

Validation of Hot Mix Asphalt

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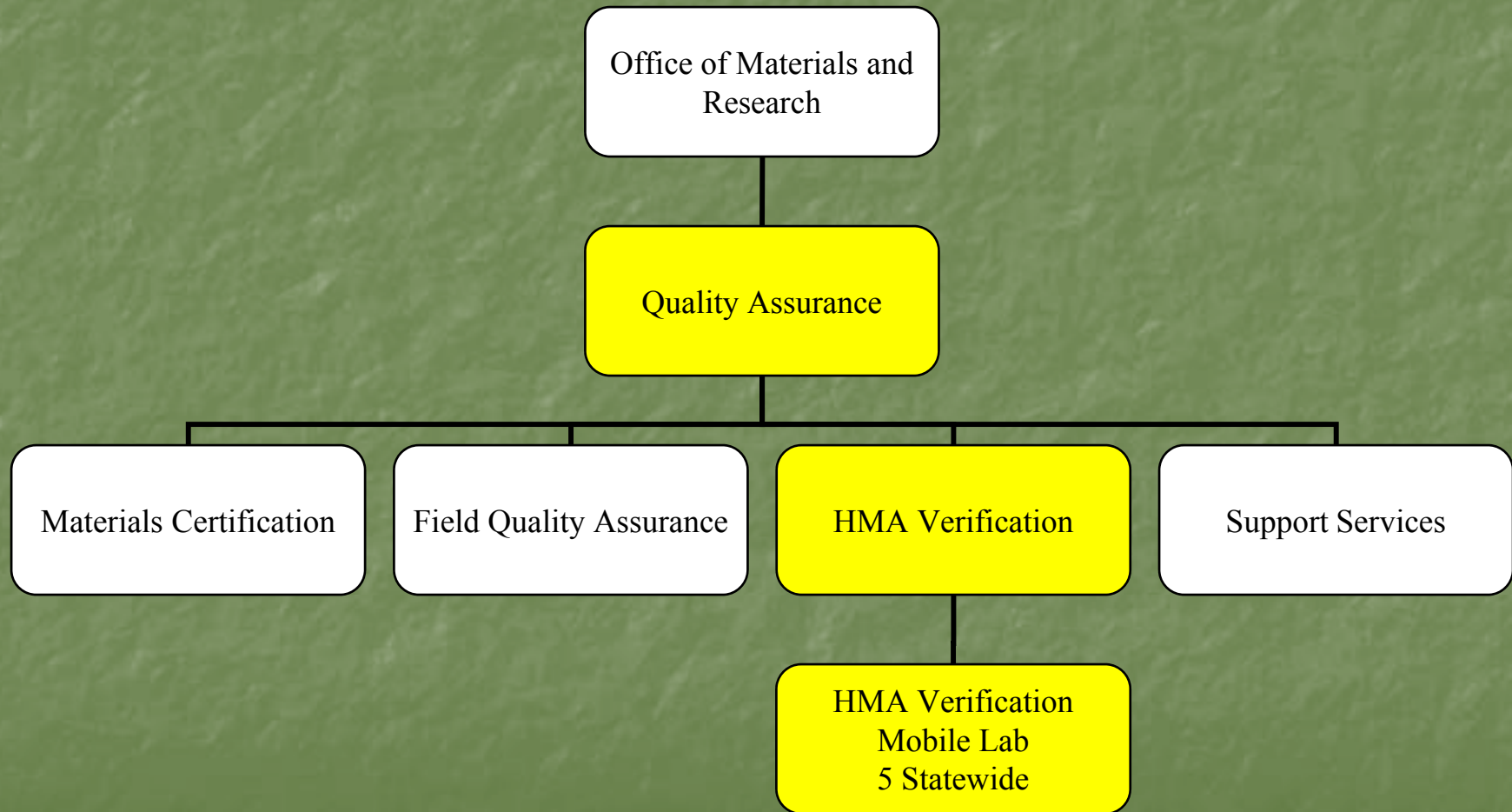
HMA Verification Program

- Who are we?
- Why are we here?
- Program details
- Mobile Labs
- Key factors
- Summary

Who are we?

- HMA Verification unit falls under the Quality Assurance Unit (QA)
- Report to the Office of Materials and Research – Columbia, SC
- Section consists of testing facilities to independently sample and test asphalt job mixes.
- Perform statistical analysis for comparison with the contractor's acceptance test results.

Organization Chart



Why are we here?

- Week of July 23, 2007 - Stewardship review conducted by FHWA's Office of Pavement Technology
- The team reviewed the SCDOT Materials Quality Assurance (QA) Program practices and procedures for compliance with current Federal Regulations, specifically 23 CFR 637
- Entire program was evaluated – emphasis on the use of Contractor quality acceptance test data in the agency's acceptance decision.

Findings - Favorable

- SCDOT is commended for:
 - Their PWL type specifications
 - Establishing the QMT and the review they perform
 - Their Technician Qualification Program
 - Using the Materials Manager portion of Site Manager
 - Taking advantage of data from NTPEP
 - Proactive in the leadership and use of APEL

Findings – Non-favorable

- SCDOT's QA system did not fully comply with the Title 23 of the Code of Federal Regulations.
- Visual observance of test procedures alone was not sufficient verification of properties used for payment.
- Independent verification samples must be sampled and tested by SCDOT personnel or their designated agent, in order to be used in the acceptance decision.

Recommendations

- Need to conduct verification testing of the volumetric properties of the mix and density of asphalt pavements.
- Verification testing must be performed on samples obtained and tested by SCDOT personnel or their designated agent, in order to be used in the acceptance decision.

Recommendations cont.

- Use “pooled data” for validating test results instead of one to one comparisons.
- All contractor QC and all SCDOT independent verification sampling and testing must be random.

Opportunities for Improvement

- Revise “rounding up” procedure to normal rounding procedures
- Allow District Asphalt Managers more time to monitor plant and field operations
- Allowable differences need to be revised
- Contractor’s testing data should be obtained much quicker
- Increase frequency of State testing at the beginning of production

Opportunities for Improvement

- Suggestions for Independent Assurance (IA) program
 - Revise the tolerances that used for comparing IA test results
 - Add Superpave volumetric characteristics to the IA program

Program Details

- Adding an additional level of sampling and testing to augment the current program.
Supplemental Specification: SC-M-400V
- Verification sampling and testing will be based on independent samples obtained completely by random and tested at a mobile lab.
- Samples will be retained by SCDOT personnel and remain in their custody.

Program Details cont.

- Verification test results will be compared *statistically* following **SC-T-97**.
- If the Results compare – Contractor's acceptance data is valid and results are used for pay.
- If the Results non-compare – SCDOT's verification data is used for calculation of pay.
- Report of F & t test results forwarded to AME and DAM

SC-T-97 Verification of Contractor HMA Acceptance Test Results

- Procedure is to validate, with a certain level of confidence, the consistency of the asphalt mix produced in the acceptance decision in accordance with the job mix formula and SCDOT Specification.
- Perform statistical analysis of two sets of data; Contractor HMA acceptance test results to SCDOT verification test results.
- Minimum of 1 Verification test per LOT

- Obtain HMA Contractors test results and SCDOT Verification test results for the asphalt mix properties for:

Binder Content

Gradation

Maximum Specific Gravity

Bulk Specific Gravity

% Air Voids

% VMA

% VFA

(Deliver either by email or fax all test results necessary to calculate payment factors to the DAM and HMA Verification Manager within **one hour** of completion of each test, or production can be halted until results are delivered)

- Input test data into the computerized statistical program spreadsheet.
- Data set to be evaluated in increments of 5 LOTS. Ex: LOT 1 thru LOT 5 will be statistically analyzed and a decision to accept the Contractor HMA acceptance test results will be based on the data set believed to equal. Non-comparison then the SCDOT verification results will be used for acceptance.
- LOT 6 thru LOT 10 analyzed. Process continues until production is complete.

- Conduct F and t-test using AASHTO R-9
 - Compute the mean and standard deviation for the Contractor acceptance tests and the SCDOT verification tests.
 - Compute the variance for both Contractor acceptance tests and SCDOT verification tests.
 - Use a Level of significance of $\alpha = 5 \%$
 - Compute F-statistic (F), using the largest variance value in the numerator.

$$F = s_v^2 \div s_c^2 = 0.9421 \div 0.2313 = 4.07$$

- Determine the critical F value from the F-distribution table using the correct degrees of freedom (n-1) and level of significance for each tests results.
- Evaluate if $F \geq F_{crit}$, or $F < F_{crit}$.
- If $F \geq F_{crit}$, conclude the data sets have significantly different variabilities.
- If $F < F_{crit}$, conclude the data sets do not have significantly different variabilities.

- Compute the t-statistic (t), using the pooled variance equation (equal variances) or the equation for unequal variances (significantly different).

$$t = \frac{|\bar{X}_c - \bar{X}_v|}{\sqrt{\frac{s_p^2}{n_c} + \frac{s_p^2}{n_v}}}$$

- Determine the critical t value using the level of significance and pooled degrees of freedom ($n_c + n_v - 2$) or the effective degrees of freedom (f') as appropriate.

- Use a Level of significance of $\alpha = 1 \%$
- Evaluate if $t \geq t_{\text{crit}}$, or $t < t_{\text{crit}}$.
- If $t \geq t_{\text{crit}}$, conclude the two data sets have significantly different means.
- If $t < t_{\text{crit}}$, conclude the data sets do not have significantly different means.
- Determine if the two data sets are statistically equal based on statistical hypothesis two-tailed tests.

- Not statistically equal (non-comparison)
 - contact the District Asphalt Manager, Asphalt Materials Manager or other appropriate personnel and investigate to determine if any discrepancies or issues in production, sampling or testing of the HMA can be identified.
- Statistically equal (compares) – Forward the test results and a statement for acceptance to the District Asphalt Manager for completing the project payment functions.

1	A	B	C	D	P	Q	R	S	T	U	V	W	X	Y	Z	AA
2	Lots:	1	5	File #	42.037177AR1				Name of QC Tester							
3	Dates:	4/05/2009	4/09/2009	Project #	IP42 (003)				Certification # of QC Tester							
4	Mix Type	Surface Type A														
5	Contract Line #'s															

Air Voids															
	Lot	Date	Contractor Quality Control Tests (%)	SCDOT Verification Test (%)	Number of Contractor Tests	Number of SCDOT Tests	F Test	F(crit)	Are Variances The Same?	Pooled Variance	T Test	T(crit)	Are Means The Same?	Effective Degrees of Freedom	Use Contractor Test Results?
8	1A	4/05/2009	4.30	4.23	4	1									Yes
9	1B	"	3.77												
10	1C	"	4.05												
11	1D	"	4.80												
12	1C														
13	1F												Pass		
14	2A	4/06/2009	2.67	3.50	8	2									Yes
15	2B	"	2.09												
16	2C		2.92												
17	2D		2.56												
18	2E														
19	2F														
20	3A	4/07/2009	2.64	4.98	12	3									Yes
21	3B	"	3.12												
22	3C	"	5.31												
23	3D	"	4.49												
24	3E														
25	3F														
26	4A	4/08/2009	4.30	5.15	16	4									Yes
27	4B	"	3.75												
28	4C	"	4.05												
29	4D	"	4.80												
30	4E														
31	4F														
32	5A	4/09/2009	4.90	6.45	20	5									Yes
33	5B	"	5.07												
34	5C	"	3.83												
35	5D	"	3.53												
36	5E														
37	5F														
							1.40	3.56	Pass	0.9317	2.10	2.81	Pass	6.26	

Microsoft Excel - Trial F & t spreadsheet														
Type a question for help														
X38 =IF(C33="", "", IF(W38>V38,2,1))														
A	B	C	D	P	Q	R	S	T	U	V	W	X	Z	
1														
2	Lots:	1	5	File #	1721.037175A				Name of QC Tester					
3	Dates:	3/08/2009	3/12/2009	Project #	IP88 (003)				Certification # of QC Tester					
4	Mix Type	Intermediate Type B										Contract Line #'s	4020320	
5	Mix Property Limits	4.17		5.03										
6														
7	Asphalt Binder Content													
8	Lot	Date	Contractor Quality Control Tests (%)	SCDOT Verification Test (%)	Number of Contractor Tests	Number of SCDOT Tests	F Test	F(crit)	Are Variances The Same?	Pooled Variance	T Test	T(crit)	Are Means The Same?	Use Contractor Test Results?
9	1A		3.50	4.87										
10	1B		4.25	4.22										
11	1C		5.50	4.12										
12	1D		4.37	5.00										
13	1E		5.83											
14	1F				5	4							Pass	
15	2A		3.97	4.48										
16	2B		4.27	4.75										
17	2C		5.11	4.57										
18	2D		3.78											
19	2E													
20	2F				9	7							Pass	
21	3A		4.64	4.62										
22	3B		4.88	4.18										
23	3C		4.62	4.37										
24	3D		4.20											
25	3E													
26	3F				13	10	3.90	3.87	Fail	0.2384	0.46	2.86	Pass	
27	4A		4.79	4.57										
28	4B		4.33	4.92										
29	4C		4.88											
30	4D		4.78											
31	4E													
32	4F				17	12	3.17	3.30	Pass	0.1986	0.42	2.77	Pass	
33	5A		4.44	4.75										
34	5B		4.74	4.35										
35	5C		4.68											
36	5D													
37	5E													
38	5F				20	14	2.95	2.96	Pass	0.1716	0.49	2.74	Pass	
39														

Microsoft Excel - Trial F & t spreadsheet														
Type a question for help														
P13														
A	B	C	D	P	Q	R	S	T	U	V	W	X	Z	
1														
2	Lots:	1	5	File #	1721.037175A				Name of QC Tester		Kelvin Harry			
3	Dates:	3/08/2009	3/12/2009	Project #	IP88 (003)				Certification # of QC Tester					
4	Mix Type	Intermediate Type B												
5	Mix Property Limits	2.8	5.1											
6														
7	Air Voids													
8	Lot	Date	Contractor Quality Control Tests (%)	SCDOT Verification Test (%)	Number of Contractor Tests	Number of SCDOT Tests	F Test	F(crit)	Are Variances The Same?	Pooled Variance	T Test	T(crit)	Are Means The Same?	Use Contractor Test Results?
9	1A	3/08/2009	4.37	4.98	4	3								
10	1B		4.02	4.79										
11	1C		3.85	4.26										
12	1D		3.16											
13	1E													
14	1F													
15	2A		4.22	4.83	8	6								
16	2B		3.09	4.77										
17	2C		3.31	4.94										
18	2D		3.04											
19	2E													
20	2F													
21	3A		3.12	4.46	12	9	4.08	4.24	Pass	0.1515	6.58	2.86	Fail	
22	3B		3.61	4.75										
23	3C		3.55	4.87										
24	3D		3.98											
25	3E													
26	3F													
27	4A		3.73	4.98	16	12	1.12	3.01	Pass	0.2109	5.83	2.78	Fail	
28	4B		2.87	3.85										
29	4C		3.63	3.52										
30	4D		3.41											
31	4E													
32	4F													
33	5A		3.85	4.25	19	15	1.53	2.70	Pass	0.2127	5.48	2.74	Fail	
34	5B		3.74	4.13										
35	5C		3.59	3.52										
36	5D													
37	5E													
38	5F													
39														

Mobile Labs : Key Factors

- “Service” HMA plants within an area of approximately 40 mile radius.
- Personnel will randomly obtain samples, perform test and forward the results to the HMA Verification Manager for analysis.
- Verification Manager will independently “verify” the contractor’s acceptance test results using statistical F and t tests.

Mobile Labs : Key Factors

- Labs will conduct the following test:
 - A) Ignition Oven - % Asphalt Content
 - B) Wash Gradation
 - C) MSG & BSG
 - D) Volumetric Properties (VMA, Air Voids)

Verification Lab Locations

- Marion (mobile)
- Greenville
- West Columbia (mobile)
- Summerville (mobile)
- District 4



Projects - Marion

- 1721.037175A
- 14.037231AR1
- Clarendon I-95 S (mp 114.2 – 119.4)
- Clarendon I-95 N (mp 122.6 – 126.7)
- Florence I-95 N (mp 156 – 159.9)

Projects - Greenville

- 42.037177AR
- 14.037173A
- 42.037126A
- 23.037181A
- 42.038400
- Spartanburg I-26 W (mp 17.2 – 18.4)
- Greenville I-385 N (mp 30.3 – 36.5)
- Greenville I-385 S (mp 22.9 – 25.3)
- Greenville I-85 S (mp 43.2 – 47.3)
- Greenville I-185 N (mp 14.9 – 16.4)

Projects – West Columbia

- 2.037242A
- 3240.037174A
- 40.037182A
- 30.038567
- Lexington I-20 W (mp 37.7 – 52.7)
- Fairfield I-77 N/S (mp 33.5 – 33.8)
- Richland I-20 W (mp 60.3 – 80)
- Aiken I-20 E (mp 35.8 – 37.5)
- Lexington I-26 E/W (mp 108 – 109.5)
- Richland I-26 W (mp 96.5 – 101)

Projects – Summerville

- Jasper I-95 N (mp 18.3-23.19)
- Orangeburg N/S (mp 85.7 – 99.4)

Projects – District 4

- None (that we are aware of)

Summary:

- HMA Contractors – Business as usual.
 - * Worksheets signed and submitted for payment within 3 days of completion of the LOT. **SC-M-400V**
- Verification Program to Randomly Sample & Test Asphalt (Volumetric Properties)
- Statistical F & t test to compare Contractor results & SCDOT Results (Are samples from the same population)
- Results forwarded to the District Asphalt Manager for PWL calculations.

Other Issues

- Roadway cores
 - SCDOT inspector marks location
 - Contractor cuts core and gives to inspector
 - Inspector transports to Contractor's lab to be trimmed
 - Inspector locks cores in cabinet / container
 - Once the cores are at a constant weight, Level 1 SCDOT inspector weighs and records data for RCE
- Issue – Transporting of cores from project to Contractor's lab.

Questions?



(from non-HMA contractors only)