification for the first six projects was essentially the same, except Stability was included as an element. The mixes on these six projects were designed using the Texas gyratory (TxG) for laboratory compaction and the Hveem stabilometer to measure stability. The Superpave™ Level 1 Mix Design [9] was used for the last three projects and the two now under construction. On page 4 of Exhibit 2, there are two Tables for element factors. The first table was used with the Superpave™ (SP) projects, the second table was included with the TxG projects. There may have other minor differences between the two specifications.

SUMMARIZED DATA FROM VA PILOT PROJECTS

Table 1 is a summary of field data from the nine VA pilot projects as submitted from the field to the Construction & Materials Branch. The projects are sorted by year completed and subaccount number, then by process number. Where there were two or more processes (defined as continued production under a single job-mix formula) on a project, the totals and averages, weighted by tons, are listed for each element. The abbreviated column headings identify the components summarized and are mostly self explanatory. There are two PF columns, first for VA and second for QPM 2. The QPM 2 data was not a component of the projects, but was added for comparison. Future VA projects are expected to use the method for PF calculations. Contractor's Code refers to codes used by the CDOT for the various contractors in evaluating QC/QA. The last column is for Aggregate Grading designation used on the projects. "C" is 3/4" nominal and "CX" is 1/2" nominal aggregate size mixes designed by TxG. SP indicates 3/4" nominal size mixes designed by Superpave™ gyratory.

In Table 2, the VA data is sorted by element, by TxG or SP, then by project and process. Each element group has a composite line for TxG and SP, then finally a composite line is shown where the data for the two mix design methods have been combined. All average values are weighted by tons represented. For each process, the target (job mix formula, or minimum for stability) is shown, followed by the algebraic difference of the process average test result from the target value. For information, the absolute difference is shown for each element group below the composite line. The significance of this can be demonstrated by looking at the composite line for all AC content tests. The algebraic difference between the target and the process averages is zero; so, on the average, the field tests were right on target. The absolute difference, however, is 0.07, showing that without regard to sign, the average process was 0.07 from target. The absolute value is more closely related to the average QL of 84.9.

Finally, at the end of Table 2, the Item composite values for the TG group, the SP group and the combination are shown. It is not possible to combine data where the order of magnitude is different, such as SD for the various elements. However, QL, PFs and I/D have been composited by calculating element averages weighted by "W".

List of Figures

For each element in both groups, frequency distribution histograms have been drawn and for selective elements, accumulated frequency curves are shown. The figures follow the tables at the end of the text, and are identified in Table A.

Table A
Description of Figures

Description	Fig. No.	Description	Fig. No.
AC%, Normal Curve and Field Distribution, Texas Gyratory	1	VMA, Normal Curve and Field Distribution, Texas Gyratory	9
AC%, Normal Curve and Field Distribution, Superpave	2	VMA, Accumulated Frequency, Normal Curve & Field Curve, TxG	10
Density, Norm Curve & Field Dist, TxG, Values in Whole Numbers	3	VMA, Normal Curve and Field Distribution, Superpave	11
Density, Normal Curve and Field Dist TxG, Values Reported to 0.1%	4	VMA, Accumulated Frequency, Normal Curve & Field Curve, SP	12
Density, Accum. Frequency, Norm Curve & Field, TxG, Values to 0.1%	5	Air Voids, Normal Curve and Field Distribution, Texas Gyratory	13
Accumulated Frequency, Norm Curve SP Density, Values to 0.1%	6	Air Voids, Accumulated Frequency, Normal Curve & Field Curve, TxG	14
Density, Normal Curve and Field Dist SP, Values Reported to 0.1%	7	Air Voids, Normal Curve and Field Distribution, Superpave	15
Stability, Normal Curve and Field Distribution, Texas Gyratory	8	Air Voids, Accumulated Frequency, Normal Curve & Field Curve, SP	16

***Discussion of Figures and Related* Data**

Only the density element has a common job mix target (94.0) for all processes in both VA groups. No adjustment or shift of data was necessary in order to plot distribution curves for density. For the other element groups, it was necessary to shift each process set to a common target in order to plot frequency charts and calculate pooled (total population) statistical data. This was accomplished by shifting the element sets to a common target, approximately the average of the group. For example, the average target for AC% in the TxG group is 5.1. The target for the first set listed is 4.8, therefore 0.3 was added to each value in the set. The target for the next set is 5.3; so 0.2 was subtracted from each value, and so on. Once the entire group of sets had been adjusted, statistical calculations were made, frequencies calculated and figures plotted.

Frequency distribution histograms have been drawn for each element in each group. An additional drawing was made for the 1993-94 field densities reported only in whole numbers. If these had been included in a histogram with values sorted to 0.1%, the results would be irrational. The asphalt content histograms (Figures 1 and 2) show the data distribution to be near normal and only slightly off target. Accumulated frequency curves were not drawn.

Accumulated frequency curves for other elements (except stability) were drawn as indicated in the above table. If the curves are closely superimposed on the normal curves, it indicates the process was close to target and normally distributed. The charts only indirectly address the magnitude of the SDs; if the SD for the group is larger than normal, then the QL will be low (excessive percent out of tolerance). If the frequency curve is shifted, but closely parallel to the normal curve, the data is normally distributed, but the average is off target. Where there is lack of parallelism (bulges or dips), the data is abnormally distributed and also may be off target. An example is evident in Figure 5 where the TxG field densities (compaction) are abnormally distributed with a dip near the lower tolerance limit (indicating some sort of sampling bias).

Figure 6 shows the SP density data is significantly bulged just inside the lower tolerance and shifted to the left by about 1.1 percentage points (below target). It is squeezed back to the right near the lower limit, indicates missing data, or sampling bias. The VMA accumulated curve (Figure 10) shows the data to be more normally distributed than its histogram (Figure 9) indicates. The average is almost exactly on target. Figure 12 shows the data for SP VMA to be poorly distributed and 0.4% below target. The TxG AV data (Figure 14) is bulged and shifted to the left, nearly 0.4% below target. Finally, the histogram and frequency curve for SP AV (Figures 15 & 16) show poor distribution of data and a shift to the left of target of nearly 0.9%.

The field densities and all volumetric data (except TxG VMA) are low, indicating there were some problems with field control. Lower values may not be too significant for the TxG mixes, as discussed on page 8, TxG Mixes, etc. But the lower values for the SP mixes could indicate borderline acceptability for performance (see discussion on page 9, SP Mixes, etc).

DISCUSSION OF ELEMENT DATA

Standard Deviations

When the VA pilot program was initiated in 1993, expected process SDs for VMA, VA and stability were estimated[2] from tests performed on six conventional HBP projects constructed in 1992. The data was used to establish tolerance limits and "V" factors for each element . "V" is approximately one historical SD and is used in VA specifications (and QC/QA) to evaluate single sample lots for PF when results are outside tolerances. If within the tolerances, the PF is 1.0. Tolerance limits for double limit elements are typically four average historical SDs in width. Tolerance limits for asphalt content and density were already in effect and historical data was available to establish their "V" factors.

Table B lists SD and tolerance values related to the Pilot VA program and the QPM projects. SD values from the six 1992 projects for VMA, AV and stability along with 1991 historical values for asphalt content and density are listed as base values in the first line.

Table B
SD & Tolerance Table (Data with References)

Identification	AC%	Density	Stability	VMA	Air Voids
6 '92 Projs or Hist	0.18(7)	1.05(7)	3.6(2)	0.51(2)	0.62(2)
VA Spec, "V"(Exh 1)	0.20	1.10	3.0	0.6	0.6
6 TxG VA Projs(Tb 2)	0.19	1.00	2.0	0.36	0.51
3 SP VA Projs(Tb 2)	0.17	0.87	NA	0.49	0.58
W'ted Avg 9 VA Projs(Tb 2)	0.19	0.97	NA	0.39	0.52
1991-95 QPM 1(7)	0.15	1.01	NA	NA	NA
1995-96 QPM 2(9)	0.17	0.93	NA	NA	NA
QPM 2 Spec, "V"	0.20(Std Prov)	1.10 (Std Prov)	NA	NA	NA
Current Tolerances For VA Elements					
VA or QPM Toler. Width	0.6(Std Spec)	4.0(Std Spec)	NA	2.4 (Exh 1)	2.4 (Exh 1)

Examination of the above table shows the values used in the VA specification are very reasonable when compared to the summarized field data. Because construction techniques for achieving density and asphalt content are essentially the same for VA projects as for QC/QA projects, the QPM 2 summary (representing 14 times as many tons) is a better indicator of actual field performance than is the SP VA summary (1996 work). An analysis of Sellers risks shows "V" should be about 1.2 times the historical SD for a recommended 5% risk. The current "V"s (VA and QPM 2) for AC% and density are almost exactly 1.2 times the QPM 2 averages. No changes are recommended. For the two specifications, the tolerance widths for these two elements are very close to four times the QPM 2 averages; these tolerances have been used by CDOT for HBP for about seven years. Experience shows the they are satisfactory; no changes are recommended.

The relevance of Stability tests on SP mixtures is currently being investigated. Stabilities may be specified on future VA projects using SP. No change is recommended in the "V" factor at this time. SD is not normally used to establish the tolerance limit for single limit specifications.

For this evaluation, some of the most important information comes from the volumetric summaries. Based on the limited number of pilot tests, the summaries in Table B indicate the tolerance widths and "V" factors for VMA and AV are approximately correct. The change from TxG to SP compaction has probably affected VMA and AV field data. But the extent is not known because of other concurrent changes taking place, as summarized by Aschenbrener in Exhibit 1, such as: (1) Test procedures were modified to take out ambiguities following round robin testing in 1994 and 1995, (2) in 1996, CAPA certification was required for the first time for all testers, (3) from 1991-1995 TxG equipment was phased in, then in 1996 the SP procedure was introduced and used on the SP projects without previous experience and (4), from 1993 to the present, there have been a number of changes in VA specifications and project quality management. For these reasons no changes are currently recommended for VMA and AV.

Target and Mean - Target

Based on all individual test values, the data in the columns (Tables 1 and 2) to the right of the tons column, have been calculated for each element in each process. The targets (job mix formulas) were as established on the projects per specifications. The mean (average) value for the process, minus target value is the algebraic difference. For example, if two AV processes of the same size had a 0.5 and -0.5 differences from their targets, the average distance from the targets would be zero. The average absolute difference would be 0.5, which is more closely related to the overall QL than is the algebraic average. The composites show both values.

Quality Level and Pay Factors

QL is calculated by CP-71[10] and represents the estimated percent of test results within tolerances. SD, distance of process mean from tolerance limits and number of test values ("n") all contribute to the calculation. PF formulas for VA and HBP are modeled after the WASHTO[11] tables for PF, based on "n" and QL. Basically, for unlimited "n", PF = 1.0 when QL = 93 . As "n" decreases, the required QL to achieve a PF of 1.0 decreases. This is related to sellers risk due to sampling error as "n" grows smaller. When "n" is three (minimum for statistical analysis), a QL of 68 provides a PF of 1.0. There is pay incentive or disincentive, based upon QL and "n". The VA formulas for PF are included in Exhibit 2. QPM 2 PF formulas are slightly modified from WASHTO and there are additional ones for larger "n"s. The QPM 2 PF column (Tables 1 and 2) is provided for comparison; the procedure is to be used for future VA projects. Over all, there is less than one percent difference in the two methods, with QPM 2 paying slightly less (the effect of paying less for processes with larger "n"s).

The VA I/D$ Column shows the actual dollars based on tons x $per ton x (PF-1.0). There was a total incentive of $47,069 for the TxG projects. The total disincentive was -$129,488 for the three SP projects, which included -$116,499 for density on a single project process. This resulted in only -$13,000 for the other elements and processes .

The less than desired results for VMA and AV on the SP projects can be partly attributed to the contractors' unfamiliarity with SP technology (i.e., SP gradations interrelated with voids and field density). Another factor may have been CDOT's unfamiliarity with the SP gyratory compactor. These two things, combined with the sampling and testing variances already inherent with HBP testing, produced lower QLs than expected for the volumetric properties.

Asphalt Content and Density

The QLs and PFs for the AC% and Density elements are significantly lower for both groups of VA projects than for QPM 1 and QPM 2 projects for the same contractors during the same calendar periods. Table C compares data taken from Table 2 and 3.

Table C
AC% and Density Data, VA & QPM 1 & 2

	"n"		SD		Ab. Mn -Tar.		QL		QPM 2 PF	
Group Identification	AC	Dn	AC	Dn	AC	Dn	AC	Dn	AC	Dn
VA by Texas Gyratory	316	615	0.19	1.00	0.06	0.81	86.3	84.1	0.997	0.966
1991-95, QPM 1	3092	5729	0.15	1.01	0.07	0.67	90.4	88.1	1.017	0.992
VA by Superpave	86	171	0.17	0.87	0.13	1.20	79.6	77.7	0.944	0.907
1995-96, QPM 2	1189	2090	0.17	0.93	0.07	0.56	89.5	91.9	1.006	1.016

The QL and PFs for the VA groups were significantly below the QPM groups. The total number of tests for the VA groups is much less, so there is danger in reaching conclusions from such small samples, particularly for SP. It appears there are complex interrelations between the mix characteristics necessary for volumetric optimization and field compaction when using SP gradations.

For conventional HBP where there are specified gradations (and no voids specifications on field mixes), sieve targets can be changed or established by the contractor (as approved) without negatively affecting the PF. Gradations could be selected in order to more easily achieve compaction without particular regard to the effect on the voids characteristics. Successful implementation of VA specifications on SP projects will require training and experience for CDOT and the contractors.

TxG Mixes, Stability, VMA and Air Voids

There was virtually no problems meeting the minimum specified stability values on the TxG mixes. The VMA average was almost right on target. The AV average was only 0.3% below target. Medium to low TxG compactive effort was used for design on all of these projects. Aschenbrener noted[3] that field mixes with air voids above 3.0% by low laboratory compactive effort should have good rut resistance. Figure 14, accumulative frequency for TxG air voids, shows that 85% of the tests yielded AV greater than 3.0%. The as-built field densities show only 0.14% more AV (less density) than the QPM 1 projects built during the same time period. The TxG designed pavements can be expected to have good resistance to rutting.

Superpave Mixes, VMA and Air Voids

The SP mix design procedure[9] does not include Hveem stability testing. For SP compaction, loose, hot asphalt mixtures are placed in molds and subjected to gyrations until the density is approximately 98% of maximum theoretical (2.0% AV). Densities between initial and end pont are estimated by automatic specimen height measurement and interpolation to find percent air voids at design gyrations. The completely compacted test specimens are not satisfactory for stability testing. To test for stability, separate specimens compacted at design gyrations are required. Until now, this has not been done routinely, but data is currently being accumulated. Stabilities may be required on SP mixtures in the future.

The SP mixes have an average field VMA about 0.4% (Table 2) below target. This is not particularly significant. The SP average AV are (Table 2) below target a greater distance than average for the TxG mixes. But not too much weight should be given to this data, their were only a couple of small processes where the average AV were below 3.0%. The SP mixtures can be expected to have adequate rut resistance, except possibly for some finely graded trial mixes. Again, this emphasizes the need for time to learn the interrelation between SP gradations, volumetric characteristics and density achievement.

COMMENTS

The number of changes being made in procedures and equipment, combined with the limited number of projects and field samples, makes it risky to make conclusions. Following is a list of comments:

1. The six TxG projects are expected to perform satisfactorily for rut and fatigue resistance. Eighty-five percent of the field AV tests are above the critical lower limit of 3.0% and the average is only 0.29% below target. The as-built field densities show only 0.14% more AV (less density) than the QPM 1 projects built during the same time period

2. Not enough data is available to predict performance on the SP projects. There needs to be more time (and SP projects) to allow CDOT personnel and the contractors to become familiar with Superpave technology. The analysis of volumetric data is complicated by its interrelation with SP technology.

3. The "V" factors and specification widths for the elements currently being evaluated on the SP projects are satisfactory, no changes are recommended at this time.

4. For both TxG and SP, there is reduction in air voids by laboratory compaction of field mixed materials versus laboratory mixed materials from same source components. This confirms the observed and documented reduction in field AV (reported by CDOT and others).

5. The data submitted to the Pavement section for analysis seems to indicate poor compliance with the requirements for compaction test sections. The first density test result in a process is supposed to be the average of the seven random tests on a test section. For work to proceed without more test sections, the PF for the first test section must be 1.0, or better. At a normal SD of 1.0, the mean value must be at least 93.0. Of 12 processes built in 1995 & 1996 (TxG and SP), 7 had first values reported ranging from 91.8 to 92.8. If the test section requirements had been adhered to, there would probably have been better compliance with overall density and volumetric requirements on these processes.

6. All three frequency histograms for field density tests (Figs 3, 4 and 7) show significant sampling bias and abnormal distribution. There is a lack of test values just below or at the minimum tolerance (92.0) with a preponderance of values just inside the limits. This may indicate a tendency towards discarding values just below the lower limit and substituting "representative" values from locations near by.

7. There is some abnormalcy in the distribution of test values around their averages for all elements for both TxG and SP. But sampling bias is not as evident as it is for density. For all the elements, part of the poor distribution can be attributed to the experimental nature of the work where frequent changes in the field processes were made. Pooled data can be expected to reflect the many process changes.

RECOMMENDATIONS

1. Consideration should be given to allowing the contractor the option of making a laboratory adjustment in design voids (higher laboratory AV) to account for anticipated decreases on construction. This might greatly reduce the amount of trial and error associated with field adjustments. There would have to be a documented prediction procedure, based on historical data for the individual contractor and source.

2. The requirements for compaction test sections should be fully adhered to.

3. Additional efforts should be made to train contractor and CDOT test persons in the proper procedures for random sampling, particularly for pavement density. The proposed pilot projects, with the contractors doing control testing for pay, present opportunity to identify sampling and testing irregularities by use of statistical "t" and "F' test procedures.

4. It is proposed that the disincentive pay factor procedures be stiffened (greater disincentive when the PF is less than 1.0). This would require the "W" factors be changed when PF is less than 1.0. Contractors who perform well and have PFs greater than 1.0 would not be affected by this change. Those inclined to accept disincentive payments in lieu of producing fully acceptable work would have greater incentive to produce higher quality work. This same recommendation is appropriate for QPM 2 projects.

5. It is recommended that as soon as feasible, the conventional HBP QPM 2 specification be merged with the VA specifications. CDOT has already stated this intent. This recommendation is to add emphasis to that objective. In the mean time, VA pilot work should proceed carefully at the same time the Superpave procedure is being implemented for conventional HBP.

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9. "Superpave™ Level 1 Mix Design", Asphalt Institute Superpave™ Seies No.2 (SP-2), Asphalt Institute, P.O. Box 14052, Lexington, KY 40512-4052.

10. Colorado Procedure 71-94 For Determining Quality Level (Percent Within Tolerance limits), 1997 Field Materials Manual. Colorado Department of Transportation, 4201 East Arkansas, Denver CO 80222.

11. WASHTO Model Quality Assurance Specifications, Prepared for WASHTO Subcommittee on Materials and on Construction, in Cooperation with the FHWA, August, 1991.

Table 1
HOT BITUMINOUS PAVEMENT QC/QA DETAILS & SUMMARY BY PROJECT AND MIX DESIGN FOR 1993 - 96 VOID ACCEPTANCE PROJECTS

PROJECT LOCATION	RG #	YR COM, SUBAC #	PRC #	ELE-MENT	BID $/ TON	TONS 1000	TEST "n"	PROCESS SD	PROCESS TARG	MEAN - TAR	QUAL LEVL	VA PF	QPM2 PF	VA I/D $	CNT CDE	AGG GRAD
CX 11-0006-17																
6th Ave, Wads-Fed	6	93,93092	A	Dns%	$29.25	21.1	42	0.79	94.0	-0.76	94.3	1.039	1.035	$9,639	W2	C
6th Ave, Wads-Fed	6	93,93092	A	AC%	$29.25	21.1	24	0.20	4.8	-0.06	84.9	1.009	0.986	$278	W2	C
6th Ave, Wads-Fed	6	93,93092	A	Stab	$29.25	21.1	24	3.60	35.0	3.20	81.8	0.996	0.965	($124)	W2	C
6th Ave, Wads-Fed	6	93,93092	A	VMA	$29.25	21.1	24	0.38	13.5	-0.63	93.9	1.038	1.041	$4,696	W2	C
6th Ave, Wads-Fed	6	93,93092	A	Voids	$29.75	21.1	24	0.40	3.3	-0.60	93.5	1.037	1.039	$6,976	W2	C
PROJECT GRADING "C" TOTALS & MEANS FOR ITEM					$29.75	21.1	NA	NA	NA	NA	92.9	1.035	1.031	$21,466	W2	C
STA 0251-131																
Jct SH 165, N & S	2	94,92410	A	Dns%	$28.20	4.4	9	1.45	94.0	0.11	84.4	1.007	1.008	$351	W2	CX
Jct SH 165, N & S	2	94,92410	B	Dns%	$28.20	10.0	20	1.30	94.0	-1.30	70.0	0.901	0.877	($11,129)	W2	CX
Jct SH 165, N & S	2	94,92410	C	Dns%	$28.20	4.4	8	1.51	94.0	-1.50	62.4	0.771	0.877	($11,288)	W2	CX
Jct SH 165, N & S	2	94,92410	D	Dns%	$28.20	21.4	43	1.32	94.0	-0.44	85.3	0.988	0.969	($2,778)	W2	CX
Jct SH 165, N & S	2	94,92410	E	Dns%	$28.20	14.7	30	1.11	94.0	-1.25	74.9	0.890	0.915	($18,242)	W2	CX
PROJECT GRADING "CX" TOTALS & MEANS FOR DENSITY						54.9	110	1.28	94.0	-0.85	77.8	0.930	0.934	($43,087)	W2	CX
Jct SH 165, N & S	2	94,92410	A	AC%	$28.20	4.4	5	0.13	5.4	-0.08	99.0	1.050	1.030	$315	W2	CX
Jct SH 165, N & S	2	94,92410	B	AC%	$28.20	10.0	10	0.18	5.1	-0.02	91.7	1.032	1.037	$447	W2	CX
Jct SH 165, N & S	2	94,92410	C	AC%	$28.20	4.4	4	0.13	5.5	-0.09	100.0	1.049	1.030	$303	W2	CX
Jct SH 165, N & S	2	94,92410	D	AC%	$28.20	21.4	21	0.16	5.1	-0.04	93.2	1.036	1.032	$1,084	W2	CX
Jct SH 165, N & S	2	94,92410	E	AC%	$28.20	14.7	15	0.11	5.5	-0.05	99.3	1.049	1.050	$1,016	W2	CX
PROJECT GRADING "CX" TOTALS & MEANS FOR AC%						54.9	55	0.15	5.3	-0.05	95.6	1.041	1.037	$3,165	W2	CX
Jct SH 165, N & S	2	94,92410	A	Stab	$28.20	4.4	5	1.00	35.0	12.00	100.0	1.050	1.030	$313	W2	CX
Jct SH 165, N & S	2	94,92410	B	Stab	$28.20	10.0	10	2.30	35.0	12.60	100.0	1.050	1.040	$704	W2	CX
Jct SH 165, N & S	2	94,92410	C	Stab	$28.20	4.4	4	2.20	35.0	9.80	100.0	1.050	1.030	$308	W2	CX
Jct SH 165, N & S	2	94,92410	D	Stab	$28.20	21.4	21	1.20	35.0	18.30	100.0	1.050	1.050	$1,507	W2	CX
Jct SH 165, N & S	2	94,92410	E	Stab	$28.20	14.7	15	1.20	35.0	8.30	100.0	1.050	1.050	$1,038	W2	CX
PROJECT GRADING "CX" TOTALS & MEANS FOR STABILITY						54.9	55	1.46	35.0	13.40	100.0	1.050	1.045	$3,871	W2	CX
Jct SH 165, N & S	2	94,92410	A	VMA	$28.20	4.4	5	0.21	14.0	-0.96	88.1	1.031	1.030	$1,174	W2	CX
Jct SH 165, N & S	2	94,92410	B	VMA	$28.20	10.0	10	0.21	14.0	-1.13	62.9	0.884	0.881	($9,831)	W2	CX
Jct SH 165, N & S	2	94,92410	C	VMA	$28.20	4.4	4	0.35	13.0	0.97	71.4	0.985	0.985	($573)	W2	CX
Jct SH 165, N & S	2	94,92410	D	VMA	$28.20	21.4	21	0.24	14.0	-0.99	80.7	0.991	0.957	($1,675)	W2	CX
Jct SH 165, N & S	2	94,92410	E	VMA	$28.20	14.7	15	0.25	14.0	-0.42	99.7	1.050	1.050	$6,170	W2	CX
PROJECT GRADING "CX" TOTALS & MEANS FOR VMA						54.9	55	0.24	13.9	-0.70	82.4	0.990	0.976	($4,736)	W2	CX
Jct SH 165, N & S	2	94,92410	A	Voids	$28.20	4.4	5	0.28	4.0	-1.12	60.2	0.903	0.902	($4,878)	W2	CX
Jct SH 165, N & S	2	94,92410	B	Voids	$28.20	10.0	10	0.38	4.0	-0.62	94.7	1.040	1.040	$4,461	W2	CX
Jct SH 165, N & S	2	94,92410	C	Voids	$28.20	4.4	4	0.37	3.0	0.85	81.6	1.022	1.025	$1,087	W2	CX
Jct SH 165, N & S	2	94,92410	D	Voids	$28.20	21.4	21	0.48	4.0	-0.52	95.1	1.041	1.048	$9,768	W2	CX
Jct SH 165, N & S	2	94,92410	E	Voids	$28.20	14.7	15	0.29	3.0	0.19	100.0	1.050	1.050	$8,301	W2	CX
PROJECT GRADING "CX" TOTALS & MEANS FOR AIR VOIDS						54.9	55	0.39	3.7	-0.29	92.4	1.030	1.033	$18,738	W2	CX
PROJECT GRADING "CX" TOTALS & MEANS FOR ITEM						54.9	NA	NA	NA	NA	85.1	0.984	0.983	($22,049)	W2	CX
Jct SH 165, N & S	2	94,92410	A	Dns%	$21.90	38.5	80	1.12	94.0	-0.86	84.0	1.005	0.939	$1,696	W2	C
Jct SH 165, N & S	2	94,92410	A1	Dns%	$21.90	1.5	NA	NA	NA	NA	NA	1.005	0.500	$66	W2	C
Jct SH 165, N & S	2	94,92410	B	Dns%	$21.90	8.5	17	1.11	94.0	-1.12	78.4	0.980	0.961	($1,489)	W2	C
Jct SH 165, N & S	2	94,92410	C	Dns%	$21.90	3.4	7	0.53	94.0	-0.57	100.0	1.035	1.035	$1,039	W2	C
Jct SH 165, N & S	2	94,92410	D	Dns%	$21.90	4.5	9	1.01	94.0	-0.44	94.7	1.040	1.040	$1,560	W2	C
PROJECT GRADING "C" TOTALS & MEANS FOR DENSITY						56.3	113	1.07	94.0	-0.85	85.0	1.006	0.971	$2,872	W2	C

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PROJECT LOCATION	RG #	YR COM, SUBAC #	PRC #	ELE-MENT	BID $/ TON	TONS 1000	TEST "n"	PROCESS SD	PROCESS TARG	MEAN - TAR	QUAL LEVL	VA PF	QPM2 PF	VA I/D $	CNT CDE	AGG GRAD
Jct SH 165, N & S	2	94,92410	A	AC%	$21.90	38.5	40	0.24	5.3	0.09	76.0	0.908	0.896	($3,891)	W2	C
Jct SH 165, N & S	2	94,92410	A1	AC%	$21.90	1.5	2	NA	5.3	-0.62	NA	0.831	0.500	($279)	W2	C
Jct SH 165, N & S	2	94,92410	B	AC%	$21.90	8.5	9	0.17	5.1	0.14	81.7	0.995	0.995	($44)	W2	C
Jct SH 165, N & S	2	94,92410	C	AC%	$21.90	3.4	3	0.23	5.3	0.14	70.3	1.007	1.002	$26	W2	C
Jct SH 165, N & S	2	94,92410	D	AC%	$21.90	4.5	5	0.18	5.3	0.04	94.5	1.045	1.030	$217	W2	C
PROJECT GRADING "C" TOTALS & MEANS FOR AC%						56.3	59	0.22	5.3	0.08	83.8	0.936	0.917	($3,972)	W2	C
Jct SH 165, N & S	2	94,92410	A	Stab	$21.90	38.5	42	1.97	35.0	10.3	100.0	1.050	1.055	$2,107	W2	C
Jct SH 165, N & S	2	94,92410	A1	Stab	$21.90	1.5	NA	NA	NA	NA	NA	1.050	0.500	$83	W2	C
Jct SH 165, N & S	2	94,92410	B	Stab	$21.90	8.5	9	1.70	35.0	11.30	100.0	1.050	1.040	$465	W2	C
Jct SH 165, N & S	2	94,92410	C	Stab	$21.90	3.4	3	0.60	35.0	9.30	100.0	1.050	1.025	$185	W2	C
Jct SH 165, N & S	2	94,92410	D	Stab	$21.90	4.5	5	0.50	35.0	9.40	100.0	1.050	1.030	$244	W2	C
PROJECT GRADING "C" TOTALS & MEANS FOR STABILITY						56.3	59	1.72	34.1	10.05	97.3	1.050	1.034	$3,085	W2	C
Jct SH 165, N & S	2	94,92410	A	VMA	$21.90	38.5	42	0.25	13.0	0.26	100.0	1.045	1.055	$11,400	W2	C
Jct SH 165, N & S	2	94,92410	A1	VMA	$21.90	1.5	NA	NA	NA	NA	NA	1.045	0.500	$447	W2	C
Jct SH 165, N & S	2	94,92410	B	VMA	$21.90	8.5	9	0.22	13.0	0.21	100.0	1.050	1.040	$2,793	W2	C
Jct SH 165, N & S	2	94,92410	C	VMA	$21.90	3.4	3	0.31	13.0	0.03	100.0	1.050	1.025	$1,113	W2	C
Jct SH 165, N & S	2	94,92410	D	VMA	$21.90	4.5	5	0.38	13.0	0.14	100.0	1.050	1.030	$1,462	W2	C
PROJECT GRADING "C" TOTALS & MEANS FOR VMA						56.3	59	0.26	12.7	0.22	97.3	1.047	1.034	$17,215	W2	C
Jct SH 165, N & S	2	94,92410	A	Voids	$21.90	38.5	42	0.62	4.0	-0.14	94.6	1.034	1.037	$11,467	W2	C
Jct SH 165, N & S	2	94,92410	A1	Voids	$21.90	1.5	NA	NA	NA	0.00	NA	1.034	0.500	$450	W2	C
Jct SH 165, N & S	2	94,92410	B	Voids	$21.90	8.5	9	0.24	4.0	-0.24	100.0	1.050	1.040	$3,723	W2	C
Jct SH 165, N & S	2	94,92410	C	Voids	$21.90	3.4	3	0.21	4.0	-0.83	100.0	1.050	1.025	$1,484	W2	C
Jct SH 165, N & S	2	94,92410	D	Voids	$21.90	4.5	5	0.52	4.0	-0.60	88.3	1.032	1.030	$1,240	W2	C
PROJECT GRADING "C" TOTALS & MEANS FOR AIR VOIDS						56.3	59	0.52	3.9	-0.23	92.7	1.037	1.022	$18,365	W2	C
PROJECT GRADING "C" TOTALS & MEANS FOR ITEM						56.3	NA	NA	NA	NA	90.3	1.022	0.999	$37,565	W2	C
PROJECT GRAND TOTAL & MEANS, ALL GRADINGS						111.2	NA	NA	NA	NA	87.8	1.003	0.991	$15,516	W2	C
															K1	C
STRS 0835 - 031																
Pierce - Nunn	2	95,93262	A	Dns%	$25.00	22.4	39	1.22	94.0	-94.00	47.1	0.765	0.750	($52,574)	K1	C
Pierce - Nunn	2	95,93262	B	Dns%	$33.00	12.8	26	0.96	94.0	-94.00	73.9	0.912	0.901	($14,880)	K1	C
PROJECT GRADING "C" TOTALS & MEANS FOR DENS						35.2	65	1.12	94.0	-94.00	56.9	0.819	0.805	($67,454)	K1	C
															K1	C
Pierce - Nunn	2	95,93262	A	AC%	$25.00	22.4	23	0.19	4.6	-4.60	87.2	1.022	0.999	$603	K1	C
Pierce - Nunn	2	95,93262	B	AC%	$33.00	12.8	13	0.15	5.0	-5.00	93.3	1.020	1.040	$428	K1	C
PROJECT GRADING "C" TOTALS & MEANS FOR AC%						35.2	36	0.18	4.7	-4.75	89.4	1.021	1.014	$1,031	K1	C
															K1	C
Pierce - Nunn	2	95,93262	A	Stab	$25.00	22.4	23	1.28	40.0	-40.00	100.0	1.048	1.050	$1,343	K1	C
Pierce - Nunn	2	95,93262	B	Stab	$33.00	12.8	13	3.67	40.0	-40.00	100.0	1.039	1.045	$825	K1	C
PROJECT GRADING "C" TOTALS & MEANS FOR STABILITY						35.2	36	2.15	40.0	-40.00	100.0	1.045	1.048	$2,168	K1	C
															K1	C
Pierce - Nunn	2	95,93262	A	VMA	$25.00	22.4	23	0.30	13.0	-13.00	98.5	1.045	1.050	$5,018	K1	C
Pierce - Nunn	2	95,93262	B	VMA	$33.00	12.8	13	0.46	13.0	-13.00	90.2	1.015	1.026	$1,267	K1	C
PROJECT GRADING "C" TOTALS & MEANS FOR VMA						35.2	36	0.36	13.0	-13.00	95.5	1.034	1.041	$6,285	K1	C
															K1	C
Pierce - Nunn	2	95,93262	A	Voids	$25.00	22.4	23	0.52	4.0	-4.00	90.8	1.015	1.022	$2,517	K1	C
Pierce - Nunn	2	95,93262	B	Voids	$33.00	12.8	13	0.51	4.2	-4.20	83.8	0.947	0.993	($6,666)	K1	C
PROJECT GRADING "C" TOTALS & MEANS FOR AIR VOIDS						35.2	36	0.52	4.1	-4.07	88.2	0.990	1.011	($4,149)	K1	C
PROJECT GRADING "C" TOTALS & MEANS FOR ITEM											77.8	0.935	0.937	($62,120)	K1	C

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PROJECT LOCATION	RG #	YR COM, SUBAC #	PRC #	ELE- MENT	BID $/ TON	TONS 1000	TEST "n"	PROCESS SD	PROCESS TARG	MEAN - TAR	QUAL LEVL	VA PF	QPM2 PF	VA I/D $	CNT CDE	AGG GRAD
C 0361-048																
US 36, Sher - Wads	6	95,10678	A	Dns%	$23.40	29.1	58	0.88	94.0	-0.53	95.2	1.041	1.041	$11,157	A1	C
US 36, Sher - Wads	6	95,10678	A	AC%	$23.40	29.1	29	0.22	4.6	0.02	82.1	0.997	0.967	($102)	A1	C
US 36, Sher - Wads	6	95,10678	A	Stab	$23.40	29.1	29	1.70	40.0	7.10	100.0	1.050	1.050	$1,701	A1	C
US 36, Sher - Wads	6	95,10678	A	VMA	$23.40	29.1	29	0.37	13.6	0.69	91.9	1.032	1.029	$4,354	A1	C
US 36, Sher - Wads	6	95,10678	A	Voids	$23.40	29.1	29	0.53	3.5	0.42	93.2	1.036	1.037	$7,347	A1	C
PROJECT GRADING "C" TOTALS & MEANS FOR ITEM					$23.40	29.1	NA	NA	NA	NA	93.4	1.036	1.033	$24,457		C
STA 0451-003																
Jct SH 50 - South	2	96,10791	A	Dns%	$26.00	72.3	146	0.88	94.0	0.02	97.7	1.041	1.057	$30,992	K1	C
Jct SH 50 - South	2	96,10791	A	AC%	$26.00	72.3	73	0.20	5.7	-0.01	85.9	1.001	0.956	$89	K1	C
Jct SH 50 - South	2	96,10791	A	Stab	$26.00	72.3	73	2.04	37.0	4.08	97.9	1.035	1.059	$3,305	K1	C
Jct SH 50 - South	2	96,10791	A	VMA	$26.00	72.3	73	0.54	16.4	-0.42	92.5	1.002	1.013	$587	K1	C
Jct SH 50 - South	2	96,10791	A	Voids	$26.00	72.3	73	0.59	4.0	-0.36	91.9	1.006	1.007	$3,533	K1	C
PROJECT GRADING "C" TOTALS & MEANS FOR ITEM					$26.00	72.3	NA	NA	NA	NA	94.4	1.020	1.029	$38,505		C
IM 0252-279																
Jct SH 85 - North	2	96,10942	A	Dns%	$34.30	10.5	22	1.03	94.0	-94.00	45.8	0.750	0.750	($36,015)	S1	C
Jct SH 85 - North	2	96,10942	B	Dns%	$34.30	30.8	59	0.71	94.0	-94.00	88.8	1.023	0.992	$9,592	S1	C
PROJECT GRADING "C" TOTALS & MEANS FOR DENS						41.3	81	0.79	94.0	-94.00	77.8	0.953	0.930	($26,423)	S1	C
Jct SH 85 - North	2	96,10942	A	AC%	$34.30	10.5	10	0.08	4.6	-4.60	95.8	1.042	1.045	$756	S1	C
Jct SH 85 - North	2	96,10942	B	AC%	$34.30	30.8	30	0.20	4.8	-4.80	83.9	1.005	0.971	$248	S1	C
PROJECT GRADING "C" TOTALS & MEANS FOR AC%						41.3	40	0.17	4.7	-4.75	86.9	1.014	0.990	$1,005	S1	C
Jct SH 85 - North	2	96,10942	A	Stab	$34.30	10.5	10	1.17	40.0	-40.00	100.0	1.050	1.045	$900	S1	C
Jct SH 85 - North	2	96,10942	B	Stab	$34.30	30.8	30	2.76	40.0	-40.00	100.0	1.050	1.055	$2,641	S1	C
PROJECT GRADING "C" TOTALS & MEANS FOR STABILITY						41.3	40	2.36	40.0	-40.00	100.0	1.050	1.052	$3,541	S1	C
Jct SH 85 - North	2	96,10942	A	VMA	$34.30	10.5	10	0.33	14.0	-14.00	98.3	1.047	1.045	$3,400	S1	C
Jct SH 85 - North	2	96,10942	B	VMA	$34.30	30.8	30	0.34	13.5	-13.50	100.0	1.050	1.055	$10,564	S1	C
PROJECT GRADING "C" TOTALS & MEANS FOR VMA						41.3	40	0.34	13.6	-13.63	99.6	1.049	1.052	$13,964	S1	C
Jct SH 85 - North	2	96,10942	A	Voids	$34.30	10.5	10	0.37	4.0	-4.00	99.1	1.049	1.045	$5,240	S1	C
Jct SH 85 - North	2	96,10942	B	Voids	$34.30	30.8	30	0.58	3.5	-3.50	93.9	1.038	1.038	$11,917	S1	C
PROJECT GRADING "C" TOTALS & MEANS FOR AIR VOIDS						41.3	40	0.53	3.6	-3.63	95.2	1.040	1.039	$17,157	S1	C
PROJECT GRADING "C" TOTALS & MEANS FOR ITEM						41.3	NA	NA	NA	NA	89.0	1.007	0.997	$9,245	S1	C
IM 0704-179																
I 70 Colfax - SH 26	6	96,11364	A	Dns%	$29.15	1.2	3	0.35	94.0	-1.57	100.0	1.050	1.025	$682	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	Dns%	$29.15	9.1	18	0.70	94.0	-1.13	89.7	1.026	1.023	$2,770	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	Dns%	$29.15	27.8	56	0.96	94.0	-1.83	56.9	0.641	0.729	($118,499)	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR DENS					$29.15	38.1	77	0.88	94.0	-1.66	66.1	0.746	0.809	($113,048)	A1	SP
I 70 Colfax - SH 26	6	96,11364	A	AC%	$29.15	1.2	2	NA	5.0	-0.03	NA	1.000	1.000	$0	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	AC%	$29.15	9.1	9	0.28	5.1	-0.13	66.8	0.851	0.909	($3,957)	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	AC%	$29.15	27.8	28	0.15	4.3	0.09	91.8	1.027	1.029	$2,190	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR AC%					$29.15	38.1	39	0.18	4.5	0.03	85.6	0.984	0.999	($1,768)	A1	SP
I 70 Colfax - SH 26	6	96,11364	A	Stab	$29.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	Stab	$29.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	Stab	$29.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
NOT APPLICABLE ON THIS PROJECT					$29.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP

Table 1
HOT BITUMINOUS PAVEMENT QC/QA DETAILS & SUMMARY BY PROJECT AND MIX DESIGN FOR 1993 - 96 VOID ACCEPTANCE PROJECTS

PROJECT LOCATION	RG #	YR COM, SUBAC #	PRC #	ELE-MENT	BID $/ TON	TONS 1000	TEST "n"	PROCESS SD	PROCESS TARG	MEAN - TAR	QUAL LEVL	VA PF	QPM2 PF	VA I/D $	CNT CDE	AGG GRAD
I 70 Colfax - SH 26	6	96,11364	A	VMA	$29.15	1.2	2	NA	13.0	0.00	NA	1.000	1.000	$0	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	VMA	$29.15	9.1	9	0.51	13.0	-0.82	100.0	0.833	1.040	($8,895)	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	VMA	$29.15	27.8	28	0.40	13.2	-0.83	82.3	1.014	0.968	$2,237	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR VMA					$29.15	38.1	39	0.43	13.1	-0.80	86.7	0.970	0.986	($6,658)	A1	SP
I 70 Colfax - SH 26	6	96,11364	A	Voids	$29.15	1.2	2	NA	4.0	-1.25	NA	0.778	0.889	($2,269)	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	Voids	$29.15	9.1	9	0.61	4.0	-1.55	29.2	0.833	0.561	($13,342)	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	Voids	$29.15	27.8	28	0.43	4.1	-0.35	98.8	1.049	1.050	$11,961	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR AIR VOIDS					$29.15	38.1	39	0.48	4.1	-0.67	81.6	0.989	0.928	($3,651)	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR ITEM					$29.15	38.1	NA	NA	NA	NA	50.4	0.589	0.576	($12,077)	A1	SP
IM 0292 - 293																
Northgate - North	6	96,11373	A	Dns%	$38.75	21.1	43	1.23	94.0	0.17	89.6	1.025	1.001	$8,177	W2	SP
Northgate - North	6	96,11373	A	AC%	$38.75	21.1	21	0.17	5.1	-0.08	88.6	1.002	1.009	$186	W2	SP
Northgate - North	6	96,11373	A	Stab	$38.75	NA	NA	NA	NA	NA	NA	NA	NA	$0	W2	SP
Northgate - North	6	96,11373	A	VMA	$38.75	21.1	21	0.41	13.0	-0.38	98.1	1.021	1.050	$3,485	W2	SP
Northgate - North	6	96,11373	A	Voids	$38.75	21.1	21	0.57	4.5	-1.44	91.0	1.003	1.024	$736	W2	SP
PROJ GRADING "SMA1" TOTALS & MEANS FOR ITEM					$38.75	21.1	NA	NA	NA	NA	91.6	1.015	1.018	$12,584	W2	SP
HB 0703-234																
I 70, Colfax - Clr Crk	6	96,11512	A	Dns%	$31.40	3.5	8	0.17	94.0	-1.93	66.4	0.906	0.905	($4,104)	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	B	Dns%	$31.40	21.3	43	0.61	94.0	-1.27	88.4	1.021	0.992	$5,627	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR DENS					$31.40	24.8	51	0.55	94.0	-1.36	85.3	1.005	0.980	$1,523	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	A	AC%	$31.40	3.5	4	0.10	4.9	0.03	100.0	1.049	1.030	$535	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	B	AC%	$31.40	21.3	22	0.17	4.9	0.27	56.9	0.845	0.766	($10,362)	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR AC%					$31.40	24.8	26	0.16	4.9	0.24	62.9	0.874	0.803	($9,827)	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	A	Stab	$31.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	B	Stab	$31.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
NOT APPLICABLE ON THIS PROJECT					$31.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	A	VMA	$31.40	3.5	4	0.47	14.0	-0.03	100.0	1.049	1.030	$1,070	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	B	VMA	$31.40	21.3	22	0.67	14.0	0.30	90.9	1.031	1.023	$4,113	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR VMA					$31.40	24.8	26	0.64	14.0	0.25	92.2	1.033	1.024	$5,182	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	A	Voids	$31.40	3.5	4	0.79	3.8	-0.35	94.1	1.046	1.030	$1,506	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	B	Voids	$31.40	21.3	22	0.76	3.8	-0.78	78.5	0.924	0.942	($15,332)	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR VOIDS					$31.40	24.8	26	0.76	3.8	-0.72	80.7	0.941	0.954	($13,826)	A1	SP
PROJECT GRADING "C" TOTALS & MEANS FOR ITEM					$31.40	24.8	NA	NA	NA	NA	83.1	0.978	0.963	($16,948)	A1	SP

Table 2
HOT BITUMINOUS PAVEMENT QC/QA DETAILS & SUMMARY BY ELEMENT, PROJECT & MIX DESIGN FOR 1993 - 96 VOID ACCEPTANCE PROJECTS

PROJECT LOCATION	RG #	YR COM, SUBAC #	PRC #	ELE-MENT	BID $/ TON	TONS 1000	TEST "n"	PROCESS SD	PROCESS TARG	MEAN - TAR	QUAL LEVL	VA PF	QPM2 PF	VA I/D $	CNT CDE	AGG GRAD
6th Ave, Wads-Fed	6	93,93092	A	AC%	$29.25	21.1	24	0.20	4.8	-0.06	84.9	1.009	0.986	$278	W2	C
Jct SH 165, N & S	2	94,92410	A	AC%	$21.90	38.5	40	0.24	5.3	0.09	76.0	0.908	0.896	($3,891)	W2	C
Jct SH 165, N & S	2	94,92410	A1	AC%	$21.90	1.5	2	NA	5.3	-0.62	NA	0.831	0.500	($279)	W2	C
Jct SH 165, N & S	2	94,92410	B	AC%	$21.90	8.5	9	0.17	5.1	0.14	81.7	0.995	0.995	($44)	W2	C
Jct SH 165, N & S	2	94,92410	C	AC%	$21.90	3.4	3	0.23	5.3	0.14	70.3	1.007	1.002	$26	W2	C
Jct SH 165, N & S	2	94,92410	D	AC%	$21.90	4.5	5	0.18	5.3	0.04	94.5	1.045	1.030	$217	W2	C
Jct SH 165, N & S	2	94,92410	A	AC%	$28.20	4.4	5	0.13	5.4	-0.08	99.0	1.050	1.030	$315	W2	CX
Jct SH 165, N & S	2	94,92410	B	AC%	$28.20	10.0	10	0.18	5.1	-0.02	91.7	1.032	1.037	$447	W2	CX
Jct SH 165, N & S	2	94,92410	C	AC%	$28.20	4.4	4	0.13	5.5	-0.09	100.0	1.049	1.030	$303	W2	CX
Jct SH 165, N & S	2	94,92410	D	AC%	$28.20	21.4	21	0.16	5.1	-0.04	93.2	1.036	1.032	$1,084	W2	CX
Jct SH 165, N & S	2	94,92410	E	AC%	$28.20	14.7	15	0.11	5.5	-0.05	99.3	1.049	1.050	$1,016	W2	CX
Pierce - Nunn	2	95,93262	A	AC%	$25.00	22.4	23	0.19	4.6	0.06	87.2	1.022	0.999	$603	K1	C
Pierce - Nunn	2	95,93262	B	AC%	$33.00	12.8	13	0.15	5.0	-0.08	93.3	1.020	1.040	$428	K1	C
US 36, Sher - Wads	6	95,10678	A	AC%	$23.40	29.1	29	0.22	4.6	0.02	82.1	0.997	0.967	($102)	A1	C
Jct SH 50 - South	2	96,10791	A	AC%	$26.00	72.3	73	0.20	5.7	-0.01	85.9	1.001	0.956	$89	K1	C
Jct SH 85 - North	2	96,10942	A	AC%	$34.30	10.5	10	0.08	4.6	-0.17	95.8	1.042	1.045	$756	S1	C
Jct SH 85 - North	2	96,10942	B	AC%	$34.30	30.8	30	0.20	4.8	-0.08	83.9	1.005	0.971	$248	S1	C
COMPOSITE OF VD ACCEPTANCE AC TESTS					$26.94	310.3	316	0.19	5.1	-0.01	86.3	1.000	0.977	$1,494		
DESIGNED BY TEXAS GYRATORY, WTED AVERAGES & TOTALS							Absolute Mean-Target			0.06						
I 70 Colfax - SH 26	6	96,11364	A	AC%	$29.15	1.2	2	NA	5.0	-0.03	NA	1.000	1.000	$0	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	AC%	$29.15	9.1	9	0.28	5.1	-0.13	66.8	0.851	0.909	($3,957)	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	AC%	$29.15	27.8	28	0.15	4.3	0.09	91.8	1.027	1.029	$2,190	A1	SP
Northgate - North	6	96,11373	A	AC%	$38.75	21.1	21	0.17	5.1	-0.08	88.6	1.002	1.009	$186	W2	SP
I 70, Colfax - Clr Crk	6	96,11512	B	AC%	$31.40	21.3	22	0.17	4.9	0.27	56.9	0.845	0.766	($10,362)	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	A	AC%	$31.40	3.5	4	0.10	4.9	0.03	100.0	1.049	1.030	$535	A1	SP
COMPOSITE OF VD ACCEPTANCE AC TESTS					$32.23	84.0	86	0.17	4.8	0.06	79.6	0.956	0.944	($11,409)		SP
DESIGNED BY SUPERPAVE, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			0.13						
COMPOSITE OF ALL VOID ACCEPTANCE					$28.07	394.3	402.0	0.19	5.07	0.00	84.9	0.991	0.970	($11,951)		
FIELD AC CONTENT TESTS, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			0.07						
6th Ave, Wads-Fed	6	93,93092	A	Dns%	$29.25	21.1	42	0.79	94.0	-0.76	94.3	1.039	1.035	$9,639	W2	C
Jct SH 165, N & S	2	94,92410	A	Dns%	$21.90	38.5	80	1.12	94.0	-0.86	84.0	1.005	0.939	$1,696	W2	C
Jct SH 165, N & S	2	94,92410	A1	Dns%	$21.90	1.5	NA	NA	94.0	NA	NA	1.005	0.500	$66	W2	C
Jct SH 165, N & S	2	94,92410	B	Dns%	$21.90	8.5	17	1.11	94.0	-1.12	78.4	0.980	0.961	($1,489)	W2	C
Jct SH 165, N & S	2	94,92410	C	Dns%	$21.90	3.4	7	0.53	94.0	-0.57	100.0	1.035	1.035	$1,039	W2	C
Jct SH 165, N & S	2	94,92410	D	Dns%	$21.90	4.5	9	1.01	94.0	-0.44	94.7	1.040	1.040	$1,560	W2	C
Jct SH 165, N & S	2	94,92410	A	Dns%	$28.20	4.4	9	1.45	94.0	0.11	84.4	1.007	1.008	$351	W2	CX
Jct SH 165, N & S	2	94,92410	B	Dns%	$28.20	10.0	20	1.30	94.0	-1.30	70.0	0.901	0.877	($11,129)	W2	CX
Jct SH 165, N & S	2	94,92410	C	Dns%	$28.20	4.4	8	1.51	94.0	-1.50	62.4	0.771	0.877	($11,288)	W2	CX
Jct SH 165, N & S	2	94,92410	D	Dns%	$28.20	21.4	43	1.32	94.0	-0.44	85.3	0.988	0.969	($2,778)	W2	CX
Jct SH 165, N & S	2	94,92410	E	Dns%	$28.20	14.7	30	1.11	94.0	-1.25	74.9	0.890	0.915	($18,242)	W2	CX
Pierce - Nunn	2	95,93262	A	Dns%	$25.00	22.4	39	1.22	94.0	-2.09	47.1	0.765	0.750	($52,574)	K1	C
Pierce - Nunn	2	95,93262	B	Dns%	$33.00	12.8	26	0.96	94.0	-1.38	73.9	0.912	0.901	($14,880)	K1	C
US 36, Sher - Wads	6	95,10678	A	Dns%	$23.40	29.1	58	0.88	94.0	-0.53	95.2	1.041	1.041	$11,157	A1	C
Jct SH 50 - South	2	96,10791	A	Dns%	$26.00	72.3	146	0.88	94.0	0.02	97.7	1.041	1.057	$30,992	K1	C
Jct SH 85 - North	2	96,10942	A	Dns%	$34.30	10.5	22	1.03	94.0	-2.11	45.8	0.750	0.750	($36,015)	S1	C
Jct SH 85 - North	2	96,10942	B	Dns%	$34.30	30.8	59	0.71	94.0	-1.14	88.8	1.023	0.992	$9,592	S1	C
COMPOSITE OF VD ACCEPT DENSITY TESTS					$26.94	310.3	615	1.00	94.0	-0.79	84.1	0.978	0.966	($82,303)		
DESIGNED BY TEXAS GYRATORY, WTED AVERAGES & TOTALS							Absolute Mean-Target			0.81						
I 70 Colfax - SH 26	6	96,11364	A	Dns%	$29.15	1.2	3	0.35	94.0	-1.57	100.0	1.050	1.025	$682	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	Dns%	$29.15	9.1	18	0.70	94.0	-1.13	89.7	1.026	1.023	$2,770	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	Dns%	$29.15	27.8	56	0.96	94.0	-1.83	56.9	0.641	0.729	($116,499)	A1	SP
Northgate - North	6	96,11373	A	Dns%	$38.75	21.1	43	1.23	94.0	0.17	89.6	1.025	1.001	$8,177	W2	SP
I 70, Colfax - Clr Crk	6	96,11512	A	Dns%	$31.40	3.5	8	0.17	94.0	-1.93	66.4	0.906	0.905	($4,104)	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	B	Dns%	$31.40	21.3	43	0.61	94.0	-1.27	88.4	1.021	0.992	$5,627	A1	SP
COMPOSITE OF VD ACCPT DENSITY TESTS					$32.23	84.0	171	0.87	94.0	-1.11	77.7	0.892	0.907	($103,348)		SP
DESIGNED BY SUPERPAVE, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			1.20						
COMPOSITE OF ALL VOID ACCEPTANCE					$28.07	394.3	786.0	0.97	94.00	-0.86	82.8	0.960	0.954	($11,951)		
FIELD DENSITY TESTS, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			0.89						

Table 2
HOT BITUMINOUS PAVEMENT QC/QA DETAILS & SUMMARY BY ELEMENT, PROJECT & MIX DESIGN FOR 1993 - 96 VOID ACCEPTANCE PROJECTS

PROJECT LOCATION	RG #	YR COM, SUBAC #	PRC #	ELE-MENT	BID $/ TON	TONS 1000	TEST "n"	PROCESS SD	PROCESS TARG	MEAN - TAR	QUAL LEVL	VA PF	QPM2 PF	VA I/D $	CNT CDE	AGG GRAD
6th Ave, Wads-Fed	6	93,93092	A	Stab	$29.25	21.1	24	3.60	35.0	3.20	81.8	0.996	0.965	($124)	W2	C
Jct SH 165, N & S	2	94,92410	A	Stab	$21.90	38.5	42	1.97	35.0	10.3	100.0	1.050	1.055	$2,107	W2	C
Jct SH 165, N & S	2	94,92410	A1	Stab	$21.90	1.5	NA	NA	NA	NA	NA	1.050	0.500	$83	W2	C
Jct SH 165, N & S	2	94,92410	B	Stab	$21.90	8.5	9	1.70	35.0	11.30	100.0	1.050	1.040	$465	W2	C
Jct SH 165, N & S	2	94,92410	C	Stab	$21.90	3.4	3	0.60	35.0	9.30	100.0	1.050	1.025	$185	W2	C
Jct SH 165, N & S	2	94,92410	D	Stab	$21.90	4.5	5	0.50	35.0	9.40	100.0	1.050	1.030	$244	W2	C
Jct SH 165, N & S	2	94,92410	A	Stab	$28.20	4.4	5	1.00	35.0	12.00	100.0	1.050	1.030	$313	W2	CX
Jct SH 165, N & S	2	94,92410	B	Stab	$28.20	10.0	10	2.30	35.0	12.60	100.0	1.050	1.040	$704	W2	CX
Jct SH 165, N & S	2	94,92410	C	Stab	$28.20	4.4	4	2.20	35.0	9.80	100.0	1.050	1.030	$308	W2	CX
Jct SH 165, N & S	2	94,92410	D	Stab	$28.20	21.4	21	1.20	35.0	18.30	100.0	1.050	1.050	$1,507	W2	CX
Jct SH 165, N & S	2	94,92410	E	Stab	$28.20	14.7	15	1.20	35.0	8.30	100.0	1.050	1.050	$1,038	W2	CX
Pierce - Nunn	2	95,93262	A	Stab	$25.00	22.4	23	1.28	40.0	8.00	100.0	1.048	1.050	$1,343	K1	C
Pierce - Nunn	2	95,93262	B	Stab	$33.00	12.8	13	3.67	40.0	16.00	100.0	1.039	1.045	$825	K1	C
US 36, Sher - Wads	6	95,10678	A	Stab	$23.40	29.1	29	1.70	40.0	7.10	100.0	1.050	1.050	$1,701	A1	C
Jct SH 50 - South	2	96,10791	A	Stab	$26.00	72.3	73	2.04	37.0	4.08	97.9	1.035	1.059	$3,305	K1	C
Jct SH 85 - North	2	96,10942	A	Stab	$34.30	10.5	10	1.17	40.0	11.60	100.0	1.050	1.045	$900	S1	C
Jct SH 85 - North	2	96,10942	B	Stab	$34.30	30.8	30	2.76	40.0	10.60	100.0	1.050	1.055	$2,641	S1	C
COMPOSITE OF ALL VOID ACCEPTANCE					$26.94	310.3	316	2.01	37.2	8.76	98.3	1.042	1.043	$17,547		
HVEEM STABILITY TESTS, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			8.76						
I 70 Colfax - SH 26	6	96,11364	A	Stab		NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	Stab		NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	Stab		NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
Northgate - North	6	96,11373	A	Stab		NA	NA	NA	NA	NA	NA	NA	NA	NA	W2	SP
I 70, Colfax - Clr Crk	6	96,11512	A	Stab		NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	B	Stab		NA	NA	NA	NA	NA	NA	NA	NA	NA	A1	SP
6th Ave, Wads-Fed	6	93,93092	A	VMA	$29.25	21.1	24	0.38	13.5	-0.63	93.9	1.038	1.041	$4,696	W2	C
Jct SH 165, N & S	2	94,92410	A	VMA	$21.90	38.5	42	0.25	13.0	0.26	100.0	1.045	1.055	$11,400	W2	C
Jct SH 165, N & S	2	94,92410	A1	VMA	$21.90	1.5	NA	NA	13.0	NA	NA	1.045	0.500	$447	W2	C
Jct SH 165, N & S	2	94,92410	B	VMA	$21.90	8.5	9	0.22	13.0	0.21	100.0	1.050	1.040	$2,793	W2	C
Jct SH 165, N & S	2	94,92410	C	VMA	$21.90	3.4	3	0.31	13.0	0.03	100.0	1.050	1.025	$1,113	W2	C
Jct SH 165, N & S	2	94,92410	D	VMA	$21.90	4.5	5	0.38	13.0	0.14	100.0	1.050	1.030	$1,462	W2	C
Jct SH 165, N & S	2	94,92410	A	VMA	$28.20	4.4	5	0.21	14.0	-0.96	88.1	1.031	1.030	$1,174	W2	CX
Jct SH 165, N & S	2	94,92410	B	VMA	$28.20	10.0	10	0.21	14.0	-1.13	62.9	0.884	0.881	($9,831)	W2	CX
Jct SH 165, N & S	2	94,92410	C	VMA	$28.20	4.4	4	0.35	13.0	0.97	71.4	0.985	0.985	($573)	W2	CX
Jct SH 165, N & S	2	94,92410	D	VMA	$28.20	21.4	21	0.24	14.0	-0.99	80.7	0.991	0.957	($1,675)	W2	CX
Jct SH 165, N & S	2	94,92410	E	VMA	$28.20	14.7	15	0.25	14.0	-0.42	99.7	1.050	1.050	$6,170	W2	CX
Pierce - Nunn	2	95,93262	A	VMA	$25.00	22.4	23	0.30	13.0	0.58	98.5	1.045	1.050	$5,018	K1	C
Pierce - Nunn	2	95,93262	B	VMA	$33.00	12.8	13	0.46	13.0	0.62	90.2	1.015	1.026	$1,267	K1	C
US 36, Sher - Wads	6	95,10678	A	VMA	$23.40	29.1	29	0.37	13.6	0.69	91.9	1.032	1.029	$4,354	A1	C
Jct SH 50 - South	2	96,10791	A	VMA	$26.00	72.3	73	0.54	16.4	-0.42	92.5	1.002	1.013	$587	K1	C
Jct SH 85 - North	2	96,10942	A	VMA	$34.30	10.5	10	0.33	14.0	-0.57	98.3	1.047	1.045	$3,400	S1	C
Jct SH 85 - North	2	96,10942	B	VMA	$34.30	30.8	30	0.34	13.5	0.11	100.0	1.050	1.055	$10,564	S1	C
COMPOSITE OF VOID ACCEPT VMA TESTS					$26.94	310.3	316	0.36	14.1	-0.10	93.4	1.023	1.022	$42,366		
DESIGNED BY TEXAS GYRATORY, W'TED AVERAGES & TOTALS							Absolute Mean-Target			0.50						
I 70 Colfax - SH 26	6	96,11364	A	VMA	$29.15	1.2	2	NA	13.0	0.00	NA	1.000	1.000	$0	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	VMA	$29.15	9.1	9	0.51	13.0	-0.82	100.0	0.833	1.040	($8,895)	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	VMA	$29.15	27.8	28	0.40	13.2	-0.83	82.3	1.014	0.968	$2,237	A1	SP
Northgate - North	6	96,11373	A	VMA	$38.75	21.1	21	0.41	13.0	-0.38	98.1	1.021	1.050	$3,485	W2	SP
I 70, Colfax - Clr Crk	6	96,11512	A	VMA	$31.40	3.5	4	0.47	14.0	-0.03	100.0	1.049	1.030	$1,070	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	B	VMA	$31.40	21.3	22	0.67	14.0	0.30	90.9	1.031	1.023	$4,113	A1	SP
COMPOSITE OF VOID ACCPT VMA TESTS					$32.23	84.0	86	0.49	13.4	-0.38	91.2	1.002	1.013	$2,009		SP
DESIGNED BY SUPERPAVE, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			0.54						
COMPOSITE OF ALL VOID ACCEPTANCE					$28.07	394.3	402.0	0.39	13.97	-0.16	92.9	1.018	1.020	($11,951)		
VMA TESTS, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			0.51						

Table 2
HOT BITUMINOUS PAVEMENT QC/QA DETAILS & SUMMARY BY ELEMENT, PROJECT & MIX DESIGN FOR 1993 - 96 VOID ACCEPTANCE PROJECTS

PROJECT LOCATION	RG #	YR COM, SUBAC #	PRC #	ELE-MENT	BID $/ TON	TONS 1000	TEST "n"	PROCESS SD	PROCESS TARG	MEAN - TAR	QUAL LEVL	VA PF	QPM2 PF	VA I/D $	CNT CDE	AGG GRAD
6th Ave, Wads-Fed	6	93,93092	A	Voids	$29.75	21.1	24	0.40	3.3	-0.60	93.5	1.037	1.039	$6,976	W2	C
Jct SH 165, N & S	2	94,92410	A	Voids	$21.90	38.5	42	0.62	4.0	-0.14	94.6	1.034	1.037	$11,467	W2	C
Jct SH 165, N & S	2	94,92410	A1	Voids	$21.90	1.5	NA	NA	4.0	0.00	NA	1.034	0.500	$450	W2	C
Jct SH 165, N & S	2	94,92410	B	Voids	$21.90	8.5	9	0.24	4.0	-0.24	100.0	1.050	1.040	$3,723	W2	C
Jct SH 165, N & S	2	94,92410	C	Voids	$21.90	3.4	3	0.21	4.0	-0.83	100.0	1.050	1.025	$1,484	W2	C
Jct SH 165, N & S	2	94,92410	D	Voids	$21.90	4.5	5	0.52	4.0	-0.60	88.3	1.032	1.030	$1,240	W2	C
Jct SH 165, N & S	2	94,92410	A	Voids	$28.20	4.4	5	0.28	4.0	-1.12	60.2	0.903	0.902	($4,878)	W2	CX
Jct SH 165, N & S	2	94,92410	B	Voids	$28.20	10.0	10	0.38	4.0	-0.62	94.7	1.040	1.040	$4,461	W2	CX
Jct SH 165, N & S	2	94,92410	C	Voids	$28.20	4.4	4	0.37	3.0	0.85	81.6	1.022	1.025	$1,087	W2	CX
Jct SH 165, N & S	2	94,92410	D	Voids	$28.20	21.4	21	0.48	4.0	-0.52	95.1	1.041	1.048	$9,768	W2	CX
Jct SH 165, N & S	2	94,92410	E	Voids	$28.20	14.7	15	0.29	3.0	0.19	100.0	1.050	1.050	$8,301	W2	CX
Pierce - Nunn	2	95,93262	A	Voids	$25.00	22.4	23	0.52	4.0	-0.51	90.8	1.015	1.022	$2,517	K1	C
Pierce - Nunn	2	95,93262	B	Voids	$33.00	12.8	13	0.51	4.2	-0.69	83.8	0.947	0.993	($6,666)	K1	C
US 36, Sher - Wads	6	95,10678	A	Voids	$23.40	29.1	29	0.53	3.5	0.42	93.2	1.036	1.037	$7,347	A1	C
Jct SH 50 - South	2	96,10791	A	Voids	$26.00	72.3	73	0.59	4.0	-0.36	91.9	1.006	1.007	$3,533	K1	C
Jct SH 85 - North	2	96,10942	A	Voids	$34.30	10.5	10	0.37	4.0	-0.44	99.1	1.049	1.045	$5,240	S1	C
Jct SH 85 - North	2	96,10942	B	Voids	$34.30	30.8	30	0.58	3.5	-0.30	93.9	1.038	1.038	$11,917	S1	C
COMPOSITE VD ACCEPT AIR VOIDS TESTS					$26.98	310.3	316	0.51	3.8	-0.29	92.9	1.024	1.024	$67,967		
DESIGNED BY TEXAS GYRATORY, W'TED AVERAGES & TOTALS							Absolute Mean-Target			0.41						
I 70 Colfax - SH 26	6	96,11364	A	Voids	$29.15	1.2	2	NA	4.0	-1.25	NA	0.778	0.889	($2,269)	A1	SP
I 70 Colfax - SH 26	6	96,11364	B	Voids	$29.15	9.1	9	0.61	4.0	-1.55	29.2	0.833	0.561	($13,342)	A1	SP
I 70 Colfax - SH 26	6	96,11364	C	Voids	$29.15	27.8	28	0.43	4.1	-0.35	98.8	1.049	1.050	$11,961	A1	SP
Northgate - North	6	96,11373	A	Voids	$38.75	21.1	21	0.57	4.5	-1.44	91.0	1.003	1.024	$736	W2	SP
I 70, Colfax - Clr Crk	6	96,11512	B	Voids	$31.40	21.3	22	0.76	3.8	-0.78	78.5	0.924	0.942	($15,332)	A1	SP
I 70, Colfax - Clr Crk	6	96,11512	A	Voids	$31.40	3.5	4	0.79	3.8	-0.35	94.1	1.046	1.030	$1,506	A1	SP
COMPOSITE VD ACCEPT AIR VOIDS TESTS					$32.23	84.0	86	0.58	4.1	-0.88	82.6	0.978	0.960	($16,741)		SP
DESIGNED BY SUPERPAVE, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			0.88						
COMPOSITE OF ALL VOID ACCEPTANCE					$28.10	394.3	402.0	0.52	3.87	-0.41	90.7	1.014	1.010	($11,951)		
AIR VOIDS TESTS, WEIGHTED AVERAGES & TOTALS							Absolute Mean-Target			0.51						
ITEM COMPOSITE OF VD ACCPT PROJECTS					$26.98	310.3	**NA**	**NA**	**NA**	**NA**	**89.41**	**1.005**	**0.999**	**$47,069**		
DESIGNED BY TEXAS GYRATORY, W'TED AVERAGES & TOTALS																
ITEM COMPOSITE OF VD ACCPT PROJECTS					$32.23	84.0	**NA**	**NA**	**NA**	**NA**	**82.04**	**0.946**	**0.948**	**($129,488)**		
DESIGNED BY SUPERPAVE, WEIGHTED AVERAGES & TOTALS																
ITEM COMPOSITE OF ALL VOID					$28.10	394.3	**NA**	**NA**	**NA**	**NA**	**87.84**	**0.993**	**0.988**	**($82,419)**		
ACCEPTANCE PROJECTS, WEIGHTED AVERAGES & TOTALS																

TABLE 3

HBP EVALUATION SUMMARIZED BY YEAR, 1991 HISTORICAL & 1992 - 1996 QC/QA

IDENTIFICATION YEAR	ELEMENT	TONS 1000s	TESTS "n"	STD DEV	MEAN - TARGET		QPM 2 QUAL LEV	QPM 1 PAY FACT	QPM 2 PAY FACT
Composites are element values weighted by "W" fa Element data are process averages weighted X tons. Gradation SD & Mean - Target									
1991	Asphalt %	2000	4027	0.18	0.07 Abs		87.0	1.005	1.000
Historical	Density %	900	1865	1.05	1.00 Abs		84.0	1.002	0.960
Elements	Gradation	2000	2317	2.59	1.82 Abs		85.7	1.005	0.989
Composite	Item	2000					85.2	1.004	0.978
1992	Asphalt %	282	214	0.14	0.06 Abs		96.3	1.039	1.042
QPM 1	Density %	282	570	1.00	0.71 Abs		88.9	1.018	0.990
Elements	Gradation	282	180	2.11	1.21 Abs		90.0	1.020	1.014
Composite	Item	282					91.3	1.025	1.010
1993	Asphalt %	482	837	0.15	0.04 Abs		93.2	1.032	1.028
QPM1	Density %	482	969	0.96	0.48 Abs		92.4	1.028	1.018
Elements	Gradation	482	309	2.31	1.53 Abs		88.8	1.016	1.010
Composite	Item	482			ABS	ALGEB	91.9	1.027	1.019
1994	Asphalt %	1496	1277	0.15	0.06	0.01	90.6	1.034	1.022
QPM1	Density %	1400	2812	0.96	0.57	-0.47	90.3	1.023	1.007
Elements	Gradation	1496	1053	2.05	1.12	-0.93	88.3	1.021	1.014
Composite	Item	1496					90.0	1.026	1.013
1995	Asphalt %	776	764	0.17	0.09	0.03	86.1	1.017	0.993
QPM1	Density %	757	1378	1.14	0.97	-0.85	81.1	0.999	0.950
Elements	Gradation	776	547	2.10	1.18	-0.18	88.9	1.017	1.015
Composite	Item	776					84.2	1.008	0.976
1991 - 1995	**Asphalt %**	**3036**	**3092**	**0.15**	**0.07**	**0.02**	**90.4**	**1.030**	**1.017**
Summary of	**Density %**	**2921**	**5729**	**1.01**	**0.67**	**-0.60**	**88.1**	**1.017**	**0.992**
QPM 1 Elements	**Gradation**	**3036**	**2089**	**2.11**	**1.21**	**-0.67**	**88.7**	**1.019**	**1.014**
SUMMARY QPM1 COMPOSITES		**3036**					**88.9**	**1.021**	**1.004**
1995	Asphalt %	328	342	0.18	0.05	0.02	88.7	1.014	1.000
QPM 2	Density %	314	625	0.99	0.46	-0.38	91.7	1.023	1.017
Elements	Gradation	328	191	2.76	1.19	0.55	85.1	1.003	0.990
Composite	Item	328					89.5	1.016	1.007
1996	Asphalt %	830	847	0.16	0.07	0.02	89.8	NA	1.008
QPM 2	Density %	830	1465	0.91	0.60	-0.56	91.9	NA	1.015
Elements	Gradation	830	438	1.98	1.53	0.15	89.6	NA	1.012
Composite	Item	830					90.8	NA	1.012
1995 - 1996	**Asphalt %**	**1158**	**1189**	**0.17**	**0.07**	**0.02**	**89.5**	**NA**	**1.006**
Summary of	**Density %**	**1144**	**2090**	**0.93**	**0.56**	**-0.51**	**91.9**	**NA**	**1.016**
QPM 2 Elements	**Gradation**	**1158**	**629**	**2.20**	**1.44**	**0.26**	**88.3**	**NA**	**1.006**
SUMMARY QPM2 COMPOSITES		**1158**					**90.4**	**NA**	**1.011**
SUMMARY QC/QA PROJECTS		**4194**					**89.3**	**NA**	**1.006**

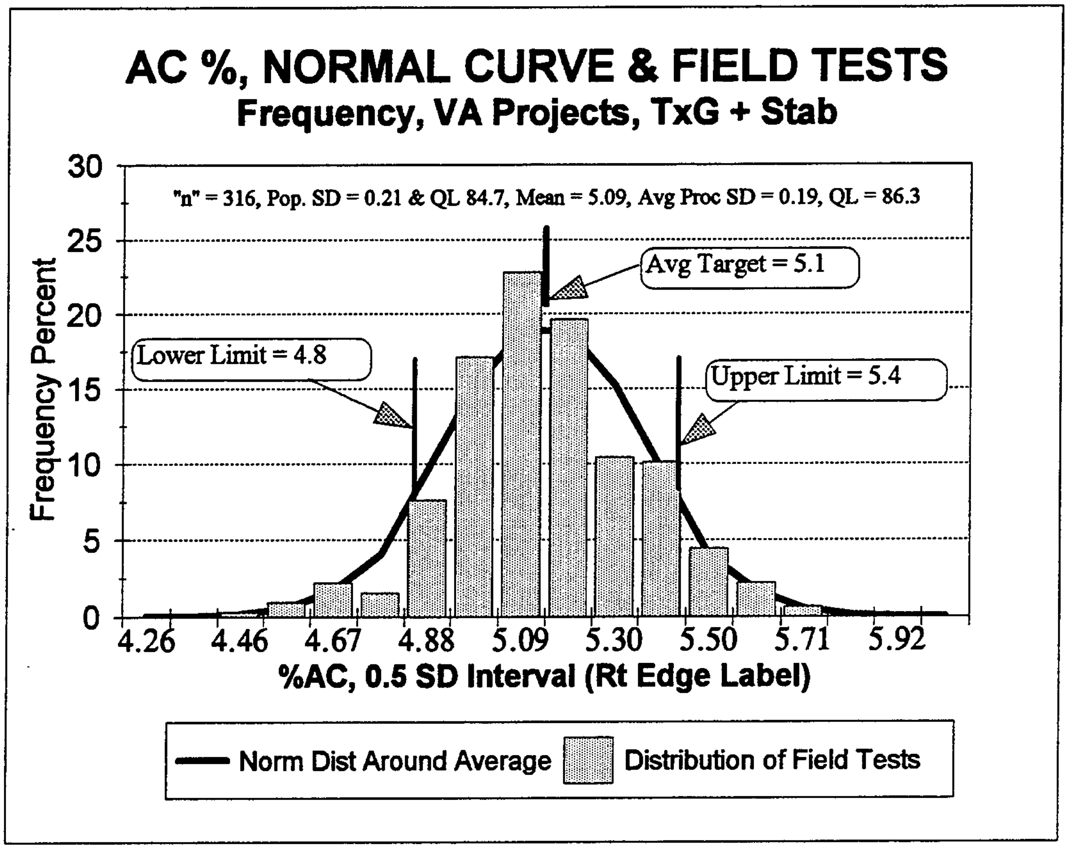


Figure 1

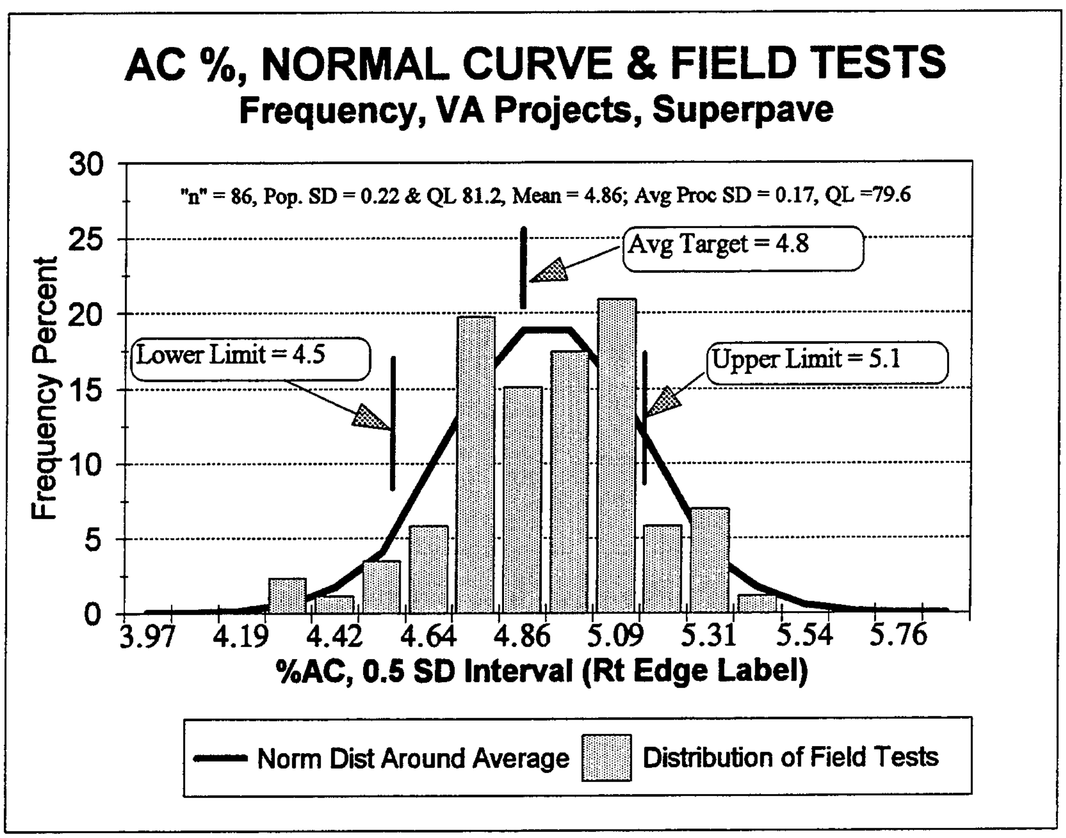
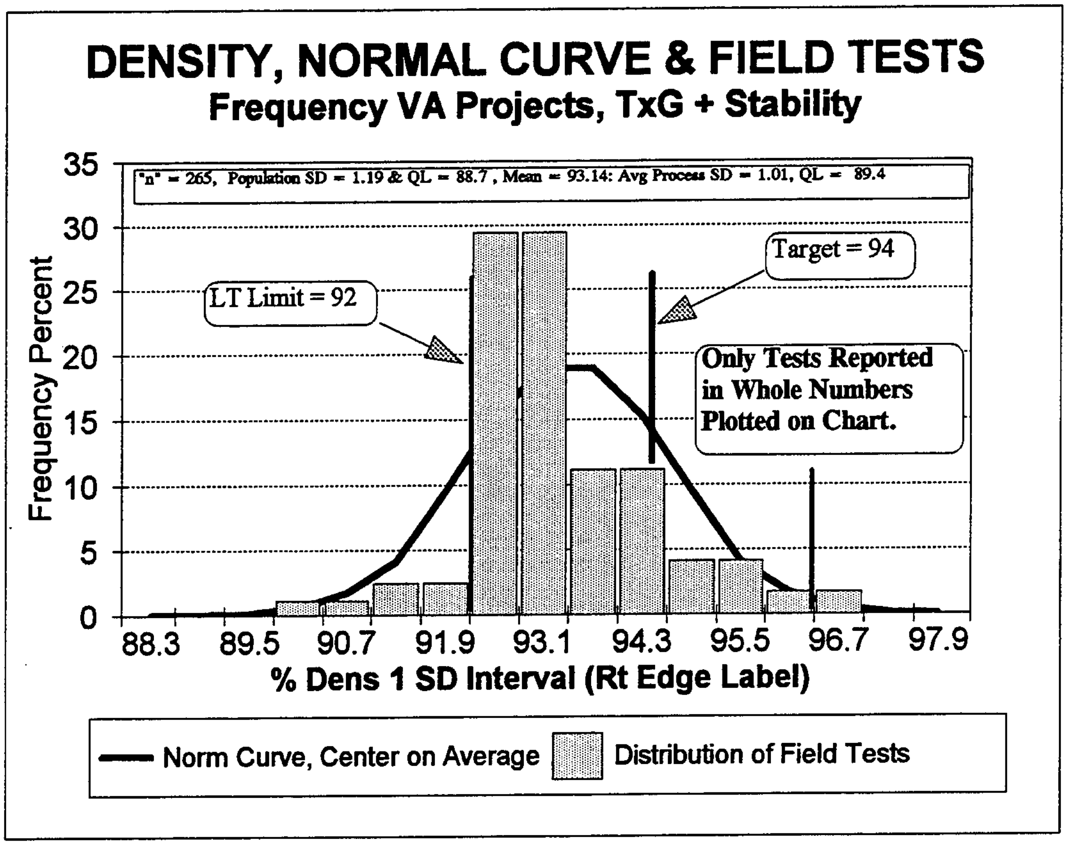


Figure 2



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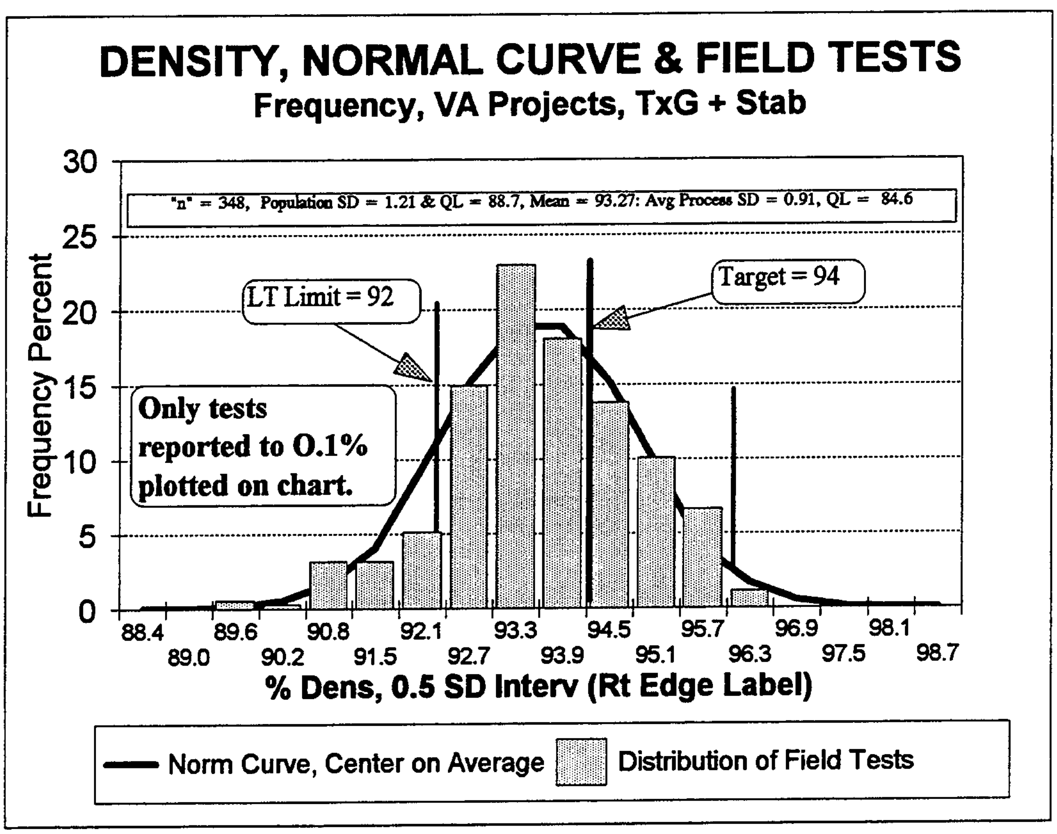

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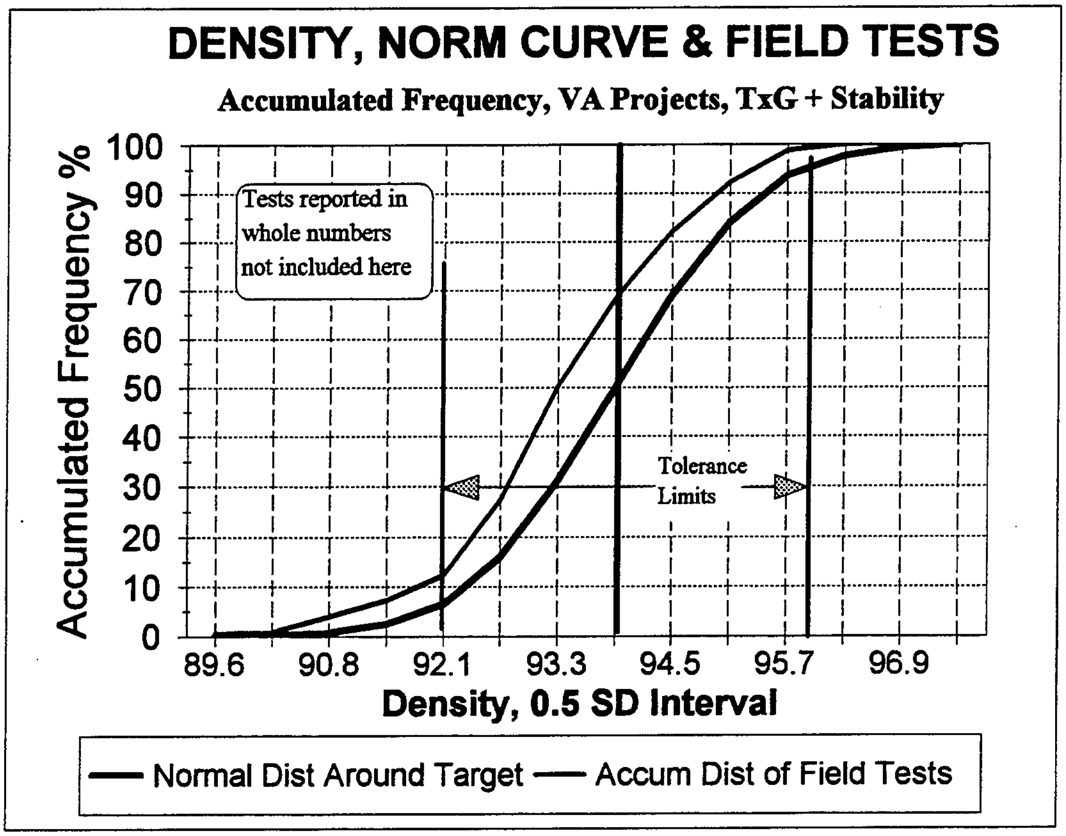

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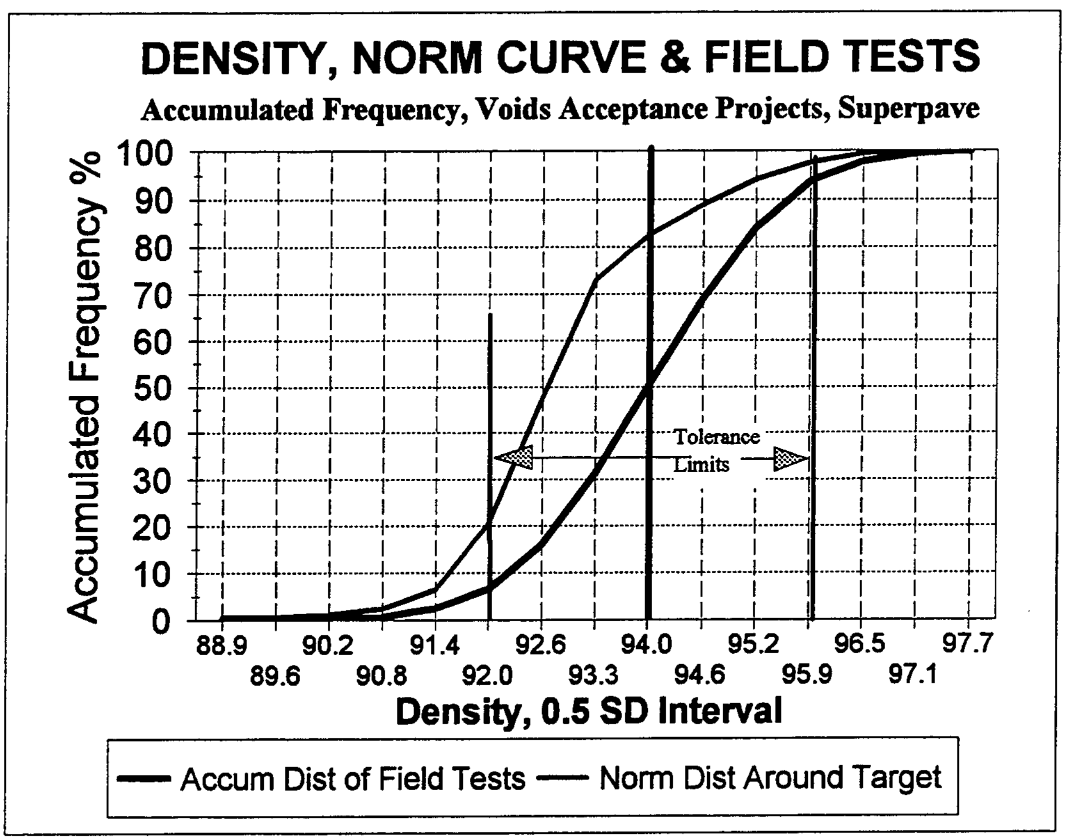

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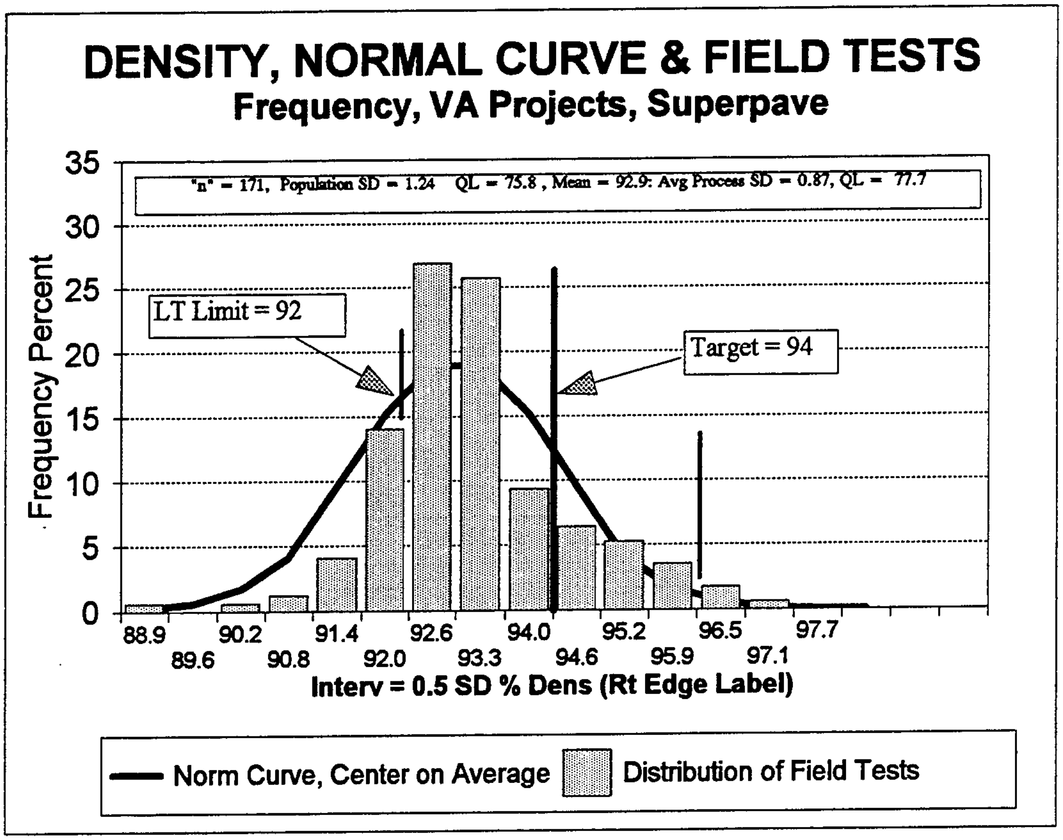

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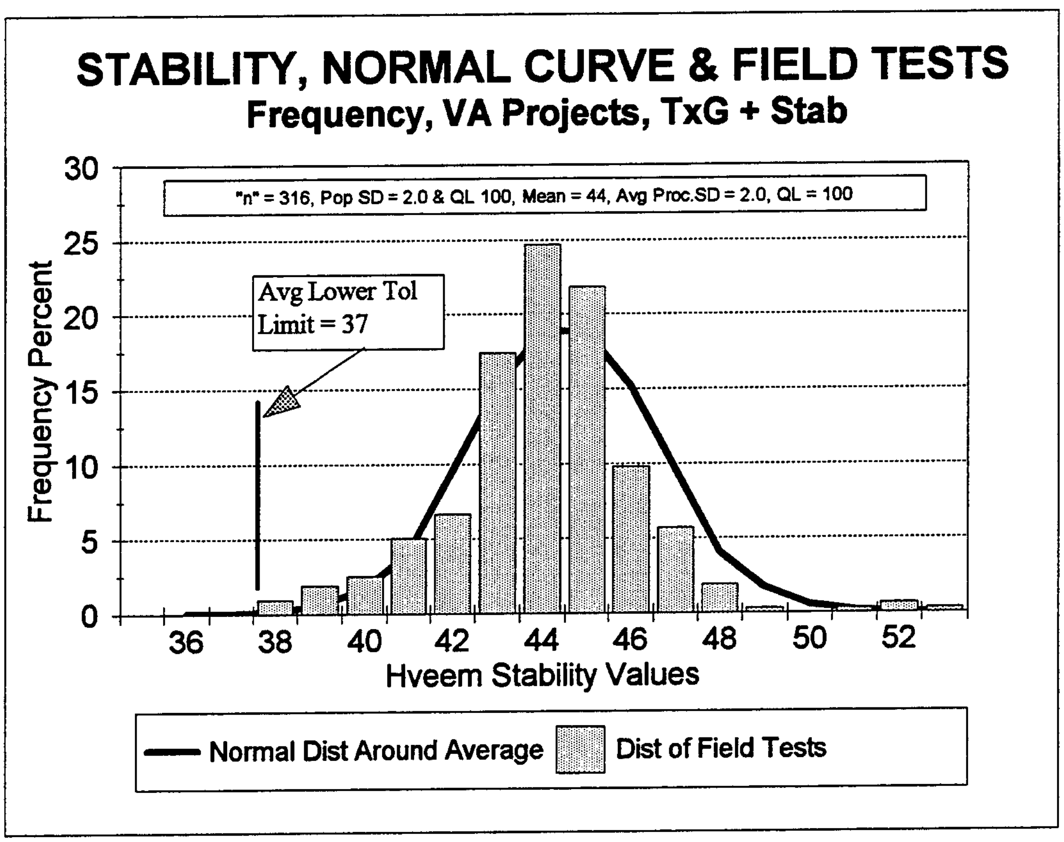

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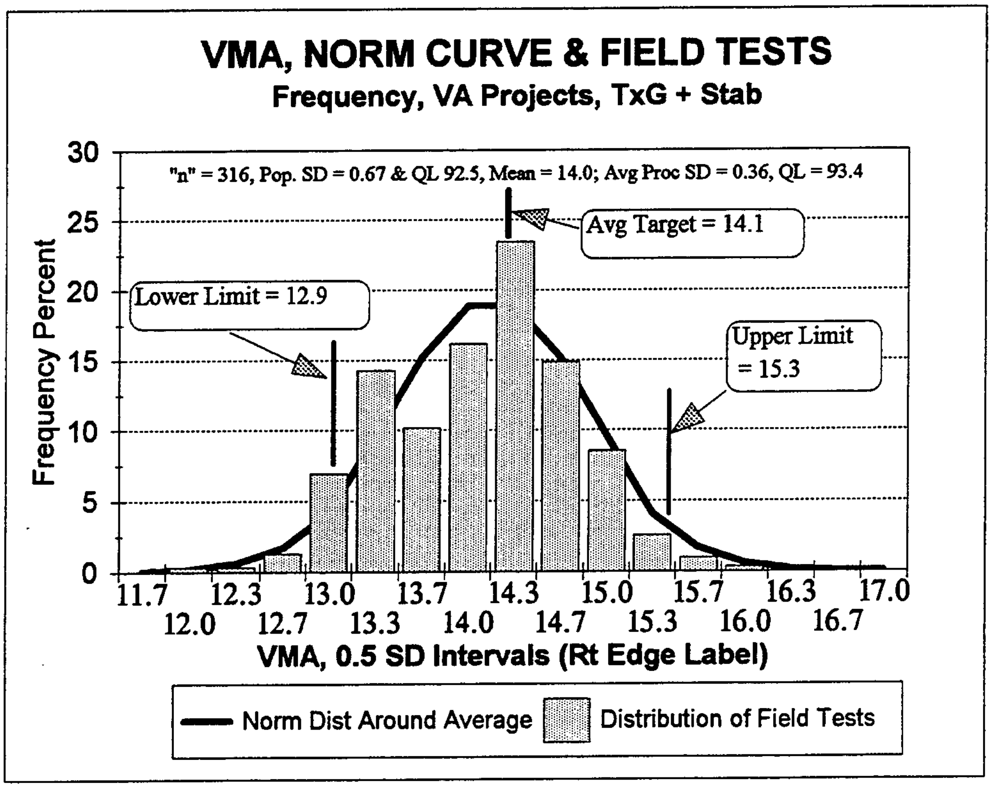

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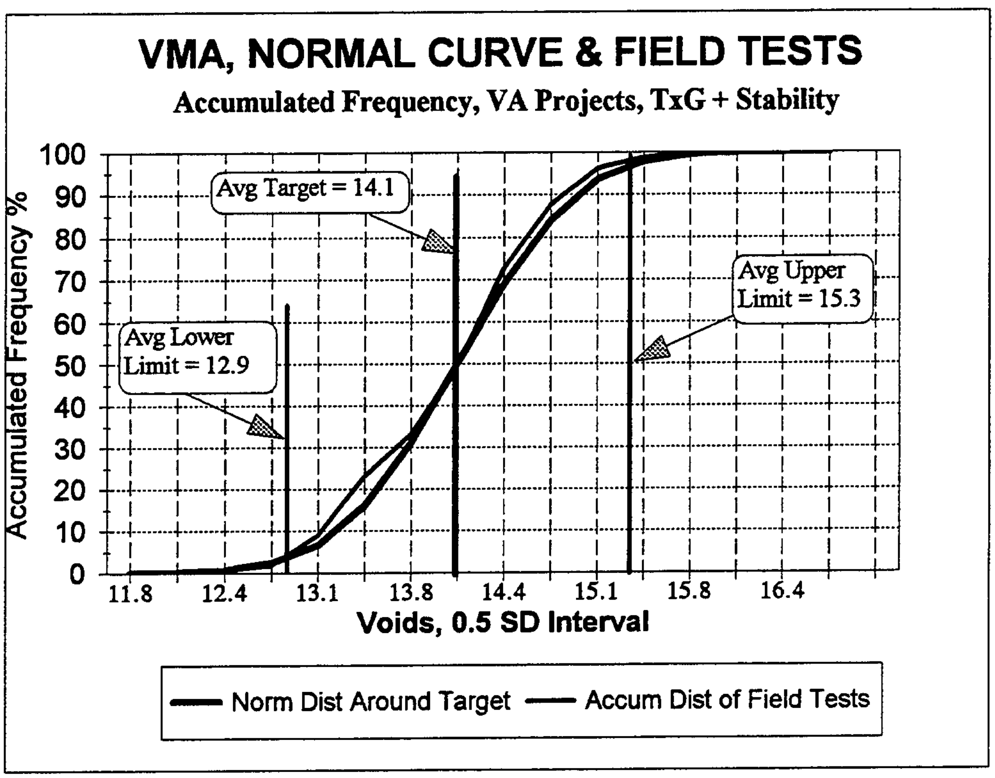
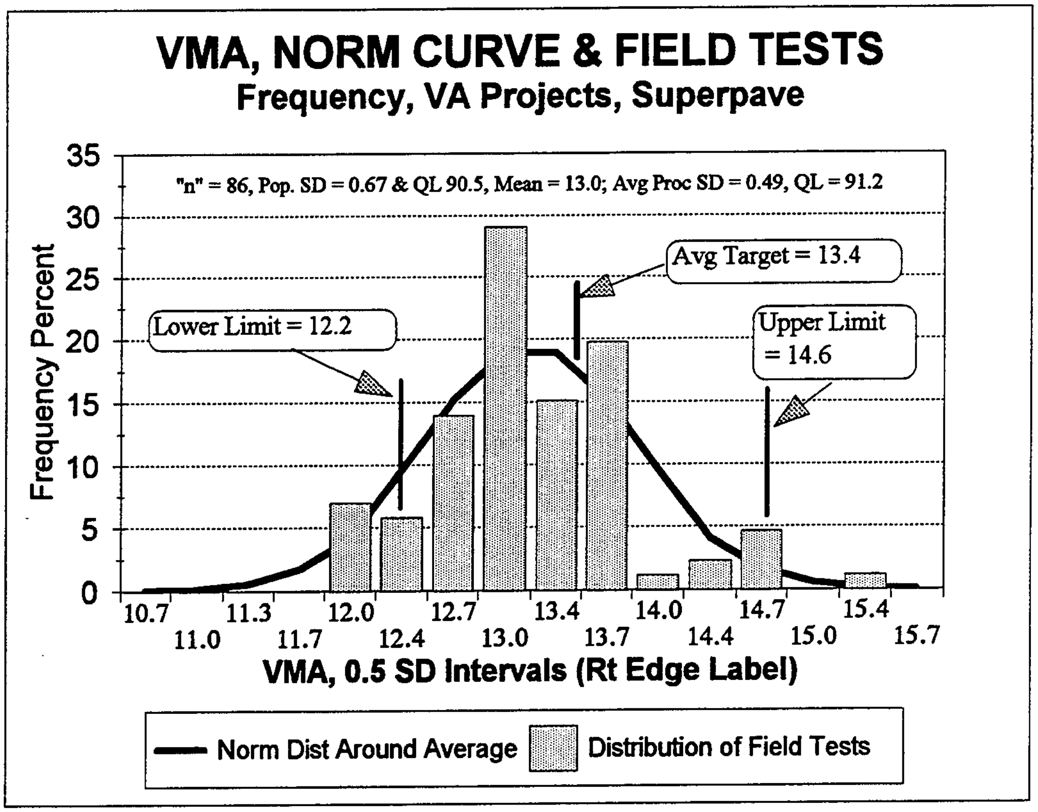


Figure 10



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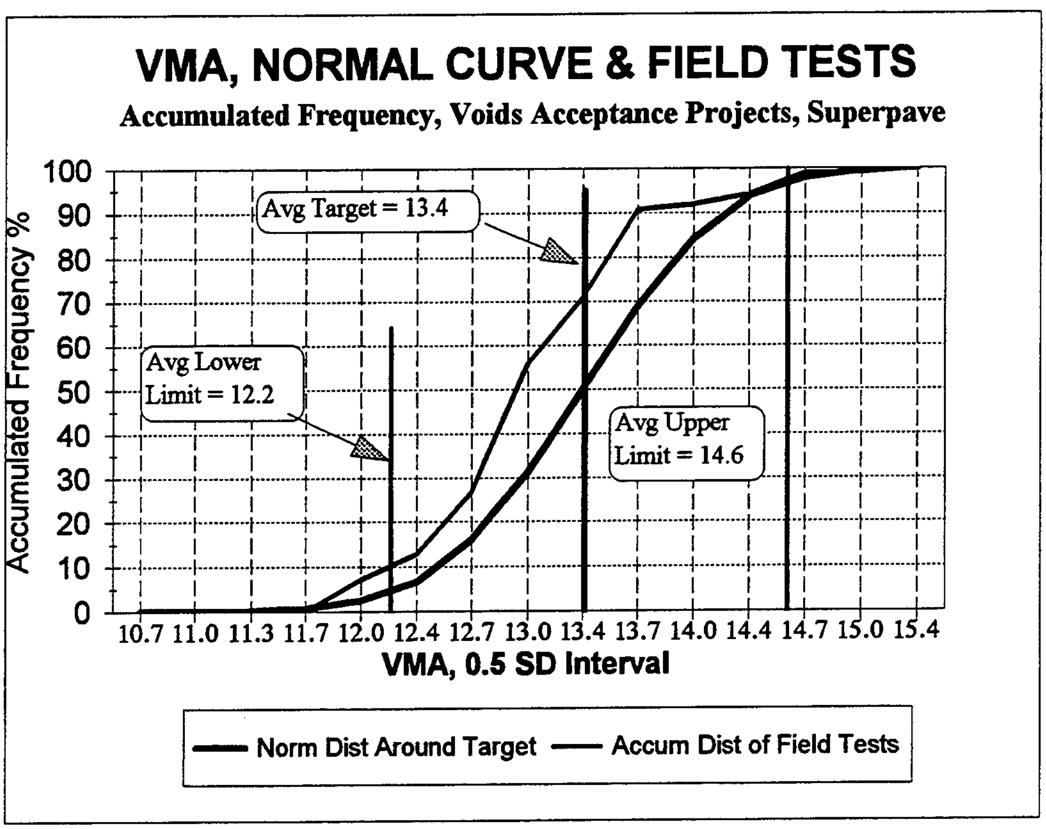

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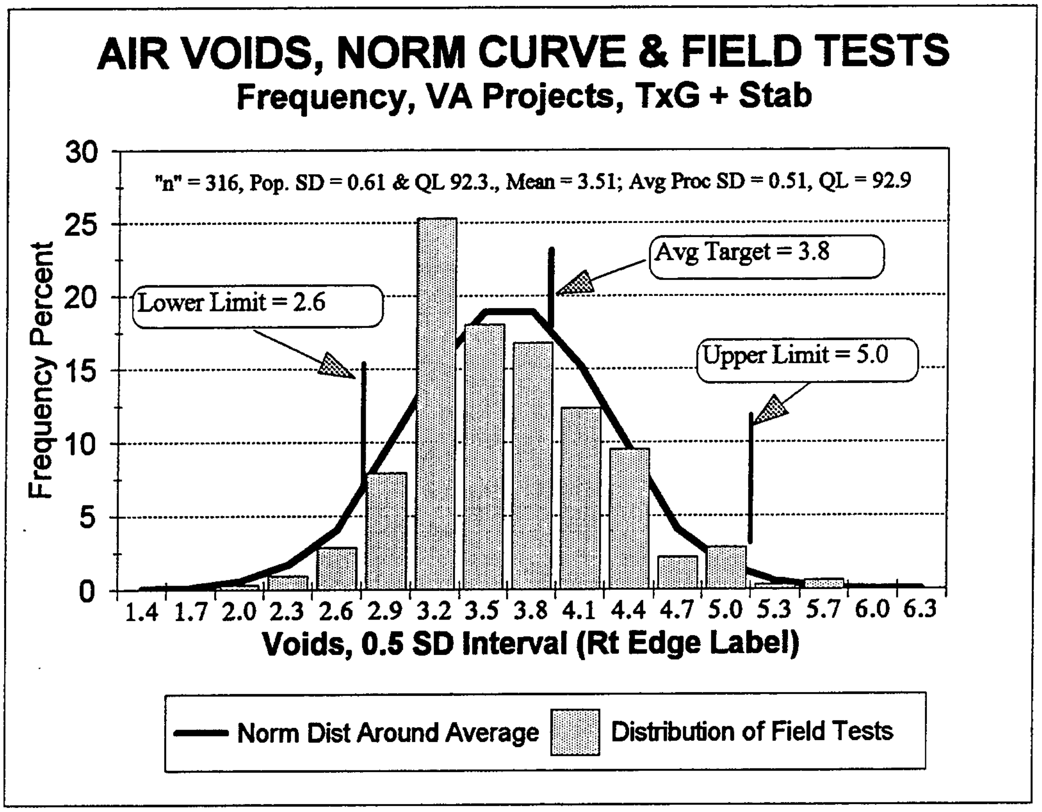

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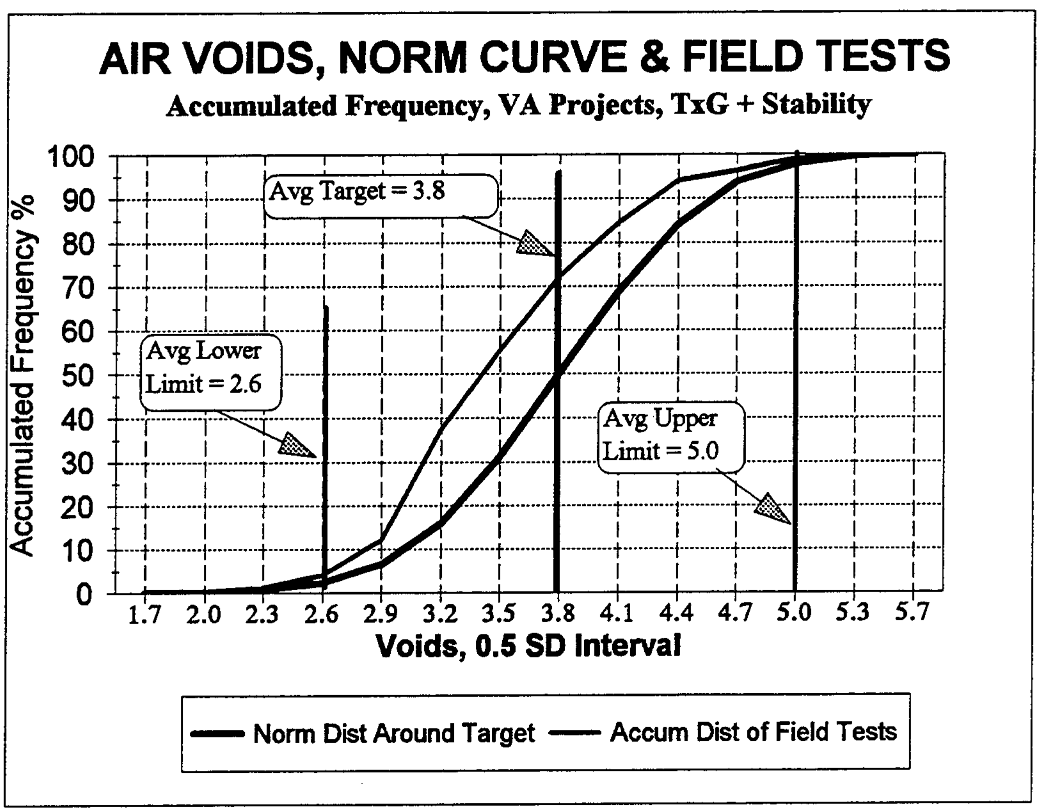

Figure 14

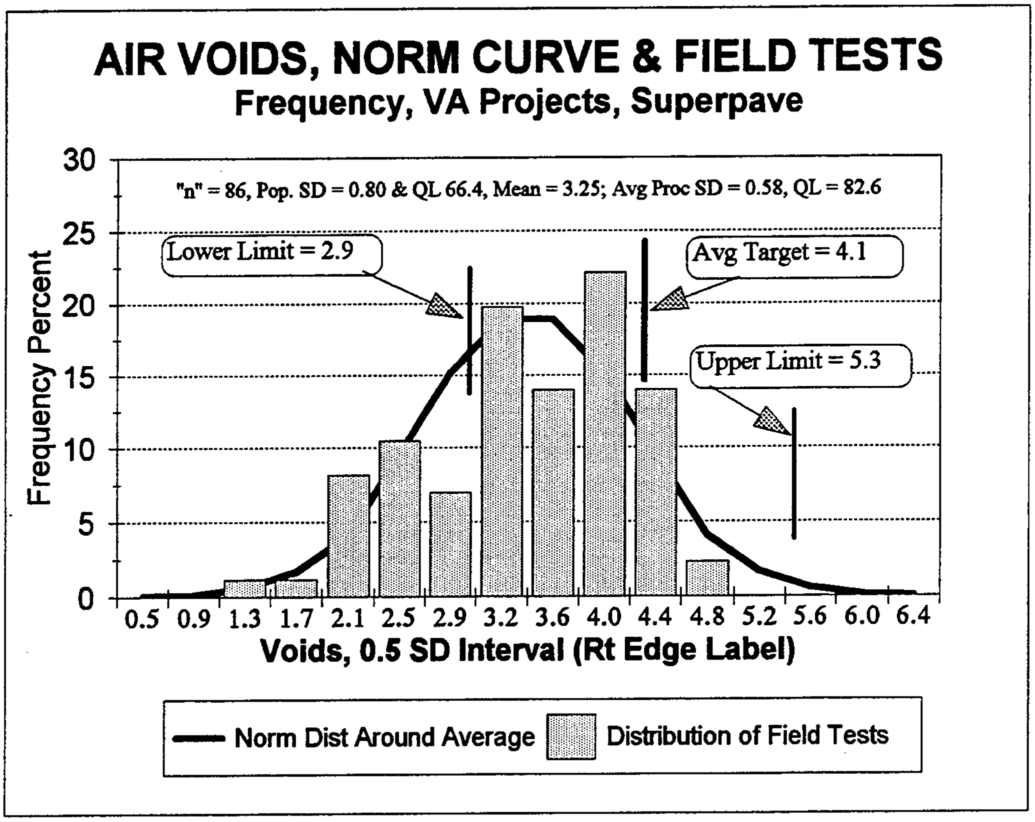

Figure 15

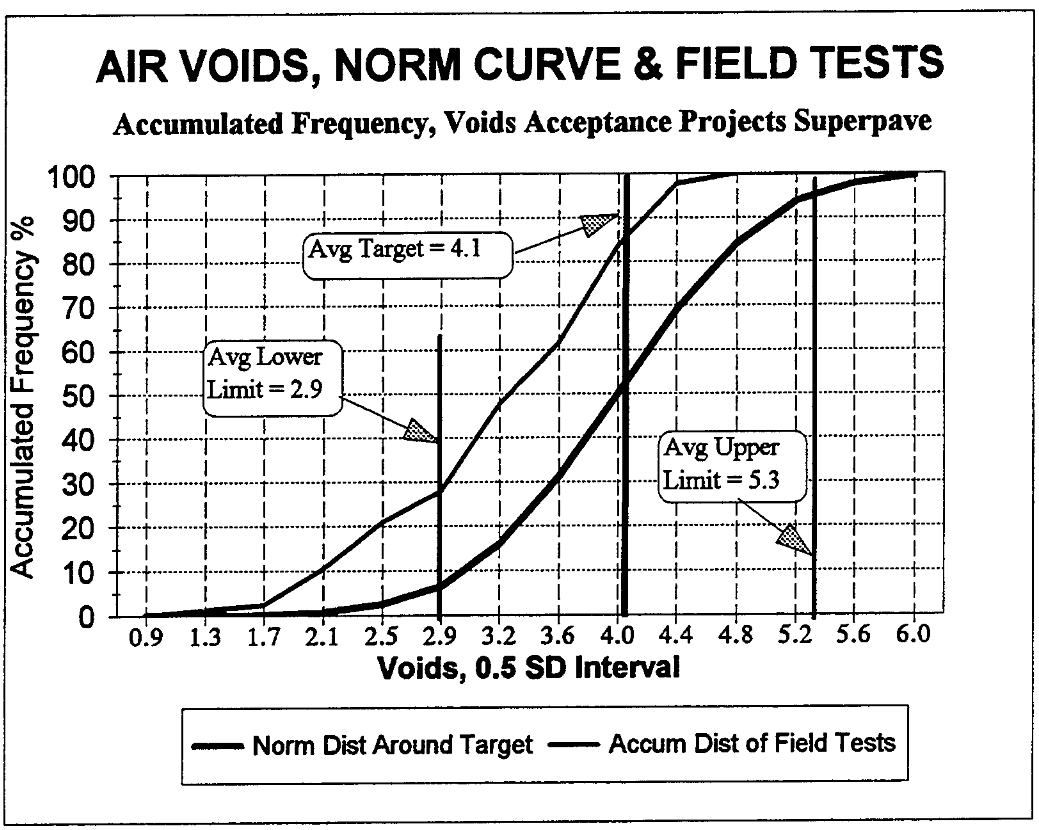

Figure 16

Exhibit 1
Explanation of the CDOT Void Acceptance Pilot Program
Tim Aschenbrener
April 21, 1997

1) Modification of the 5-year plan. There have been modifications to the original 5-year plan. The original 5-year plan was developed based on a best guess of the time it would take to implement the program. The modifications to the plan have been essential to the proper implementation of the volumetric acceptance program. The purpose of this section is to document some of these reasons for the modifications.

After the first project in 1993, 3 different labs got 3 different answers. It was clear the implementation process would take longer. A brief summary follows documenting the increased time it took to ensure proper procedures were followed, operator training and checking was implemented, and equipment acquired.

Repeatable Tests.

1994/1995	A great deal of study went into the procedures to make sure that tests were performed uniformly. This included round robin testing.
1996	The CP-Ls were re-written to take out ambiguities.
Spring 1996	CAPA certification became a requirement. This step was necessary to ensure all testers had experience and background to perform tests.

Equipment Acquisition.

1991/1994	Equipment for the Texas gyratory mixes were acquired.
1996/1997	Equipment for the Superpave mixes were acquired.
Fall 1995	Trailers were made available to the Regions to demonstrate the volumetric acceptance program because projects were not always in the back yard of the Region lab. 1996 was really the first year all projects were field verified; however, this was a "shakedown" year.

Specifications.

1993	The first volumetric acceptance specification (using test results for payment) was written and used.
1994/1997	Provisional volumetric specifications were used that did not apply pay factors for routine use in HBP projects. This was to help contractors learn about the process without being penalized. Additionally, the provisions encouraged adjustments to be made to the mixes.
1996	A check system is now in place for quality assurance of the volumetric test results. This uses 10K samples and the comparisons are done with each Region by the Central lab.
1996/1997	Superpave is a huge implementation effort. Superpave trial projects were built in 1996 and full implementation was available in 1997. This stalled the volumetric acceptance for 1 year. It would be too overwhelming to implement multiple specifications.
1997	With the arrival of the trailers and equipment, this is the first year that CDOT

can really use the field verification of HBP effectively for all of the projects in each of the Regions.

1997 A specification was written to allow contractors test results to be used for pay. Each Region was encouraged to use 2 projects. This specification was controversial and confusing so implementation was delayed by the Regions. It is estimated that it will be used on 2 pilot projects in Region 6.

Projects.

1993	1 project: 6th Avenue.
1994	1 project: I-25 at Colorado City
1995	2 projects: US-85 at Nunn, US-36 from Sheridan to Wadsworth,
1996	2 projects: I-25 at Fountain, SH-45 in Pueblo
1996	5 projects (Superpave): I-70 at Colfax, I-70 at Clear Creek, I-25 at AFA, I-25 south of Pueblo, I-25 north of Trinidad

It is more important to implement the program correctly than to follow a preliminary schedule based on a best guess. Many obstacles have been overcome, and implementation is continuing.

2) Reason for Implementation of Voids Acceptance. There have been many studies showing that the volumetric properties of the HMA relate to performance. Although gradation acceptance is commonly used, it does not always relate to the long term performance of the pavement. These references can be found by myself on Colorado pavements, John D'Angelo in AAPT, and recommendations in Superpave. NCHRP 9-7 "Field Procedures and Equipment to Implement SHRP Asphalt Specifications" is also recommending using volumetrics for acceptance of HMA.

EXHIBIT 2

REVISION OF SECTION 105
CONTROL OF WORK

Section 105 of the Standard Specifications is hereby revised for this project as follows:

Subsection 105.03 shall include the following:

Conformity to the Contract of all Hot Bituminous Pavement, Item 403, will be determined in accordance with the following:

All work performed and all materials furnished shall conform to the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the Contract.

For those items of work where working tolerances are not specified, the Contractor shall perform the work in a manner consistent with reasonable and customary manufacturing and construction practices.

When the Engineer finds the materials or work furnished, work performed, or the finished product are not in conformity with the Contract and has resulted in an inferior or unsatisfactory product, the work or material shall be removed and replaced or otherwise corrected at the expense of the Contractor.

Materials will be sampled and tested by the Division in accordance with Section 106 and with the applicable procedures contained in the Division's Field Materials Manual. The approximate maximum quantity represented by each sample will be as set forth in Section 106, Table 106-1. Additional samples may be selected and tested at the Engineer's discretion.

Evaluation of materials for pay factors (PF) will be done on a lot basis. Lots will consist of a consecutive series of random samples, one from each sublot, for those items and elements listed in Section 106, Table 106-1. All materials produced will be assigned to a lot. Each lot will have a pay factor computed in accordance with the requirements of this Section. Test results determined to have sampling or testing errors will not be used.

Whenever two consecutive test results for an element are outside the tolerances, the Engineer shall create an experimental one-sample lot of each individual test. Each test shall be individually evaluated in accordance with the following:

(1) A PF shall be computed for each test.
(2) If the PF for the test is less than 0.75, the test shall constitute a lot and the material represented by the test shall be handled in accordance with subsection 105.03(e).
(3) If the PF for the test is 0.75 or greater, the test shall not constitute a lot, and the test shall be placed in the appropriate lot.

REVISION OF SECTION 105
CONTROL OF WORK

The Engineer shall establish a new lot when there are major changes in materials, a change in the job-mix formula, extended suspension of production or as otherwise deemed necessary. New lots may be established following the close of the pay estimate period.

Providing none of the above conditions exist, a lot may consist of any number of consecutive samples.

If there are less than three samples in a lot, the material will be evaluated as one-sample lots in accordance with the procedure below.

When it is necessary to represent a quantity by one or two tests, lots will be established represented by one test each, as determined by the Engineer. If the value of the test is within the specification limits, the lot will be assigned a pay factor (PF) of 1.00.

If the value of the test is above the maximum specified limit, then

$$PF = 1.00 - [(T_o - T_u)/V]^2$$

If the value of the test is below the minimum specified limit, then

$$PF = 1.00 - [(T_L - T_o)/V]^2$$

Where: PF = pay factor
V = V factor from table 105-1
T_o = the individual test value
T_L, T_u = lower and upper specification limits, respectively

(a) Each lot of materials or work represented by three or more tests will be evaluated for Quality Level (QL) by CP 71.

Each lot of materials or work represented by three or more tests will be evaluated for Pay Factor (PF) by the following formulae:

1. When n = 3 and QL < 68, then

$$PF = 0.410702 + 1.157738\ (QL/100) - 0.423928\ (QL/100)^2$$

2. When n = 3 and QL $\geq$ 68, then

$$PF = 0.572303 + 0.953058\ (QL/100) - 0.475399\ (QL/100)^2$$

3. When n = 4, then

$$PF = 0.264319 + 1.566711\ (QL/100) - 0.781846\ (QL/100)^2$$

4. When n = 5, then

$$PF = 0.232740 + 1.557903\ (QL/100) - 0.739563\ (QL/100)^2$$

5. When n = 6, then

$$PF = 0.161687 + 1.679072\ (QL/100) - 0.790861\ (QL/100)^2$$

6. When n = 7, then

$$PF = 0.121571 + 1.727903\ (QL/100) - 0.798947\ (QL/100)^2$$

7. When $n \geq 8$, then

$$PF = 0.103228 + 1.739576\ (QL/100) - 0.792804\ (QL/100)^2$$

(b) A pay factor will be determined for each lot of material or work. For pay period estimates, or for any interim time period, each individual element will have the average pay factor (PF_A) for all the lots of the period, weighted by the quantities represented by each lot, computed as follows:

$$PF_A = \frac{[M_1(PF_1) + M_2(PF_2) + \ldots\ldots M_j(PF_j)]}{\Sigma M}$$

Where: M_j = Quantity of item represented by the lot.

PF_j = The lot pay factor.

ΣM = Sum of Quantities, M_1 to M_j (the total quantity for the period).

(c) When there is more than one element for the item, determine the composite pay factor (PF_C) for the time period as follows (ΣM used to compute each element PF_A must be numerically the same):

$$PF_C = \frac{[W_1(PF_{A1}) + W_2(PF_{A2}) + \ldots\ldots W_j(PF_{Aj})]}{\Sigma W}$$

Where: W = element factor from Table 105-1.

PF_{Aj} = element average pay factor.

ΣW = sum of the element factors.

(d) Numbers in the above calculations will be carried to significant figures and rounded according to AASHTO Standard Recommended Practice R-11.

(e) When PF for any element in a lot is between 0.75 and 1.05, the finished product will be accepted at the appropriate pay factor. If PF for any element in a lot is less than 0.75, the Contractor shall take corrective action before being permitted to continue production. If proper corrective measures can't be readily determined, the Engineer will suspend the use of such material until Laboratory tests indicate that the corrective measures taken by the Contractor will provide material that is in compliance. In addition, the Engineer may: (1) require complete removal and replacement with specification material at no additional cost to the Division; or (2) document the basis for acceptance by Contract Modification Order (CMO) and permit the Contractor to leave the material in place, if the finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected. If the material remains in place, the CMO will make an appropriate price adjustment such that PF will not be greater than 0.75. The pay factor (PF) for the lot will be used in the applicable formulas when computing the average pay factor (PF_A) and composite pay factor (PF_C).

The Contractor will not have the option of accepting a price reduction in lieu of producing specification material. Continued production of non-specification material will not be permitted. All costs related to redesign of the asphalt mix and subsequent delays shall be borne by the Contractor. Material which is obviously defective may be isolated and rejected without regard to sampling sequence or location within a lot.

TABLE 105-1
Factors for Various Elements

Hot Bituminous Pavement		
Element	V factor	W factor
Asphalt Content	0.20	10
Voids in Mineral Aggregate (VMA)	0.60	20
Air Voids (AV)	0.60	30
In-Place Density	1.10	40

TABLE 105-1
(Where stability is included)
"V' And "W" Factors for Various Elements

Hot Bituminous Pavement		
Element	V Factor	W Factor
Asphalt Content	0.2	5
Stability	3.0	5
Voids in Mineral Aggregate (VMA)	0.6	20
Air Voids (AV)	0.6	30
Field Compaction	1.3	40

REVISION OF SECTION 105
CONTROL OF WORK

TABLE 105-2
Approximate Pay Factors

	Required Quality Level for a given sample size (n) and given Pay Factor					
Pay Factor	n= 3	n= 4	n= 5	n= 6	n= 7	n = 8 TO n = X
1.05	100	100	100	100	100	100
1.04	90	91	92	93	93	93
1.03	80	85	87	88	89	90
1.02	75	80	83	85	86	87
1.01	71	77	80	82	84	85
1.00	68	74	78	80	81	82
0.99	66	72	75	77	79	80
0.98	64	70	73	75	77	78
0.97	62	68	71	74	75	77
0.96	60	66	69	72	73	75
0.95	59	64	68	70	72	73
0.94	57	63	66	68	70	72
0.93	56	61	65	67	69	70
0.92	55	60	63	65	67	69
0.91	53	58	62	64	66	67
0.90	52	57	60	63	64	66
0.89	51	55	59	61	63	64
0.88	50	54	57	60	62	63
0.87	48	53	56	58	60	62
0.86	47	51	55	57	59	60
0.85	46	50	53	56	58	59
0.84	45	49	52	55	56	58
0.83	44	48	51	53	55	57
0.82	42	46	50	52	54	55
0.81	41	45	48	51	53	54
0.80	40	44	47	50	52	53
0.79	38	43	46	48	50	52
0.78	37	41	45	47	49	51
0.77	36	40	43	46	48	50
0.76	34	39	42	45	47	48
0.75	33	38	41	44	46	47

REVISION OF SECTION 106
CONTROL OF MATERIAL

Section 106 of the Standard Specifications is hereby revised for this project as follows:

Subsection 106.03 shall include the following:

All Hot Bituminous Pavement, Item 403, shall be tested in accordance with the following program of acceptance and assurance testing:

(a) **Acceptance Testing.** The Colorado Department of Transportation (CDOT) shall be responsible for acceptance testing on all items in the Contract listed in Table 105-1.

1. **Frequency of Tests.** Acceptance tests will be taken at the frequency specified in Table 106-1.

2. **Point of Sampling.** The material for acceptance testing shall be sampled by the Contractor using approved procedures. The location where material samples will be taken shall be determined by the Engineer.

3. **Calculations.** Percent VMA in compacted paving mixtures and calculations of air voids in campacted mixtures will be calculated using methods described in the Asphalt Institute Handbook (MS-4)(1989) Section 4.2.

(b) **Assurance Testing.** Except for asphalt content and in-place density, the CDOT Staff Materials Laboratory shall be responsible for assurance testing. Check tests for Stability, Voids in the Mineral Aggregate (VMA), and Air Voids (AV) shall become Independent Assurance Tests.

All materials being used are subject to inspection and testing at any time prior to, during, or after incorporation into the work. Assurance sampling and testing procedures will be in accordance with the Schedule for Minimum Materials Sampling, Testing and Inspection in the CDOT Field Materials Manual.

REVISION OF SECTION 106
CONTROL OF MATERIAL

TABLE 106-1
TESTING SCHEDULE FOR HOT BITUMINOUS PAVEMENT
ACCEPTANCE TESTS

	TEST	FREQUENCY
CP-42 or CPL 5120	Determining Asphalt Cement Content of Hot Bituminous Pavements Determination of the Asphalt Binder Content of Bituminous Mixtures by the Ignition Method	1/1000 T minimum 1/Day
CP-44 CP-81	Determining Percent Relative Compaction of Bituminous Pavment	1/500 T
CPL 5102	Maximum Specific Gravity of Bituminous Paving Mixtures	1/1000 T minimum 1/Day
CPL 5103	Bulk Specific Gavity of Compacted Bituminous Mixtures	1/1000 T minimum 1/Day
CPL 5115	Standard Method for Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the SHRP Gyratory Compactor	1/1000 T minimum 1/Day

TESTS FOR INFORMATION ONLY

CPL 5109	Resistence of Compacted Bituminous Mixtures to Moisture Induced Damage	1/work week

Copies of CPL 5115 and CPL 5120 are available from the Region Materials Engineer.

REVISION OF SECTIONS 401
COMPOSITION OF MIXTURES

Sections 401 of the Standard Specifications are hereby revised for this project as follows:

In subsection 401.02, Table 401-1, delete the tolerances for Hot Bituminous Pavement - Item 403 , and replace with the following:

Hot Bituminous Pavement - Item 403

Voids in the Mineral Aggregate (VMA)	±1.2%
Air Voids	±1.2%

In subsection 401.02 delete the tenth paragraph.

REPORTS PUBLICATION LIST
CDOT/CTI Research

96-1 Long-Term Performance Tests of Soil-Geosynthetic Composites
96-2 Efficiency of Sediment Basins: Analysis of the Sedient Basins Constructed as Part of the Straight Creek Erosion Control Project.
96-3 The Role of Facing Connection Strength in Mechanically Stabilized Backfill Walls
96-4 Revegetation of MSB Slopes
96-5 Roadside Vegetation Management
96-6 Evaluation of Slope Stabilization Methods (US-40 Berthod Pass) (Construction Report)
96-7 SMA (Stone Matrix Asphalt) Colfax Avenue Viaduct
96-8 Determinating Asphalt Cement Content Using the NCAT Asphalt Content Oven
96-9 HBP QC & QA Projects Constructed in 1995 Under QPM1 and QPM2 Specifications
96-10 Long-Term Performance of Accelerated Rigid Pavements, Project CXMP 13-006-07
96-11 Determining the Degree of Aggregate Degradation After Using the NCAT Asphalt Content Oven
96-12 Evaluation of Rumble Treatments on Asphalt Shoulders

97-1 Avalanche Forecasting Methods, Highway 550

97-2 Ground Access Assessment of North American Airport Locations

97-3 Special Polymer Modified Asphalt Cement (Final Report)

97-4 Avalanche Detection Using Atmospheric Infrasound

97-5 Keway Curb (Final Report)

97-6 IAUAC - (Interium Report)

97-7 Evaluation of Design-Build Practice in Colorado (Pre-Construction Report)

97-8 HBP Pilot Void Acceptance Projects Completed in 1993-1996 (Interim Report)

97-9 QC & QA Projects Constructed in 1996 Under QPM2 Specifications (Fifth Annual Report)

95-1 SMA (Stone Matrix Asphalts) Flexible Pavement
95-2 PCCP Texturing Methods
95-3 Keyway Curb (Contruction Report)
95-4 EPS, Flow Fill and Structure Fill for Bridge Abutment Backfill
95-5 Environmentally Sensitive Sanding and Deicing Practices
95-6 Reference Energy Mean Emission Levels for Noise Prediction in Colorado
95-7 Investigation of the Low Temperature Thermal Cracking in Hot Mix Asphalt
95-8 Factors Which Affect the Inter-Laboratory Repeatability of the Bulk Specific Gravity of Samples Compacted Using the Texas Gyratory Compactor
95-9 Resilient Modulus of Granular Soils with Fine Contents
95-10 High Performance Asphalt Concrete for Intersections
95-11 Dynamic Traffic Modelling of the I-25/HOV Corridor
95-12 Using Ground Tire Rubber in Hot Mix Asphalt Pavements
95-13 Research Status Report
95-14 A Documentation of Hot Mix Asphalt Overlays on I-25 in 1994
95-15 EPS, Flowfill, and Structure Fill for Bridge Abutment Backfill
95-16 Concrete Deck Behavior in a Four-Span Prestressed Girder Bridge: Final Report
95-17 Avalanche Hazard Index For Colorado Highways
95-18 Widened Slab Study

REPORTS PUBLICATION LIST
CDOT/CTI RESEARCH

94-1 Comparison of the Hamburg Wheel-Tracking Device and the Environmental Conditioning System to Pavements of Known Stripping Performance
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94-2 Demonstration of a Volumenteric Acceptance Program for Hot Mix Asphalt in Colorado
2-94 The Deep Patch Technique for Landslide Repair
94-3 Comparison of Test Results from Laboratory and Field Compacted Samples
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94-6 Implementation of a Fine Aggregate Angularity Test
94-7 Influence of Refining Processes and Crude Oil Sources Used in Colorado on Results from the Hamburg Wheel-Tracking Device
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94-9 Influence of Compaction Temperature and Anti-Stripping Treatment on the Results from the Hamburg Wheel-Tracking Device
94-10 Denver Metropolitan Area Asphalt Pavement Mix Design Recommendation
94-11 Short-Term Aging of Hot Mix Asphalt
94-12 Dynamic Measurements or Penetrometers for Determination of Foundation Design
94-13 High-Capacity Flexpost Rockfall Fences
94-14 Preliminary Procedure to Predict Bridge Scour in Bedrock (Interim Report)

REPORTS PUBLICATION LIST
CDOT Research

93-1 Dense Graded Concrete
93-2 Research 92- Reality and Vision, Today and Tomorrow (Status Report)
93-3 Investigation of the Modified Lottman Test to Predict the Stripping Performance of Pavements in Colorado
93-4 Lottman Repeatability
93-5 Expert System for Retaining Wall System Phase I
93-6 Crack Reduction Pavement Reinforcement Glasgrid
93-7 A Case Study of Elastic Concrete Deck Behavior in a Four Panel Pre-stressed Girder Bridge Finite Element Analysis
93-8 Rehabilitation of Rutted Asphalt Pavements (Project IR-25-3(96)
93-9 Cold Hand Patching
93-10 Ice Detection and Highway Weather Information Systems, FHWA Experiment Project No. 13
93-11 Comparison of 1992 Colorado Hot Mix Asphalt With Some European Specification
93-12 Curtain Drain
93-13 Type T Manhole (Experimental Feature)
93-14 Interim Report for the HBP QA/QC Pilot Projects Constructed in 1992
93-15 SHRP Seasonal Monitoring Program in Delta
93-16 DOT Research Management Questionnaire Response Summary
93-17 Inservice Evaluation of Highway Safety Devices
93-18 Courtesy Patrol Pilot Program
93-19 I-70 Silverthorne to Copper Mountain: A History of Use of European Testing Equipment
93-20 Analytical Simulation of Rockfall Prevention Fence Structures
93-21 Investigating Performance of Geosynthetic-Reinforced Soil Walls
93-22 Influence of Testing Variables on the Results from the Hamburg Wheel-Tracking Device
93-23 Determining Optimum Asphalt Content with the Texas Gyratory Compactor

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