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HOT MIX ASPHALT VOIDS ACCEPTANCE REVIEW OF QC/QA DATA 2000 THROUGH 2010

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16. Abstract
This report analyzes the quality control/quality assurance (QC/QA) data for hot mix asphalt (HMA) using voids acceptance as the testing criteria awarded in the years 2000 through 2010. Analysis of the overall performance of the projects is accomplished by reviewing the Calculated Pay Factor Composite (CPFC) and Incentive/Disincentive Payments (I/DP). Analysis of each of the elements: asphalt content, voids in mineral aggregate (VMA), air voids, mat density, and joint density is presented in tables, figures, and reports. Various data groupings are used to evaluate the data including: year, region, and grading.

The specification and the projects are performing reasonably well. The results for the data show that quality of the projects is remaining fairly consistent. No definite upward or downward trends can be seen in the data. Over the eleven-year time period more projects have received incentive payments than disincentive payments. The average CPFC over the eleven years evaluation is 1.00569. The quality levels in the individual elements are at relatively high levels. The VMA and mat density elements show the best results being above 93 percent within the specification limits. The asphalt content and air voids elements are at approximately 90 percent. The joint density pay factor is under 1.0 but is expected to rise as contractors gain experience in this area.

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1.0 INTRODUCTION AND COMMENTS

This report summarizes the voids acceptance data for the years 2000 through 2010. The test data for asphalt content, voids in mineral aggregate, air voids, mat density, and joint density sorted by year and region are included in the analysis. A review of the data sorted by grading is also presented. Charts comparing the quality level and pay factor information for the years 2000 through 2010 are displayed for the percent asphalt, voids in mineral aggregate, air voids, and mat density elements. The joint density test information for the years 2003 through 2010 is also presented.

The major data grouping used in this report is start date, the date the paving began. On numerous projects the paving began in the following year after the project was awarded to contract. Utilizing the start date, more accurately groups the projects according to the time of their construction.

2.0 SPECIFICATIONS

Specifications - Revision of Sections 105 and 106, Conformity to the Contract of Hot Mix Asphalt (Voids Acceptance). In 1994, the Colorado Department of Transportation (CDOT) adopted a QC/QA voids acceptance (VA) specification for hot bituminous pavement (HBP). In 1998, four test elements were included in the calculations for pay factors: percent asphalt, voids in mineral aggregate, air voids, and mat density. In July 1999, the specification was released as a standard special provision. In December 2002, joint density testing was added to the calculation for Incentive/Disincentive (I/DP) Payment. The joint density element accounts for 15 percent of the total in the calculation for I/DP. The weights associated with the other test elements were adjusted to account for the new testing element. Table 1 shows current weights and test elements. No other changes were made in the specification that affected the calculations for quality level, pay factor, or I/DP.

Table 1. "W" Factors for Various Elements

	W Factor				
Specification	**Percent Asphalt**	**VMA**	**Air Voids**	**Mat Density**	**Joint Density**
12/19/02 & Older	10	10	40	40	
12/20/02 & Newer	10	10	30	35	15

The calculation for quality levels has remained unchanged since testing began. CDOT's Voids 03, QC/QA computer program is based on this specification and use of the program is a requirement of the specification.

3.0 CALCULATIONS AND DEFINITIONS

Award Date – The date on which the project was awarded to contractor.

Bid Date – Same as Award Date.

Calculated Pay Factor Composite (CPFC) – The Calculated Pay Factor Composite is a way to evaluate the overall quality of the hot mix asphalt (HMA) used on the project. The CPFC represents the percentage increase or decrease to the unit price for HMA paid on the project. Projects with a CPFC greater than 1.0 will receive an incentive payment. Projects with a CPFC less than 1.0 will be assigned a disincentive. The CPFC is back calculated from the project's Final Incentive/Disincentive Payment (I/DP). This calculation is used rather than an overall quality level calculation since a project can contain processes in which no quality level is calculated, processes with less than three tests. The calculation used here also addresses the problem that occurred in some of the reported projects in which the final element quantities were not equal between test elements. The main reason this calculation is used is to avoid the problems associated with averaging of the data.

The calculation is as follows:

$$CPFC = (I/DP / ((UP_P) * (QR_P))) + 1$$

Where: CPFC = Calculated Pay Factor Composite.

I/DP = Incentive/Disincentive Payment for the project.

UP_P = Calculated Unit Price for the project.

QR_P = Quantity Represented Project, average of the tons reported in the percent asphalt, VMA, and air voids elements.

$$UP_P = (\sum (UP_n * T_n)) / \sum T_n$$

Where: UPn = Unit Price for the process.

Tn = Tons represented by the process, average of the tons reported in the percent asphalt, VMA, and air voids elements.

Small Quantities Calculation:

When it is necessary to represent a process by only one or two test results, PF will be the average of PFs resulting from the following:

If the test result is within the tolerance limits then PF = 1.00.

If the test result is above the maximum specified limit, then PF = 1.00 – [0.25(T_o –T_u)/V].

If the test result is below the minimum specified limit, then PF = 1.00 – [0.25(T_L – T_o)/V].

The calculated PF will be used to determine the I/DP for the process.

Note: The Asphalt Content, VMA, and Air Voids elements are the sources utilized to obtain quantities which are used in the calculation of average tons and average price. A review of the project data have shown that these quantities most accurately represented the actual produced quantity when the reported quantities were not equal in the test elements.

Compaction Test Section (CTS) – A compaction pavement test section used to establish the number of rollers and rolling pattern needed to achieve specified densities, see Subsection 401.17 Compaction for details.

Compaction Test Section tons (CTS Tons) – Tons of material accounted for in the mat density test element by the construction of compaction test sections within the project.

Compaction Test Section Incentive/Disincentive Payment (CTS I/DP) – The calculated I/DP for compaction test sections.

Incentive/Disincentive Payment (I/DP) **-** The amount of increase or decrease paid for a quantity of material within a test element. The I/DP for a project is the summation of all calculated element I/DPs.

Joint Density – Density measurements taken on the longitudinal joint between paving passes.

Mean, or Average **-** Is the mathematical average of a set of numbers. The average is calculated by adding up two or more scores and dividing the total by the number of scores.

Mean to TV – The absolute value of the difference between the mean for the process and the target value for the test element. The lower the value the closer the mean approaches the target value of the specification.

Pay Factor - The amount of increase or decrease, displayed as a percentage, applied to the unit price of the pavement. Multiplied by the W factor for the element to calculate I/DP for an element.

Pay Factor 1.0 Tons (PF 1.0 Tons) – Used in the mat density element to account for tons of material in which the pay factor is set to 1.0 by specification. Usually used on a project when the thickness of the mat being placed becomes too thin to be accurately tested.

Process Quantities – Process quantities are used for most calculations in this report, with the exception of the Calculated Pay Factor Composite calculation. In general, processes group similar material or construction techniques. As long as the material being evaluated remains unchanged it will be added to the current process. If a change to the material or the construction technique occurs then a new process will be created. Please see the Revision to Sections 105 & 106, Quality of Hot Mix Asphalt (Voids Acceptance) for details on processes.

Project Code – An alpha-numeric identifier unique to each project.

Quality Level – Quality Levels (Percent within limits) are calculated in accordance with Colorado Procedure 71 (CP 71). Quality Level analysis is a statistical procedure for estimating the percent compliance to specification limits and is affected by shifts in the arithmetic mean and by the sample standard deviation. Analysis of both factors is essential whenever evaluating quality level results.

Start Date – The date the HMA paving began on the project.

Standard Deviation (Std. Dev.) - A statistical measure of spread or variability. The standard deviation is the root mean square (RMS) deviation of the values from their arithmetic mean.

equation: $$SD = \sqrt{\frac{\sum (x_i - \overline{x})^2}{n - 1}}$$

Standard Deviation minus the V Factor (Std. Dev. – V) - A comparison of the standard deviation for the process to the historical standard deviation for the element, the V factor. Negative values indicate that the process has a smaller standard deviation than historically reported. The standard deviation for the process is one of the two factors that affect the calculation for quality level.

Subaccount – A unique five digit numeric identifier for a project.

Target Value (TV) - The midpoint of the specification range.

V Factor (V) – The approximation of standard deviation for the test element based on historical data.

Voids Acceptance (VA) - Acceptance of the hot mix asphalt based on the test results of percent asphalt, voids in mineral aggregate, air voids, mat density, and joint density.

Variance - A measure of the average distance between each set of data points and their mean value; equal to the sum of the squares of the deviation from the mean value. The square root of the variance is the standard deviation.

equation: σ = $SD^2 = \frac{\sum (x_i - \bar{x})^2}{n-1}$

Where: ∑ = summation

x_i = individual test value

$\bar{x}$ = mean

n = number of samples

Voids in Mineral Aggregate (VMA) - VMA is the volume of inter granular void space between the aggregate particles of a compacted paving mixture. It includes the air voids and the volume of the asphalt not absorbed into the aggregate, the portion of space which is not occupied by the aggregate in a paving mixture.

W Factor – The weight given the test element. Used in the calculation of I/DP's, see Table 1 for the values.

Weighted Average – The weighted average used in this report is calculated on the tons of material represented.

2V Adjustment (2V Adj.) – Test results in the asphalt content or mat density test elements that are greater than 2 x V outside the tolerance limits are designated as a separate process and the quantity it represents is price reduced according to Subsection 105.03(d). This requires that adjustments are made to the original calculations for I/DP in the other test elements.

4.0 ANALYSIS OF THE DATA

The primary grouping of all projects is by start date, the date on which the paving began. A Calculated Pay Factor Composite (CPFC), gives an index of the overall quality of the HMA and, is calculated for each project. Each project will obtain an overall incentive/disincentive (I/DP) amount, calculated for the HMA. All material is grouped into processes by the specification. Processes group like material or construction techniques together. As long as the material being evaluated remains unchanged it will be added to the current process. An I/DP is also calculated for each process. Quality levels (Percent within limits) are calculated on all processes that contain more than two tests. Any process with less than three tests will be excluded from the analysis containing quality level calculations. I/DPs on processes that contain one and two tests are calculated using the small quantity equation. For each year, the best, worst, and weighted average are given for quality level, pay factor, I/DP, mean minus target value, standard deviation, and standard deviation minus the V factor. The mean to target value and standard deviation minus V factor calculations are important whenever evaluating the quality level for the process.

There is not a direct correlation between quality level and pay factor. The calculations for pay factors are dependent on the number of tests and the quantity of material associated with each process. A difference in the number of tests in two processes can result in a different calculation for pay factor even if the quality levels are the same.

The best or worst results displayed do not necessarily come from the same process. The calculations for quality level and pay factor are dependent on the number of test results included in the process and vary slightly as the number of tests are changed. Also, the calculation for quality level is dependent on both the standard deviation of the process and the mean for the process as it relates to the specification limits. A small standard deviation does not necessarily mean a high quality level. Likewise, a larger standard deviation does not necessarily mean a lower quality level.

5.0 DISCUSSION OF THE DATA

5.1 Projects Evaluated

Table 2 displays the number of Voids Acceptance projects and tons of material awarded by year. It also addresses the bid and start date of projects by year. All projects evaluated in this report were constructed using the standard special provision, voids acceptance specification. Additional project data will be added to the database as it is received by the Pavement Design Program.

Table 2. Projects Evaluated by Bid and Start Date

			Evaluated by Bid Date		Evaluated by Start Date	
	Awarded		Voids Acceptance		Voids Acceptance	
Year	Projects	Tons	**Projects**	**Tons**	**Projects**	**Tons**
2000	75	2,237,259	**12**	**778,263**	**6**	**252,588**
2001	50	1,294,829	**3**	**155,270**	**9**	**680,945**
2002	71	1,972,361	**21**	**826,936**	**11**	**421,562**
2003	70	2,263,836	**21**	**967,742**	**29**	**1,265,596**
2004	81	2,530,425	**36**	**1,488,985**	**24**	**1,239,435**
2005	57	1,617,833	**21**	**1,011,870**	**32**	**1,226,821**
2006	63	1,643,265	**26**	**965,479**	**24**	**961,106**
2007	47	1,285,829	**17**	**652,026**	**19**	**715,780**
2008	66	1,542,185	**16**	**590,928**	**17**	**658,665**
2009	114	2,250,586	**6**	**139,149**	**6**	**114,207**
2010	122	1,464,212	**4**	**304,748**	**6**	**344,691**

5.2 Calculated Pay Factor Composite

The Calculated Pay Factor Composite (CPFC) information for the years 2000 through 2010 is displayed in Table 3. The information is sorted by start date, year and then by region. The maximum and minimum values are displayed for each data grouping. The weighted average is calculated for each. The CPFC represents the percentage increase or decrease to the unit price for HMA paid on the project. A CPFC above 1.0 indicates that an incentive payment was paid for the HMA. A CPFC below 1.0 indicates that a disincentive was applied to the pavement.

Table 3. Calculated Pay Factor Composite – Voids by Year/Region

				Calculated Pay Factor Composite	
2000	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	1	12,317	1.03974	1.03974	1.03974
	2	2	122,774	1.00330	0.99521	1.01140
	4	1	74,292	0.98801	0.98801	0.98801
	6	2	57,304	1.03035	1.02798	1.03272
	Totals	6	266,687	1.01584	0.98801	1.03974

					Calculated Pay Factor Composite	
2001	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	2	4	264,164	1.02421	0.99949	1.05302
	4	3	250,886	1.03080	1.02708	1.03414
	5	1	70,475	0.97118	0.97118	0.97118
	6	1	53,879	1.04691	1.04691	1.04691
	Totals	9	639,404	1.02304	0.97118	1.05302

					Calculated Pay Factor Composite	
2002	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	1	71,404	1.04132	1.04132	1.04132
	2	3	128,628	0.89072	0.76392	0.98500
	3	1	38,628	1.00929	1.00292	1.00929
	4	1	75,069	1.01807	1.01807	1.01807
	6	5	144,641	1.02319	0.98943	1.04162
	Totals	11	458,370	0.98698	0.76392	1.04162

					Calculated Pay Factor Composite	
2003	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	1	16,978	1.00047	1.00047	1.00047
	2	10	384,758	1.01097	0.96642	1.02979
	3	3	149,180	0.99094	0.97720	1.00292
	4	4	354,150	1.01462	0.97187	1.03799
	5	1	113,295	0.99338	0.99338	0.99338
	6	10	213,162	1.00784	0.83698	1.04771
	Totals	29	1,231,523	1.00736	0.83698	1.04771

					Calculated Pay Factor Composite	
2004	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	3	212,060	1.00909	0.96524	1.03872
	2	7	333,756	1.02320	0.98449	1.04055
	3	2	206,299	0.99636	0.98525	1.00747
	4	3	261,023	1.01310	1.00383	1.02639
	6	9	178,898	1.01585	0.94133	1.03329
	Totals	24	1,192,036	1.01518	0.94133	1.04055

					Calculated Pay Factor Composite	
2005	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	1	38,348	1.03938	1.03938	1.03938
	2	5	262,348	0.99071	0.94632	1.02281
	3	2	110,752	0.99421	0.99412	0.99430
	4	5	426,313	1.02795	1.01590	1.03903
	5	2	105,906	1.02911	1.01363	1.04458
	6	17	260,721	1.01583	0.98476	1.04176
	Totals	32	1,204,382	1.01401	0.94632	1.04458

					Calculated Pay Factor Composite	
2006	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	2	87,975	1.00511	0.97743	1.03279
	2	4	312,772	1.02039	0.98582	1.04597
	3	1	29,256	0.99455	0.99455	0.99455
	4	7	406,717	1.01649	0.97891	1.04687
	5	1	60,457	1.05364	1.05364	1.05364
	6	9	102,695	1.00674	0.93690	1.04358
	Totals	24	999,872	1.01317	0.93690	1.05364

					Calculated Pay Factor Composite	
2007	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	4	156,078	1.00887	0.99796	1.03292
	2	6	349,162	1.02618	1.00076	1.04914
	3	2	58,362	1.01522	1.01316	1.01728
	4	4	126,915	1.02586	1.00699	1.03803
	6	3	58,565	1.00388	0.99119	1.01539
	Totals	19	749,082	1.01779	0.99119	1.04914

					Calculated Pay Factor Composite	
2008	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	3	96,481	1.01992	1.01320	1.02904
	2	3	240,567	1.00472	1.00087	1.00801
	3	1	29,540	0.99322	0.99322	0.99322
	4	5	213,317	0.82813	1.02358	1.04760
	6	5	52,530	1.01398	1.00025	1.04139
	Totals	17	632,435	0.95751	0.99322	1.04760

					Calculated Pay Factor Composite	
2009	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	1	14,731	0.91338	0.91338	0.91338
	5	5	56,087	0.99020	0.91133	1.02673
	Totals	6	70,818	0.97922	0.91133	1.02673

					Calculated Pay Factor Composite	
2010	**Region**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
	1	1	20,230	0.99384	0.99384	0.99384
	2	1	34,190	0.98861	0.98861	0.98861
	4	2	66,808	1.03083	1.02607	1.03560
	6	2	28,640	0.67145	0.98938	1.02496
	Totals	6	149,868	0.75731	0.98861	1.03560
11 yrs	**All Regions**	**Total Projects**	**Total Tons**	**Average**	**Minimum**	**Maximum**
00-10		186	7,594,477	0.99479	0.76392	1.05364

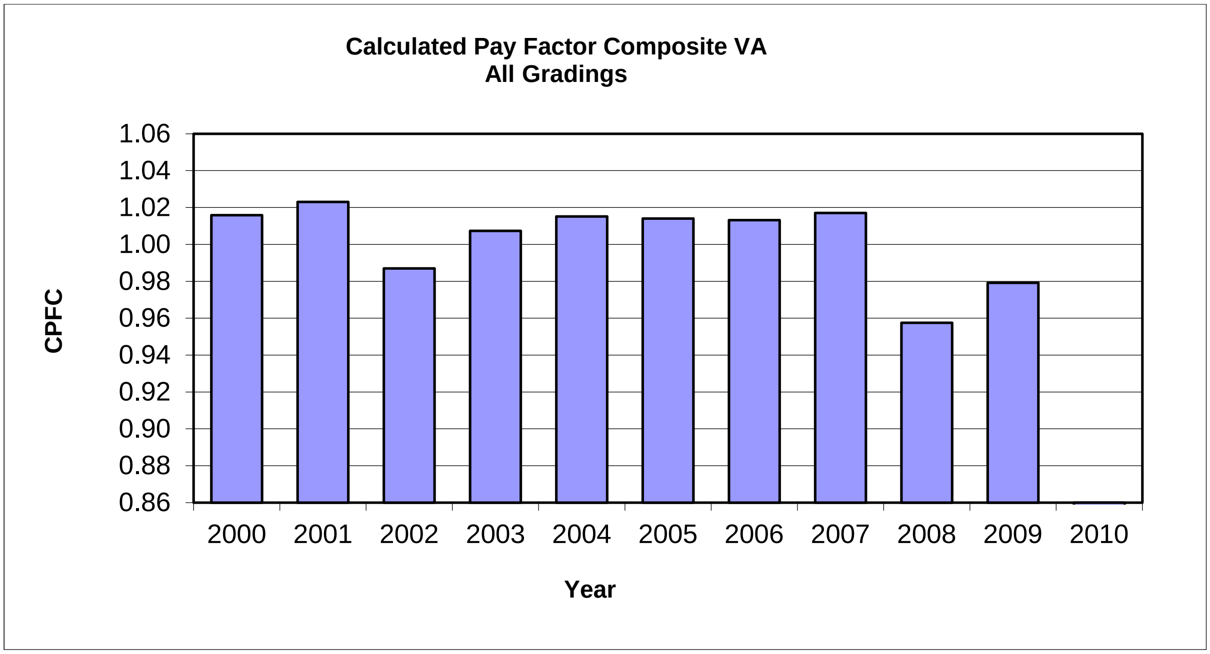

Figure 1. Calculated Pay Factor Composite – Voids Acceptance, All Gradings by Year

5.3 Eleven-Year Calculated Pay Factor Composite by Region

Figure 1 displays the CPFC for all projects from 2000 to 2010. The eleven-year average for all gradings is 1.002263. More incentive payments were made over this time period than disincentive adjustments for VA, HMA. Through the eleven year evaluation, four years have shown a CPFC lower than 1percent. In 2002, the CPFC fell to .98698. In 2008, the CPFC was at 0.95751. In 2009, the CPFC was at 0.97922. In 2010, the CPFC was at 0.75731, the lowest of the eleven years evaluated.

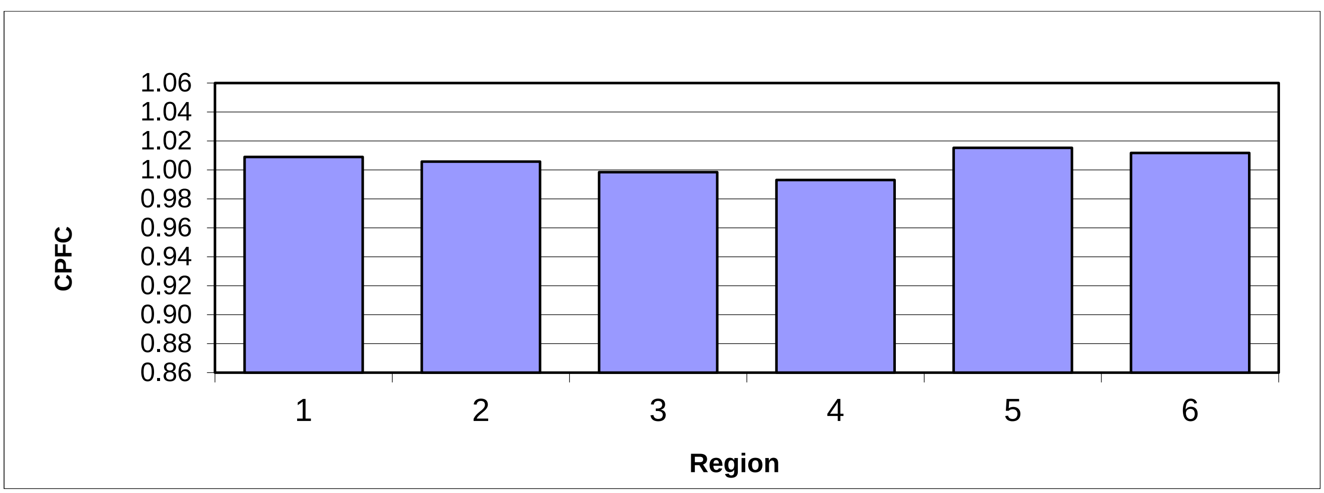

Figure 2. Calculated Pay Factor Composite 2000 to 2010 by Region – All Gradings

Figure 2 displays the average CPFC for all projects in each region, for years 2000 to 2010. All regions have high CPFC for the eleven year evaluation period. Of the 6 regions, 3 and 4 have fallen below 1.0 which means on average a disincentive was applied. For the same time frame, regions 1, 2, 5 and 6, on average, received incentives.

5.4 Incentive/Disincentive Payments

A recap of the Incentive/Disincentive (I/DP) for the years 2000 through 2010 is presented in Table 4. For each year, the total number of projects and the number that had incentive/disincentive applied is displayed.
When an incentive has been earned, it will be referenced in this report as incentive payment. When a disincentive has been earned it will be referenced as disincentive applied.

The summation of the I/DPs along with the maximum, minimum, and average are given for each year. The calculation for I/DP is directly related to the amount of material used in the project, pay factor multiplied by tons represented. The projects with the largest incentive payment do not necessarily represent the projects with the best reported quality levels. The smaller incentive payment reported in some of the projects or years does not necessarily mean that they had lower quality. It is more likely due to the smaller size of the project. The Calculated Pay Factor Composite and quality levels are used to evaluate the HMA materials that have been produced for each project, from 2000 to 2010.

The highest percentage of disincentives applied was in 2009. Seven projects were constructed, four projects, Fifty-seven percent, had a disincentive applied. Eleven projects were constructed in 2002. Four projects, thirty-six percent, had a disincentive applied. The lowest number of projects that had a disincentive applied was in 2008. Seventeen projects were constructed, two projects, twelve percent, had a disincentive applied. The calculation for percent disincentive includes all projects that received some amount of disincentive adjustment. However, it does not account for the severity of the penalty. A project with a disincentive of $100 is treated the same as a project with a $50,000 disincentive in the calculation.

Table 4. Incentive/Disincentive Payments – Recap by Year

2000	No. of Projects	6		Sum I/DPs	$85,018.15
	Positive I/DPs	4		Maximum	$43,606.33
	Negative I/DPs	2	33.3%	Minimum	($34,248.47)
	Total Tons	266,687		Average I/DP	$14,169.69
2001	No. of Projects	9		Sum I/DPs	$489,645.08
	Positive I/DPs	7		Maximum	$119,561.18
	Negative I/DPs	2	22.2%	Minimum	($67,655.18)
	Total Tons	639,404		Average I/DP	$54,405.01
2002	No. of Projects	11		Sum I/DPs	$113,487.41
	Positive I/DPs	7		Maximum	$99,877.90
	Negative I/DPs	4	36.4%	Minimum	($95,998.88)
	Total Tons	458,370		Average I/DP	$10,317.04
2003	No. of Projects	29		Sum I/DPs	$533,992.91
	Positive I/DPs	22		Maximum	$109,804.69
	Negative I/DPs	7	24.1%	Minimum	($53,185.02)
	Total Tons	1,231,523		Average I/DP	$18,413.55
2004	No. of Projects	24		Sum I/DPs	$490,668.88
	Positive I/DPs	20		Maximum	$119,310.36
	Negative I/DPs	4	16.7%	Minimum	($83,206.36)
	Total Tons	1,192,036		Average I/DP	$20,444.54
2005	No. of Projects	32		Sum I/DPs	$690,740.23
	Positive I/DPs	25		Maximum	$163,274.51
	Negative I/DPs	7	21.9%	Minimum	($118,685.25)
	Total Tons	1,204,382		Average I/DP	$21,585.63
2006	No. of Projects	24		Sum I/DPs	$774,006.88
	Positive I/DPs	17		Maximum	$190,172.14
	Negative I/DPs	7	29.2%	Minimum	($61,977.14)
	Total Tons	999,872		Average I/DP	$32,250.29
2007	No. of Projects	19		Sum I/DPs	$759,333.77
	Positive I/DPs	16		Maximum	$136, 614.69
	Negative I/DPs	3	15.8%	Minimum	($10,874.00)
	Total Tons	749,082		Average I/DP	$39.964.94
2008	No. of Projects	17		Sum I/DPs	$662,191.34
	Positive I/DPs	15		Maximum	$128,347.77
	Negative I/DPs	2	11.8%	Minimum	($13,283.09)
	Total Tons	632,435		Average I/DP	$38,952.43
2009	No. of Projects	7		Sum I/DPs	($110,631.28)
	Positive I/DPs	3		Maximum	$23,228.33
	Negative I/DPs	4	57.1%	Minimum	($74,810.78)
	Total Tons	70,818		Average I/DP	($15,804.47)

2010	No. of Projects	7		Sum I/DPs	$142,610.26
	Positive I/DPs	4		Maximum	$141,643.64
	Negative I/DPs	3	43%	Minimum	($17,270.43)
	Total Tons	149,868		Average I/DP	$17,826.28
2000 to 2010	No. of projects	185		Sum I/DPs	$4,631,063.63
	Positive I/DPs	140		Maximum	$190,172.14
	Negative I/DPs	45	24.7%	Minimum	($118,685.25)
	Total Tons	7,594,477		Average I/DP	$24,898.19

5.5 Review of Yearly Data by Test Element, 2000 through 2010

The overall results, all grading included, for each of the test elements for the years 2000 through 2010 are listed in Table 5. The quality level, pay factor, and standard deviation are shown for each element. The mean to target value (TV) and standard deviation minus V factor values are also calculated. The mean to TV calculation shows the relationship between the mean for the processes in comparison to the midpoint of the specification limits, the TV. The calculated value is the absolute difference between the mean and the TV. The lower the value the closer the mean is to the TV, which increases the probability that the material will be within specification. The standard deviation minus V factor shows the comparison of the standard deviation for the processes to the historical standard deviation for the element, the V factor. A negative number indicates that the standard deviation for the processes is less than the historical value. This increases the probability that the material will be within specification. Positive values show that the standard deviations have exceeded the historical values. The calculation of quality levels is dependent on the relationship of both of these values as they relate to the specification limits. Quality levels are not calculated on processes with less than three tests. Therefore, these processes are excluded from the evaluations that include the quality level calculation. When fewer than three tests were taken for a project, the small quantity calculation is utilized.

Fifty-two pay factors were evaluated from 2000 to 2010. The pay factor elements asphalt content, VMA, air voids and mat density had a yearly pay factor evaluated for each year from 2000 to 2010. The joint density element was evaluated for eight years from 2003 to 2010. Forty-five of the fifty-two yearly pay factors are above 1.0. On average, incentives have been paid on each of the elements every year. Two of the elements, VMA and mat density, have average pay factors above 1.0 in all of the years evaluated. Over the eleven-year time period, 2000 to 2010, most of the average element pay factors are above 1.0, with the exception of joint density. Joint density is the newest test element included in the calculation for I/DP, beginning in 2003. The average joint density pay factor for 2003 through 2010 is at 0.966.

For every year evaluated, 2000 to 2010, the following quality level results were displayed. The lowest reported quality level is 51.1, for joint density in 2009. The next lowest quality level is 84.0 for percent asphalt in 2009. The third lowest quality level is 82.93 for joint density in 2007.

Forty-one of the fifty-two quality levels are greater than 87 percent. At or above this level, incentives will be paid for the HMA. Thirty-seven of the fifty-two quality levels are above 90 percent. Greater than 90 percent of the material produced was within specification limits.

The mean to TV calculations show the relationship of the mean for the process as it relates to the midpoint of the specification limits, the TV. A mean to TV calculation of zero would denote that the process mean is exactly on the TV, midpoint of the specification range. Producing material close to the TV increases the probability that the material will be within specification limits. Values that are 1.0 times the V value from the TV would be one standard deviation away from the midpoint of the specification limits.

The standard deviations reported for the test results show that the majority of the material being produced is below the variation of the historical data, negative values in the standard deviation minus V value column. For all the data evaluated, only seven of the fifty-two yearly averages are greater than the element's V value. In three of the elements: percent asphalt, VMA, and mat density, all of the averages are less than the V value. Standard deviations that are less than the V value increases the probability that the material will be within specification limits.

The quality levels and pay factors for each of the elements are displayed in Figures 3 – 13. The first projects utilizing Voids Acceptance specification were constructed in 2000. In years 2000 to 2003 the quality level fluctuated between 87.678 and 96.691. In years 2004 to 2008 Quality Levels were higher, between 89.132 and 96.691. In 2009, quality levels dropped to between 80.703 and 96.964 and rebounded in 2010 to between 86.873 and 93.910.

Joint density testing became a requirement in 2003. The average quality level from 2003 to 2007 for this element was 88.072. Average quality level from 2008 to 2010 was 76.618. The overall average quality level for joint density 2003 to 2010 is 83.777.

Table 5. Recap of Yearly Data by Test Element, All Gradings

Percent Asphalt

Year	Proc.	Tons	Tests	Quality Level	Pay Factor	Mean to TV	St. Dev.	V	St. Dev. - V
2000	15	266,687	271	91.155	1.01690	0.089	0.144	0.200	-0.056
2001	24	638,541	641	91.889	1.01833	0.062	0.152	0.200	-0.048
2002	21	445,348	478	92.385	1.02744	0.062	0.151	0.200	-0.049
2003	68	1,223,050	1248	87.678	0.99472	0.078	0.168	0.200	-0.032
2004	67	1,185,868	1208	90.001	1.01169	0.072	0.157	0.200	-0.043
2005	68	1,189,573	1142	88.855	0.99932	0.076	0.160	0.200	-0.039
2006	50	984,302	875	89.781	1.00506	0.076	0.161	0.200	-0.039
2007	42	738,175	760	92.519	1.02403	0.065	0.148	0.200	-0.052
2008	36	603,928	635	90.065	1.01084	0.072	0.158	0.200	-0.042
2009	12	70,097	77	87.589	1.00182	0.089	0.167	0.200	-0.033
2010	8	107,876	108	87.357	1.00408	0.095	0.164	0.200	-0.036

VMA

Year	Proc.	Tons	Tests	Quality Level	Pay Factor	Mean to TV	St. Dev.	V	St. Dev. - V
2000	16	266,687	271	95.560	1.03611	0.27	0.487	0.600	-0.113
2001	24	638,540	641	96.691	1.04257	0.26	0.417	0.600	-0.183
2002	21	445,348	475	93.464	1.02296	0.27	0.504	0.600	-0.096
2003	69	1,223,050	1254	93.925	1.02450	0.38	0.421	0.600	-0.179
2004	67	1,185,868	1209	96.232	1.03446	0.28	0.415	0.600	-0.185
2005	68	1,189,573	1210	95.112	1.03409	0.28	0.464	0.600	-0.136
2006	49	984,302	1007	95.629	1.03889	0.28	0.475	0.600	-0.125
2007	42	738,175	760	95.537	1.03511	0.32	0.405	0.600	-0.195
2008	36	603,928	623	95.477	1.03725	0.26	0.467	0.600	-0.133
2009	13	146,097	155	96.964	1.03944		0.388	0.600	-0.212
2010	11	148,692	150	92.029	1.01688	0.25	0.545	0.600	-0.055

Notes: Mean to TV – The closer the calculated value is to zero the better.

Std. Dev. - V – The smaller the value the better.

Air Voids

Year	Proc.	Tons	Tests	Quality Level	Pay Factor	Mean to TV	St. Dev.	V	St. Dev. - V
2000	15	266,687	271	88.095	0.99579	0.39	0.594	0.600	-0.006
2001	23	617,540	620	90.942	1.01246	0.31	0.575	0.600	-0.025
2002	21	445,348	461	89.503	1.00273	0.25	0.628	0.600	0.028
2003	69	1,222,085	1253	89.369	1.00613	0.36	0.593	0.600	-0.007
2004	67	1,185,868	1209	92.268	1.02256	0.31	0.552	0.600	-0.048
2005	68	1,188,303	1210	89.132	1.00570	0.37	0.618	0.600	0.018
2006	48	981,875	1005	91.301	1.01420	0.27	0.614	0.600	0.014
2007	42	737,175	759	92.478	1.02277	0.26	0.557	0.600	-0.043
2008	36	602,928	622	91.994	1.02156	0.28	0.593	0.600	-0.007
2009	13	146,097	155	91.633	1.02728		0.592	0.600	-0.008
2010	11	148,692	150	89.836	1.01314	0.27	0.581	0.600	-0.019

Mat Density

Year	Proc.	Tons	Tests	Quality Level	Pay Factor	Mean to TV	St. Dev.	V	St. Dev. - V
2000	16	265,409	538	90.158	1.00271	0.668	0.968	1.100	-0.132
2001	23	586,423	1,180	93.449	1.02151	0.595	0.879	1.100	-0.221
2002	23	408,517	818	92.807	1.02312	0.559	0.897	1.100	-0.203
2003	68	1,118,739	2,289	93.586	1.02641	0.424	0.919	1.100	-0.181
2004	57	1,045,014	2,104	92.767	1.01912	0.484	0.962	1.100	-0.138
2005	70	1,083,553	2,234	94.532	1.03107	0.501	0.841	1.100	-0.259
2006	52	853,439	1,800	91.862	1.01453	0.461	0.981	1.100	-0.119
2007	44	627,074	1,282	94.831	1.03519	0.437	0.880	1.100	-0.220
2008	45	551,032	1,145	94.514	1.03305	0.404	0.887	1.100	-0.213
2009	14	143,818	334	95.332	1.04362	0.342	0.895	1.100	-0.205
2010	13	145,480	326	93.910	1.03069	0.335	0.982	1.100	-0.118

Joint Density

Year	Proc.	Tons	Tests	Quality Level	Pay Factor	Mean to TV	St. Dev.	V	St. Dev. - V
2003	28	730,560	398	90.171	1.00955	1.577	1.600	1.600	-0.014
2004	33	985,444	627	84.009	0.96731	2.035	1.671	1.600	0.071
2005	49	1,078,732	653	90.399	1.00749	1.588	1.552	1.600	-0.048
2006	36	850,447	483	92.849	1.02619	1.645	1.406	1.600	-0.194
2007	23	604,511	349	82.936	0.96774	2.365	1.529	1.600	-0.071
2008	19	434,294	251	87.507	0.99263	2.074	1.489	1.600	-0.111
2009	7	123,822	68	66.017	0.84893	2.749	4.379	1.600	2.779
2010	11	130,653	73	91.242	1.01213	1.690	1.348	1.600	-0.252

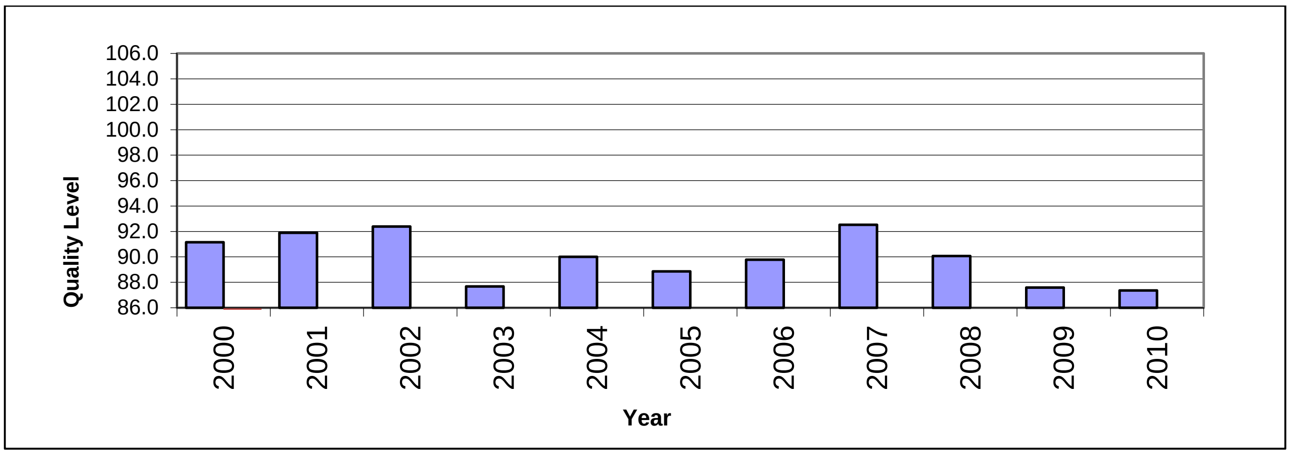

Figure 3. Percent Asphalt – Quality Levels

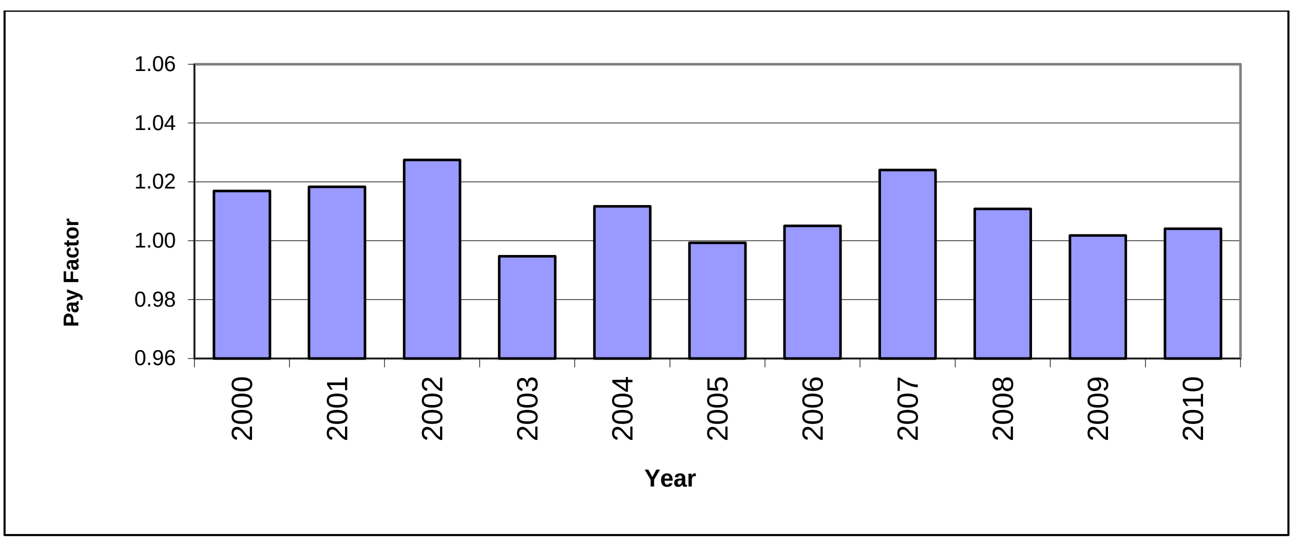

Figure 4. Percent Asphalt – Pay Factor

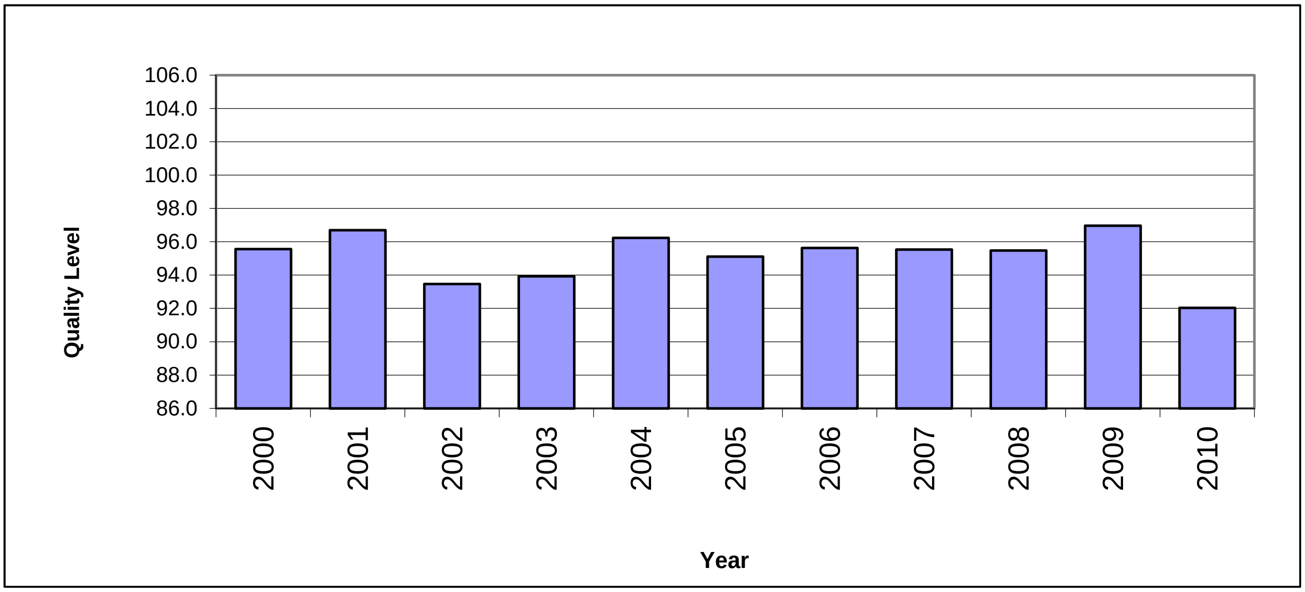

Figure 5. VMA Quality Level

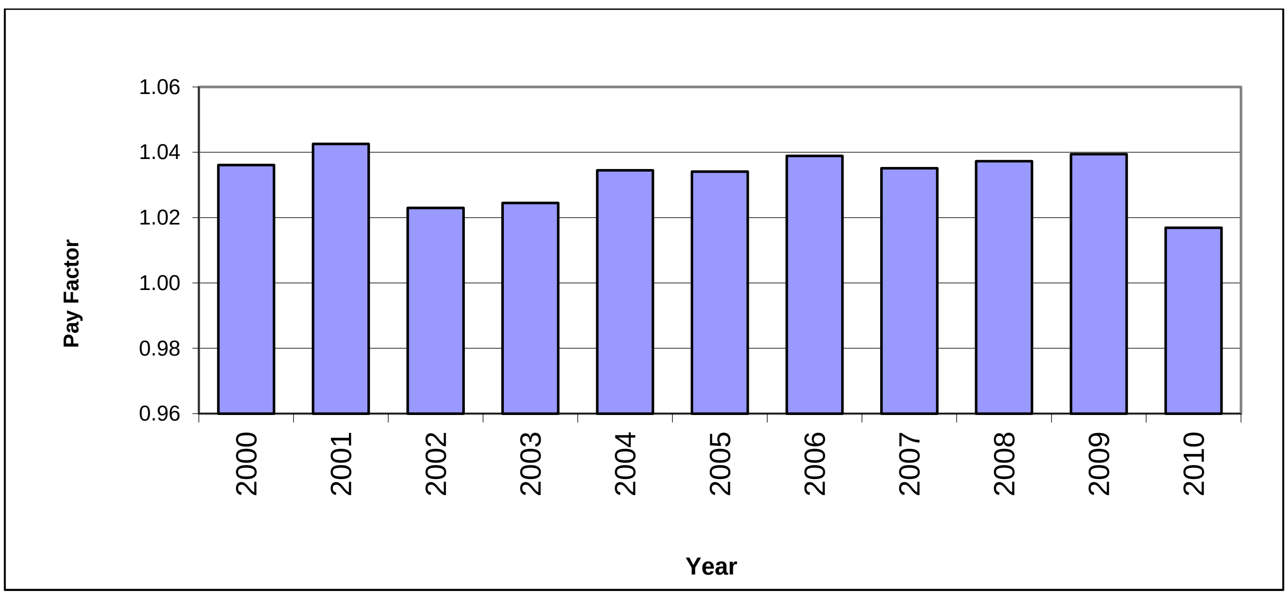

Figure 6. VMA Pay Factor

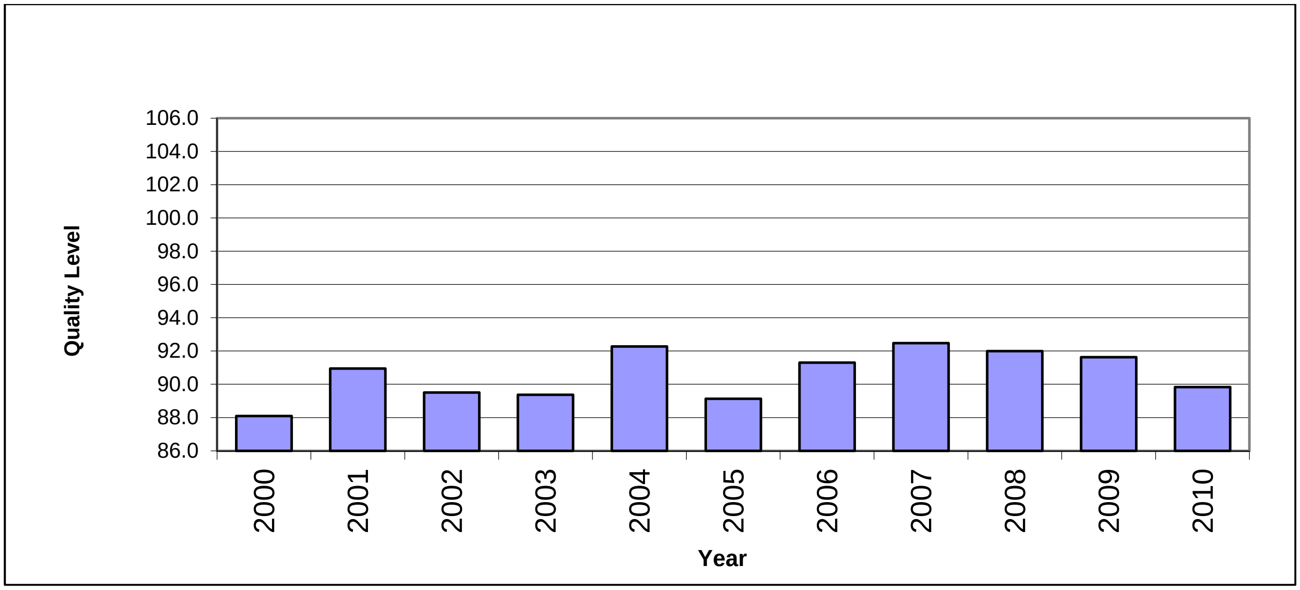

Figure 7. Air Voids – Quality Levels

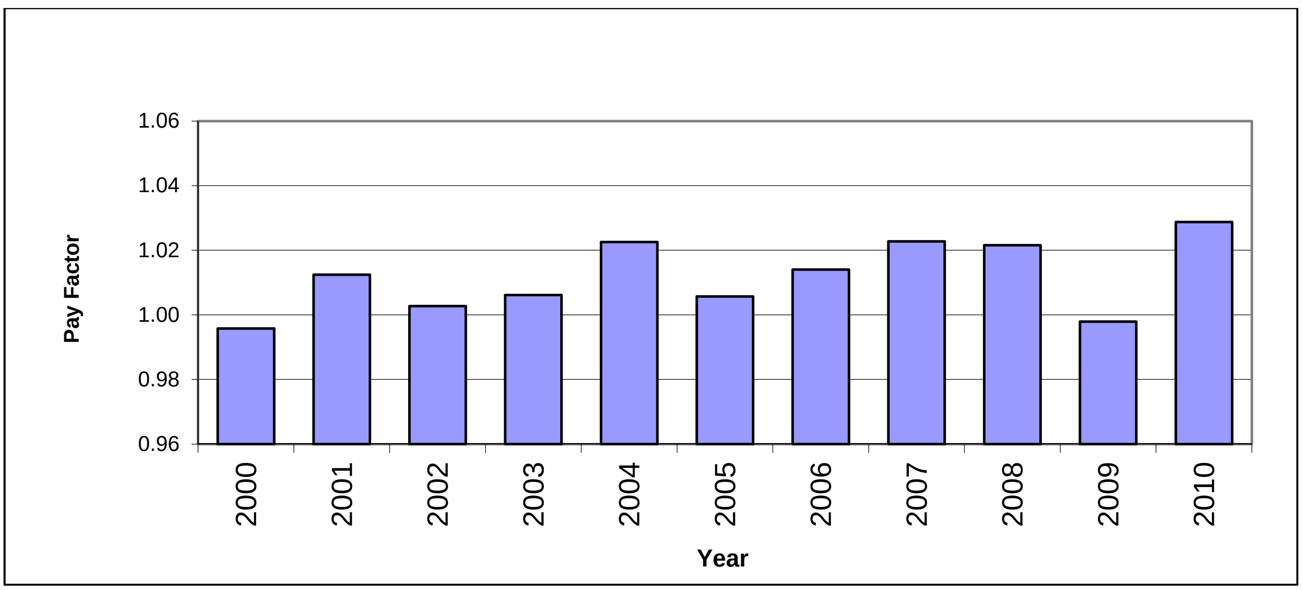

Figure 8. Air Voids – Pay Factors

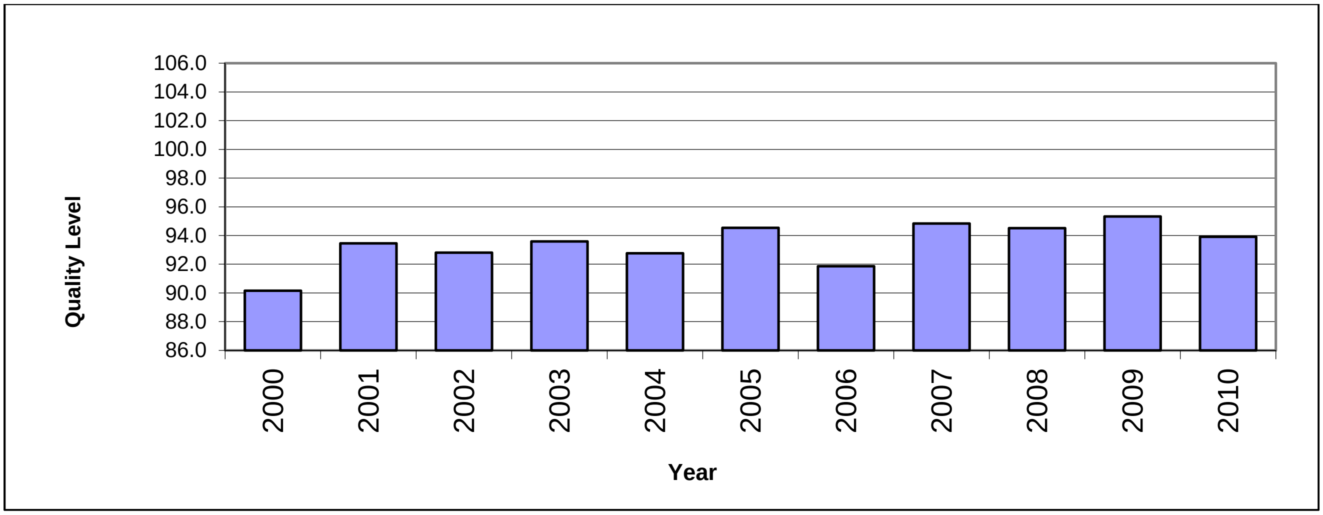

Figure 9. Mat Density – Quality Levels

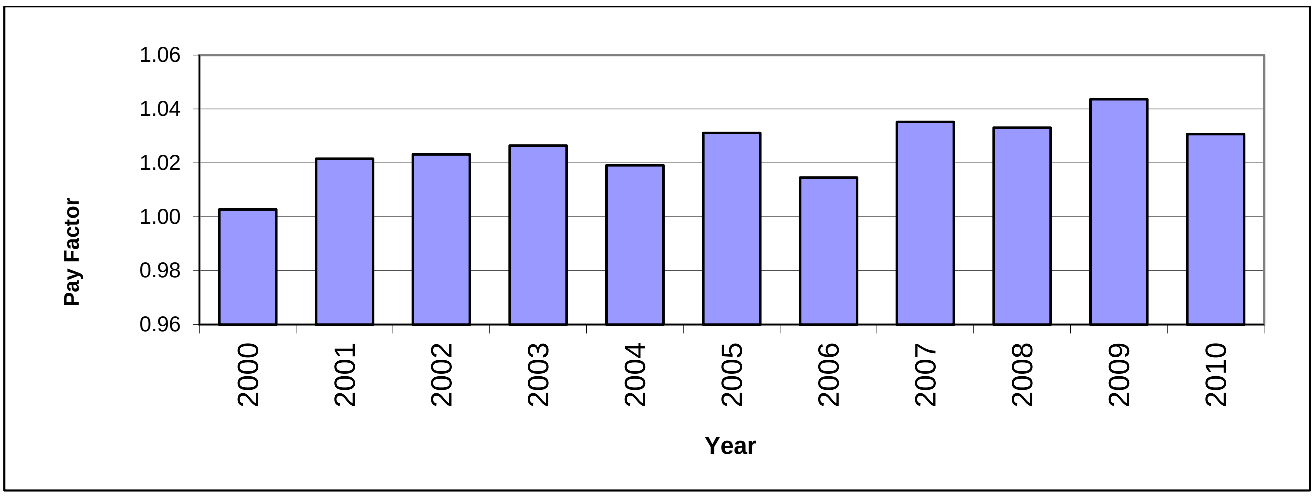

Figure 10. Mat Density – Pay Factors

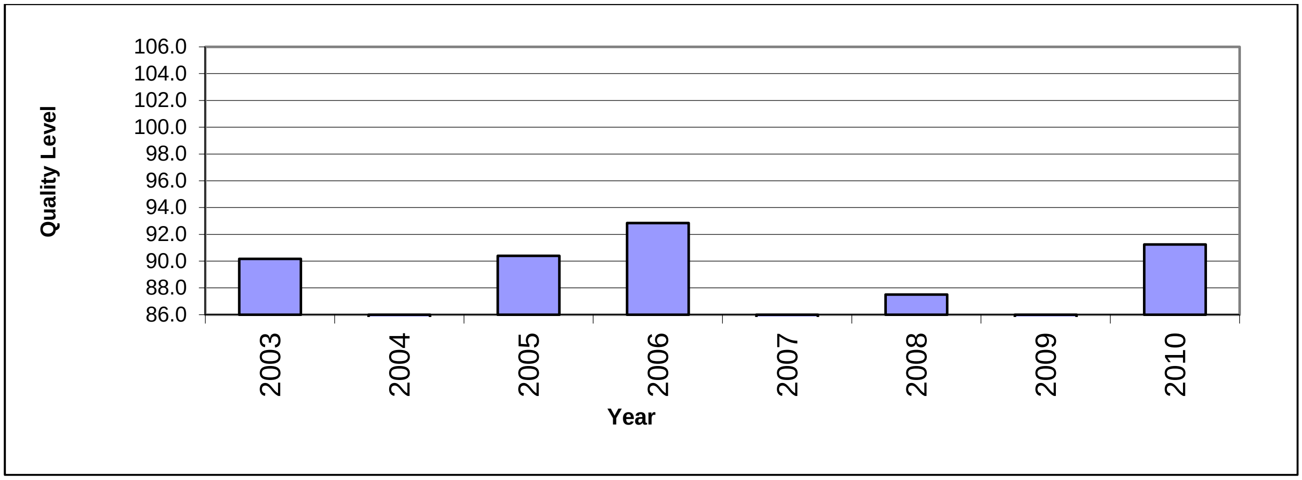

Figure 11. Joint Density – Quality Levels

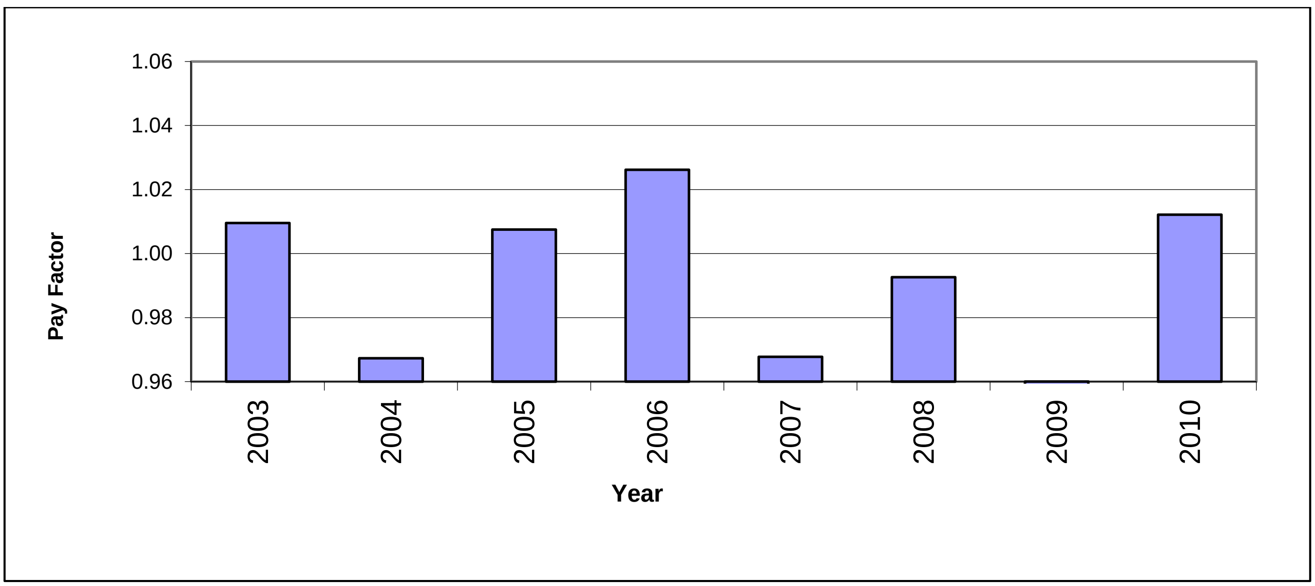

Figure 12. Joint Density – Pay Factors

5.6 Comparison of Quality Levels between Test Elements, 2000 through 2010

The quality levels for the elements by year, 2000 through 2010, are displayed in Figure 13. This displays the relationship between the quality levels of the different test elements. There are two key points to evaluate when analyzing the relationship between the test elements. The first; how the elements rank lowest to highest in terms of quality levels. The second; to evaluate the difference between the reported quality levels, the gaps between test elements over time. The quality levels for the VMA element have been the highest of any of the elements in each year. Excluding joint density, the ranking of the elements, highest to lowest, in the last six years is: VMA, mat density, percent asphalt, and air voids. The reported quality levels in the VMA, mat density, air voids, and percent asphalt elements tend to move together, for the most part, at a somewhat constant interval from each other. The exception to this pattern is in the mat density element in 2004 and 2006. In these years the mat density quality levels declined when the other three elements showed increases.

The results for joint density vary greatly from the other elements. It showed movement independent of the other elements with its lowest quality level result in 2009 at 51.105.

The yearly pay factor results for the elements are displayed in Figure 14. In the eleven years evaluated, only nine of the pay factors are below 1.0, air voids in 2000, percent asphalt in 2003 and 2005 and joint density in 2004, 2007, 2008 and 2009.

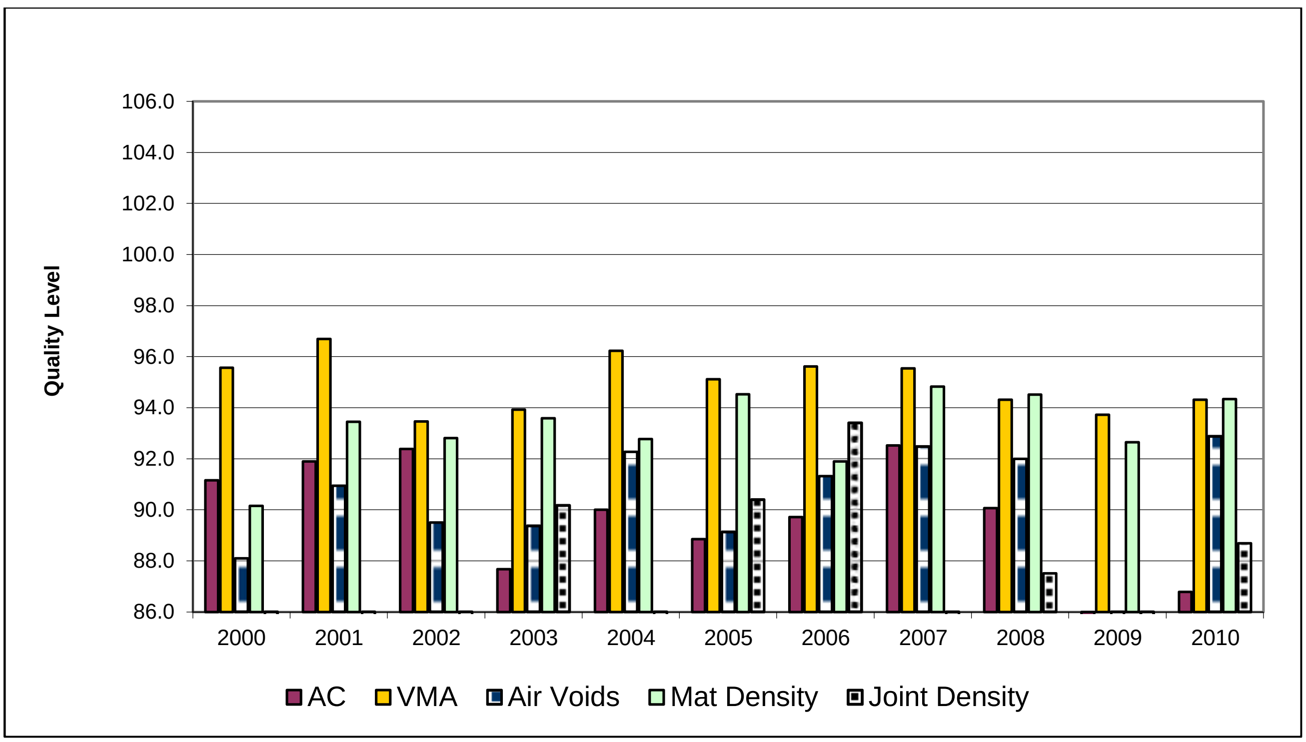

Figure 13. Element Quality Level

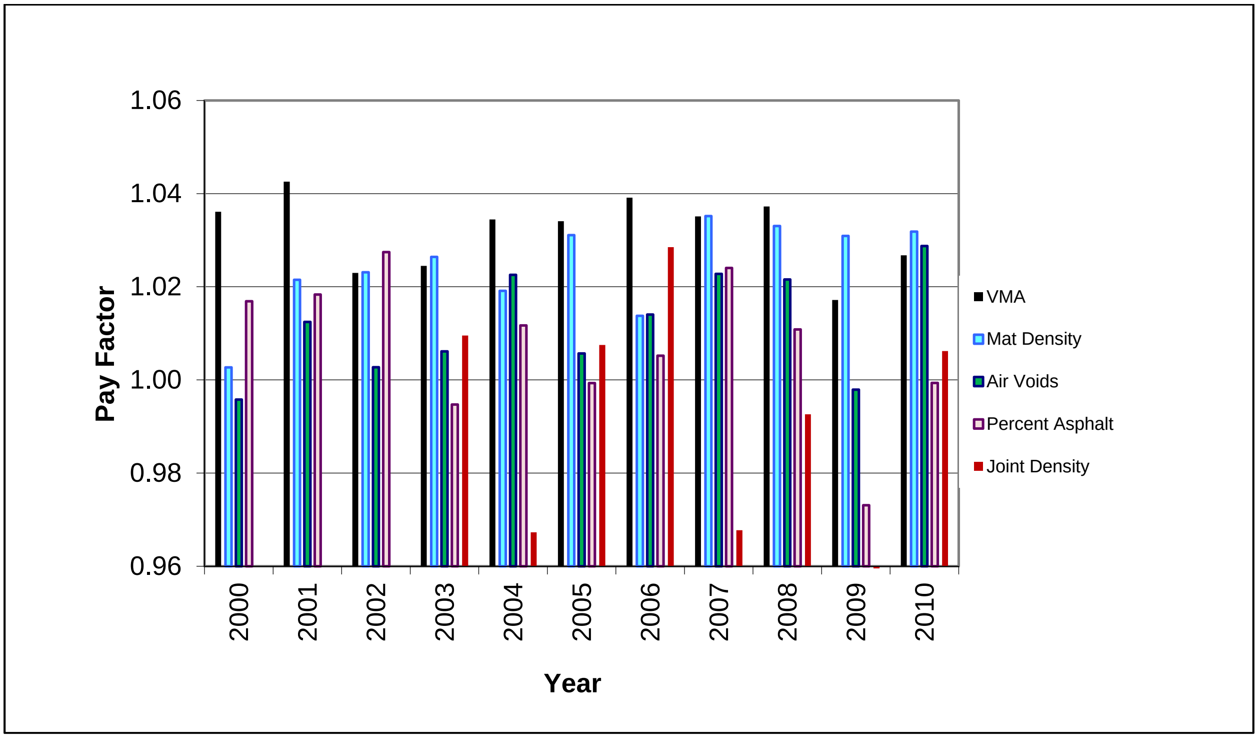

Figure 14. Pay Factors by Test Element

5.7 Element Weight and Quality Levels

One factor that might influence the quality level results of an element is the importance given that element, its W Factor (the element's weight.) To review this we looked at how the elements ranked, highest to lowest, in terms of quality levels. "W" Factors for Various Elements displays the weights given to each of the elements.

Figure 15 displays the average quality levels, 2000 through 2010, for each of the test elements and its assigned weight. The "W" factor for mat density is 35 percent, the highest of any of the elements. This element ranks second in reported quality levels. The air voids element has a "W" factor of 30 percent and is ranked third behind mat density. The "W" factor for VMA and asphalt is 10 percent. VMA has the highest reported quality levels. The utilization of joint density as a testing requirement began in 2003. Its "W" factor is 15 percent, this report presents all eight years of reported Joint Density data. Joint density ranks lowest in quality levels. The elements with the highest weights are ranked second and third in terms of quality levels. Asphalt content and joint density have the lowest reported quality levels and lower weights.

Figure 16 displays the average pay factor for each of the test elements, 2000 through 2010. Most of the average pay factors are above 1.0, incentives being paid. An exception to this is Joint density's decrease in quality and pay factor in 2004, 2007, 2008 and 2009. The lowest of quality level and pay factor for joint density was in 2009, with quality level at 66.017, and the pay factor of 0.84893.

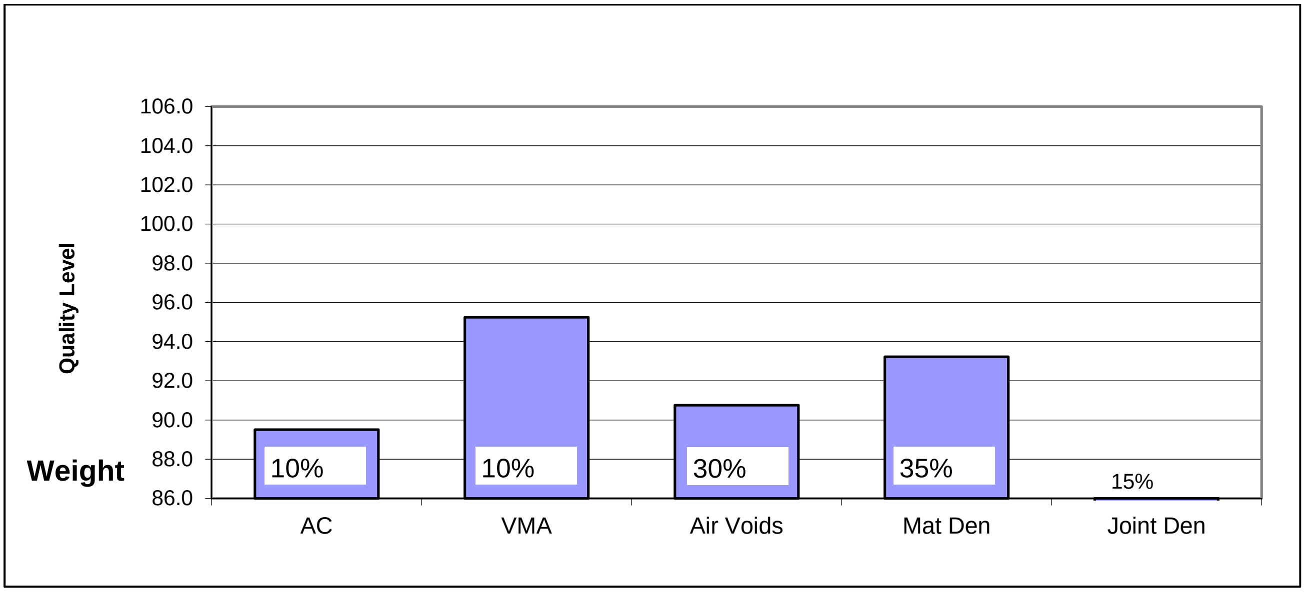

Figure 15. Quality Levels by Test Element 2000 to 2010 & "W" Factor

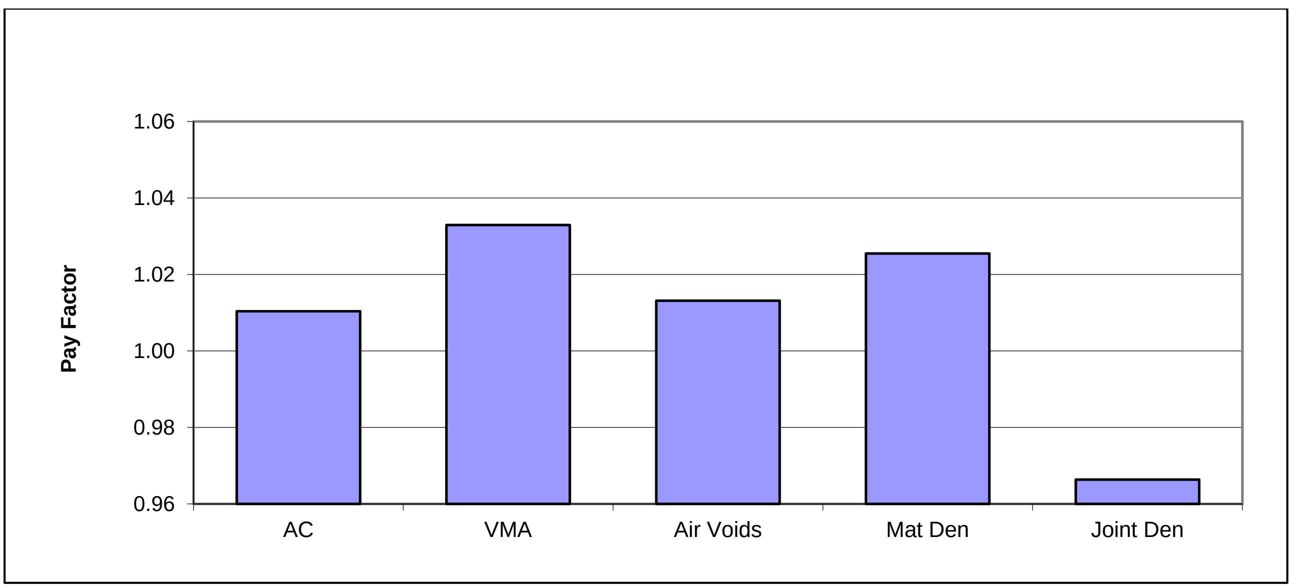

Figure 16. Average Pay Factors 2000 to 2010

5.8 Calculated Pay Factor Composite for Gradings S & SX, 2000 through 2010

Table 6 displays the yearly calculated pay factor composite for grading S and SX. No projects in 2000 contained grading SX. Only one project in 2001 and two in 2002 contained grading SX. The largest difference between the two gradings, 0.06 is in 2008. In the years 2004 through 2006 the difference was less than 1.0 percent, calculated at 0.7 percent or less each year. Grading S had better results in 2003 and 2004. In the years 2005 and 2006 grading SX had only slightly better results than grading S. In 2007 both gradings were equal. S grading remained the same in 2008.and SX grading dipped to its lowest CPFC In 2009, S grading dipped to its lowest point and SX went up. In 2010 S had an increased CPFC, at 1.03 and SX increased to 1.00. Over the eleven-year time period, 2000 to 2010, the difference between the two gradings averaged 0.19 percent. During this time frame, grading SX received an average CPFC of 0.9 percent and grading S received an average of 1.0 percent. Both gradings on average are receiving incentive payments. Figure 17 displays the CPFC for each grading 2000 through 2010. Projects with two gradings are excluded from Table 6.

Table 6. Calculated Pay Factor Composite by Year and Grading

				CPFC		
Year	**Grading**	**Projects**	**Tons**	**Average**	**Minimum**	**Maximum**
2000	S	6	266,687	1.01584	0.98801	1.03974
	Totals	6	266,687	1.01584	0.98801	1.03974
2001	S	8	568,929	1.02952	0.99949	1.05302
	SX	1	70,475	0.97118	0.97118	0.97118
	Totals	9	639,404	1.02304	0.98533	1.05302
2002	S	9	348,338	0.97847	0.76392	1.04162
	SX	2	110,032	1.02530	1.00929	1.04132
	Totals	11	458,370	0.98698	0.76392	1.04162
2003	S	21	762,090	1.01000	0.83698	1.04771
	SX	5	289,475	0.99410	0.97720	1.00431
	Totals	26	1,051,565	1.00695	0.83698	1.04771
2004	S	16	629,304	1.01922	0.94133	1.04055
	SX	5	367,665	1.01395	0.98525	1.03872
	Totals	21	996,969	1.01797	0.94133	1.04055
2005	S	14	739,451	1.01149	0.94632	1.03903
	SX	16	385,835	1.01743	0.98478	1.04458
	Totals	30	1,125,286	1.01465	0.94632	1.04458
2006	S	8	392,731	1.01983	0.97891	1.04687
	SX	12	438,255	1.01863	0.98582	1.05364
	Totals	20	830,986	1.01911	0.97891	1.05364
2007	S	0	0	0	0	0
	SX	16	624,587	1.01711	0.99119	1.04914
	Totals	16	624,587	1.01711	0.99119	1.04914
2008	S	4	118,516	1.01760	1.00545	1.02383
	SX	13	485,973	0.93843	0.99322	1.04760
	Totals	17	604,489	0.95706	0.99322	1.04760
2009	S	3	11,015	0.97817	0.91338	1.01367
	SX	6	59,803	0.97348	0.91133	1.02673
	Totals	9	70,818	0.97504	0.91133	1.02673
2010	S	3	77,009	0.68685	1.02496	1.03560
	SX	6	105,873	0.83714	0.98861	1.02607
	Totals	9	182,882	0.78705	0.98861	1.03560
11-Year TOTAL 00 through 10	Totals	174	6,852,043	1.00226	0.933545	1.04363

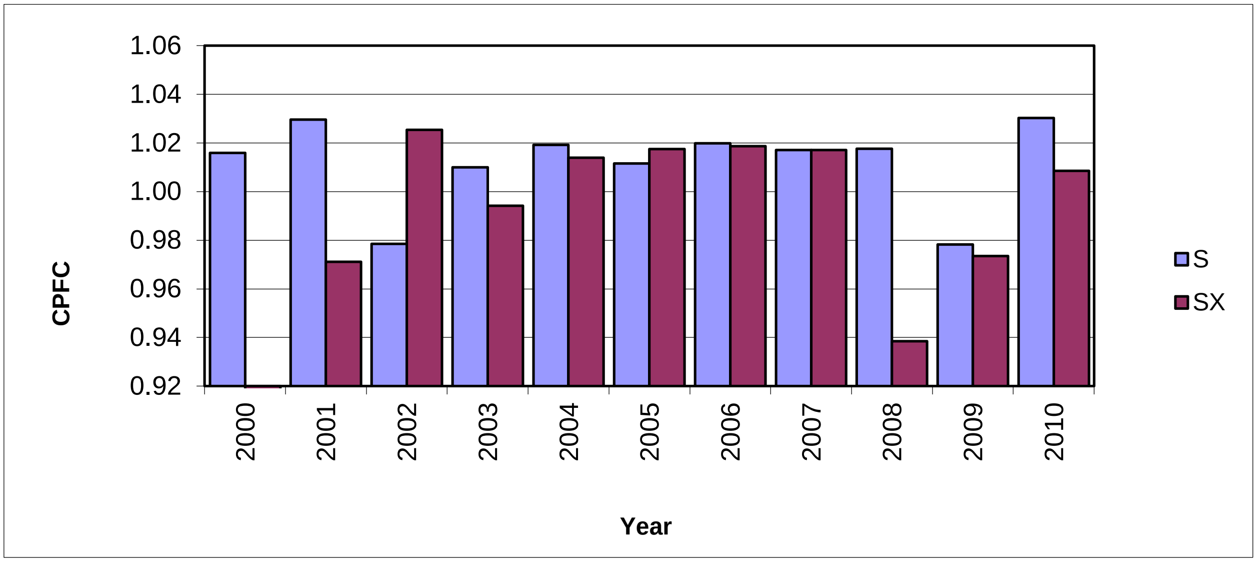

Figure 17. Calculated Pay Factor Composite by Year, Grading S & SX

5.9 Test Element Quality Levels for Gradings S & SX, 2000 through 2010

The tracking of the quality level is not by project, but by element and by year. Element Quality Levels tracked in years 2000 through 2002, were the AC, VMA, air voids, and mat density elements. Joint density was not utilized until 2003.

Table 7 displays each of the gradings S and SX, for each element in the eleven year evaluation period. Of the ninety-nine element quality levels calculated, for the individual S and SX gradings, from 2000 to 2010, eighty of them are above 87 percent within specification limits. At a level around 87 percent within specification the resulting pay factor is close to the neutral mark of 1.0. Above a quality level of 87 percent the pay factors are usually above 1.0 and result in incentive payments being awarded. Sixty-five of the ninety-one quality levels are above 90 percent within specification. For both gradings a high percentage of the material, 90 percent, is being produced within specification limits

When making comparisons between the two grading types, the analysis shows that the average difference between the two gradings was never over 5.percent Overall, the differences between the two gradings are within reasonable limits, less than 3 percent. Both gradings show good quality level results and do not differ significantly depending on the grading used. Figures 18 to 25 graphically present this quality level information, in years 2000 to 2010, for each element.

Table 7. Review of Test Elements – Gradings S & SX

Percent Asphalt							
Grading	**Year**	**Projects**	**Processes**	**Tests**	**Tons**	**Quality Level**	**Pay Factor**
S							
	2000	6	15	271	226,687	91.155	1.01690
	2001	8	21	569	568,066	92.889	1.023989
	2002	9	17	365	339,316	91.991	1.02581
	2003	24	54	928	904,748	88.652	1.00191
	2004	19	42	730	715,264	89.666	1.01099
	2005	16	40	725	713,621	88.973	0.99821
	2006	12	24	490	479,907	89.762	1.00825
	2007	3	7	75	69,946	78.355	0.98463
	2008	5	8	134	123,412	83.025	0.96947
	2009	3	4	15	11,015	79.751	0.98434
	2010	2	1	10	9,566	96.153	1.04500

Grading	Year	Projects	Processes	Tests	Tons	Quality Level	Pay Factor
SX							
	2000	0	0	0	0		
	2001	1	3	72	70,475	83.847	0.97351
	2002	2	4	113	110,032	93.599	1.03248
	2003	8	14	320	312,324	84.857	0.97390
	2004	8	25	478	470,411	90.509	1.01274
	2005	18	28	417	411,659	89.208	1.00263
	2006	15	18	382	372,791	90.962	1.00813
	2007	16	37	695	674,748	93.172	1.02728
	2008	19	28	501	492,967	91.827	1.02120
	2009	6	8	62	59,082	80.880	0.97102
	2010	4	17	496	349,651	96.590	1.04270

		VMA					
Grading	**Year**	**Projects**	**Processes**	**Tests**	**Tons**	**Quality Level**	**Pay Factor**
S	2000	6	16	271	266,687	95.560	1.03611
	2001	8	21	569	568,065	97.891	1.04875
	2002	9	17	362	335,316	91.679	1.01300
	2003	24	54	933	909,726	96.924	1.04388
	2004	19	42	731	715,457	95.854	1.03092
	2005	16	40	793	777,914	95.184	1.03276
	2006	12	24	512	501,544	96.140	1.04306
	2007	3	5	65	63,427	97.065	1.04456
	2008	5	8	134	123,412	99.185	1.04992
	2009	3	4	15	11,015	93.445	1.02094
	2010	2	4	77	77,009	99.694	1.05036
SX	2000	0	--	--	--	--	--
	2001	1	3	72	70,475	87.015	0.99281
	2002	2	4	113	110,032	98.906	1.05330
	2003	8	15	321	313,324	85.220	0.96826
	2004	8	25	478	470,411	96.808	1.03983
	2005	18	28	417	411,659	94.976	1.03660
	2006	15	24	492	480,331	95.293	1.03508
	2007	16	37	695	674,748	95.394	1.03423
	2008	19	28	489	480,516	94.524	1.03400
	2009	6	9	140	135,082	97.251	1.04095
	2010	4	7	73	71,683	83.794	0.98090

		Air Voids					
Grading	**Year**	**Projects**	**Processes**	**Tests**	**Tons**	**Quality Level**	**Pay Factor**
S	2000	6	15	271	266,687	88.095	0.99579
	2001	8	20	548	547,065	91.863	1.01741
	2002	9	17	348	335,316	87.493	0.98952
	2003	24	54	932	908,761	91.184	1.01829
	2004	19	42	731	715,457	91.781	1.02120
	2005	16	40	793	776,644	88.212	1.00023
	2006	12	24	512	501,544	91.548	1.01742
	2007	3	5	65	63,427	95.801	1.04395
	2008	5	8	134	123.412	90.132	1.01322
	2009	3	4	15	11,015	91.490	1.02745
	2010	2	4	77	77,009	97.424	1.04533

SX	2000	0	---	--	--	--	--
	2001	1	3	72	70,475	83.789	0.97401
	2002	2	4	113	110,032	95.631	1.04299
	2003	8	15	321	313,324	84.103	0.97088
	2004	8	25	478	470,411	93.008	1.02462
	2005	18	28	417	411,659	90.867	1.01603
	2006	15	17	383	373,791	91.043	1.01083
	2007	16	37	695	674,748	92.166	1.02077
	2008	19	28	501	492,967	91.474	1.02371
	2009	6	9	140	135,082	91.644	1.02726
	2010	4	7	73	71,683	81.684	0.97835

		Mat Density					
Grading	Year	Projects	Processes	Tests	Tons	Quality Level	Pay Factor
S	2000	6	16	538	265,409	90.158	1.00271
	2001	8	21	1,084	539,011	94.411	1.02832
	2002	9	21	692	344,383	92.926	1.02415
	2003	24	58	1,739	849,001	94.099	1.03151
	2004	19	39	1,344	668,359	92.811	1.01982
	2005	15	43	1,492	715,515	94.162	1.02921
	2006	12	28	955	474,407	90.071	1.00119
	2007	3	10	109	51,890	97.658	1.04405
	2008	5	7	46	20,897	97.488	1.04814
	2009	3	3	27	8,869	82.024	1.00066
	2010	2	2	18	5,566	96.954	1.04524

SX	2000	0	--	--	--	--	--
	2001	1	2	96	47,412	82.510	0.94405
	2002	2	2	126	63,679	92.166	1.01752
	2003	8	10	550	269,738	91.973	1.01035
	2004	8	187	760	376,655	92.687	1.01788
	2005	18	27	742	368,038	95.251	1.03468
	2006	15	23	840	376,605	94.437	1.03295
	2007	16	35	1160	566,648	94.529	1.03425
	2008	19	33	866	425,274	93.635	1.02858
	2009	6	10	306	133,303	96.381	1.04701
	2010	4	9	161	69,971	90.624	1.01498

Joint Density							
Grading	Year	Projects	Processes	Tests	Tons	Quality Level	Pay Factor
S	2003	13	25	342	628,271	89.603	1.00652
	2004	18	24	367	610,331	86.137	0.98632
	2005	15	29	418	709,465	92.350	1.02202
	2006	9	17	214	474,351	93.904	1.03104
	2007	2	2	34	58,541	92.186	1.01914
	2008	4	7	65	111,961	93.402	1.03208
	2009	1	1	7	10,700	0	0.16709
	2010	2	6	44	74,689	90.146	1.00409
SX	2003	3	3	56	102,289	93.654	1.02815
	2004	8	9	260	375,113	80.547	0.93638
	2005	17	20	235	369,267	86.650	0.97956
	2006	12	19	269	376,096	91.518	1.02007
	2007	19	21	315	546,060	81.946	0.96224
	2008	10	12	186	322,233	85.459	0.97893
	2009	3	6	61	113,122	72.261	0.91343
	2010	5	5	29	55,964	92.710	1.02286

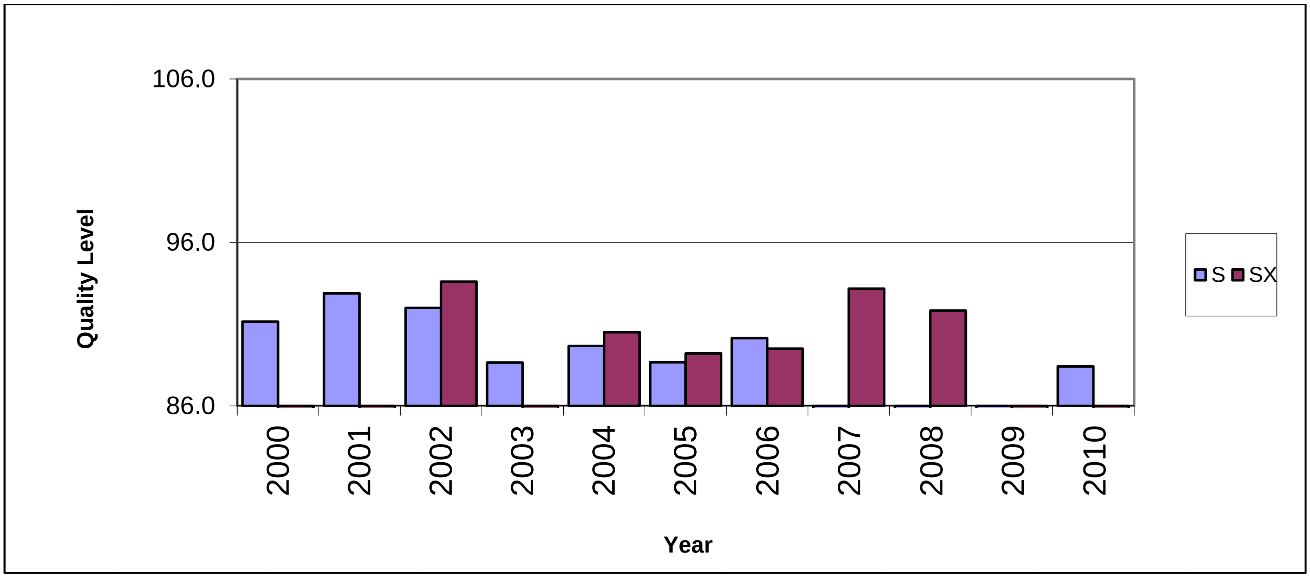

Figure 18. Percent Asphalt - Quality Levels

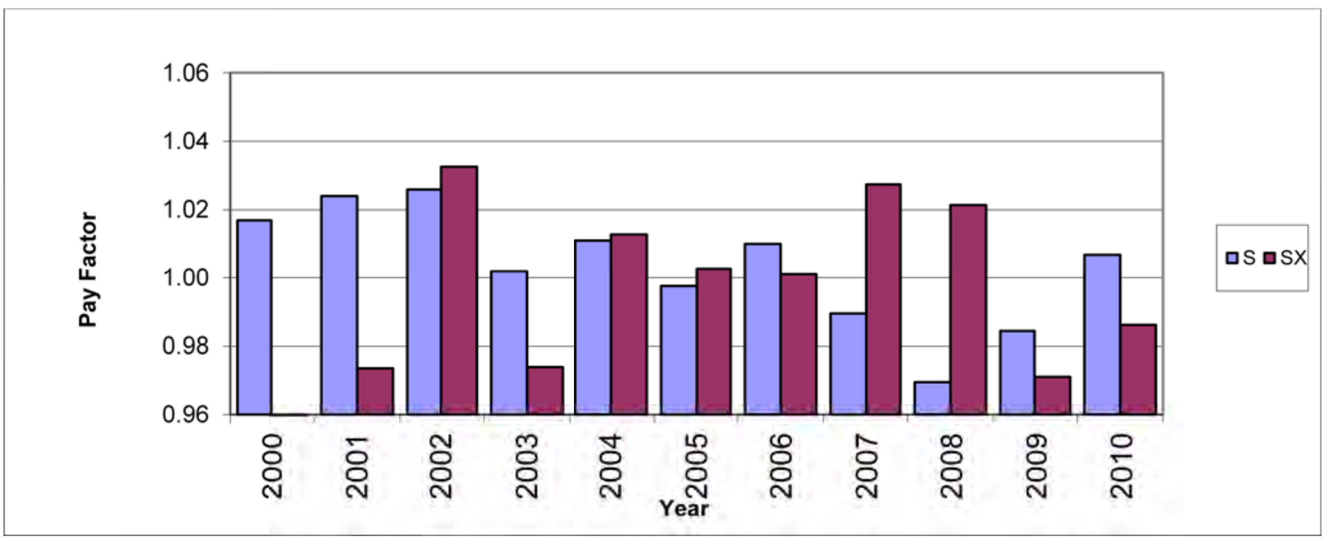

Figure 19. Percent Asphalt Pay Factors

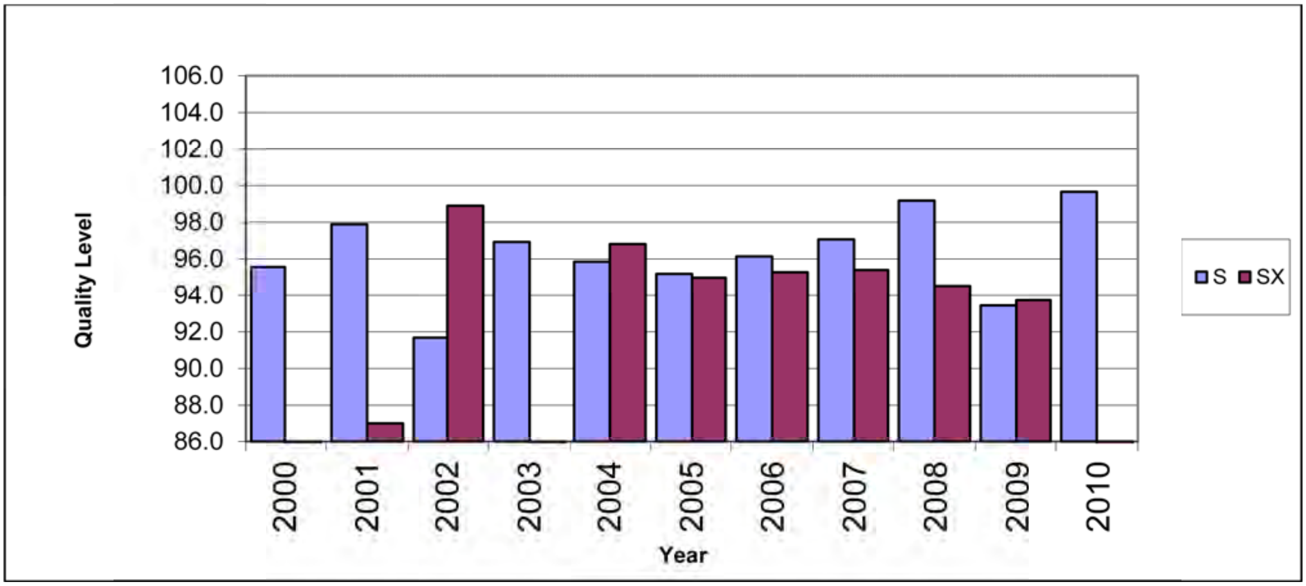

Figure 20. VMA Quality Levels – Gradings S & SX

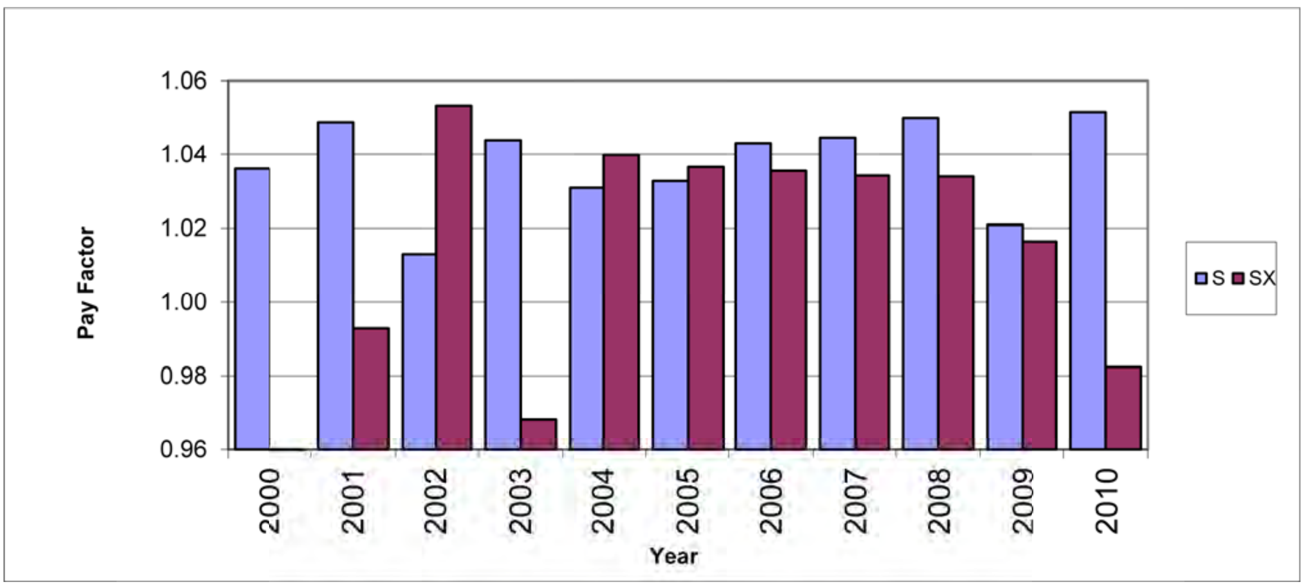

Figure 21. VMA Pay Factors – Gradings S & SX

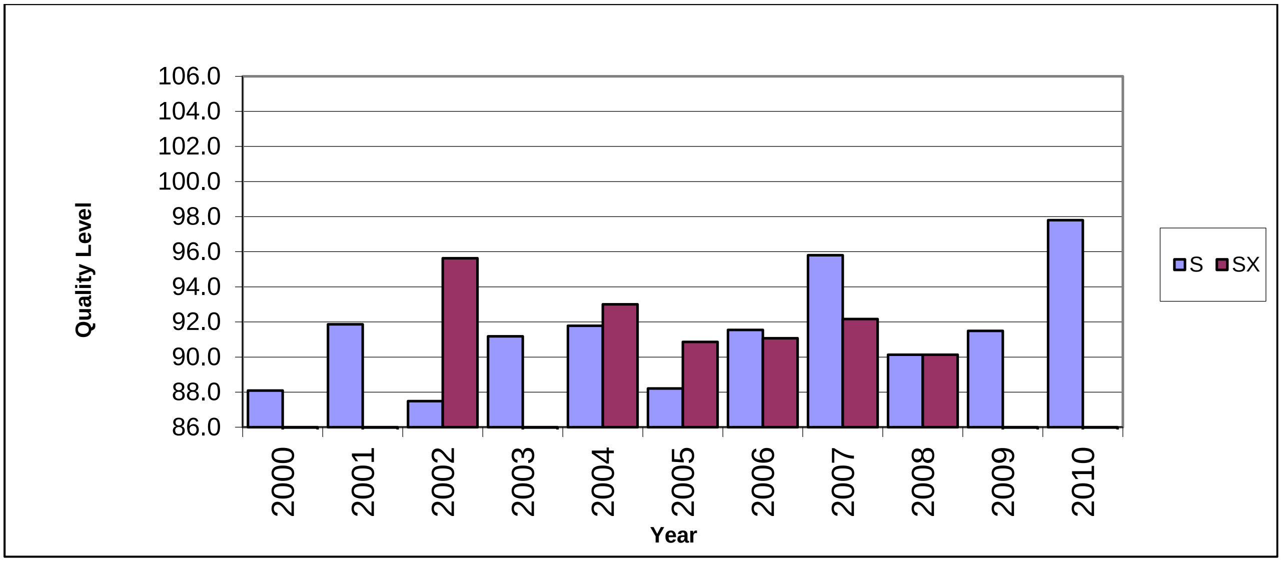

Figure 22. Air Voids Quality Levels – Gradings S & SX

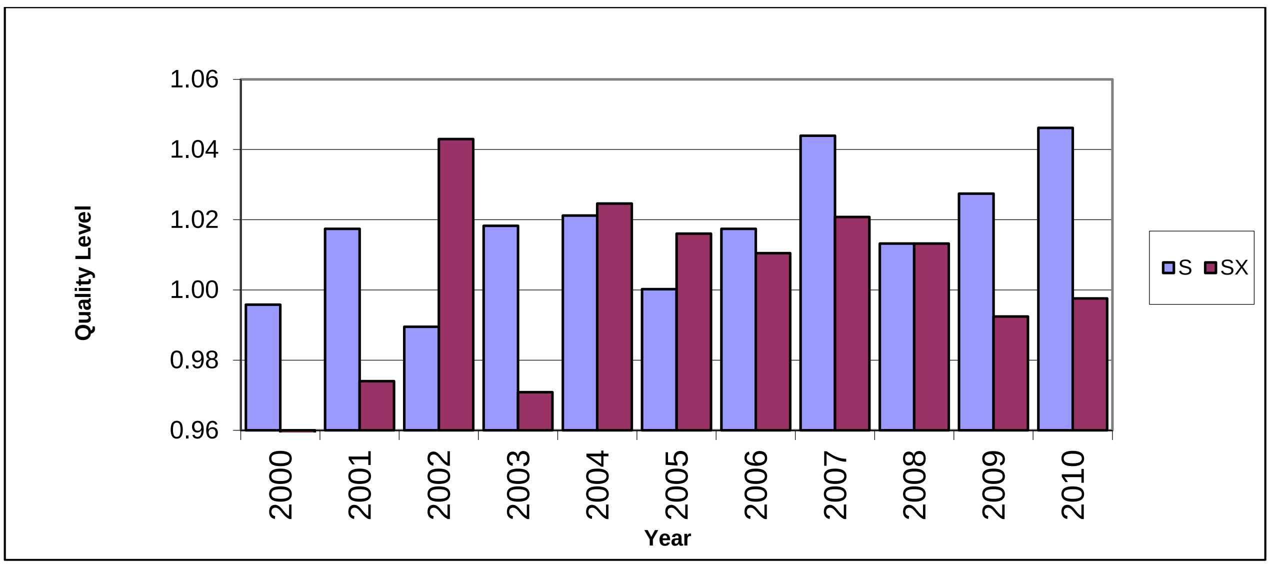

Figure 23. Air Voids Pay Factors – Gradings S & SX

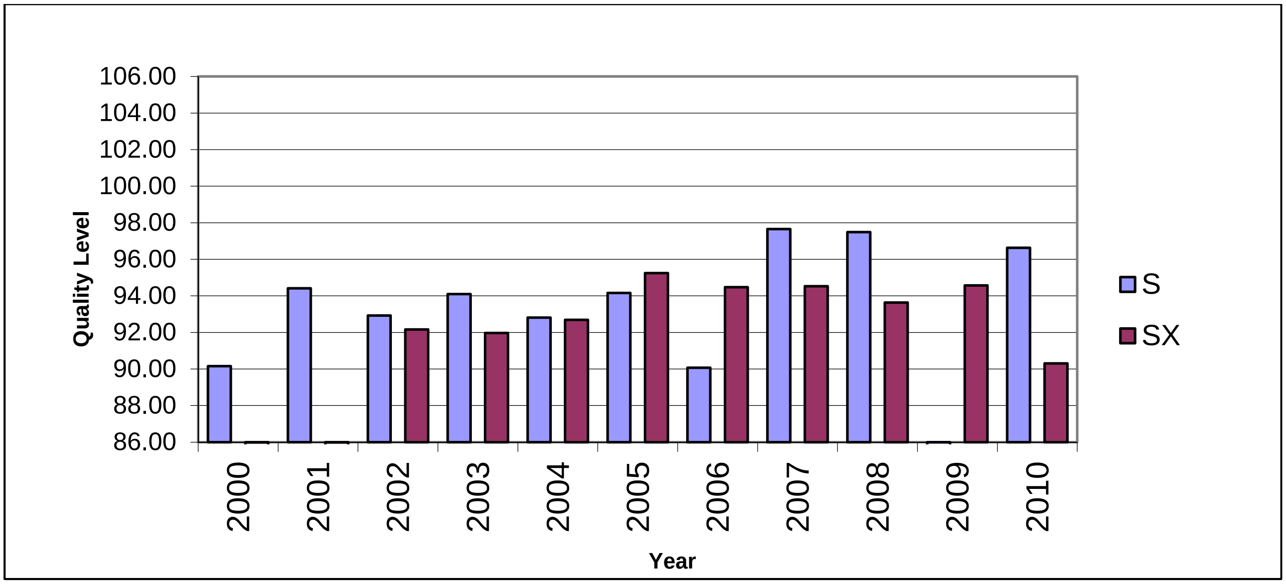

Figure 24. Mat Density Quality Levels – Gradings S & SX

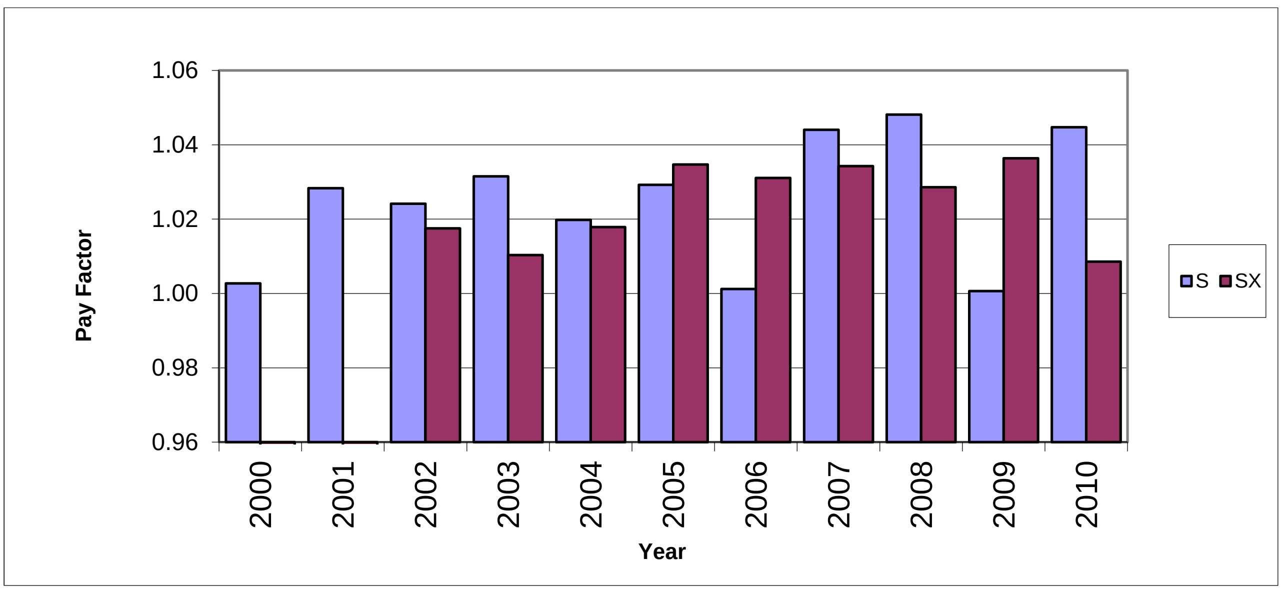

Figure 25. Mat Density Pay Factors – Gradings S & SX

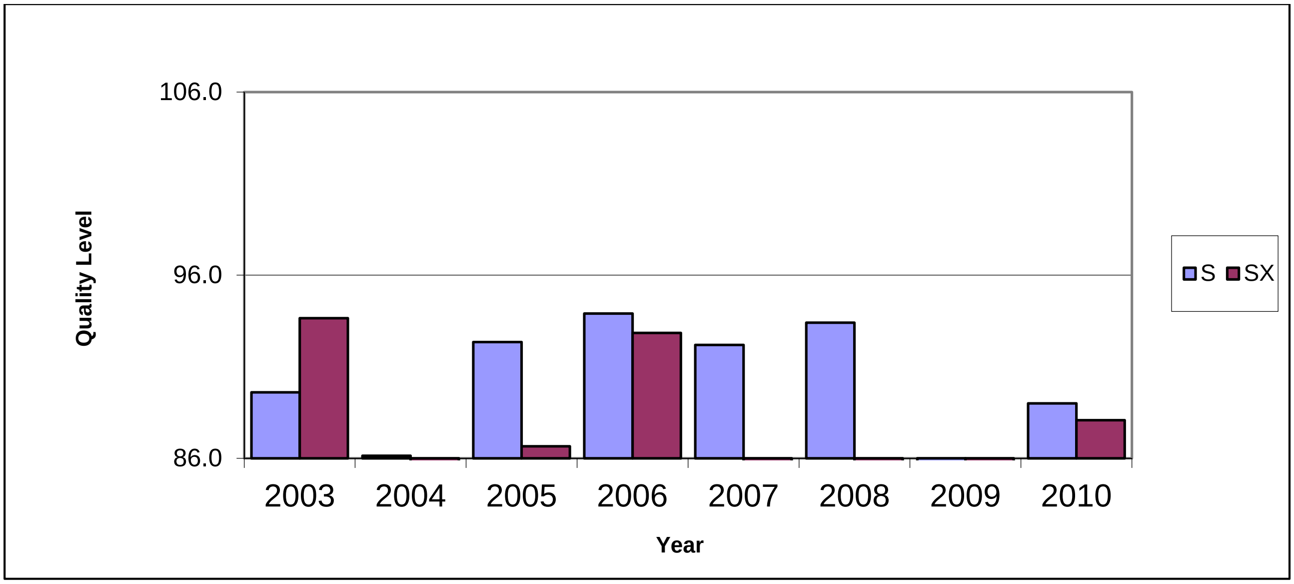

Figure 26. Joint Density Quality Levels – Gradings S & SX

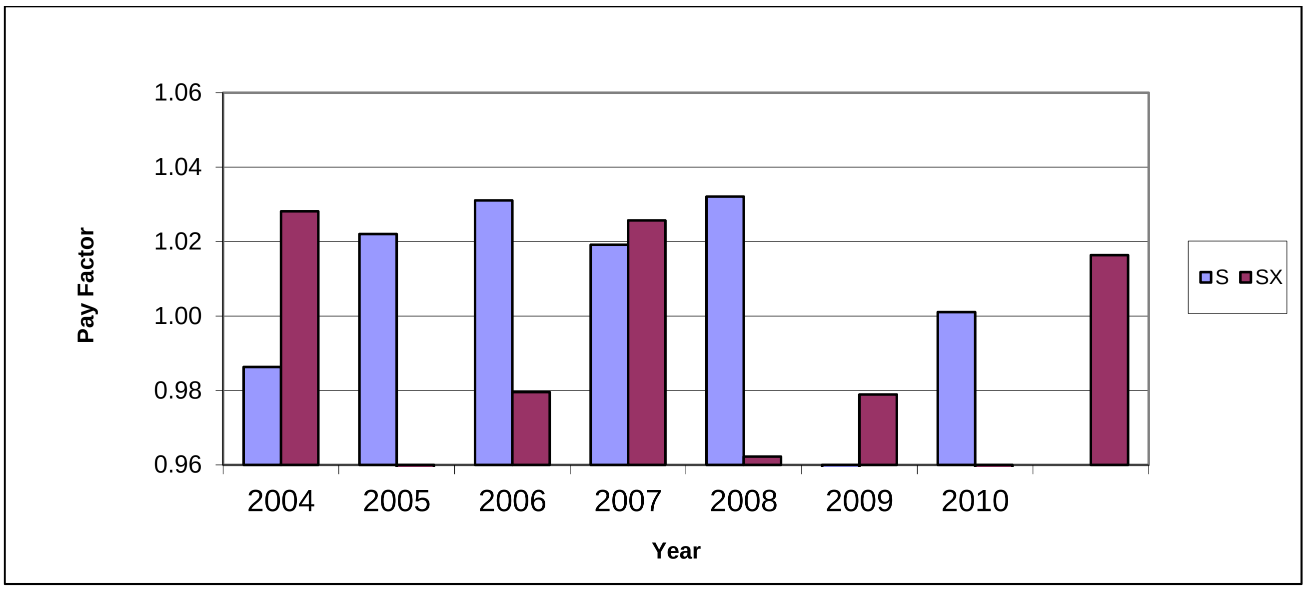

Figure 27. Joint Density Pay Factors – Gradings S & SX

6.0 SUMMARY

On average, the projects constructed from 2000 to 2010 received approximately a 0.99 percent CPFC on the voids acceptance projects. Individually, Region 1 had an eleven-year average CPFC of 0.99603, which equaled an average incentive of $16,755.54. Region 2 had an average CPFC of 0.99712, which equaled an average incentive of $3,912.26. Region 3 had an average CPFC of 0.97580, and equaled an average incentive of $11855.68. Region 4 received an average CPFC of 0.95104, which equaled an average incentive of $16,736.64. Region 5 received an average CPFC of 1.05423, which equaled an average incentive of $27,008.47. And Region 6 received an average CPFC of 0.97546, which equaled an average incentive of $8,923.85.

From 2000 to 2010 twenty-five percent of the VA projects evaluated had some amount of disincentive applied. The majority of the projects, Seventy-five percent are receiving incentive payments. In 2008, the lowest disincentive was applied, 11.8%. The average incentive for the same time period was just under $39,000.00.

The individual test element pay factors for 2000 to 2010, for VMA, mat density, air voids, and percent asphalt, during the eleven-year time period have been very close to the 1.0 percent range. Over the eleven-year time period, percent asphalt fell below a pay factor of 1.0 in years 2005, 2007, 2008 and 2009. Air Voids fell below a pay factor of 1.0 in 2000 and 2003. Joint Density fell below a pay factor of 1.0 in years 2004 and 2009. VMA and Mat Density met the pay factor of 1.0 for all eleven years evaluated. The lowest pay factor for the eleven-year range was 0.84893 in the joint density element.

A high percentage of the material produced in the eleven-year time frame has been within specification limits. Of the fifty-two elements, S & SX grading combined, forty-five have quality levels of eighty-eight percent or higher. Thirty-eight of the fifty-two are above ninety percent within specification limits. The material is being produced close to the target value of the specification limits.

The yearly ranking of the elements by quality level, highest to lowest, in the last eleven-years is as follows: VMA, mat density, air voids, percent asphalt, and joint density. The results for joint density were quite varied, ranking from second to fifth. The reported quality levels in the VMA, mat density, air voids, and percent asphalt elements tend to move together at a somewhat constant interval. The only exception to the ranking was the mat density element in 2004 and 2006, which declined when the other three elements showed increases. The results for joint density showed movement independent of the other elements.

The relationship between the element's weight, W Factor, and reported quality levels was also analyzed. The elements with the highest weights are ranked second and third in terms of quality levels. Asphalt content and joint density have the lowest reported quality levels and lower weights. Overall, there seems to be a relationship between the element weight and the resulting quality levels. The exception to this is the results of the VMA element which has the highest reported quality levels but the lowest weight.

7.0 UPDATES AND CONTACT

The QC database will be updated as additional project data is received. Project data that was received after the cut-off date was not able to be included in this report. If you have any questions concerning this report please contact Veronica DeLuccie at 303 398-6528 or email at Veronica.DeLuccie@dot.state.co.us
If you find any errors in the project data please report them to Veronica DeLuccie.

REFERENCES

1. Standard Recommended Practice for Acceptance Sampling Plans for Highway Construction, AASHTO Designation: R9-97 (2000)

2. Hot Bituminous Pavement Gradation Acceptance Review of QC/QA Data 2000 to 2002, (March 2004, Eric Chavez, Colorado Department of Transportation, 4201 East Arkansas Ave, Denver, CO 80222), Report No. CDOT-DTD-R-2004-04.

3. Hot Bituminous Pavement Voids Acceptance Review of QC/QA Data 2000 through 2003, (March 2005, Eric Chavez, Colorado Department of Transportation, 4201 East Arkansas Ave, Denver, CO 80222), Report No. CDOT-DTD-R-2005-8.

4. Hot Mix Asphalt Voids Acceptance Review of QC/QA Data 2000 through 2004, (July 2006, Eric Chavez, Colorado Department of Transportation, 4201 East Arkansas Ave, Denver, CO 80222), Report No. CDOT-DTD-R-2006-12.

5. Hot Mix Asphalt Voids Acceptance Review of QC/QA Data 2000 through 2005, (October 2007, Eric Chavez, Colorado Department of Transportation, 4670 Holly St., Denver, CO 80216), Report No. CDOT-M&G-2007-02.

URLs

CDOT Library: http://www.coloradodot.info/library/materials-from-our-library
CDOT 2005 and 2011 Construction Specifications Book:
http://www.coloradodot.info/business/designsupport/construction-specifications
CDOT Standard Special Provisions: http://www.coloradodot.info/business/designsupport/construction-specifications/2011-Specs/standard-special-provisions
CDOT Field Materials Manual: http://www.coloradodot.info/business/designsupport/bulletins_manuals/field-materials-manuals/2012_field_materials_manual
CDOT Application Software: http://www.coloradodot.info/business/engineeringapplications

APPENDIX A

Hot Mix Asphalt Voids acceptance - 2000 to 2010 by contractor				
COMPANY	**# OF PROJECTS**	**YEAR**	**QUANTITY**	**AVERAGE CPFC**
A & S Const. Co. Affil. Co.	3	2000	38,668	0.98442
	5	2001	148,129	0.98830
	3	2003	148,784	1.03226
	5	2004	315,037	0.98288
	5	2005	133,685	1.00872
	2	2007	56,315	0.99838
	3	2008	99,867	1.00002
	3	2009	44,269	1.02399
TOTALS	**29**		**984,754**	**1.00063**
ACI CONSTRUCTORS	1	2009	4,862	1.01122
TOTALS	**1**		**4,862**	**1.01122**
AGGREGATE INDUSTRIES	1	2000	27,645	1.04014
	2	2001	33,380	1.01509
	2	2002	14,887	1.00851
	3	2003	29,442	1.00514
	4	2004	69,292	1.00980
	5	2005	50,412	1.00174
	4	2006	127,347	1.01033
	1	2007	18,862	1.00699
	1	2008	2,758	1.00645
	1	2009	3,065	1.03675
	1	2010	5,676	1.02496
TOTALS	**25**		**382,766**	**1.01069**
ALL RITE PAVING	3	2002	24,819	0.99597
TOTALS	**3**		**24,819**	**0.99597**
ANDREWS SAND & GRAVEL	1	2000	7,757	0.96594
TOTALS	**1**		**7,757**	**0.96594**
APC NORTHERN	1	2008	23,041	1.00122
	1	2009	29,020	0.99871
TOTALS	**2**		**52,061**	**0.99996**

APC SOUTHERN CONST. CO. LLC	1	2005	41,984	1.03500
	3	2006	188,590	1.02382
	3	2007	96,354	1.01885
	3	2008	231,924	1.02206
	2	2009	108,367	0.51269
	4	2010	219,408	1.01843
TOTALS	**16**		**886,627**	**0.95802**

ASPHALT CONSTRUCTORS INC.	1	2001	4,172	1.00459
	3	2003	6,201	0.94009
	1	2004	3,542	1.00750
	1	2006	4,614	1.00210
TOTALS	**6**		**18,529**	**0.97241**

ASPHALT PAVING CO.	2	2000	53,007	1.00465
	2	2001	71,141	1.04871
	2	2002	78,529	1.01717
	3	2003	101,659	1.02247
	4	2004	121,790	1.01572
	6	2005	168,154	1.02699
	8	2006	137,217	0.99022
	4	2007	79,651	1.01231
	3	2008	74,951	0.67713
	2	2009	26,570	0.96903
	2	2010	291,005	0.99513
TOTALS	**38**		**1,203,674**	**0.98326**

ASPHALT SPECIALTIES CO.	1	2000	7,477	0.97898
	3	2001	76,017	1.01615
	5	2002	153,297	101512
	6	2003	115,314	0.98642
	7	2004	225,261	1.00498
	3	2005	59,167	1.02352
	1	2006	6,690	1.03523
	1	2007	21,614	0.99547
	2	2008	76,154	1.02916
	1	2009	10,687	1.01367
	3	2010	23,752	0.65212
TOTALS	**33**		**775,430**	**0.97533**

B & B EXCAVATING	1	2009	11,800	1.00100
TOTALS	**1**		**11,800**	**1.00100**

BRANNAN SAND & GRAVEL CO.	1	2000	19,661	1.03272
	3	2001	30,139	1.01131
	2	2002	26,216	1.03017
	3	2003	69,279	1.04129
	4	2004	104,545	1.01193
	9	2005	99,460	1.02775
	7	2006	125,201	1.02712
	6	2007	137,909	0.99565
	7	2008	105,999	0.86402
	4	2009	130,777	0.72361
	2	2010	13,889	0.99659
TOTALS	**48**		**862,984**	**0.97183**

BURDICK PAVING, INC.	3	2000	61,748	1.03392
TOTALS	**3**		**61,748**	**1.03392**

CONNELL RES INC. DBA LOVELAND	1	2000	36,553	1.03926
	1	2001	19,124	1.04569
	1	2003	30,737	0.97187
	1	2006	23,656	1.00424
	1	2009	21,555	
TOTALS	**5**		**131,625**	**0.81221**

COULSON EXCAVATING	1	2001	20,504	1.03670
	2	2003	41,711	1.02202
	3	2004	40,171	1.03305
	1	2005	82,150	1.02973
	1	2006	26,535	1.04687
	4	2007	73,579	1.02807
	1	2008	46,082	1.04760
	3	2010	570,590	1.02460
TOTALS	**16**		**901,322**	**1.03064**

D.G. HUSKIN CONST. CO & MINNE.	5	2000	198,031	1.01344
	3	2001	114,205	1.02436
	2	2004	103,774	1.04683
TOTALS	**10**		**416,010**	**1.02340**
D.G. HUSKINS CONST. CO.	1	2001	59,068	1.04384
	3	2002	147,681	1.01536
	8	2003	329,335	1.00671
	4	2004	171,687	1.02527
TOTALS	**16**		**707,771**	**1.01529**

DBA FOUR CORNER MATERIALS	1	2001	3,318	1.02168
TOTALS	**1**		**3,318**	**1.02168**

ELAM CONSTRUCTION	6	2000	211,548	1.01846
	2	2001	60,238	1.01883
	4	2002	146,143	1.01006
	6	2003	267,882	1.00654
	5	2004	201,849	1.01291
	3	2005	67,052	1.02404
	4	2006	105,025	0.98105
	1	2007	39,958	0.99138
	3	2008	40,153	1.00268
	4	2009	117,005	0.76877
	3	2010	79,329	0.67568
TOTALS	**41**		**1,336,152**	**0.96074**

EVERIST MATERIALS	1	2003	3,614	1.015
	2	2004	9,714	1.00842
	2	2005	13,313	1.00869
	2	2006	26,254	1.00529
	2	2007	40,038	1.01060
	1	2008	8,959	0.98144
	1	2010	18,596	1.00729
TOTALS	**11**		**120,488**	**1.00634**

FOUR CORNER MATERIALS, INC.	1	2003	5,149	1.038
	2	2004	33,891	0.99999
	1	2006	28,787	1.00562
TOTALS	**4**		**67,827**	**1.0109**

FREMONT REDI-MIX	1	2002	8,404	1.03501
TOTALS	**1**		**8,404**	**1.03501**

GRAND RIVER CONST. CO.	1	2010	13,552	0.95339
TOTALS	**1**		**13,552**	**0.95339**

GRANITE CONST. CO.	1	2001	98,733	0.96192
TOTALS	**1**		**98,773**	**0.96192**

GRASSER CONST. CO.	1	2000	10,912	1.02921
TOTALS	**1**		**10,912**	**1.02921**

HANK WILLIAMS DBA WILLIAMS CONST.	1	2007	5,398	0.97759
TOTALS	**1**		**5,398**	**0.97759**

KIEWIT & AGG INDS.	1	2002	84,224	1.00871
	1	2010	11,402	0
TOTALS	**2**		**95,626**	**0.50436**

KIEWIT WESTERN CO.	6	2000	63,366	1.0045
	6	2001	109,038	1.0036
	3	2002	71,838	1.00134
	5	2003	128,565	1.00463
	1	2004	15,116	0.9946
	5	2005	146,006	1.02144
	3	2006	46,327	0.98967
	1	2007	65,710	1.03292
	4	2008	16,314	1.01753
TOTALS	**34**		**662,280**	**1.00734**

KIRKLAND CONST., RLLP	2	2000	66,932	1.00273
	3	2001	149,584	1.00879
	4	2002	86,536	0.99374
	4	2003	79,905	1.01602
	2	2004	103,923	1.00246
	2	2005	40,278	1.01325
	1	2007	19,251	0.96557
TOTALS	**18**		**546,409**	**1.00377**

KOCH	1	2004	16,045	1.03223
	1	2005	72,014	1.02397
TOTALS	**2**		**88,059**	**1.0281**

L.G. EVERIST	1	2001	56,275	1.02265
TOTALS	**1**		**56,275**	**1.02265**

LAFARGE DBA LAFARGE WEST, INC.	6	2002	264,540	1.02328
	12	2003	483,652	1.0138
	9	2004	417,761	1.01489
	6	2005	394,770	1.00055
	5	2006	229,123	1.00537
	7	2007	266,158	1.02827
	4	2008	309,755	1.00954
	5	2009	309,755	1.00954
	2	2010	70,214	1.00587
TOTALS	**56**		**2,745,728**	**1.01464**

LAFARGE DBA LAFARGE WESTERN MOBILE, INC.	6	2000	274,243	1.00712
	8	2001	488,506	1.02529
	1	2002	7,441	0.93652
	1	2003	56512	0.99468
	2	2004	121,183	1.01308
	3	2005	19,610	0.99144
	1	2006	4,025	1.00606
	1	2007	5,023	0.99616
TOTALS	**23**		**976,543**	**1.00778**

LAFARGE DBA WESTERN MOBILE SOUTH	1	2000	3,600	0.81968
	4	2001	47,833	0.93591
	1	2002	13,794	1.0318
	3	2003	40,163	0.99401
	2	2005	63,200	1.01237
	1	2007	3,747	0.99403
	1	2008	28,734	1.00801
TOTALS	**13**		**201,071**	**0.96953**

LAFARGE-BURLINGTON	1	2009	140,185	1.01522
TOTALS	**1**		**140,185**	**1.01522**

LAWSON CONSTRUCTION	1	2009	292475	0
TOTALS	**1**		**292475**	**0**

MCATEE	2	2001	25,873	0.9976
	2	2004	122,244	1.02571
	2	2005	67,725	0.97406
	1	2006	20,890	1.02384
	1	2007	23,307	1.01971
	1	2009	3,160	1.0097
	1	2010	1,576	0
TOTALS	**10**		**264,775**	**0.9048**

NIELSONS SKANSKA, INC.	2	2002	132,308	1.01913
	1	2004	58,784	1.01618
	1	2005	44,490	1.00692
TOTALS	**4**		**235,582**	**1.01534**
NIELSONS, INC.	1	2000	162,966	1.02432
	1	2001	30,021	0.95729
TOTALS	**2**		**192,987**	**0.99081**

OLDCASTLE SW GROUP, DBA UNITED	2	2005	67,475	1.02161
	2	2006	65,942	0.99233
	3	2007	102,209	1.0008
	1	2008	4,273	1.00701
TOTALS	**8**		**239,899**	**1.00466**

PREMIER PAVING, INC.	2	2002	21,272	0.87660
	1	2003	18,192	1.01228
	4	2004	44,451	1.02827
	5	2005	115,884	0.99982
	1	2006	10,637	0.93690
	1	2007	8,353	0.96595
	3	2008	47,880	1.01479
	2	2009	23,477	1.01402
TOTALS	**19**		**290,146**	**1.04174**

RITCHIE PAVING, INC. & SUBSID	1	2001	62,570	1.04174
TOTALS	**1**		**62,570**	**1.04174**

ROCKY MOUNTAIN MAT. & ASPHALT	1	2002	17,036	1.03800
	3	2003	84,695	1.02462
	2	2005	35,316	1.03496
	2	2006	75,326	1.03008
TOTALS	**8**		**212,373**	**1.03024**

SCHMIDT CONSTRUCTION CO.	4	2000	91,200	1.00302
	2	2001	137,444	1.00897
	2	2002	16,152	1.01717
	3	2003	132,761	0.99380
	3	2004	131,898	1.02765
	4	2005	81,985	1.00915
	6	2006	83,126	0.99844
	1	2007	31,615	0.99821
	1	2008	59,790	1.00087
	1	2010	2,641,487	0.99821
TOTALS	**27**		**3,407,458**	**1.00532**

SIMON CONTRACTORS	1	2005	38,392	1.03938
	2	2006	103,419	1.02379
	1	2007	21,982	1.03760
	1	2008	23,320	1.02058
TOTALS	**5**		**187,113**	**1.02903**

SOUTHWEST PAVING	1	2007	33,516	0.97092
TOTALS	**1**		**33,516**	**0.97092**

TONY J BELTRAMO & SONS	1	2005	18,107	1.02288
TOTALS	**1**	**2005**	**18,107**	**1.02288**

UNITED COMPANIES OF MESA CO.	5	2001	39,351	1.00296
	4	2002	92,017	1.01554
	5	2003	110,773	1.01371
	2	2004	107,440	1.01048
	2	2005	9,829	0.99998
	1	2006	4,370	1.02748
	1	2007	5,152	1.01951
	2	2008	71,824	0.99706
	1	2009	21,525	1.00044
	3	2010	10,312	0.66679
TOTALS	**26**		**472,593**	**0.96955**

UNITED CONSTRUCTION	1	2010	2,723	0.00000
TOTALS	**1**		**2,723**	**0.00000**

WALSENBURG SAND & GRAVEL CO.	1	2001	21,278	1.01872
	1	2002	15,841	0.76392
	2	2003	28,060	0.98968
	1	2004	19,652	1.03253
	1	2005	60,822	0.94632
TOTALS	**6**		**145,653**	**0.95681**

WESTERN ENGR CO DBA WECO INC.	1	2003	167,691	1.01545
	2	2006	151,191	0.98636
TOTALS	**3**		**318,882**	**0.99424**