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Evaluation of the Muffle Furnace Method

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EVALUATION OF THE MUFFLE FURNACE METHOD

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16. Abstract

The ignition method was evaluated as an alternative method to the nuclear asphalt content gauge and the solvent methods for determining asphalt content. A Troxler Model 4155 Asphalt Quality Analyzer was used in the study. The study focused on determining what aggregates commonly used in Arkansas HMA mixes would be adversely effected by the method. Also, mixes with polymer modified asphalt cements were compared with traditional mixes. Finally, the ignition oven was compared with the nuclear asphalt content gauge.

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EVALUATION OF THE MUFFLE FURNACE METHOD

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INTRODUCTION

Asphalt content and aggregate gradation have been important measures used in the process of evaluating hot mix asphalt (HMA) since the introduction of solvent extraction. The solvent method of extraction involves the use of chlorinated hydrocarbon solvents which are classified as carcinogenic compounds and considered to be toxic.

Another alternative, the nuclear asphalt content gauge, requires the operator / user to obtain a license and maintain stringent records due to the nuclear source. This method delivers reliable asphalt content results when the unit is calibrated properly but offers no gradation analysis.

Recent research at the National Center for Asphalt Technology (NCAT) at Auburn University has indicated accuracy of the ignition method (muffle furnace) in determining asphalt cement content and aggregate gradations of asphalt concrete hot mix samples (HMA). The method is a potential alternate to the extraction method (AHTD 450 or AHTD 451 and AASHTO T30) and to the nuclear gauge/wash method (AHTD 449/449A and AHTD 460).

The ignition method incinerates the asphalt cement in the HMA by the high temperatures (538°C / 1000°F) of the oven, leaving only the aggregate. Asphalt cement content is determined by comparing the weight difference before and after incineration of the asphalt cement.

OBJECTIVES

The objective of this study was to determine the capabilities of the ignition method. This objective was subdivided into three categories:

1. Identify aggregates commonly used in HMA in Arkansas that would be adversely effected by the extreme heat.

2. Determine if the method can be utilized in testing mixes containing polymer modified asphalt cements.

3. Compare the ignition method with the nuclear asphalt content gauge, (NACG).

TESTING METHODOLOGY

Initially, mix designs were chosen from various parts of the state that would provide different types of aggregates (syenite, limestone, sandstone, gravel) for ignition testing. The aggregates were sampled, dried and batched according to the mix design.

A correction factor was established to allow for the percentage of mass loss attributable to the aggregate when testing at such extreme temperatures. A correction factor was determined for each specific mix by burning off two samples with the same "true" asphalt content ("true" asphalt content is defined as the exact percentage of asphalt cement contained in the sample after correcting for the residue remaining on the mixing tools). The percent loss for each sample was recorded and subtracted from the "true" asphalt content. Each sample yielded a number and, when averaged, equaled the correction factor for the mix.

Specimens were made at the mix design asphalt content, 0.5% above, and 0.5% below. The "true" asphalt content was determined by burning off any residue from the mixing utensils and deducting this percentage from the target asphalt content. This step provided a more precise evaluation of the ignition oven's results.

In addition, specimens were made with modified and unmodified asphalt cements (i.e. PG 64-22 and PG 76-22).

DISCUSSION OF RESULTS

The results from this initial testing are in Table I in Appendix A.

The accuracy proved to be + or - 0.077% for the 52 tests run. One aggregate source, a gravel from RazorRock at White Hall, fractured from the extreme temperatures during testing. The use of modified asphalt cements (as compared to unmodified) in this initial testing presented no problems in determining the asphalt content by the ignition method.

The next phase of this project involved comparison testing between the ignition oven and the nuclear asphalt content gauge.

Initially, an eighteen to nineteen pound HMA sample was mixed in the lab at the design asphalt content. This sample was split and one part tested in the ignition oven and the other part delivered to an asphalt plant to be tested in the nuclear asphalt content gauge. Additionally, an HMA sample of equal size was obtained at the asphalt plant and split to be tested in the same way.

This testing was done in conjunction with two asphalt plants, McClinton-Anchor at Avoca and E. C. Rowlett at North Little Rock. The results from this testing are in Table II in Appendix A.

The first round of testing with McClinton-Anchor at Avoca indicated nuclear asphalt content gauge results to be very close (0.5 - 0.6%) to the mix design asphalt content, both for lab and field samples. The ignition method results varied more from the mix design asphalt content (0.10 - 0.15%), but collectively the results were favorable.

The second round of testing with E. C. Rowlett at North Little Rock indicated less favorable results with differences from the mix design asphalt content as much as 0.33%. As a result, additional samples were blended and rerun. Results improved for the nuclear asphalt content gauge (0.07%), but again varied (0.29%) for the ignition method.

It was determined at this time to alter the approach to the ignition method / nuclear asphalt content gauge comparison. This was due to the difficulties associated with determining the "true" asphalt content from the eighteen to nineteen pound HMA sample prepared in the lab. The new approach consisted of requesting several asphalt plants to hold their NACG sample after testing for this research. The "pretested" samples were delivered to the Materials Division for ignition method testing. Due to the nature of this testing, an exact correction factor for each mix was not determined. Previous ignition testing correction factors were averaged to supply this data. The asphalt content results from both methods were then compared. .

The results from this testing are in Table III in Appendix A. Again, results were varied. General guidelines were applied to this data. Guidelines were derived from data analysis and discussion of the results with AHTD personnel. Any comparison testing with results not differing more than 0.14% was considered acceptable. Marginal was considered 0.21% to 0.31%. A difference of more than 0.42% was considered poor.

CONCLUSIONS AND RECOMMENDATIONS

As defined previously, the objectives of this research were: identify aggregates commonly used in HMA in Arkansas that would be adversely effected by the extreme heat; determine if the ignition method can be utilized in testing mixes containing polymer modified asphalt cements; and compare the ignition method with the nuclear asphalt content gauge.

With the exception of one aggregate, all aggregates tested showed no adverse effects from the extreme temperatures.

Both polymer modified and unmodified asphalt cements were included in the testing. The HMA samples mixed with polymer modified asphalt cement showed no significant differences from the unmodified HMA samples.

Achieving a good comparison between the ignition method with the nuclear asphalt content gauge proved to be more difficult than anticipated. Results were inconclusive. This may have been due to the initial size of the sample, calibration of the NACG in the field, or a combination of the two. However, when the approach was altered to include actual field samples, results were again mixed.

Inconsistent results between the NACG and the ignition oven limits the recommendation that can be made from this research concerning the effectiveness of the ignition oven in determining asphalt content. However, this study did conclude gradation results after ignition oven testing to be reliable.

As a result, this study can only recommend the ignition oven be allowed for determining aggregate gradation for quality control purposes.

Table I
Ignition Method Results
550C/1022F

	Actual AC Content	Calibrated AC Content	Difference		Actual AC Content	Calibrated AC Content	Difference
Hogan/GMQ	4.10	3.90	-0.20	McClinton/	4.90	5.09	0.19
CD102-93	4.48	4.58	0.10	Anchor/Avoca	5.48	5.48	0
PG76-22	4.93	4.99	0.06	CD036-95	4.60	4.82	0.22
	4.92	4.73	-0.19	PG76-22	5.79	5.91	0.12
	4.92	4.92	0		5.22	5.48	0.26
	4.96	4.97	0.01		5.24	5.16	-0.08
	5.37	5.34	-0.03		5.25	5.28	0.03
	5.78	5.64	-0.14		5.20	5.27	0.07
avg.+ or -			***0.091***	***avg.+ or -***			***0.121***
std. dev.			***0.114***	***std. dev.***			***0.118***
variance			***0.013***	***variance***			***0.014***
Hogan/GMQ	4.54	4.39	-0.15	McClinton/	4.98	4.75	-0.23
CD102-93	4.12	4.02	-0.10	Anchor/Avoca	5.50	5.32	-0.18
AC30	5.34	5.24	-0.10	CD036-95	4.60	4.49	-0.11
	5.71	5.71	0	AC 20	5.83	5.78	-0.05
	4.91	4.92	0.01		5.30	5.25	-0.05
	4.94	4.92	-0.02		5.23	5.27	0.04
avg.+ or -			***0.063***	***avg.+ or -***			***0.110***
std. dev.			***0.065***	***std. dev.***			***0.098***
variance			***0.004***	***variance***			***0.010***
Rowlett/NLR	5.93	5.97	0.04	RzrRck/WhtHl	5.71	5.76	0.05
CD049-91	5.89	5.84	0.05	CD186-95	5.71	5.80	0.09
PG 76-22	5.54	5.56	0.02	PG 76-22	5.29	5.37	0.08
	6.36	6.42	0.06	aggr. fractured	6.03	6.05	0.02
	5.18	5.18	0		4.98	4.97	-0.01
	4.87	4.74	-0.13		4.70	4.74	0.04
avg.+ or -			***0.050***	***avg.+ or -***			***0.048***
std. dev.			***0.070***	***std. dev.***			***0.037***
variance			***0.005***	***variance***			***0.001***
Rowlett/NLR	5.92	5.84	-0.08	RzrRck/WhtHl	5.74	5.79	0.05
CD049-91	5.99	6.07	0.08	CD186-95	5.76	5.70	-0.06
AC30	5.59	5.65	0.06	AC30	5.40	5.39	-0.01
	6.43	6.42	-0.01	aggr. fractured	6.07	6.05	-0.02
	5.19	5.34	0.15		5.03	4.78	-0.25
	4.86	4.86	0		4.76	4.77	0.01
avg.+ or -			***0.063***	***avg.+ or -***			***0.067***
std. dev.			***0.080***	***std. dev.***			***0.106***
variance			***0.006***	***variance***			***0.011***

precision = + or - 0.077 for the above 52 tests
value for 95% reliability = + or - 0.25
value for 90% reliability = + or - 0.20

TABLE II
Ignition Method vs. Nuclear Asphalt Content Gauge I

	Mix Design % AC	Nuclear Gauge AC Content	Difference from Design	Ignition Method AC Content	Difference from Design	Difference in Tests
McClinton/	5.30	5.38*	0.08	5.44*	0.14	0.06
Anchor/Avoca	5.30	5.34*	0.04	5.41*	0.11	0.07
CD036-95	5.30	5.36*	0.06	5.25*	-0.05	0.11
ERGON 20		**Average from Design**	**0.06**	**Average from Design**	**0.10**	
	5.30	5.27**	-0.03	5.48**	0.18	0.21
	5.30	5.23**	-0.07	5.22**	-0.08	0.01
	5.30	5.26**	-0.04	5.12**	-0.18	0.14
		Average from Design	**0.05**	**Average from Design**	**0.15**	
	*sampled from Dist. 9 Maint. Job **samples blended in lab					

Ignition Method vs. Nuclear Asphalt Content Gauge II

	Mix Design % AC	Nuclear Gauge AC Content	Difference from Design	Ignition Method AC Content	Difference from Design	Difference in Tests
Rowlett/NLR	5.30	5.58*	0.28	5.56*	0.26	0.02
	5.30	5.53*	0.23	5.31*	0.01	0.22
CMD038-97	5.30	5.79*	0.49	5.70*	0.4	0.09
Lion PG64-22		**Average from Design**	**0.33**	**Average from Design**	**0.22**	
	5.30	5.04**	-0.26	5.44**	0.14	0.40
	5.30	5.12**	-0.18	5.39**	0.09	0.27
	5.30	4.83**	-0.47	5.34**	0.04	0.51
		Average from Design	**0.30**	**Average from Design**	**0.09**	
	5.30	5.28**	-0.02	5.26**	-0.04	0.02
	5.30	5.26**	-0.04	4.75**	-0.55	0.51
	5.30	5.15**	-0.15	5.02**	-0.28	0.13
		Average from Design	0.07	Average from Design	0.29	
	*sampled from State Job 060835 **samples blended in lab ***highlighted data is rerun of lab mixed material***					

TABLE III

Ignition Method vs. Nuclear Asphalt Content Gauge

Source	Mix Design (%)	Asphalt Content %		Difference
		N. A. C. G.	Muffle Furnace	
T&T-Clinton	*SP27-97 (5.1)*	5.24	5.80	0.56
T&T-Clinton	*SP27-97 (5.1)*	5.21	5.67	0.46
T&T-Clinton	*SP27-97 (5.1)*	5.08	5.68	0.60
T&T-Clinton	*SP27-97 (5.1)*	5.15	5.62	0.47
T&T-Clinton	*SP27-97 (5.1)*	4.93	5.50	0.57

Comments: muffle furnace indicates **more** asphalt content than the nuclear gauge.
These samples rec'd 10/8/98.

Source	Mix Design (%)	Asphalt Content %		Difference
		N. A. C. G.	Muffle Furnace	
Rowlet NLR	*SP167-98 (5.4)*	5.61	5.11	0.50
RowlettNLR	*SP167-98 (5.4)*	5.53	5.39	0.14
RowlettNLR	*SP037-98 (4.3)*	4.59	4.46	0.13

Comments: muffle furnace indicates **less** *asphalt content than the nuclear gauge.*
These samples rec'd 10/27/98.

Source	Mix Design (%)	Asphalt Content %		Difference
		N. A. C. G.	Muffle Furnace	
Cranford NLR	*MD068-96(4.6)*	4.68	4.26(4.49,4.23*)	0.42
Cranford NLR	*MD072-96(5.6)*	5.64	5.66(5.40,5.44*)	0.02
Cranford NLR	*MD073-96(6.0)*	6.04	5.62(5.63,5.72*)	0.42

Comments: muffle furnace indicates **less** *asphalt content than the nuclear gauge (in 2 of 3 tests).*
*These results indicate add'l. testing on same material.
These samples rec'd 12/2/98.

Source	Mix Design (%)	Asphalt Content %		Difference
		N. A. C. G.	Muffle Furnace	
Rowlet NLR	*SP167-98 (5.4)*	5.69	5.48(5.26,5.38*)	0.21
RowlettNLR	*SP167-98 (5.4)*	5.36	5.37(5.48,5.22*)	0.01
RowlettNLR	*SP037-98 (4.3)*	5.49	5.45(5.59,5.48*)	0.04

Comments: muffle furnace indicates **less** *asphalt content than the nuclear gauge.*
*These results indicate add'l. testing on same material.
These samples rec'd 12/11/98.

Source	Mix Design (%)	Asphalt Content %		Difference
		N. A. C. G.	Muffle Furnace	
Rowlett NLR	*SP167-98 (5.4)*	5.41	5.07(5.12)	0.31
Rowlett NLR	*SP037-98 (4.3)*	3.95	3.98(4.06)	0.09

Comments: these samples rec'd 1/5&1/12/99 and were check samples blended by D. Crain.

Source	Mix Design (%)	Asphalt Content %		Difference
		N. A. C. G.	Muffle Furnace	
CranfordNLR	*MD068-96 (4.6*	4.56	4.48(4.57)	0.03
CranfordNLR	*MD072-96 (5.6*	5.58	5.77(5.86)	0.24

Comments: these samples rec'd 1/8/99 and were check samples blended by G. Tomboli.

Source	Mix Design (%)	Asphalt Content %		Difference
		N. A. C. G.	Muffle Furnace	
T&T-Clinton	*SP27-97 (5.1)*	5.06	5.50(5.60)	0.49

Comments: these samples rec'd 1/19/99 and were check samples blended by K. Lowrance.