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Evaluation of the Binder Ignition System Method

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16. Abstract

Investigation was conducted on the binder ignition system ovens and the provisional test methods, on bituminous mixes using materials that are native to Missouri. The investigation included an analysis on the accuracy of the percent of asphalt cement, which were calculated from the binder ignition ovens and the provisional test methods. The investigation also included an analysis of the aggregate, with respect to gradation and degradation, which was remaining from the procedure after the asphalt cement was burned off.

Findings are presented on how chert and the percent of absorption of an aggregate affect the amount of degradation of the aggregate in the binder ignition ovens and, the final aggregate gradation from the ignition method use for specification compliance.

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SPR STUDY NO. 96-01

Evaluation of the Binder Ignition System Method

PREPARED BY
MISSOURI DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION

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JEFFERSON CITY, MISSOURI
DATE SUBMITTED: JANUARY 31, 1997

The opinions, findings, and conclusions expressed in this publication are not necessarily those of the Federal Highway Administration.

EXECUTIVE SUMMARY

This study was initiated to investigate the accuracy of the Binder Ignition System's capability for determining the percent of asphalt cement in bituminous concrete mixtures. It was also set up to see if the final aggregate gradations could be used for specification compliance.

At the onset of the study, it was believed that the percent absorption in an aggregate could effect the amount of aggregate degradation in the ignition ovens. Therefore the investigation was set up to use two coarse aggregates, one with high absorptivity and one with low absorptivity.

As the study proceeded, it was found the percent absorption of an aggregate may not be the determining variable that contributed to the amount of aggregate degradation. Instead, the percent chert seemed to be? Once the percent chert was thought to be the cause, further investigation was conducted on aggregates with different levels of chert content.

Both the ASTM and AASHTO provisional test methods were evaluated in the study. The findings of the investigation indicated that the AASHTO provisional test method TP53-96, yielded the most accurate results. Therefore, it is recommended that the AASHTO provisional test method be used by MoDOT.

The findings of this investigation are: the ignition systems are accurate in determining the percent of asphalt cement in a bituminous mixture and they can be used for specification compliance. The absorptivity and percent chert content of an aggregate did not prove to be the core determining factors in the amount of aggregate degradation in the ignition ovens. Instead, it is believed that the overall chemical and physical characteristics, its lithology, will dictate the amount of degradation. Since there are so many variables in the lithology of an aggregate, this study did not pursue the cause of aggregate degradation any further.

Therefore, it is recommended that a gradation calibration be performed as part of the test method. This gradation calibration should be performed to ascertain the amount of expected aggregate breakdown in the ignition ovens. It should be performed on every asphalt concrete mix design, at the same frequency as the aggregate calibration factor for determining the amount of asphalt cement in the mixture. This would then allow the use of the final gradation for specification compliance. Without this type of gradation calibration, the final gradations should not be used for specification compliance.

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ABS.	Absorption
APPR.	Apparent
ASTM	American Society for Testing and Materials
DEL.	Deleterious
F.O.	Field Office
HMA	Hot Mix Asphalt
MoDOT	Missouri Department of Transportation
NCAT	National Center for Asphalt Technology
Sp. G.	Specific Gravity
SPR	State Planning and Research
TCE	Trichloroethylene
TFO	Thin Film Oven

ABSTRACT

Investigation was conducted on the binder ignition system ovens and the provisional test methods, on bituminous mixes using materials that are native to Missouri. The investigation included an analysis on the accuracy of the percent of asphalt cement, which were calculated from the binder ignition ovens and the provisional test methods. The investigation also included an analysis of the aggregate, with respect to gradation and degradation, which was remaining from the procedure after the asphalt cement was burned off.

Findings are presented on how chert and the percent of absorption of an aggregate affect the amount of degradation of the aggregate in the binder ignition ovens and, the final aggregate gradation from the ignition method use for specification compliance.

OBJECTIVE

The objective of this study was to determine the accuracy of the binder ignition system method by evaluating multiple binder ignition systems. Comparing the results obtained from the binder ignition systems to each other, as well as to the solvent extraction method (AASHTO T164), the nuclear method (AASHTO T287), and to the components of the actual mix sample.

Other objectives were, to evaluate and compare the current AASHTO and ASTM provisional test methods for their accuracy in determining the asphalt content in a bituminous mixture and, to analyze the remaining aggregate for gradation, degradation, and specification compliance.

INTRODUCTION

Past research by the National Center For Asphalt Technology at Auburn University, Alabama, and the Alabama Department of Transportation has illustrated the accuracy of the ignition method. The Missouri Department of Transportation decided to investigate the binder ignition method on materials that are native to Missouri. The objective of this investigation was to try to find an accurate alternative to the solvent extraction method and the nuclear method.

This research study was set up to compare the binder ignition method to the solvent extraction method, the nuclear method, and to the original components of the mix sample. The results obtained from the comparison can be used to verify the accuracy of the binder ignition system method on materials that are native to Missouri.

The following is a brief summary of the investigation procedure. The detailed procedure is within the context of the report. The study was set up to investigate a high absorptive aggregate mix and a low absorptive aggregate mix, in an attempt to see if the final aggregate from the binder ignition oven was prone to degradation. A bituminous concrete surface mix (Type C Mix) was selected for evaluation in the study. These mixtures were composed of 75% coarse aggregate, 23% natural sand as fine aggregate, and 2% mineral filler. Two Missouri limestone formations, one formation having a low to medium absorption of about 2% and the other formation having a high absorption of about 4 % were selected for the coarse aggregate. These two coarse aggregate fractions were selected because of their similar gradation characteristics and because of the wide variation in absorption. The same fine aggregate, mineral filler, and asphalt cement were used in both the high absorptive mix and the low absorptive mix. Three separate asphalt contents, by total weight of mixture, were employed in both the high and low absorptive mixtures. The three asphalt contents are 4.0%, 5.5%, and 7.0%. Therefore, the only variables, besides the varying percent of asphalt content, was thought to be the coarse aggregate absorption, specific gravity, and gradations. But, as the study proceeded, it was found that the percent chert in an aggregate fraction may play an important part in the amount of aggregate degradation in the ignition ovens.

INVESTIGATION PROCEDURE

PURCHASE AND INSTALLATION:

From reviewing past research on the subject matter, a decision was made to conduct a research study on the binder ignition system. A plan was then formulated on how to conduct the research study to provide the needed data to prove or disprove the accuracy of the binder ignition method on materials native to Missouri. Once the decision was made and a detailed research plan was formulated, the purchase and installation of the NCAT and Gilson Binder Ignition systems was accomplished in October and November, 1995. As the study progressed, both Troxler and Soil Test learned of the ongoing study and asked if their ignition systems could be included. Therefore, Troxler and Soil Test loaned the department their ignition systems and they were included in the study.

SELECTION OF MIX AND MATERIALS:

The mixes, one with high absorptive aggregate and one with low absorptive aggregate, are both a surface mix (Type C mix) with an aggregate blend of 75% coarse aggregate, 23% natural sand, 2% mineral filler, and an AC-20 asphalt cement. The same source of natural sand, mineral filler, and AC-20 binder was used in both of the mixes. Three separate asphalt cement contents were used in both the high and low absorption mixes. These asphalt cement contents, by weight of total mix, are 4.0%, 5.5%, and 7.0%. The only significant variables were thought to be the varying percent AC, the coarse aggregate absorption, the coarse aggregate specific gravity, and gradation. During the course of the investigation, the chert content in the coarse aggregate was thought to be an important variable which affects the amount of aggregate degradation.

The gradation of the coarse aggregate will differ from one aggregate source to the next. This variable was minimized by selecting aggregate sources which have very similar gradations but different percent of absorption and specific gravity. In the binder ignition method, past research has found that the gradation is not critical to the aggregate calibration factor.

The high absorption mix used a coarse aggregate from Doss & Harper #1, West Plains, MO.. This aggregate has an absorption of 4.4%. (Note: this high of absorption is usually not employed in the departments bituminous mixtures but was used specifically for this study.) The low absorption mix used a coarse aggregate from Central Stone #4, Paris, MO.. This aggregate has an absorption of 2.0%. The natural sand was Missouri river sand from Capital #1, Jefferson City, Mo., the mineral filler was from Quincy Carbonate, Quincy IL., and the asphalt cement was AC-20 from Shell Oil Co., Wood River IL.. The needed materials were ordered from the Districts and the two Type C mix designs were developed by the Field Office.

MATERIAL CHARACTERISTICS:

The material characteristics of the coarse aggregate, fine aggregate, mineral filler, and asphalt cement were determined in MoDOT's Central Laboratory and the results are listed in Table 1 and Table 2. The gradations of the coarse and fine aggregate fractions represents the gradations used to develop the initial combined aggregate gradations of the mix design. ASSHTO T11 was then performed on these initial combined gradations to wash and discard all of the -200 material that was clinging to the aggregate. This washed gradation was then dried back, recombined, and 2% mineral filler was then added. This procedure gave the resulting combined aggregate gradation that was used in the mixing and testing process. This procedure was used so as to know the most accurate amount of -200 in the mix before the mix was subjected to the binder ignition systems.

TABLE 1 AGGREGATE CHARACTERISTICS OF EACH FRACTION

CHARACTERISTIC	SIEVE	LOW ABS. COARSE AGGR.	HIGH ABS. COARSE AGGR.	FINE AGGR	MINERAL FILLER
GRADATION	3/4"	100	100		
	1/2"	98.1	98.0		
	3/8"	81.4	81.7	100	
	#4	35.1	37.3	99.6	
	#8	11.2	9.0	96.3	
	#16	4.5	4.9	85.5	
	#30	3.0	4.3	60.6	
	#50	2.5	4.2	36.8	
	#100	2.2	4.1	11.0	100
	#200	1.9	4.0	3.1	98.5
BULK SP. G.		2.550	2.493	2.618	2.727
APPR. SP.G		2.686	2.798	2.651	
ABSORPTION		2.0	4.4	0.5	
DELETERIOUS					
DEL. ROCK		1.0%	1.2%		
SHALE		0.2%	0.1%		
CHERT		13.2%	1.3%		

TABLE 2 ASPHALT CEMENT CHARACTERISTICS

TEST METHOD	DESCRIPTION	RESULT
	ORIGINAL ASPHALT	
AASHTO T228	SPECIFIC GRAVITY (60/60F)	1.034
AASHTO T44	BITUMEN (SOLUBLE IN TCE) PERCENT	99.98
AASHTO T48	FLASH POINT (F)	500 +
AASHTO T49	PENETRATION (77 F, 100 gm, 5 sec.)	65
AASHTO T201	KINEMATIC VISCOSITY, (cs, 275 F)	395
AASHTO T202	ABSOLUTE VISCOSITY, (poise @ 140 F & 300 mm Hg)	2,010
AASHTO T179	% LOSS TFO TEST, (1/8", 325 F, 5 hrs.)	-0.01
	TESTS ON RESIDUE (TFO)	
AASHTO T49	PENETRATION (77 F, 100 gm, 5 sec.)	49
	PERCENT OF ORIGINAL PENETRATION	75.38
AASHTO T151	DUCTILITY OF 77 F	75
AASHTO T201	KINEMATIC VISCOSITY, (cs, 275 F)	596
AASHTO T202	ABSOLUTE VISCOSITY, (poises @ 140 F & 300mm Hg)	5,778

From the material characteristic results on the coarse aggregate fractions, it can be seen that the high absorption aggregate has an absorption of 4.4%. This high of absorption is generally not allowed in Missouri's bituminous concrete material, but for the sake of this study the material was selected to provide the contrast between the low and high absorptive mixes. Also, the material characteristics of the low absorption coarse aggregate shows a 13.2% chert content, which was later thought to be the cause of the aggregate dispersion and degradation in the binder ignition ovens.

GRADATIONS OF COMBINED AGGREGATE BLEND:

Prior to the calibration of the nuclear gauge, calibration of the binder ignition systems, and mixing of the HMA sample batches, the gradations of each aggregate blend were tested by AASHTO T11 and T27. Then, after the binder ignition method was performed, the gradations of the remaining aggregate were again tested by AASHTO T11 and T27 to check if there was any degradation of the aggregate caused by the ignition method. This was completed as follows;

: combine coarse and fine aggregate fractions according to the mix design batch sheets
: perform AASHTO T11 washed gradation on these two combined fractions (to remove the -200 which was clinging to the aggregates)
: dry back combined fractions and perform AASHTO T27, so as to know an accurate percent passing of each sieve
: combine sieves back and add the 2% mineral filler, (the Quincy Carbonate mineral filler was chosen because it has 98.5% -200 material)

The 2% mineral filler was used to simulate the -200 material which was lost in performing of AASHTO T11. This procedure allowed the study to know an accurate gradation of the combined aggregate blends before and after the binder ignition ovens. This also allowed us to see the most accurate change in the -200 material. The question was, would the -200 increase from the degradation of the aggregate or would it even possibly decrease due to possible inorganic impurities in the aggregate blend being burned off in the oven?

NUCLEAR GAUGE CALIBRATION:

Prior to testing the batches at the proposed mix design of 4%, 5.5%, and 7% asphalt cement content, the nuclear gauge was calibrated by mixing and testing of three separate batches at varying asphalt cement contents. For the calibration of the nuclear gauge, section 7.1.3 of AASHTO T 287 recommends that the three batches be prepared as follows: one at the mix design asphalt content, one at 1% above the mix design, and one at 1% below the mix design or, at other percentages as required to cover the range of the expected use. Therefore, to eliminate overlapping batches, this study opted to create batches at 0.75% above and below the three mix design asphalt contents.

All batches were 8,000 ± grams. Approximately 400 ± grams were removed from each batch so as to perform the nuclear gauge calibration on a 7,600 ± gram batch. Then, the 400 ± grams were added back to the original batch from which it came. This provided seven 8,000 ± gram batches at the following asphalt cement contents:

3.25% 4.00% 4.75% 5.50% 6.25% 7.00% 7.75%

All of these 8,000 gram batches were labeled and stored. The samples were sealed in plastic bags and stored in loose mix boxes. Since the gradation and asphalt content of these nuclear calibration samples were known, they were stored for possible use later in the study.

BINDER IGNITION SYSTEM CALIBRATION:

In the AASHTO and ASTM provisional test methods, there are two aggregate calibration methods. (See APPENDIX A for the provisional test methods. Note the most recent AASHTO provisional has only the HMA calibration procedure, the aggregate calibration procedure was deleted.) One uses just a blank aggregate and the other uses an asphalt concrete mixture. Both the blank aggregate calibration procedure and the mixture calibration procedure was investigated to calculate the aggregate calibration factor.

Three separate 2,000 gram combined blank aggregate samples were used to calculate the aggregate calibration factor. This was performed on both the high absorptive aggregate mix and the low absorptive aggregate mix. The gradation of these samples were recorded before and after they were subjected to the calibration process in the ovens. These aggregate samples were strictly aggregates only with no asphalt cement.

Two seperate 2,000 gram mixture samples were also used to calculate the aggregate calibration factor. Again, this was performed on both the high absorptive aggregate mix and the low absorptive aggregate mix. The gradation of these samples were recorded before and after they were subjected to the calibration process in the ovens. These mixtures employed 5.5% asphalt cement by total weight of mix.

The labeling of these Binder Ignition Calibration samples were as follows:

LABELING PROCEDURE FOR AGGREGATE CALIBRATION FACTORS

C95-LABS-BIC1-NCAT
C95-LABS-BIC2-NCAT
C95-LABS-BIC3-NCAT
C95-LABS-BIC1-GILS
C95-LABS-BIC2-GILS
C95-LABS-BIC3-GILS
C95-LABS-BIC1-TRXLR
C95-LABS-BIC2-TRXLR
C95-LABS-BIC3-TRXLR
C95-LABS-BIC1-SOILT
C95-LABS-BIC2-SOILT
C95-LABS-BIC3-SOILT

C95-HABS-BIC1-NCAT
C95-HABS-BIC2-NCAT
C95-HABS-BIC3-NCAT
C95-HABS-BIC1-GILS
C95-HABS-BIC2-GILS
C95-HABS-BIC3-GILS
C95-HABS-BIC1-TRXLR
C95-HABS-BIC2-TRXLR
C95-HABS-BIC3-TRXLR
C95-HABS-BIC1-SOILT
C95-HABS-BIC2-SOILT
C95-HABS-BIC3-SOILT

NCAT = NCAT IGNITION SYSTEM
BIC = BINDER IGNITION CALIBRATION
GILS = GILSON IGNITION SYSTEM
TRXLR = TROXLER IGNITION SYSTEM

HABS = HIGH ABSORPTION
LABS = LOW ABSORPTION
SOILT = SOIL TEST IGNITION SYSTEM

Tables 3, 4, 5, and 6 are the gradations of the blank aggregate samples before and after they had been used in the aggregate calibration procedure of the binder ignition systems. Tables 7, 8, 9, and 10 are the gradations of the aggregates from the mixture calibration samples before and after they were used in the aggregate calibration procedure.

From viewing these tables, it can be seen that the low absorption aggregate, which contained the high chert content of 13.2%, appreciably degraded in all of the ignition systems. The amount of degradation was higher in the mixture calibration procedure. It is believed that this is due to the spike in oven temperatures when the asphalt ignites. The aggregate gradations, of the low absorption aggregate which contained the high chert content, had degraded to the extent where the end resultant gradations would not be usable for specification compliance.

TABLE 3 NCAT GRADATIONS BEFORE & AFTER BLANK AGGREGATE CALIBRATION

	BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER		
	LABS	LABS		LABS	LABS		LABS	LABS		
	BIC1	BIC1		BIC2	BIC2		BIC3	BIC3		AVG.
	NCAT	NCAT	***	NCAT	NCAT	***	NCAT	NCAT	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.11	98.29	0.18	98.32	98.14	-0.18	97.81	97.99	0.18	0.06
3/8"	86.60	87.08	0.48	86.23	86.88	0.65	86.48	86.30	-0.18	0.32
#4	52.32	54.98	2.66	52.28	54.34	2.06	51.54	53.26	1.72	2.15
#8	32.21	35.96	3.75	32.39	36.14	3.75	32.36	35.04	2.68	3.39
#16	24.03	28.06	4.03	24.08	27.55	3.47	24.14	27.22	3.08	3.53
#30	17.94	21.39	3.45	17.35	20.56	3.21	17.77	20.58	2.81	3.16
#50	11.70	14.93	3.23	11.18	14.08	2.90	11.65	14.15	2.50	2.88
#100	5.15	7.33	2.18	4.97	6.94	1.97	5.01	6.58	1.57	1.91
#200	2.36	3.35	0.99	2.54	3.23	0.69	2.28	3.08	0.80	0.83
	BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER		
	HABS	HABS		HABS	HABS		HABS	HABS		
	BIC1	BIC1		BIC2	BIC2		BIC3	BIC3		AVG.
	NCAT	NCAT	***	NCAT	NCAT	***	NCAT	NCAT	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.43	98.47	0.04	98.07	97.95	-0.12	98.44	98.27	-0.17	-0.08
3/8"	85.86	85.44	-0.42	85.54	85.36	-0.18	86.26	85.96	-0.30	-0.30
#4	52.36	52.32	-0.04	51.82	51.88	0.06	51.85	51.85	0.00	0.01
#8	29.27	29.11	-0.16	29.22	29.22	0.00	29.21	29.12	-0.09	-0.08
#16	23.15	23.04	-0.11	23.16	23.24	0.08	23.58	23.52	-0.06	-0.03
#30	16.87	16.66	-0.21	16.95	16.89	-0.06	17.44	17.39	-0.05	-0.11
#50	10.79	10.65	-0.14	10.85	10.80	-0.05	11.40	11.31	-0.09	-0.09
#100	4.56	4.48	-0.08	4.53	4.45	-0.08	5.00	4.76	-0.24	-0.13
#200	2.07	2.10	0.03	2.10	2.20	0.10	2.43	2.46	0.03	0.05

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE FROM THE THREE CALIBRATION SAMPLES.

TABLE 4 GILSON GRADATIONS BEFORE & AFTER BLANK AGGREGATE CALIBRATION

	BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER		
	LABS	LABS		LABS	LABS		LABS	LABS		
	BIC1	BIC1		BIC2	BIC2		BIC3	BIC3		AVG.
	GILS	GILS	***	GILS	GILS	***	GILS	GILS	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.51	98.29	-0.22	98.72	98.40	-0.32	98.41	98.60	0.19	-0.12
3/8"	85.78	86.47	0.69	86.57	86.59	0.02	85.95	86.93	0.98	0.56
#4	51.34	53.94	2.60	52.63	54.43	1.80	52.97	56.27	3.30	2.57
#8	31.83	35.72	3.89	32.12	35.67	3.55	31.79	35.72	3.93	3.79
#16	23.16	27.15	3.99	23.96	27.78	3.82	23.63	27.56	3.93	3.91
#30	16.74	20.39	3.65	17.56	21.08	3.52	17.07	20.80	3.73	3.63
#50	10.63	13.88	3.25	11.40	14.58	3.18	10.96	14.30	3.34	3.26
#100	4.48	6.91	2.43	4.84	7.11	2.27	4.60	7.07	2.47	2.39
#200	2.03	3.04	1.01	2.06	3.24	1.18	1.91	3.09	1.18	1.12
	BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER		
	HABS	HABS		HABS	HABS		HABS	HABS		
	BIC1	BIC1		BIC2	BIC2		BIC3	BIC3		AVG.
	GILS	GILS	***	GILS	GILS	***	GILS	GILS	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.54	98.22	-0.32	98.65	98.43	-0.22	98.33	98.63	0.30	-0.08
3/8"	85.40	85.74	0.34	85.65	85.93	0.28	85.92	85.68	-0.24	0.13
#4	52.10	52.00	-0.10	52.11	52.27	0.16	51.18	51.38	0.20	0.09
#8	29.34	29.39	0.05	29.13	29.22	0.09	28.91	29.05	0.14	0.09
#16	23.63	23.81	0.18	23.31	23.52	0.21	23.70	23.91	0.21	0.20
#30	17.55	17.70	0.15	17.17	17.25	0.08	17.91	18.09	0.18	0.14
#50	11.57	11.64	0.07	11.19	11.29	0.10	11.86	12.00	0.14	0.10
#100	5.24	5.27	0.03	5.00	5.01	0.01	5.18	5.29	0.11	0.05
#200	2.50	2.87	0.37	2.48	2.82	0.34	2.59	2.72	0.13	0.28

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE FROM THE THREE CALIBRATION SAMPLES.

TABLE 5 TROXLER GRADATIONS BEFORE & AFTER BLANK AGGREGATE CALIBRATION

	BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER		
	LABS	LABS		LABS	LABS		LABS	LABS		
	BIC1	BIC1		BIC2	BIC2		BIC3	BIC3		AVG.
	TRXLR	TRXLR	***	TRXLR	TRXLR	***	TRXLR	TRXLR	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.24	98.19	-0.05	98.52	98.66	0.14	98.36	98.66	0.30	0.13
3/8"	86.26	86.83	0.57	86.08	87.03	0.95	86.08	86.98	0.90	0.81
#4	51.40	54.06	2.66	51.02	53.88	2.86	51.02	53.18	2.16	2.56
#8	31.85	36.16	4.31	31.67	35.92	4.25	32.39	36.26	3.87	4.14
#16	21.31	27.57	6.26	23.63	27.74	4.11	23.17	26.85	3.68	4.68
#30	16.80	20.52	3.72	17.08	20.89	3.81	15.91	19.18	3.27	3.60
#50	10.35	13.47	3.12	10.63	13.84	3.21	9.71	12.34	2.63	2.99
#100	4.21	6.37	2.16	4.39	3.24	-1.15	4.29	6.01	1.72	0.91
#200	2.10	3.13	1.03	2.15	2.98	0.83	2.11	2.88	0.77	0.88
	BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER		
	HABS	HABS		HABS	HABS		HABS	HABS		
	BIC1	BIC1		BIC2	BIC2		BIC3	BIC3		AVG.
	TRXLR	TRXLR	***	TRXLR	TRXLR	***	TRXLR	TRXLR	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.38	98.48	0.10	98.69	98.69	0.00	98.64	98.53	-0.11	0.00
3/8"	86.42	86.32	-0.10	86.24	86.49	0.25	86.81	85.81	-1.00	-0.28
#4	51.13	51.33	0.20	51.87	52.09	0.22	52.18	52.35	0.17	0.20
#8	29.15	29.38	0.23	29.16	29.37	0.21	29.24	29.52	0.28	0.24
#16	22.94	23.15	0.21	22.58	22.82	0.24	22.88	23.14	0.26	0.24
#30	16.67	16.81	0.14	16.16	16.38	0.22	16.46	16.75	0.29	0.22
#50	10.35	10.47	0.12	10.00	10.15	0.15	10.20	10.52	0.32	0.20
#100	4.30	4.34	0.04	4.31	4.34	0.03	4.21	4.55	0.34	0.14
#200	2.23	2.35	0.12	2.19	2.35	0.16	2.30	2.40	0.10	0.13

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE FROM THE THREE CALIBRATION SAMPLES.

TABLE 6 SOIL TEST GRADATIONS BEFORE & AFTER BLANK AGGREGATE CALIBRATION

	BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER		
	LABS	LABS		LABS	LABS		LABS	LABS		
	BIC1	BIC1		BIC2	BIC2		BIC3	BIC3		AVG
	SOILT	SOILT	***	SOILT	SOILT	***	SOILT	SOILT	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.82	98.43	-0.39	98.24	98.18	-0.06	98.38	98.26	-0.12	-0.19
3/8"	85.91	86.81	0.90	84.88	85.68	0.80	86.57	86.93	0.36	0.69
#4	50.02	52.59	2.57	47.73	49.65	1.92	49.24	51.97	2.73	2.41
#8	30.23	33.62	3.39	29.38	32.44	3.06	29.34	32.84	3.50	3.32
#16	22.22	25.72	3.50	21.63	24.94	3.31	20.93	24.60	3.67	3.49
#30	15.11	18.48	3.37	14.83	18.06	3.23	13.86	17.39	3.53	3.38
#50	8.45	11.45	3.00	8.37	11.36	2.99	7.44	10.62	3.18	3.06
#100	2.37	4.54	2.17	2.43	4.54	2.11	2.05	4.22	2.17	2.15
#200	0.96	1.62	0.66	1.05	1.87	0.82	0.07	1.68	1.61	1.03
	BEFORE	AFTER		BEFORE	AFTER		BEFORE	AFTER		
	HABS	HABS		HABS	HABS		HABS	HABS		
	BIC1	BIC1		BIC2	BIC2		BIC3	BIC3		AVG
	SOILT	SOILT	***	SOILT	SOILT	***	SOILT	SOILT	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.67	98.66	-0.01	98.67	98.33	-0.34	98.66	98.49	-0.17	-0.17
3/8"	87.94	87.96	0.02	84.58	84.73	0.15	86.17	86.90	0.73	0.30
#4	53.28	53.76	0.48	49.81	49.88	0.07	50.67	51.18	0.51	0.35
#8	28.89	29.02	0.13	26.42	26.24	-0.18	27.39	27.46	0.07	0.01
#16	22.00	22.17	0.17	19.84	19.86	0.02	20.71	20.97	0.26	0.15
#30	14.78	14.98	0.20	13.60	13.59	-0.01	13.99	14.10	0.11	0.10
#50	8.11	8.30	0.19	7.79	7.88	0.09	7.85	7.99	0.14	0.14
#100	2.44	2.56	0.12	2.54	2.60	0.06	2.56	2.68	0.12	0.10
#200	1.04	1.11	0.07	1.03	1.27	0.24	1.06	1.12	0.06	0.12

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE FROM THE THREE CALIBRATION SAMPLES.

TABLE 7 NCAT GRADATIONS BEFORE & AFTER MIXTURE CALIBRATION

	BEFORE	AFTER		BEFORE	AFTER		
	LABS	LABS		LABS	LABS		
	BIC1	BIC1		BIC2	BIC2		AVG.
	NCAT	NCAT	***	NCAT	NCAT	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	97.88	97.61	-0.27	97.64	97.40	-0.24	-0.25
3/8"	85.07	86.43	1.36	85.84	86.78	0.94	1.15
#4	50.91	53.95	3.04	48.92	51.89	2.97	3.01
#8	30.99	36.24	5.25	29.14	33.82	4.68	4.97
#16	22.18	27.19	5.01	21.55	26.31	4.76	4.88
#30	14.50	19.28	4.78	14.86	19.36	4.50	4.64
#50	7.69	11.99	4.30	8.57	12.70	4.13	4.21
#100	2.13	5.40	3.27	2.61	5.64	3.03	3.15
#200	1.00	2.38	1.38	1.03	2.42	1.39	1.39
	BEFORE	AFTER		BEFORE	AFTER		
	HABS	HABS		HABS	HABS		
	BIC1	BIC1		BIC2	BIC2		AVG.
	NCAT	NCAT	***	NCAT	NCAT	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	99.03	99.18	0.15	98.51	99.82	1.31	0.73
3/8"	86.20	86.56	0.36	87.44	87.46	0.02	0.19
#4	50.71	51.38	0.67	52.91	53.32	0.41	0.54
#8	26.69	27.02	0.33	28.99	29.52	0.53	0.43
#16	20.30	20.77	0.47	22.52	23.22	0.70	0.58
#30	13.92	14.30	0.38	15.74	16.40	0.66	0.52
#50	7.81	8.26	0.45	9.03	9.76	0.73	0.59
#100	2.40	2.93	0.53	2.67	3.63	0.96	0.75
#200	1.08	1.57	0.49	1.22	1.61	0.39	0.44

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE FROM THE TWO CALIBRATION SAMPLES.

TABLE 8 GILSON GRADATIONS BEFORE & AFTER MIXTURE CALIBRATION

	BEFORE	AFTER		BEFORE	AFTER		
	LABS	LABS		LABS	LABS		
	BIC1	BIC1		BIC2	BIC2		AVG.
	GILS	GILS	***	GILS	GILS	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.20	98.47	0.27	98.24	98.45	0.21	0.24
3/8"	85.12	86.92	1.80	85.05	85.44	0.39	1.09
#4	48.85	53.65	4.80	49.37	54.01	4.64	4.72
#8	29.96	34.91	4.95	29.96	35.74	5.78	5.36
#16	21.79	27.16	5.37	22.02	27.61	5.59	5.48
#30	15.22	20.14	4.92	15.01	20.03	5.02	4.97
#50	9.04	13.35	4.31	8.56	13.06	4.50	4.41
#100	2.87	6.05	3.18	2.66	5.92	3.26	3.22
#200	1.06	2.26	1.20	1.04	2.37	1.33	1.26
	BEFORE	AFTER		BEFORE	AFTER		
	HABS	HABS		HABS	HABS		
	BIC1	BIC1		BIC2	BIC2		AVG.
	GILS	GILS	***	GILS	GILS	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	99.69	99.50	-0.19	100.00	100.00	0.00	-0.09
3/8"	88.29	87.90	-0.39	86.23	87.00	0.77	0.19
#4	52.72	53.30	0.58	50.28	50.99	0.71	0.64
#8	28.81	29.36	0.55	26.60	27.15	0.55	0.55
#16	22.55	23.13	0.58	20.54	21.07	0.53	0.55
#30	16.05	16.53	0.48	14.32	14.76	0.44	0.46
#50	9.49	9.99	0.50	8.26	8.84	0.58	0.54
#100	2.81	3.57	0.76	2.54	3.31	0.77	0.76
#200	1.14	1.60	0.46	1.09	1.54	0.45	0.46

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE FROM THE TWO CALIBRATION SAMPLES.

TABLE 9 TROXLER GRADATIONS BEFORE & AFTER MIXTURE CALIBRATION

	BEFORE	AFTER		BEFORE	AFTER		
	LABS	LABS		LABS	LABS		
	BIC1	BIC1		BIC2	BIC2		AVG.
	TROXLR	TROXLR	***	TROXLR	TROXLR	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.66	98.76	0.10	97.74	97.95	0.21	0.16
3/8"	85.99	87.10	1.11	85.92	86.02	0.10	0.60
#4	49.48	53.33	3.85	50.05	54.72	4.67	4.26
#8	29.21	34.77	5.56	29.20	35.06	5.86	5.71
#16	20.28	25.63	5.35	20.34	25.89	5.55	5.45
#30	13.14	17.89	4.75	12.86	18.00	5.14	4.95
#50	6.89	11.16	4.27	6.70	11.26	4.56	4.42
#100	1.92	4.93	3.01	1.91	5.30	3.39	3.20
#200	0.96	2.18	1.22	0.91	2.26	1.35	1.29
	BEFORE	AFTER		BEFORE	AFTER		
	HABS	HABS		HABS	HABS		
	BIC1	BIC1		BIC2	BIC2		AVG.
	TROXLR	TROXLR	***	TROXLR	TROXLR	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.05	98.50	0.45	98.85	98.54	-0.31	0.07
3/8"	86.37	86.43	0.06	86.04	85.44	-0.60	-0.27
#4	50.53	50.97	0.44	52.31	52.20	-0.11	0.16
#8	27.39	27.81	0.42	27.83	28.13	0.30	0.36
#16	21.15	21.55	0.40	21.17	21.51	0.34	0.37
#30	14.62	15.00	0.38	14.62	14.84	0.22	0.30
#50	8.33	8.79	0.46	8.18	8.52	0.34	0.40
#100	2.60	3.16	0.56	2.44	2.72	0.28	0.42
#200	1.26	1.66	0.40	0.99	1.45	0.46	0.43

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE FROM THE TWO CALIBRATION SAMPLES.

TABLE 10 SOIL TEST GRADATIONS BEFORE & AFTER MIXTURE CALIBRATION

	BEFORE	AFTER		BEFORE	AFTER		
	LABS	LABS		LABS	LABS		
	BIC1	BIC1		BIC2	BIC2		AVG.
	SOILT	SOILT	***	SOILT	SOILT	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	97.53	97.79	0.26	98.93	98.92	-0.01	0.13
3/8"	85.47	86.61	1.14	85.09	86.70	1.61	1.38
#4	49.56	53.47	3.91	48.80	51.84	3.04	3.48
#8	29.36	35.00	5.64	29.56	34.49	4.93	5.29
#16	21.23	26.82	5.59	20.70	25.61	4.91	5.25
#30	14.22	19.42	5.20	13.32	18.01	4.69	4.95
#50	7.82	12.53	4.71	6.80	11.08	4.28	4.50
#100	2.15	5.75	3.60	1.87	5.08	3.21	3.41
#200	0.85	2.65	1.80	0.99	2.25	1.26	1.53
	BEFORE	AFTER		BEFORE	AFTER		
	HABS	HABS		HABS	HABS		
	BIC1	BIC1		BIC2	BIC2		AVG.
	SOILT	SOILT	***	SOILT	SOILT	***	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	0.00
1/2"	98.88	98.88	0.00	98.55	98.60	0.05	0.02
3/8"	86.86	86.50	-0.36	86.34	85.88	-0.46	-0.41
#4	51.25	51.67	0.42	50.68	51.02	0.34	0.38
#8	28.20	28.57	0.37	27.81	28.16	0.35	0.36
#16	21.52	21.86	0.34	21.67	22.04	0.37	0.35
#30	14.53	14.90	0.37	15.19	15.45	0.26	0.32
#50	8.08	8.60	0.52	8.65	8.97	0.32	0.42
#100	2.39	3.06	0.67	2.57	2.85	0.28	0.48
#200	1.03	1.64	0.61	1.05	1.45	0.40	0.50

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE FROM THE TWO CALIBRATION SAMPLES.

In the AASHTO and ASTM provisional test methods, there is a Method A and Method B for obtaining the calibration factor. (See APPENDIX A for the provisional test methods.) Method A is to be used by ignition systems which have internal weighing systems and Method B is used by ignition systems that are not equipped with internal weighing devices. In the aggregate only calibration procedure both of the provisional methods use the same equation to calculate the calibration factor. However, in the HMA mixture calibration procedure, the two provisional methods use different equations to calculate the calibration factors. These different equations yield slightly different calibration factors and therefore slightly different asphalt contents in the mix.

The NCAT and the Troxler ignition ovens are equipped with the internal weighing devices and therefore Method A was used only for these two ignition systems. The Soil Test and the Gilson ignition ovens are not equipped with internal weighing devices and, therefore, Method B was used for these two ignition systems. Method B was also performed for the NCAT and Troxler so as to compare the calibration factors that were obtained using both the methods. The AASHTO provisional Method A uses the Method B equation to calculate the asphalt binder content. The internal software programs in the NCAT and Troxler employ the AASHTO equation in Method A of the HMA mixture calibration procedure. The ASTM values for Method A in Table 11 and 12 were hand calculated using the ASTM equation and values from the results of the print out from the NCAT and Troxler.

The calibration factors are shown in Tables 11 and 12. The results indicate variability between the different types of ignition ovens, between Method A and Method B, and between the AASHTO and ASTM results using the different equations for Method A.

TABLE 11
LOW ABSORPTION BLANK AGGREGATE CALIBRATION FACTORS

OVEN TYPE	METHOD A	METHOD B
GILSON		0.578
NCAT	0.769	0.839
TROXLER	0.580	0.570
SOILTEST		0.489

LOW ABSORPTION HMA MIXTURE CALIBRATION FACTORS

OVEN TYPE	METHOD A (AASHTO)	METHOD A (ASTM)	METHOD B (AASHTO)	METHOD B (ASTM)
GILSON			0.5054	0.5354
NCAT	0.5540	0.6885	0.6051	0.6420
TROXLER	0.2829	0.4054	0.3853	0.4080
SOILTEST			0.2481	0.2627

TABLE 11

HIGH ABSORPTION BLANK AGGREGATE CALIBRATION FACTORS

OVEN TYPE	METHOD A	METHOD B
GILSON		0.564
NCAT	0.542	0.614
TROXLER	0.441	0.496
SOILTEST		0.560

HIGH ABSORPTION HMA MIXTURE CALIBRATION FACTORS

OVEN TYPE	METHOD A (AASHTO)	METHOD A (ASTM)	METHOD B (AASHTO)	METHOD B (ASTM)
GILSON			0.2529	0.2679
NCAT	0.6034	0.7136	0.6042	0.6403
TROXLER	0.1518	0.2667	0.3312	0.3508
SOILTEST			0.8098	0.8582

MIXING AND LABELING OF THE ASPHALT CONCRETE BATCH SAMPLES:

The combined aggregate gradation and the percent asphalt cement were that of the specified mix design. The combined aggregate gradation and its weight were recorded before it was mixed with the specified percent asphalt cement. The weight of the asphalt cement and it's percent of the total mix were also recorded at the time of mixing. The grams of asphalt cement, by weight of total mix, was calculated from the combined aggregate weight before the procedure of washing, drying, and the addition of mineral filler was performed. This resulted in asphalt contents that were not exactly 4%, 5.5%, and 7.% by weight of total mix.

Of the two mix designs, the low absorption mix designs were mixed and tested first. They were mixed at 4%, 5.5%, and 7% asphalt cement respectively. Then, the high absorption mix designs were mixed. They were also mixed at 4%, 5.5%, and 7% respectively. The weight of each batch was approximately 8,000 grams. After the components had been mixed, care was taken to clean the mixing beaters, bowl, and utensils so as to minimize the loss of material.

The labeling for the sample identification was as follows. The low absorption Type C mixes were labeled C95-LABS and the high absorption Type C mixes were labeled C95-HABS. All batches were labeled and recorded so as to track the results and their procession through the study.

C95-LABS4.0M = 4.0% AC Main C95-HABS4.0M = 4.0% AC Main
C95-LABS5.5M = 5.5% AC Main C95-HABS5.5M = 5.5% AC Main
C95-LABS7.0M = 7.0% AC Main C95-HABS7.0M = 7.0% AC Main

PERFORMANCE OF THE NUCLEAR METHOD:

The same nuclear density gauge was used through out the study. This eliminated any extraneous variables that could have been introduced by use of more than one gauge.

Results from the nuclear method were recorded and compared to the results from the solvent extraction and binder ignition methods. After the nuclear method was performed, the batches were then quartered by AASHTO T248, Method B.

QUARTERING AND LABELING OF THE QUARTERED SAMPLES:

Quartering of the 8,000 gram sample (AASHTO T248, Method B). After the percent of asphalt cement had been determined by the nuclear method, the batches were then quartered. Whenever possible, this quartering proceeded directly after the nuclear gauge asphalt content was determined. If the mix was not hot enough to be quartered, it was re-heated to allow for quartering.

The batch weight was recorded before the quartering, and the weight of each quarter was also recorded after the quartering. The quarters were labeled by placing a 1, 2, 3, and 4 at the end of the identification number of the batch. For example, if the identification number for the batch was C95-LABS4.0M, then the quartered samples were C95-LABS4.0M1, C95-LABS4.0M2, C95-LABS4.0M3, and C95-LABS4.0M4 .

PERFORMANCE OF THE SOLVENT EXTRACTION METHOD:

Quantitative Extraction of Bitumen from Bituminous Paving Mixtures (AASHTO T164). Best results are obtained when the test is made on mixtures shortly after their preparation. The nominal maximum aggregate size of the mix was 1/2", therefore a minimum sample size of 1,500 grams was required. The quartered batches yielded a more than ample batch size of 2,000 ± grams. Test specimens for the determination of moisture content were not required because the aggregates were dried before the mixing process.

The solvent extraction method was performed on the quarter sample labeled quarter #1. The weight of the sample, before and after the procedure was recorded and the percent of asphalt to the nearest one hundredth of a percent was also recorded. The gradations of the remaining aggregate sample were then determined by performing AASHTO T11 & T27.

PERFORMANCE OF THE BINDER IGNITION METHOD:

Standard Test Method for Asphalt content of Hot Mix Asphalt by the Ignition Method (Proposed ASTM Provisional) and Standard Method of Test for Asphalt Content of Hot Mix Asphalt by the Ignition Method (Proposed AASHTO Provisional TP 53) were used in the performance of the ignition method. The percent of asphalt cement was recorded to the nearest one hundredth of one percent. The NCAT Binder Ignition System was performed on quartered sample number 2, the Gilson Binder Ignition System was performed on quartered sample number 3, and the Troxler was performed on quartered sample number 4. As previously mentioned the Soil Test ignition system was entered late into the study. Therefore, the retained nuclear calibration samples were used for the Soil Test Ignition system.

The gradations of the remaining aggregate were ascertained by performing AASHTO T11 & T27.

ANALYSIS OF THE RESULTS:

Percent of asphalt cement from the nuclear method, the solvent extraction method, and the binder ignition method are compared to each other, as well as the percent of asphalt cement in the as-mixed sample. The remaining aggregate gradations from the solvent extraction method, binder ignition systems, and the as-mixed gradations are also compared in the following tables.

TABLE 12 QUANTITATIVE EXTRACTION RESULTS. GRADATIONS AND PERCENT A.C.

LOW ABSORPTIVE AGGREGATE

	BATCH SAMPLE 4.0M	QUANT. EXTR. METHOD 4.0M1	(M1-M) ***	BATCH SAMPLE 5.5M	QUANT. EXTR. METHOD 5.5M1	(M1-M) ***	BATCH SAMPLE 7.0M	QUANT. EXTR. METHOD 7.0M1	(M1-M) ***	AVG. ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.22	98.16	-0.06	98.56	97.64	-0.92	98.40	97.83	-0.57	-0.517
3/8"	86.05	86.68	0.63	86.30	85.57	-0.73	86.08	85.42	-0.66	-0.253
#4	51.26	51.53	0.27	51.15	50.96	-0.19	51.62	51.26	-0.36	-0.093
#8	31.79	32.29	0.50	32.07	31.73	-0.34	31.69	31.83	0.14	0.100
#16	24.15	24.48	0.33	24.05	23.99	-0.06	23.58	23.65	0.07	0.113
#30	16.79	17.39	0.60	17.02	17.09	0.07	16.31	16.68	0.37	0.347
#50	10.54	10.86	0.32	10.54	10.66	0.12	9.88	10.29	0.41	0.283
#100	4.17	4.64	0.47	4.24	4.65	0.41	3.84	4.64	0.80	0.560
#200	2.26	2.29	0.03	2.24	2.40	0.16	2.20	2.32	0.12	0.103
%AC.	4.219	4.15	-0.07	5.714	5.6	-0.11	7.222	7.03	-0.19	-0.125

HIGH ABSORPTIVE AGGREGATE

	BATCH SAMPLE 4.0M	QUANT. EXTR. METHOD 4.0M1	(M1-M) ***	BATCH SAMPLE 5.5M	QUANT. EXTR. METHOD 5.5M1	(M1-M) ***	BATCH SAMPLE 7.0M	QUANT. EXTR. METHOD 7.0M1	(M1-M) ***	AVG. ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.78	98.80	0.02	98.62	98.73	0.11	98.90	99.19	0.29	0.140
3/8"	85.72	84.51	-1.21	86.05	83.71	-2.34	85.95	86.55	0.60	-0.983
#4	52.10	52.03	-0.07	52.79	51.49	-1.30	52.14	51.98	-0.16	-0.510
#8	29.14	29.02	-0.12	29.31	29.17	-0.14	29.49	28.89	-0.60	-0.287
#16	22.82	22.68	-0.14	22.53	22.49	-0.04	23.12	22.57	-0.55	-0.243
#30	16.20	16.40	0.20	15.99	16.11	0.12	16.62	16.31	-0.31	0.003
#50	10.09	10.23	0.14	10.00	10.06	0.06	10.37	10.16	-0.21	0.003
#100	3.78	4.49	0.71	4.15	4.37	0.22	4.30	4.36	0.06	0.330
#200	2.28	2.27	-0.01	2.30	2.24	-0.06	2.36	2.41	0.05	-0.007
%AC.	4.201	4.01	-0.19	5.809	5.41	-0.40	7.342	7.03	-0.31	-0.301

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE SAMPLES.

TABLE 13 NCAT IGNITION SYSTEM RESULTS

LOW ABSORPTIVE AGGREGATE GRADATIONS

	BATCH SAMPLE 4.0M	NCAT IGNIT. SYSTEM 4.0M2	(M2-M) ***	BATCH SAMPLE 5.5M	NCAT IGNIT. SYSTEM 5.5M2	(M2-M) ***	BATCH SAMPLE 7.0M	NCAT IGNIT. SYSTEM 7.0M2	(M2-M) ***	AVG. ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.22	97.44	-0.78	98.56	98.76	0.20	98.40	98.46	0.06	-0.173
3/8"	86.05	85.32	-0.73	86.30	88.58	2.28	86.08	88.32	2.24	1.263
#4	51.26	53.25	1.99	51.15	55.38	4.23	51.62	55.72	4.10	3.440
#8	31.79	36.57	4.78	32.07	37.83	5.76	31.69	36.93	5.24	5.260
#16	24.15	28.90	4.75	24.05	29.70	5.65	23.58	28.65	5.07	5.157
#30	16.79	21.67	4.88	17.02	22.17	5.15	16.31	21.04	4.73	4.920
#50	10.54	14.78	4.24	10.54	15.12	4.58	9.88	14.08	4.20	4.340
#100	4.17	7.55	3.38	4.24	8.01	3.77	3.84	7.34	3.50	3.550
#200	2.26	3.50	1.24	2.24	3.82	1.58	2.20	3.67	1.47	1.430

HIGH ABSORPTIVE AGGREGATE GRADATIONS

	BATCH SAMPLE 4.0M	NCAT IGNIT. SYSTEM 4.0M2	(M2-M) ***	BATCH SAMPLE 5.5M	NCAT IGNIT. SYSTEM 5.5M2	(M2-M) ***	BATCH SAMPLE 7.0M	NCAT IGNIT. SYSTEM 7.0M2	(M2-M) ***	AVG. ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.78	98.56	-0.22	98.62	99.20	0.58	98.90	98.30	-0.60	-0.080
3/8"	85.72	87.96	2.24	86.05	87.51	1.46	85.95	86.12	0.17	1.290
#4	52.10	53.97	1.87	52.79	53.59	0.80	52.14	50.75	-1.39	0.427
#8	29.14	30.73	1.59	29.31	29.41	0.10	29.49	28.64	-0.85	0.280
#16	22.82	24.00	1.18	22.53	22.51	-0.02	23.12	22.47	-0.65	0.170
#30	16.20	17.27	1.07	15.99	16.19	0.20	16.62	16.35	-0.27	0.333
#50	10.09	10.87	0.78	10.00	10.20	0.20	10.37	10.35	-0.02	0.320
#100	3.78	5.02	1.24	4.15	4.61	0.46	4.30	4.78	0.48	0.727
#200	2.28	2.98	0.70	2.30	2.73	0.43	2.36	2.78	0.42	0.517

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE SAMPLES.

TABLE 13 NCAT IGNITION SYSTEM RESULTS

LOW ABSORPTIVE AGGREGATE PERCENT A.C.

DETERMINED USING BLANK AGGREGATE CALIBRATION FACTORS

	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.219	4.050	-0.169	5.714	5.580	-0.134	7.222	6.970	-0.252	0.185
2 A		4.070	-0.145		5.650	-0.064		7.080	-0.142	0.117
1 B		4.048	-0.171		5.725	0.011		7.095	-0.127	0.103
2 B		4.079	-0.140		5.768	0.054		7.144	-0.078	0.091

DETERMINED USING AASHTO HMA MIXTURE CALIBRATION FACTORS

	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.219	4.262	0.043	5.714	5.790	0.076	7.222	7.181	-0.041	0.053
2 A		4.278	0.059		5.816	0.102		7.209	-0.013	0.058
1 B		4.282	0.063		5.959	0.245		7.329	0.107	0.138
2 B		4.304	0.085		5.990	0.276		7.362	0.140	0.167

DETERMINED USING ASTM HMA MIXTURE CALIBRATION FACTORS

	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.219	4.128	-0.091	5.714	5.656	-0.058	7.222	7.046	-0.176	0.108
2 A		4.149	-0.070		5.689	-0.025		7.084	-0.138	0.078
1 B		4.245	0.026		5.922	0.208		7.292	0.070	0.101
2 B		4.269	0.050		5.955	0.241		7.328	0.106	0.132

NOTE: 1A = AASHTO METHOD A
: 2A = ASTM METHOD A
: 1B = AASHTO METHOD B
: 2B = ASTM METHOD B
: THE *** COLUMN IS THE DIFFERENCE BETWEEN THE CALCULATED ASPHALT CONTENT AND THE ACTUAL ASPHALT CONTENT OF THE BATCH.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE BATCHES.

TABLE 13 NCAT IGNITION SYSTEM RESULTS

HIGH ABSORPTIVE AGGREGATE PERCENT A.C.

DETERMINED USING BLANK AGGREGATE CALIBRATION FACTORS

	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.201	4.422	0.221	5.809	5.822	0.013	7.342	7.298	-0.044	0.093
2 A		4.446	0.245		5.854	0.045		7.338	-0.004	0.098
1 B		4.335	0.134		5.768	-0.041		7.205	-0.137	0.104
2 B		4.362	0.161		5.804	-0.005		7.249	-0.093	0.086

DETERMINED USING AASHTO HMA MIXTURE CALIBRATION FACTORS

	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.201	4.360	0.159	5.809	5.760	0.049	7.342	7.237	-0.105	0.104
2 A		4.387	0.186		5.796	-0.013		7.281	-0.061	0.087
1 B		4.345	0.144		5.778	-0.031		7.214	-0.128	0.101
2 B		4.371	0.170		5.813	0.004		7.258	-0.084	0.086

DETERMINED USING ASTM HMA MIXTURE CALIBRATION FACTORS

	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	BATCH	NCAT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.201	4.250	0.049	5.809	5.650	-0.159	7.342	7.127	-0.215	0.141
2 A		4.281	0.080		5.692	-0.117		7.178	-0.164	0.120
1 B		4.309	0.108		5.742	-0.067		7.178	-0.164	0.113
2 B		4.336	0.135		5.779	-0.030		7.225	-0.117	0.094

NOTE: 1A = AASHTO METHOD A
: 2A = ASTM METHOD A
: 1B = AASHTO METHOD B
: 2B = ASTM METHOD B
: THE *** COLUMN IS THE DIFFERENCE BETWEEN THE CALCULATED ASPHALT CONTENT AND THE ACTUAL ASPHALT CONTENT OF THE BATCH.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE BATCHES.

TABLE 14 GILSON IGNITION SYSTEM RESULTS

LOW ABSORPTIVE AGGREGATE

	BATCH SAMPLE 4.0M	GILSON IGNIT. SYSTEM 4.0M3	(M3-M) ***	BATCH SAMPLE 5.5M	GILSON IGNIT. SYSTEM 5.5M3	(M3-M) ***	BATCH SAMPLE 7.0M	GILSON IGNIT. SYSTEM 7.0M3	(M3-M) ***	AVG. ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.22	97.51	-0.71	98.56	98.41	-0.15	98.40	98.35	-0.05	-0.303
3/8"	86.05	85.85	-0.20	86.30	85.14	-1.16	86.08	87.29	1.21	-0.500
#4	51.26	53.48	2.22	51.15	53.41	2.26	51.62	56.02	4.40	2.960
#8	31.79	36.32	4.53	32.07	36.64	4.57	31.69	36.80	5.11	4.737
#16	24.15	28.82	4.67	24.05	28.96	4.91	23.58	28.36	4.78	4.787
#30	16.79	21.48	4.69	17.02	21.68	4.66	16.31	20.97	4.66	4.670
#50	10.54	14.67	4.13	10.54	14.85	4.31	9.88	14.18	4.30	4.247
#100	4.17	7.49	3.32	4.24	7.84	3.60	3.84	7.61	3.77	3.563
#200	2.26	3.59	1.33	2.24	4.00	1.76	2.20	3.83	1.63	1.573

HIGH ABSORPTIVE AGGREGATE

	BATCH SAMPLE 4.0M	GILSON IGNIT. SYSTEM 4.0M3	(M3-M) ***	BATCH SAMPLE 5.5M	GILSON IGNIT. SYSTEM 5.5M3	(M3-M) ***	BATCH SAMPLE 7.0M	GILSON IGNIT. SYSTEM 7.0M3	(M3-M) ***	AVG. ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.78	98.64	-0.14	98.62	98.59	-0.03	98.90	98.94	0.04	-0.043
3/8"	85.72	85.97	0.25	86.05	87.12	1.07	85.95	86.24	0.29	0.537
#4	52.10	51.79	-0.31	52.79	54.79	2.00	52.14	52.52	0.38	0.690
#8	29.14	29.18	0.04	29.31	29.82	0.51	29.49	30.28	0.79	0.447
#16	22.82	22.82	0.00	22.53	22.83	0.30	23.12	23.79	0.67	0.323
#30	16.20	16.52	0.32	15.99	16.52	0.53	16.62	17.30	0.68	0.510
#50	10.09	10.43	0.34	10.00	10.58	0.58	10.37	11.03	0.66	0.527
#100	3.78	4.83	1.05	4.15	5.05	0.90	4.30	5.15	0.85	0.933
#200	2.28	2.82	0.54	2.30	3.02	0.72	2.36	3.16	0.80	0.687

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE SAMPLES.

TABLE 14 GILSON IGNITION SYSTEM RESULTS

LOW ABSORPTIVE AGGREGATE PERCENT A.C.

DETERMINED USING BLANK AGGREGATE CALIBRATION FACTORS

	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.219	4.043	-0.176	5.714	5.312	-0.402	7.222	6.833	-0.389	0.322
2 B		4.067	-0.152		5.342	-0.372		6.873	-0.349	0.291

DETERMINED USING AASHTO HMA MIXTURE CALIBRATION FACTORS

	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.219	4.116	-0.103	5.714	5.384	-0.330	7.222	6.906	-0.316	0.250
2 B		4.137	-0.082		5.411	-0.303		6.941	-0.281	0.222

DETERMINED USING ASTM HMA MIXTURE CALIBRATION FACTORS

	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.219	4.086	-0.133	5.714	5.354	-0.360	7.222	6.876	-0.346	0.280
2 B		4.108	-0.111		5.383	-0.331		6.913	-0.309	0.250

HIGH ABSORPTIVE AGGREGATE PERCENT A.C.

DETERMINED USING BLANK AGGREGATE CALIBRATION FACTORS

	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.201	4.091	-0.110	5.809	5.507	-0.302	7.342	6.928	-0.414	0.275
2 B		4.114	-0.087		5.539	-0.270		6.967	-0.375	0.244

DETERMINED USING AASHTO HMA MIXTURE CALIBRATION FACTORS

	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.201	4.402	0.201	5.809	5.819	0.010	7.342	7.239	-0.103	0.105
2 B		4.413	0.212		5.833	0.024		7.257	-0.085	0.107

DETERMINED USING ASTM HMA MIXTURE CALIBRATION FACTORS

	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	BATCH	GILS	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.201	4.387	0.186	5.809	5.804	-0.005	7.342	7.224	-0.118	0.103
2 B		4.399	0.198		5.819	0.010		7.243	-0.099	0.102

NOTE: 1B = AASHTO METHOD B
: 2B = ASTM METHOD B
: THE *** COLUMN IS THE DIFFERENCE BETWEEN THE CALCULATED ASPHALT CONTENT AND THE ACTUAL ASPHALT CONTENT OF THE BATCH.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE BATCHES.

TABLE 15 TROXLER IGNITION SYSTEM

LOW ABSORPTIVE AGGREGATE

	BATCH SAMPLE 4.0M	TROXL. IGNIT. SYSTEM 4.0M4	(M4-M) ***	BATCH SAMPLE 5.5M	TROXL. IGNIT. SYSTEM 5.5M4	(M4-M) ***	BATCH SAMPLE 7.0M	TROXL. IGNIT. SYSTEM 7.0M4	(M4-M) ***	AVG. ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.22	98.73	0.51	98.56	98.55	-0.01	98.40	98.96	0.56	0.353
3/8"	86.05	88.67	2.62	86.30	89.01	2.71	86.08	87.42	1.34	2.223
#4	51.26	56.95	5.69	51.15	55.96	4.81	51.62	55.73	4.11	4.870
#8	31.79	38.48	6.69	32.07	38.26	6.19	31.69	37.17	5.48	6.120
#16	24.15	30.07	5.92	24.05	29.78	5.73	23.58	28.81	5.23	5.627
#30	16.79	22.53	5.74	17.02	22.24	5.22	16.31	21.24	4.93	5.297
#50	10.54	15.33	4.79	10.54	15.19	4.65	9.88	14.22	4.34	4.593
#100	4.17	8.02	3.85	4.24	7.98	3.74	3.84	7.38	3.54	3.710
#200	2.26	3.95	1.69	2.24	3.82	1.58	2.20	3.72	1.52	1.597

HIGH ABSORPTIVE AGGREGATE

	BATCH SAMPLE 4.0M	TROXL. IGNIT. SYSTEM 4.0M4	(M4-M) ***	BATCH SAMPLE 5.5M	TROXL. IGNIT. SYSTEM 5.5M4	(M4-M) ***	BATCH SAMPLE 7.0M	TROXL. IGNIT. SYSTEM 7.0M4	(M4-M) ***	AVG. ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.78	98.20	-0.58	98.62	97.93	-0.69	98.90	98.53	-0.37	-0.547
3/8"	85.72	86.04	0.32	86.05	86.24	0.19	85.95	86.46	0.51	0.340
#4	52.10	51.49	-0.61	52.79	52.83	0.04	52.14	53.41	1.27	0.233
#8	29.14	29.26	0.12	29.31	29.89	0.58	29.49	30.48	0.99	0.563
#16	22.82	22.72	-0.10	22.53	22.77	0.24	23.12	23.60	0.48	0.207
#30	16.20	16.56	0.36	15.99	16.42	0.43	16.62	17.10	0.48	0.423
#50	10.09	10.51	0.42	10.00	10.30	0.30	10.37	10.75	0.38	0.367
#100	3.78	4.85	1.07	4.15	4.62	0.47	4.30	4.87	0.57	0.703
#200	2.28	2.72	0.44	2.30	2.67	0.37	2.36	2.88	0.52	0.443

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE SAMPLES.

TABLE 15 TROXLER IGNITION SYSTEM RESULTS

LOW ABSORPTIVE AGGREGATE PERCENT A.C.

DETERMINED USING BLANK AGGREGATE CALIBRATION FACTORS

	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.219	4.094	-0.125	5.714	5.597	-0.117	7.222	6.808	-0.414	0.219
2 A		4.118	-0.101		5.630	-0.084		6.847	-0.375	0.187
1 B		4.152	-0.067		5.555	-0.159		6.880	-0.342	0.189
2 B		4.175	-0.044		5.587	-0.127		6.919	-0.303	0.158

DETERMINED USING AASHTO HMA MIXTURE CALIBRATION FACTORS

	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.219	4.392	0.173	5.714	5.894	0.180	7.222	7.105	-0.117	0.157
2 A		4.404	0.185		5.911	0.197		7.125	-0.097	0.160
1 B		4.336	0.117		5.740	0.026		7.065	-0.157	0.100
2 B		4.353	0.134		5.762	0.048		7.092	-0.130	0.107

DETERMINED USING ASTM HMA MIXTURE CALIBRATION FACTORS

	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.219	4.269	0.050	5.714	5.772	0.058	7.222	6.982	-0.240	0.116
2 A		4.286	0.067		5.795	0.081		7.011	-0.211	0.120
1 B		4.314	0.095		5.717	0.003		7.042	-0.180	0.093
2 B		4.331	0.112		5.740	0.026		7.071	-0.151	0.096

NOTE: 1A = AASHTO METHOD A
: 2A = ASTM METHOD A
: 1B = AASHTO METHOD B
: 2B = ASTM METHOD B
: THE *** COLUMN IS THE DIFFERENCE BETWEEN THE CALCULATED ASPHALT CONTENT AND THE ACTUAL ASPHALT CONTENT OF THE BATCH.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE BATCHES.

TABLE 15 TROXLER IGNITION SYSTEM RESULTS

HIGH ABSORPTIVE AGGREGATE PERCENT A.C.

DETERMINED USING BLANK AGGREGATE CALIBRATION FACTORS

	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.201	4.413	0.212	5.809	6.116	0.307	7.342	7.345	0.003	0.174
2 A		4.433	0.232		6.143	0.334		7.378	0.036	0.201
1 B		4.306	0.105		6.019	0.210		7.251	-0.091	0.135
2 B		4.328	0.127		6.049	0.240		7.288	-0.054	0.140

DETERMINED USING AASHTO HMA MIXTURE CALIBRATION FACTORS

	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.201	4.702	0.501	5.809	6.405	0.596	7.342	7.634	0.292	0.463
2 A		4.709	0.508		6.415	0.606		7.646	0.304	0.473
1 B		4.471	0.270		6.184	0.375		7.416	0.074	0.240
2 B		4.486	0.285		6.204	0.396		7.441	0.099	0.260

DETERMINED USING ASTM HMA MIXTURE CALIBRATION FACTORS

	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	BATCH	TROX.	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 A	4.201	4.587	0.386	5.809	6.290	0.481	7.342	7.520	0.177	0.348
2 A		4.600	0.399		6.307	0.498		7.540	0.198	0.365
1 B		4.451	0.250		6.164	0.356		7.397	0.055	0.220
2 B		4.467	0.266		6.265	0.457		7.423	0.081	0.255

NOTE: 1A = AASHTO METHOD A
: 2A = ASTM METHOD A
: 1B = AASHTO METHOD B
: 2B = ASTM METHOD B
: THE *** COLUMN IS THE DIFFERENCE BETWEEN THE CALCULATED ASPHALT CONTENT AND THE ACTUAL ASPHALT CONTENT OF THE BATCH.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE BATCHES

TABLE 16 SOIL TEST IGNITION SYSTEM

LOW ABSORPTIVE AGGREGATE

	BATCH SAMPLE 4.0N	SOILT IGNIT. SYSTEM 4.0N5	(N5-N) ***	BATCH SAMPLE 5.5N	SOILT IGNIT. SYSTEM 5.5N5	(N5-N) ***	BATCH SAMPLE 7.0N	SOILT IGNIT. SYSTEM 7.0N5	(N5-N) ***	AVG ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.81	97.51	-1.30	98.66	98.15	-0.51	98.59	98.63	0.04	-0.590
3/8"	85.97	85.06	-0.91	86.07	87.93	1.86	85.76	87.10	1.34	0.763
#4	51.12	52.58	1.46	52.96	57.58	4.62	50.78	56.42	5.64	3.907
#8	31.67	34.97	3.30	32.03	37.93	5.90	31.70	39.27	7.57	5.590
#16	24.11	27.56	3.45	24.14	29.86	5.72	23.67	30.13	6.46	5.210
#30	17.28	21.05	3.77	17.26	22.61	5.35	16.67	22.32	5.65	4.923
#50	10.94	14.55	3.61	10.77	15.66	4.89	10.58	15.29	4.71	4.403
#100	4.50	7.33	2.83	4.40	8.36	3.96	4.35	7.85	3.50	3.430
#200	2.21	3.31	1.10	2.15	3.98	1.83	2.16	3.67	1.51	1.480

HIGH ABSORPTIVE AGGREGATE

	BATCH SAMPLE 4.0N	SOILT IGNIT. SYSTEM 4.0N5	(N5-N) ***	BATCH SAMPLE 5.5N	SOILT IGNIT. SYSTEM 5.5N5	(N5-N) ***	BATCH SAMPLE 7.0N	SOILT IGNIT. SYSTEM 7.0N5	(N5-N) ***	AVG ***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00	0.000
1/2"	98.62	97.74	-0.88	98.73	98.09	-0.64	98.77	98.24	-0.53	-0.683
3/8"	85.80	84.97	-0.83	86.12	85.75	-0.37	86.30	86.81	0.51	-0.230
#4	51.38	50.41	-0.97	51.18	50.58	-0.60	52.15	52.79	0.64	-0.310
#8	29.08	28.74	-0.34	28.79	28.88	0.09	29.14	29.07	-0.07	-0.107
#16	22.70	22.77	0.07	22.15	22.37	0.22	23.50	23.29	-0.21	0.027
#30	16.53	16.75	0.22	15.89	16.15	0.26	17.66	17.50	-0.16	0.107
#50	10.52	10.78	0.26	10.18	10.31	0.13	11.37	11.33	-0.04	0.117
#100	4.02	4.76	0.74	4.23	4.59	0.36	4.61	4.93	0.32	0.473
#200	2.30	2.51	0.21	2.24	2.35	0.11	2.23	2.41	0.18	0.167

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN BEFORE AND AFTER GRADATIONS.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE SAMPLES.

TABLE 16 SOIL TEST IGNITION SYSTEM RESULTS

LOW ABSORPTIVE AGGREGATE PERCENT A.C.

DETERMINED USING BLANK AGGREGATE CALIBRATION FACTORS

	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.219	3.848	-0.371	5.714	5.283	-0.431	7.222	7.103	-0.119	0.307
2 B		3.867	-0.352		5.309	-0.405		7.138	-0.084	0.280

DETERMINED USING AASHTO HMA MIXTURE CALIBRATION FACTORS

	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.219	4.089	-0.130	5.714	5.524	-0.190	7.222	7.344	0.122	0.147
2 B		4.099	-0.120		5.337	-0.377		7.362	0.140	0.212

DETERMINED USING ASTM HMA MIXTURE CALIBRATION FACTORS

	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.219	4.074	-0.145	5.714	5.509	-0.205	7.222	7.330	0.108	0.153
2 B		4.085	-0.134		5.524	-0.190		7.349	0.127	0.150

HIGH ABSORPTIVE AGGREGATE PERCENT A.C.

DETERMINED USING BLANK AGGREGATE CALIBRATION FACTORS

	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.201	4.055	-0.146	5.809	6.047	0.239	7.342	6.932	-0.410	0.265
2 B		4.077	-0.124		6.081	0.273		6.971	-0.371	0.256

DETERMINED USING AASHTO HMA MIXTURE CALIBRATION FACTORS

	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.201	3.805	-0.396	5.809	5.797	-0.011	7.342	7.086	-0.256	0.221
2 B		3.836	-0.365		5.845	-0.036		7.144	-0.198	0.200

DETERMINED USING ASTM HMA MIXTURE CALIBRATION FACTORS

	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	BATCH	SOILT	(M2-M)	AVG.
	4.0M	4.0M2	***	5.5M	5.5M2	***	7.0M	7.0M2	***	***
1 B	4.201	3.756	-0.445	5.809	5.749	-0.060	7.342	7.038	-0.304	0.270
2 B		3.789	-0.412		5.799	-0.010		7.099	-0.243	0.222

NOTE: 1B = AASHTO METHOD B
: 2B = ASTM METHOD B
: THE *** COLUMN IS THE DIFFERENCE BETWEEN THE CALCULATED ASPHALT CONTENT AND THE ACTUAL ASPHALT CONTENT OF THE BATCH.
: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE BATCHES.

TABLE 17 NUCLEAR GAUGE RESULTS, PERCENT ASPHALT CEMENT

LOW ABSORPTIVE AGGREGATE

BATCH	NUC.	***	BATCH	NUC.	***	BATCH	NUC.	***	***
4.0M	4.0M'	(M'-M)	5.5M	5.5M'	(M'-M)	7.0M	7.0M'	(M'-M)	AVG.
4.219	4.20	-0.019	5.714	5.770	0.056	7.222	7.230	0.008	0.028

HIGH ABSORPTIVE AGGREGATE

BATCH	NUC.	***	BATCH	NUC.	***	BATCH	NUC.	***	***
4.0M	4.0M'	(M'-M)	5.5M	5.5M'	(M'-M)	7.0M	7.0M'	(M'-M)	AVG.
4.201	4.440	0.239	5.809	5.900	0.091	7.342	7.410	0.068	0.133

NOTE: THE *** COLUMN IS THE DIFFERENCE BETWEEN THE CALCULATED ASPHALT CONTENT AND THE ACTUAL ASPHALT CONTENT OF THE BATCH.

: THE SHADED COLUMN IS THE AVERAGE DIFFERENCE OF THE THREE BATCHES.

From viewing the results in Tables 12 through 17, the following general statements can be made.

The aggregate calibration factor obtained from the asphalt concrete mixture procedure yielded the overall best results in the calculation of the percent of asphalt cement. In most instances, the most accurate asphalt contents were determined by using this calibration factor. Overall results indicate that the AASHTO provisional test method yielded the most accurate asphalt contents.

Therefore, by using the aggregate calibration factor obtained from the asphalt concrete mixture procedure in the AASHTO provisional test method, and the AASHTO provisional's equation to calculate the asphalt content, the best results can be obtained.

By using the AASHTO procedure, the NCAT ignition system proved to be the most accurate of the four ovens. It calculated the asphalt contents, for both the high and low absorption aggregate mixes, to within 0.058 to 0.104 percent of the actual mix content. The results from the Gilson oven yielded calculated asphalt contents, for both the high and low absorption aggregate mixes, to within 0.105 to 0.250 percent of the actual mix content. The results from the Soil Test oven yielded calculated asphalt contents, for both the high and low absorption aggregate mixes, to within 0.147 to 0.221 percent of the actual mix content. And the Troxler oven calculated the asphalt contents for low absorption aggregate mixes to within 0.157 and the high absorption mix to within 0.463 percent of the actual mix content.

In the quantitative extraction procedure, the asphalt content was, in the low absorption mix, calculated to within 0.125 percent of the actual mix content. And the asphalt content in the high absorption mix was calculated to within 0.301 percent of the actual mix content. In the nuclear method procedure, the asphalt content was, in the low absorption mix, calculated to within 0.028 percent of the actual mix content. And the asphalt content in the high absorption mix was calculated to within 0.133 percent of the actual mix content.

The binder ignition systems can accurately determine the percent of asphalt cement in an asphalt concrete mixture. And, in some instances, are as good as, if not better, than the results from the solvent extraction method and the nuclear method. Therefore, the binder ignition systems can be used for determining the percent of asphalt cement for specification compliance.

Without a gradation calibration factor, for each sieve to determine the amount of degradation to be expected during the burn off, the final gradations can not be used for specification compliance.

INVESTIGATION OF CHERT

From analyzing the before and after gradations of the high and low absorptive mixes, it was ascertained that the low absorptive stone mixes appreciably degraded in the ignition ovens. The cause of the degradation was thought to be the high chert content of the coarse aggregate. It was then decided to further pursue the analysis of chert content in aggregates.

The investigation of the chert content consisted of choosing six coarse aggregates with varying levels of chert content from zero to ten percent. Whenever possible, these aggregates were graded out to the same gradation. A 2,000 gram sample of each of these aggregates was then subjected to the blank aggregate calibration process in the ignition oven. The same ignition oven was employed throughout the chert investigation. The before and after gradations were then compared and analyzed for the amount of aggregate degradation in the ignition ovens.

The results were unexpected. At the onset of the chert investigation, it was thought that the amount of degradation would increase as the chert content in the aggregate increased. This was found not to be necessarily true, so the analysis of the chert was somewhat inconclusive. Therefore, it seems that the amount of aggregate degradation does not solely hinge on the amount of chert content, but must also be affected by many other variables. These other variables maybe within the lithology of the aggregate.

The results of the investigation are listed in Table 18. As can be seen, no clear conclusion can be determined from the results. It is therefore recommended that, during the aggregate calibration process, a gradation calibration should also be performed. This will give the amount of degradation that can be expected on the combined aggregate gradation of the asphalt concrete. Without some type of aggregate gradation calibration, the final gradations from the ignition ovens can not be used for specification compliance.

TABLE 18 CHERT ANALYSIS

	1.3%	1.3%		3.2%	3.2%		4.4%	4.4%	
	CHERT	CHERT		CHERT	CHERT		CHERT	CHERT	
SIEVE	BEFORE	AFTER	***	BEFORE	AFTER	***	BEFORE	AFTER	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00
1/2"	97.93	97.25	-0.68	97.93	98.22	0.29	100.00	100.00	0.00
3/8"	81.44	82.54	1.10	81.44	81.24	-0.20	91.64	93.24	1.60
#4	34.02	36.09	2.07	34.02	34.49	0.47	38.28	44.63	6.35
#8	7.21	9.94	2.73	7.21	8.18	0.97	8.12	17.07	8.95
#16	3.09	6.05	2.96	3.09	4.06	0.97	3.48	12.70	9.22
#30	2.06	4.86	2.80	2.06	3.12	1.06	2.32	11.13	8.81
#50	2.06	4.35	2.29	2.06	2.91	0.85	2.32	9.67	7.35
#100	1.03	2.53	1.50	1.03	1.87	0.84	1.16	5.71	4.55
#200	0.00	0.62	0.62	0.00	0.31	0.31	0.00	1.45	1.45
DEL.			2.1			0.8			1.1
SHALE			0.6			0			0
CHERT			1.3			3.2			4.4
ABS.			2.1			1.7			1.4
BULK SP.G			2.64			2.671			2.59
APP.SP. G			2.796			2.801			2.686

	5.3%	5.3%		8.4%	8.4%		10.0%	10.0%	
	CHERT	CHERT		CHERT	CHERT		CHERT	CHERT	
SIEVE	BEFORE	AFTER	***	BEFORE	AFTER	***	BEFORE	AFTER	***
3/4"	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00
1/2"	97.93	97.18	-0.75	97.93	98.38	0.45	97.93	97.25	-0.68
3/8"	81.44	80.94	-0.50	81.44	84.15	2.71	81.44	82.54	1.10
#4	34.02	34.40	0.38	34.02	40.83	6.81	34.02	36.09	2.07
#8	7.21	7.54	0.33	7.21	17.61	10.40	7.21	9.94	2.73
#16	3.09	3.59	0.50	3.09	13.45	10.36	3.09	6.05	2.96
#30	2.06	2.65	0.59	2.06	11.89	9.83	2.06	4.86	2.80
#50	2.06	2.49	0.43	2.06	10.28	8.22	2.06	4.35	2.29
#100	1.03	1.56	0.53	1.03	6.23	5.20	1.03	2.53	1.50
#200	0.00	0.20	0.20	0.00	1.76	1.76	0.00	0.06	0.06
DEL.			0			1			2.8
SHALE			0.2			0			0
CHERT			5.3			8.4			10
ABS.			0.9			1.4			3.9
BULK SP.G			2.728			2.591			2.425
APP.SP. G			2.799			2.686			2.678

NOTE: THE *** COLUMN REPRESENTS THE AMOUNT OF DEGRADATION

RESULTS AND CONCLUSIONS

The findings of this investigation are: the ignition systems are accurate in determining the percent of asphalt cement in a bituminous mixture and they can be used for specification compliance. The absorption and percent chert content of an aggregate did not prove to be the core determining factors in the amount of aggregate degradation in the ignition ovens. Instead, it is believed that the overall chemical and physical characteristics, its lithology, will dictate the amount of degradation. Since there are so many variables in the lithology of an aggregate, this study did not further pursue the cause of aggregate degradation.

Therefore, it is recommended that a gradation calibration be performed as part of the test method. This gradation calibration should be performed to ascertain the amount of expected aggregate breakdown in the ignition ovens. It should be performed on every asphalt concrete mix design, along with the aggregate calibration factor for determining the amount of asphalt cement in the mixture. This would then allow the use of the final gradation for specification compliance. Without this type of gradation calibration, the final gradations should not be used for specification compliance.

The aggregate calibration factor obtained from the asphalt concrete mixture procedure yielded the overall best results in the calculation of the percent of asphalt cement. And, the AASHTO provisional test method equation for determining the asphalt content proved to be the most accurate. Therefore, it is recommended that MoDOT use the AASHTO provisional test method.

The NCAT ignition system proved to be the most accurate of the four ovens that were tested.

From the investigation of chert, it was determined that the amount of degradation of an aggregate does not solely hinge on the percent of chert in the aggregate. Instead, it is believed that the lithology, overall chemical and physical characteristics of the aggregate, may dictate the amount of breakdown in the ignition ovens. Since there are so many variables in the lithology of an aggregate, it is recommended that a gradation calibration should also be performed for each asphalt concrete mixture.

The provisional test methods are still being changed to reflect the best way to perform the procedure. It is recommended that MoDOT use the most current AASHTO provisional to perform the test.

REFERENCES

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H.A. Todres, S. Bhattacharja, A.P. Jacobs, "Asphalt Content and Gradations of some Canadian Hot-Mix Asphalt Concretes by Pyrolysis and by Conventional Techniques - A comparative Study", Proceedings of the Thirty-Ninth Annual Conference of Canadian Technical Asphalt Association, 1994.

APPENDICES

Draft - August 14, 1996

Standard Method of Test For
Asphalt Binder Content
of Hot-Mix Asphalt
by the Ignition Method

AASHTO Designation TP 53-96

1. **Scope**

1.1 This test method covers the determination of asphalt content of hot-mixed paving mixtures by ignition of the asphalt cement at 538°C (1000°F) or less in a furnace. The aggregate remaining can be used for sieve analysis using AASHTO Test Method T30.

1.2 The values in metric units are to be regarded as the standard.

1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. **Referenced Documents**

2.1 AASHTO Standards

T2	Sampling Aggregates
T30	Mechanical Analysis of Extracted Aggregate
T100	Moisture or Volatile Distillates in Bituminous Paving Mixtures
T168	Sampling Bituminous Paving Materials
T248	Reducing Field Samples of Aggregate to Testing Size

2.2 Manufacturer's instruction manual

3. **Summary of Test Methods**

3.1 The asphalt cement in the paving mixture is ignited using the furnace equipment applicable to the particular method. The asphalt content is calculated as the difference between the initial mass of the asphalt paving mixture and the mass of the residual aggregate, the calibration factor and moisture content. The asphalt content is expressed as mass percent of moisture-free mixture.

4. **Significance and Use**

4.1 This method can be used for quantitative determinations of asphalt binder content and gradation in hot-mixed paving mixtures and pavement samples for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents. Aggregate obtained by this test method may be used for gradation analysis according to AASHTO T 30.

5. **Sampling**

5.1 Obtain samples of aggregate in accordance with AASHTO Method T2.

5.2 Obtain samples of freshly produced hot-mix asphalt in accordance with AASHTO Method T 168.

5.3 The test specimen shall be the end result of quartering a larger sample taken in accordance with T 248.

5.4 If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan in an oven at 125°C ± 5°C (257°F± 9°F).

5.5 The size of the test sample shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1. When the mass of the test specimen exceeds the capacity of the equipment used the test specimen may be divided into suitable increments, tested, and the results appropriately combined for calculation of the asphalt content (weighted average). Specimen sizes shall not be more than 400 g greater than the minimum recommended specimen mass.

Note A - Large samples of fine mixes tend to result in incomplete ignition of asphalt.

Table 1

Nominal Max. Agg. Size, mm	Sieve Size	Min. Mass Specimen, g
4.75	No. 4	1200
9.5	3/8 in.	1200
12.5	1/2 in.	1500
19.0	3/4 in.	2000
25.0	1 in.	3000
37.5	1 1/2 in.	4000

5.6 When considered necessary, obtain a test specimen for moisture determination according to T287, Sections 3.2 and 8.2. The specimen used for moisture determination shall not be used for asphalt content determination. The specimen shall be conditioned in the same manner as the specimen used for asphalt content determination.

6. Calibration

6.1 This method may be affected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, a calibration factor will be established with the testing of a set of calibration samples for each mix type. This procedure must be performed before any acceptance testing is completed. Certain aggregate types may result in an unusually high calibration factor (>0.5%) and erroneous gradation results due to aggregate breakdown. Such mixes should be calibrated and tested at a lower temperature, typically 482°C (900°F).

6.2 The calibration should be repeated each time there is a change in the mix ingredients, design or as required by the engineer.

6.3 According to the requirements of Section 5.4, prepare a total of six calibration specimens at the following asphalt contents:

At design asphalt content	=	2 specimens
At design plus 0.5 percent asphalt content	=	2 specimens
At design minus 0.5 percent asphalt content	=	2 specimens
Total	=	6 specimens

Prepare a butter mix at the design asphalt content. The purpose of the butter mix is to provide a coating of asphalt and fines in the bowl. Mix and discard the butter mix prior to mixing any of the calibration specimens to ensure an accurate asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season and designated to be used on the candidate project. Any method may be used to combine the aggregates, however, an additional "blank" specimen shall be batched and tested according to T 30. The washed gradation shall fall within the mix design tolerances.

6.4 The freshly mixed specimens may be placed directly in the sample baskets. If allowed to cool, the samples must be preheated in a 125°C oven for 25 minutes. Do not preheat the sample baskets.

6.5 Test specimens in accordance with Section 7 (Test Method) or Section 9 (Test Method B).

6.6 Perform a gradation analysis on the residual aggregate as indicated in Section 11. Compare the gradation to the gradation of the unburned, "blank" specimen to evaluate the amount of aggregate breakdown.

6.7 Once all of the calibration specimens have been burned, determine the difference between the actual and measured asphalt contents for each sample. The calibration factor is the average of the measured differences expressed in percent by weight of the asphalt mixture.

6.8 If the calibration factor exceeds 0.5 percent, lower the test temperature to 482±5°C (900±8°F) and repeat test. If the calibration factor continues to exceed 0.5 percent, lower the test temperature to 427±5°C (800±8°F) and repeat test. Continue to lower the test temperature until the calibration factor is less than 0.5 percent.

6.9 The temperature for testing HMA samples in Section 8.1 and 10.1 shall be the same temperature selected for testing mixture calibration samples.

TEST METHOD A – w/ balance

7. Apparatus

7.1 Ignition Furnace - A forced air ignition furnace, capable of maintaining the temperature at 578°C (1072°F), with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3,500 gram sample in addition to the sample baskets. A data collection system will be included so that the weight can be automatically determined and displayed during the test. The furnace shall have a built in computer program to calculate change in mass of the sample baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt content (%), test time, and test temperature. The furnace chamber dimensions shall be adequate to accommodate sample size of 3,500 grams. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.02 percent of the total sample mass for two consecutive minutes. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and when set up properly shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with capability to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

7.2 Sample Basket - of appropriate size that allows the samples to be thinly spread and allows air to flow up through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh or perforated stainless steel plate or other suitable material.

NOTE 1 - Screen mesh or other suitable material with maximum and minimum opening of 2.36 mm (No. 8) and 600 microns (No. 30) respectively has been found to perform well.

7.3 Catch Pan - of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

7.4 Oven - capable of maintaining 125±5°C (257±9°F).

7.5 Balance - of sufficient capacity and conforming to the requirements of M231 Class G2 for weighing specimen in basket(s).

7.6 Safety Equipment - safety glasses or face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 650°C(1202°F) and a protective cage capable of surrounding the sample baskets during the cooling period.

7.7 Miscellaneous Equipment - a pan larger than the sample basket(s) for transferring samples after ignition, spatulas, bowls, and wire brushes.

8. <u>Test Procedure</u>

8.1 Preheat the ignition furnace to 538°C (1000°F) or as determined in Section 6.7. Record the furnace temperature (set point) prior to the initiation of the test.

8.2 Enter the calibration factor for the specific mix to be tested as determined in Section 6 in the ignition furnace.

8.3 Weigh and record the mass of the sample basket(s) and catch pan (with guards in place).

8.4 Prepare the sample as described in Section 5. Evenly distribute this sample in the sample basket(s) that have been placed in the catch pan, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

8.5 Weigh and record the total mass of the sample, basket(s), catch pan, and basket guards. Calculate and record the initial mass of the specimen (total mass - mass of the sample basket assembly).

8.6 Input the initial mass of the sample specimen in whole grams into the ignition furnace controller. Verify that the correct mass has been entered.

8.7 Open the chamber door and place the sample basket in the furnace. Close the chamber door and verify that the sample mass (including the basket(s)) displayed on the furnace scale equals the total mass recorded in Section 8.5 within ±5 g. Differences greater than 5 grams or failure of the furnace scale to stabilize may indicate that the sample basket(s) are contacting the furnace wall. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

8.8 Allow the test to continue until the stable light and audible stable indicator indicate the test is complete (the change in mass does not exceed 0.02 percent for two consecutive minutes). Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

8.9 Open the chamber door, remove the sample basket(s) and allow to cool to room temperature (approximately 30 minutes).

TEST METHOD B - no balance

9.0 Apparatus

9.1 Ignition Furnace - A forced air ignition furnace, capable of maintaining the temperature at 578°C (1072°F). The furnace chamber dimensions shall be adequate to accommodate a sample size of 3,500 grams. The furnace door shall be equipped so that the door cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided. The furnace shall be vented into a hood or to the outside and when set up properly shall have no noticeable odors escaping into the laboratory. The furnace shall have a fan with capability to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

9.2 Sample Basket(s) - of appropriate size that allows the samples to be thinly spread and allows air to flow up through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh or perforated stainless steel plate or other suitable material.

NOTE 1 - Screen mesh or other suitable material with maximum and minimum openings of 2.36 mm (No. 8) and 600 microns (No. 30) respectively has been found to perform well.

9.3 Catch pan - of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

9.4 Oven - capable of maintaining 125±5°C (257±9°F).

9.5 Balance - of sufficient capacity and conforming to the requirements M231, Class G2.

9.6 Safety Equipment - safety glasses or face shield, high temperature gloves, long sleeve jacket, a heat resistant surface capable of withstanding 650°C (1202°F) and a protective cage capable of surrounding the sample baskets during the cooling period.

9.7 Miscellaneous Equipment - pan larger than the sample basket (s) for transferring samples after ignition, spatulas, bowls, and wire brushes.

10. Test Procedure

10.1 Preheat the ignition furnace to 538°C(1000°F) or as determined in Section 6.8.

10.2 Record the calibration factor for the specific mix to be tested as determined in Section 6.

10.3 Weigh and record the mass of the sample basket(s) and catch pan (with guards in place).

10.4 Prepare the sample as described in Section 5. Place the sample baskets in the catch pan. Evenly distribute the sample in the basket(s) taking care to keep the material away from the edges.

10.5 Weigh and record the total mass of the sample, basket(s), catch pan, and basket guards. Calculate and record the initial mass of the sample specimen (total mass - the mass of the sample basket assembly).

10.6 Burn the HMA sample in the furnace for at least 45 minutes.

10.7 Remove the sample from the furnace after ignition and allow it to cool to approximately room temperature (at least 30 minutes).

10.8 Weigh and record the mass (W_A) of the sample after ignition to the nearest 0.1 gram.

10.9 Place the sample back into the furnace.

10.10 After the furnace reaches the set temperature, burn the sample for at least 15 minutes.

10.11 Remove the sample from the furnace and allow it to cool to approximately room temperature (at least 30 minutes).

10.12 Weigh and record the mass (W_A) of the sample after ignition.

10.13 Repeat these steps until the change in measured mass (W_A) of the sample after ignition does not exceed 0.02 percent of the initial sample mass (W_S)..

10.14 Record the last value obtained for (W_A) as the mass (W_A) of the sample after ignition.

10.15 Calculate the asphalt content of the sample as follows:

M1

$$AC\% = \left[\frac{(W_S - W_A)}{W_S} \times 100\right] - C_F$$

where:

AC%	=	the measured (corrected) asphalt content percent by weight of the HMA sample.
W_A	=	the total weight of aggregate remaining after ignition.
W_S	=	the total weight of the HMA sample prior to ignition, and
C_F	=	calibration factor, percent by weight of HMA sample

11. <u>Gradation</u>

11.1 Allow the specimen to cool to room temperature in the sample baskets.

11.2 Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets.

11.3 Perform the gradation analysis according to AASHTO T 30.

12. <u>Report</u>

12.1 Always report the test method, corrected asphalt content, mix correction factor, temperature compensation factor, total percent loss, sample mass, and test temperature. Attach the original printed ticket to the report for units with internal balances.

13. <u>Precision and Bias</u>

13.1 Precision and Bias were determined in an NCAT Round-Robin study for surface mixes using Test Method A. Precision and Bias has not yet been determined for Test Method B.

TP53

Asphalt Content	Standard Deviation, %	Acceptable Range of Two Test Results, %
Single- Operator Precision	0.04	0.11
Multi laboratory Precision	0.06	0.17

Note: These precision statements are based on 4 aggregate types, 4 replicates, and 12 laboratories participating with 0 laboratory results deleted as outlying observations. All 4 aggregates were tested in surface mixes and had relatively low absorption values.

ITEM 1

ASTM Draft No. 4
(July 2, 1996)

Standard Test Method for Asphalt Content of Hot Mix Asphalt by the Ignition Method

1. Scope

1.1 This test method covers the determination of asphalt content of hot mix asphalt (HMA) paving mixtures and pavement samples by removing the asphalt cement at 538°C (1000°F) or less by ignition in a furnace. Aggregate obtained by the test method may be used for sieve analysis.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 566 Total Moisture Content of Aggregate by Drying
C 670 Preparing Precision and Bias Statements for Test Methods for Construction Materials
C 702 Reducing Field Samples of Aggregate to Testing Size
D 75 Sampling Aggregates
D 140 Sampling Bituminous Materials
D 979 Sampling Bituminous Paving Mixtures
D 1461 Moisture or Volatile Distillates in Bituminous Paving Mixtures
D 4753 Specifications for Evaluating, Selecting and Specifying Balances and Scales for Use in Testing Soils, Rock and Related Construction Materials

2.2 Furnace manufacturer's instruction manual

3. Summary of Test Methods

3.1 The asphalt cement in the paving mixture is ignited using the furnace equipment applicable to the particular method. The asphalt content is calculated by difference from the mass of the residual aggregate and moisture content. The asphalt content is expressed as mass percent of moisture-free mixtures. Method A is intended for furnaces with an internal, automated weighing system. Method B is intended for furnaces without an internal weighing system.

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4. Significance and Use

4.1 This method can be used for quantitative determinations of asphalt content in hot mix asphalt (HMA) paving mixtures and pavement samples for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents.

5. Apparatus

5.1 *Balance*, readable to 0.1 gram, and capable of measuring the mass of sample, sample trays and catch pan. The balance shall conform to the requirement of ASTM D 4753, Class GP2.

5.2 *Sample Tray(s)*, of appropriate size that allows the samples to be thinly spread and allows air to flow up through and around the sample particles. The sample shall be completely enclosed with screen mesh or perforated stainless steel plate or other suitable material.

NOTE 1 - Screen mesh or other suitable material with maximum and minimum openings of 2.36 mm (No. 8) and 600 microns (No. 30) respectively has been found to perform well.

5.3 *Catch Pan*, will be used having sufficient size to hold the sample trays so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

5.4 *Catch Pan/Sample Tray(s) Handling Apparatus*, suitable for inserting catch pan and sample tray(s) into furnace and removing hot catch pan and sample tray(s) from furnace.

5.5 *Assorted spatulas, pans, bowls and wire brushes* for preparing hot-mix asphalt mixtures and removing aggregate from sample tray(s) and catch pan.

5.6 *Protective Gloves*, well insulated and capable of withstanding 578°C (1072°F).

5.7 *Ovens*--Mechanical oven, convection or forced draft, shall be provided for drying aggregates and HMA mixtures, and preheating HMA mixtures prior to ignition testing.

6. Sampling

6.1 Obtain samples of aggregate in accordance with ASTM Method D 75.

6.2 Obtain samples of hot mix asphalt in accordance with ASTM Method D 979.

6.3 *Preparation of Test Specimens:*

6.3.1 If the mixture is not soft enough to separate with a spatula or trowel, place it in a large, flat pan and warm in an oven set at 110±5°C (230±9°F) until it can be handled or mixed. Split or

quarter the material in accordance with ASTM Method C702 until the mass of material required for the test is obtained.

6.3.2 The size of the test sample shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1 (Note 2):

NOTE 2 - When the mass of the test specimen exceeds the capacity of the equipment used (for a particular method), the test specimen may be divided into suitable increments, tested, and the results appropriately combined for calculation of asphalt content (Sections 10 or 13).

6.4 Obtain samples of asphalt cement in accordance with ASTM Method D 140.

TABLE 1 Size of Sample

Nominal Maximum Aggregate Size Standard, mm	Sieve Size	Minimum Mass of Sample, kg
4.75	No. 4	0.5
9.5	3/8 in.	1
* 12.5	1/2 in.	1.5
* 19.0	3/4 in.	2
25.0	1 in.	3
37.5	1½ in.	4

7. Hazards

7.1 The temperature of the furnace, sample, sample tray(s) and catch pan after removal from the furnace is extremely high. Caution, therefore, must be exercised at all times when handling these items as failure to do so could result in serious injury, severe burns or fire. The sample, sample tray(s) and catch pan should be placed inside a safety cage and should not be allowed to cool near any materials which are subject to ignition at the high temperatures used in this procedure.

TEST METHOD A

8. Apparatus

8.1 In addition to the apparatus listed in Section 5, the following apparatus is required for Test Method A:

8.1.1 *Furnace*, having a temperature capability of 578°C (1072°F) and having an internal weighing system capable of measuring the mass of sample sizes of at least 2500 grams. The furnace chamber shall be of sufficient size to accommodate sample sizes of at least 2500 grams. A data collection system shall also be included so that the sample mass loss can be automatically

determined to an accuracy of 0.1 gram and displayed during a test. The test is deemed complete when the measured mass loss does not exceed 0.01 percent of the sample mass for three consecutive one minute intervals. The equipment shall provide a printout of the test results. A filter capable of reducing furnace emissions to an acceptable level shall also be incorporated in the furnace. The furnace shall be vented into a hood or to the outside and when set up properly will have no noticeable odors escaping into the laboratory. Furnace will have fan with capability to pull air through the furnace to expedite the test and to reduce escape of smoke into laboratory. The furnace shall be equipped so that the door cannot be opened during the ignition test.

8.1.2 *Filters*, if required, of the type specified by the furnace manufacturer.

9. Calibration

9.1 The results of this test method may be affected by the type of aggregate in the mixture because different aggregates lose mass on ignition to varying degrees. Accordingly, to optimize accuracy, a calibration factor shall be established by testing two calibration samples for each mix type. The calibration can be performed on the aggregate blend or on a prepared sample of asphalt mixture.

9.2 Aggregate Calibration

9.2.1 Obtain samples of blended aggregate to be used in HMA in accordance with Section 6.1. The sample should be approximately the same size and gradation as that to be used for the HMA test sample (Section 10.1).

NOTE 3 - When the mass of the test specimen exceeds the capacity of the equipment, the test specimen may be divided into suitable increments in accordance with ASTM C 702. The specimens may then be tested and the results appropriately combined for calculation of a calibration factor (Section 9.2.10).

9.2.2 Oven-dry the aggregate calibration samples to a constant mass or determine moisture content of samples according to ASTM C 566 so that measured mass loss can be corrected for moisture.

9.2.3 Set the temperature of the furnace to 578±5°C (1072±8°F) for calibration using aggregate only.

NOTE 4 - The increase in temperature when burning an asphalt mixture is approximately 40°C and depends upon the amount of material and location of the temperature measuring probe. Therefore, the temperature for calibration is increased by 40°C from 538°C (1000°F) to 578°C (1072°F).

9.2.4 Determine and record the mass of the sample tray(s) and catch pan.

9.2.5 Evenly distribute the aggregate sample in the sample tray(s).

9.2.6 Determine the mass of the sample, sample tray(s) and catch pan to the nearest 0.1 gram. Calculate and record the initial mass of the sample (M_i).

9.2.7 Heat the aggregate calibration sample in the furnace at 578±5°C (1072±8°F) until the change in mass of the sample over a three minute interval does not exceed 0.01 percent of the initial sample mass (M_I).

EXAMPLE 200 GRAMS * $\frac{0.01}{100}$ = 0.2 GRAMS IN 3 MIN.

9.2.8 Measure and record the mass of the sample after heating (M_L) to the nearest 0.1 gram. The mass can be obtained immediately upon completion of the test from the printout or display.

9.2.9 Calculate the measured percent mass loss (C_S) as follows:

$$C_S = \frac{M_I - M_L}{M_I} * 100$$

where:

C_S = the measured mass loss (percent) of the calibration sample by mass of aggregate,
M_I = the mass of the aggregate calibration sample prior to heating in furnace, and
M_L = the mass of the aggregate calibration sample after heating.

9.2.10 Repeat these steps for two aggregate calibration samples. The reported calibration factor (C_F) is calculated as follows:

$$C_F = \frac{C_{S1} - C_{S2}}{2}$$

where:

C_F = the average measured mass loss (percent) of the calibration samples by mass of total mixture, and

C_{S1}, C_{S2} = the measured mass loss (percent) of calibration samples number 1 and number 2, respectively, by mass of aggregate.

9.2.11 If the difference between samples C_{S1} and C_{S2} exceeds 0.15 percent, repeat the two tests, and average the four results. If the average measured mass loss exceeds 0.5 percent, lower the test temperature to 522±5°C (972±8°F) and repeat test. If the mass loss continues to exceed 0.5 percent, lower the test temperature to 467±5°C (873±8°F) and repeat test. Use the calibration factor (C_F) determined from this step to calibrate the measured asphalt content (Section 10).

9.2.12 The temperature for burning aggregate calibration samples is increased 40°C above the temperature for burning an asphalt mixture. Therefore, if the temperature for calibration is decreased, the test temperature for burning the asphalt mixture (Section 10.3) should be 40°C lower than that used for calibration.

9.3 Mixture Calibration

9.3.1 Obtain samples of blended aggregate to be used in HMA in accordance with Section 6.1. The sample should be approximately the same size and gradation as that to be used for the HMA test sample (Section 10.1).

NOTE 5 - When the mass of the test specimen exceeds the capacity of the equipment, the test specimen may be divided into suitable increments. The specimens may then be tested and the results appropriately combined for calculation of a calibration factor (Section 9.3.14).

9.3.2 Obtain samples of asphalt cement to be used in HMA in accordance with Section 6.4.

9.3.3 Oven-dry the aggregate samples to a constant mass.

9.3.4 Set the furnace temperature to 538±5°C (1000±8°F) for calibration using mixtures only.

9.3.5 Heat the aggregates and asphalt cement to approximately 150°C (300°F). Heat all mixing bowls and tools to approximately 150°C (300°F).

9.3.6 Prior to mixing of calibration samples, an initial or "butter" mix is required to condition the mixing equipment. Remove and discard the "butter" mix from the bowl by scraping, leaving a uniform coating of asphalt mix residue.

NOTE 6 - The "butter" mix prevents calibration samples from being biased by residual asphalt mix retained in the mixing bowl.

9.3.7 Prepare two calibration samples at the design asphalt cement content.

9.3.8 Determine and record the mass of the sample tray(s) and catch pan to the nearest 0.1 gram.

9.3.9 Evenly distribute the sample in the sample tray(s).

9.3.10 Determine the mass of the sample, sample tray(s) and catch pan to the nearest 0.1 gram. Calculate and record the initial mass of the sample (M_I).

9.3.11 Heat the calibration sample in the furnace at 538±5°C (1000±8°F) until the change in mass of the sample over a three minute interval does not exceed 0.01 percent of the sample mass (M_I).

9.3.12 Measure and record the mass (M_L) of the sample after ignition to the nearest 0.1 gram. The mass can be obtained immediately upon completion of the test from printout or display.

9.3.13 Calculate the measured percent mass loss (C_S) as follows:

$$C_S = \frac{M_I(1-AC)-M_L}{M_I(1-AC)} \cdot 100$$

where:

C_S = measured mass loss (percent) of the calibration sample by mass of aggregate,
M_L = total mass of the mixture calibration sample after ignition,
M_I = total mass of the mixture calibration sample prior to ignition, and
AC = percentage of asphalt cement in the mix by mass of the total mix expressed as a fraction.

9.3.14 Repeat these steps for two calibration samples. The reported calibration factor (C_F) is calculated as follows:

$$C_F = \frac{C_{S1}+C_{S2}}{2}$$

where:

C_F = the average measured mass loss (percent) of the calibration samples by mass of total aggregate, and
C_{S1}, C_{S2} = the measured mass loss (percent) of calibration samples number 1 and number 2, respectively, by mass of total aggregate.

9.3.15 If the difference between samples C_{S1} and C_{S2} exceeds 0.15 percent, repeat the two tests, and average the four results. If the average measured mass loss exceeds 0.5 percent, lower the test temperature to 482±5°C (900±8°F) and repeat test. If the mass loss continues to exceed 0.5 percent, lower the test temperature to 427±5°C (800±8°F) and repeat test. Use the calibration factor (C_F) determined from this step to calibrate the measured asphalt content (Section 10).

9.3.16 The temperature for testing HMA samples in Section 10.3 shall be the same temperature selected for testing mixture calibration samples.

10. Procedure

10.1 Obtain an HMA sample in accordance with Section 6.2.

10.2 Oven-dry the HMA sample to constant mass at a temperature of 105±5°C (221±9°F) or determine the moisture content of samples according to ASTM D 1461 so that the measured mass loss can be corrected for moisture.

10.3 Set the furnace temperature to 538±5°C (1000±8°F) or as determined in Section 9.2.12 or 9.3.15. Samples can be placed in the furnace at significantly lower temperature since the furnace will quickly heat to the desired temperature once the sample begins to burn. The furnace temperature is likely to increase during the ignition phase of the test.

10.4 Determine and record the mass of the sample tray(s) and catch pan to the nearest 0.1 gram.

10.5 Evenly distribute the sample over the entire area of the sample tray(s).

10.6 Determine the mass of the sample, sample tray(s) and catch pan to the nearest 0.1 gram. Calculate and record the initial mass of the sample (M_B).

10.7 Heat the sample in the furnace at the specified temperature until the change in mass of the sample over a three minute interval does not exceed 0.01 percent of the sample mass (M_B).

10.8 Measure and record the aggregate mass (M_A) of the sample after ignition to the nearest 0.1 gram. The mass can be obtained immediately upon completion of tests by subtracting the mass loss measured by the furnace from the initial mass of the mix (M_B).

10.9 Calculate the corrected asphalt content as follows:

$$\%AC = \frac{1 - \frac{M_A}{M_B} - C_F}{(1 - C_F)} \cdot 100$$

where:
AC = measured asphalt content percent by mass of the oven-dry HMA sample
M_A = total mass of aggregate remaining after ignition,
M_B = total mass of the HMA sample prior to ignition, and
C_F = calibration factor obtained in Section 9 expressed as a fraction.

TEST METHOD B

11. Apparatus

11.1 In addition to the apparatus listed in Section 5, the following apparatus is required for Test Method B:

11.1.1 *Furnace*, having a temperature capability of 578°C (1072°F) and equipped with a fan capable of pulling air through the furnace to expedite the test and to reduce escape of smoke into the

laboratory. The furnace chamber shall be of sufficient size to accommodate samples sizes of at least 2500 grams. A filtering system capable of reducing furnace emissions to an acceptable level shall also be incorporated in the furnace. The furnace shall be vented into a hood or to the outside and when set up properly will have no noticeable odors escaping into the laboratory. The furnace shall be equipped so that the door cannot be opened during the ignition test.

11.1.2 *Filters*, if required, of the type specified by the furnace manufacturer.

12. Calibration

12.1 The results of this test method may be affected by the type of aggregate in the mixture because different aggregates lose mass on ignition to varying degrees. Accordingly, to optimize accuracy, a calibration factor shall be established by testing two calibration samples for each mix type. The calibration can be performed on the aggregate blend or on a sample of prepared asphalt mixture.

12.2 Aggregate Calibration

12.2.1 Obtain samples of blended aggregate to be used in HMA in accordance with Section 6.1. The sample should be approximately the same size and gradation as that to be used for the HMA test sample (Section 13.1).

NOTE 7 - When the mass of the test specimen exceeds the capacity of the equipment, the test specimen may be divided into suitable increments in accordance with ASTM C 702. The specimens may then be tested and the results appropriately combined for calculation of a calibration factor (Section 12.2.10).

12.2.2 Dry the aggregate calibration samples to a constant mass or determine moisture content of samples according to ASTM C 566 so that measured mass loss can be corrected for moisture.

12.2.3 Set the temperature of the furnace to 578±5°C (1072±8°F) for calibration using aggregate only.

NOTE 8 - The increase in temperature when burning an asphalt mixture is approximately 40°C. Therefore, the temperature for calibration is increased by 40°C from 538°C (1000°F) to 578°C (1072°F).

12.2.4 Determine and record the mass of the sample tray(s) and catch pan to the nearest 0.1 gram.

12.2.5 Evenly distribute the aggregate sample in the sample tray(s).

12.2.6 Determine the mass of the aggregate sample, sample tray(s) and catch pan to the nearest 0.1 gram. Calculate and record the initial mass of the sample (M_i).

12.2.7 Heat the aggregate calibration sample in the furnace at 578±5°C (1072±8°F) for at least 45 minutes.

12.2.8 Remove the sample from the furnace and allow it to cool to approximately room temperature.

12.2.9 Measure and record the mass (M_L) of the sample after heating in the furnace to the nearest 0.1 gram.

12.2.10 Place the sample back into the furnace.

12.2.11 After the furnace reaches the set point temperature, heat the calibration sample for 15 minutes.

12.2.12 Remove the sample from the furnace and allow it to cool to approximately room temperature.

12.2.13 Measure and record the mass of the sample after heating (M_L) to the nearest 0.1 gram.

12.2.14 Repeat these steps until the change in measured mass (M_L) of the sample after heating does not exceed 0.01 percent of the initial sample mass (M_I).

12.2.15 Record the last value obtained for (M_I) as the mass (M_L) of the sample after heating in the furnace.

12.2.16 Calculate the measured percent mass loss (C_S) as follows:

$$C_S = \frac{M_I - M_L}{M_I} \cdot 100$$

where:

C_S = the measured mass loss (percent) of the calibration sample by mass of aggregate,
M_I = the mass of the aggregate calibration sample prior to heating in the furnace, and
M_L = the mass of the aggregate calibration sample after heating in the furnace.

12.2.17 Repeat these steps for two aggregate calibration samples. The reported calibration factor (C_F) is calculated as follows:

$$C_F = \frac{C_{S1} - C_{S2}}{2}$$

where:

C_F = the average measured mass loss (percent) of the calibration samples by mass of total mixture, and

C_{S1}, C_{S2} = the measured mass loss (percent) of calibration samples number 1 and number 2, respectively, by mass of aggregate.

12.2.18 If the difference between samples C_{S1} and C_{S2} exceeds 0.15 percent, repeat the two tests and average the four results. If the averaged measured mass loss exceeds 0.5 percent, lower the test temperature to 522±5°C (972±8°F) and repeat test. If the mass loss continues to exceed 0.5 percent, lower the test temperature to 467±5°C (873±8°F) and repeat test. Use the calibration factor (C_F) determined from this step to calibrate the measured asphalt content (Section 13).

12.2.19 The temperature for burning aggregate calibration samples is increased 40°C above the temperature for burning an asphalt mixture. Therefore, if the temperature for calibration is decreased, the test temperature for burning the asphalt mixture (Section 12.3) should be 40°C lower than that used for calibration.

12.3 Mixture Calibration

12.3.1 Obtain samples of blended aggregate to be used in HMA in accordance with Section 6.1. The sample should be approximately the same size and gradation as that to be used for the HMA test sample (Section 9.1).

NOTE 9 - When the mass of the test specimen exceeds the capacity of the equipment, the test specimen may be divided into suitable increments. The specimens may then be tested and the results appropriately combined for calculation of a calibration factor (Section 12.3.21).

12.3.2 Obtain samples of asphalt cement to be used in HMA in accordance with Section 6.4.

12.3.3 Dry the aggregate samples to a constant mass.

12.3.4 Set the furnace temperature to 538±5°C (1000±8°F) for calibration using mixtures only.

12.3.5 Heat the aggregates and asphalt cement to approximately 150°C (300°F). Heat all mixing bowls and tools to approximately 150°C (300°F).

12.3.6 Prior to mixing of calibration samples, an initial or "butter" mix should be required to condition the mixing equipment. Remove the "butter" mix from the bowl by scraping, leaving a uniform coating of asphalt mix residue.

NOTE 10 - The "butter" mix prevents calibration samples from being biased by residual asphalt mix retained in the mixing bowl.

12.3.7 Prepare two calibration samples at the design asphalt cement content.

12.3.8 Determine and record the mass of the sample tray(s) and catch pan to the nearest 0.1 gram.

12.3.9 Evenly distribute the sample over the entire area of the sample tray(s).

12.3.10 Determine the mass of the sample, sample tray(s) and catch pan to the nearest 0.1 gram. Calculate and record the initial mass of the sample (M_I).

12.3.11 Heat the calibration sample in the furnace at 538±5°C (1000±8°F) for at least 45 minutes.

12.3.12 Remove the sample from the furnace and allow it to cool to approximately room temperature.

12.3.13 Measure and record the mass (M_L) of the sample after ignition to the nearest 0.1 gram.

12.3.14 Place the sample back into the furnace.

12.3.15 After the furnace reaches the set point temperature, heat the calibration sample for 15 minutes.

12.3.16 Remove the sample from the furnace and allow it to cool to approximately room temperature.

12.3.17 Measure and record the mass (M_L) of the sample after ignition to the nearest 0.1 gram.

12.3.18 Repeat these steps until the change in measured mass (M_L) of the sample after ignition does not exceed 0.01 percent of the initial sample mass (M_I).

12.3.19 Record the last value obtained for (M_L) as the mass (M_L) of the sample after ignition.

12.3.20 Calculate the measured percent mass loss (C_S) as follows:

$$C_s = \frac{M_I(1-AC)-M_L}{M_I(1-AC)} \cdot 100$$

where:

C_S = measured mass loss (percent) of the calibration sample by mass of aggregate.
M_L = total mass of the calibration sample after ignition.
M_I = total mass of the calibration sample prior to ignition, and
AC = percentage of asphalt in the mix by mass of the total mix expressed as a fraction.

12.3.21 Repeat these steps for two calibration samples. The reported calibration factor (C_F) is calculated as follows:

$$C_F = \frac{C_{S1} + C_{S2}}{2}$$

where:

C_F = the average measured mass loss (percent) of the calibration samples by mass of total aggregate, and

C_{S1}, C_{S2} = the measured mass loss (percent) of calibration samples number 1 and number 2 respectively by mass of total aggregate.

12.3.22 If the difference between samples C_{S1} and C_{S2} exceeds 0.15 percent, repeat the two tests and average the four results. If the average measured mass loss exceeds 0.5 percent, lower the test temperature to 482±5°C (900±8°F) and repeat test. If the mass loss continues to exceed 0.5 percent, lower the test temperature to 427±5°C (800±8°F) and repeat test. Use the calibration factor (C_F) determined from this step to calibrate the measured asphalt content (Section 13).

12.3.23 The temperature for testing HMA samples in Section 13.3 shall be the same temperature selected for testing mixture calibration samples.

13. Procedure

13.1 Obtain an HMA sample in accordance with Section 6.2.

13.2 Oven-dry the HMA sample to constant mass at a temperature of 105±5°C (221±9°F) or determine the moisture content of samples according to ASTM D 1461 so that the measured mass loss can be corrected for moisture.

13.3 Set the furnace temperature to 538±5°C (1000±8°F) or as determined in Section 12.2.19 or 12.3.22. Samples can be placed in the furnace at significantly lower temperatures since the furnace will quickly heat to the desired temperature once the sample begins to burn. The furnace temperature is likely to increase during the ignition phase of the test.

13.4 Determine and record the mass of the sample tray(s) and catch pan to the nearest 0.1 gram.

13.5 Evenly distribute the sample in the sample tray(s).

13.6 Determine the mass of the sample, sample tray(s) and catch pan to the nearest 0.1 gram. Calculate and record the initial mass of the sample (M_B).

13.7 Heat the HMA sample in the furnace at 538±5°C (1000±8°F) for at least 45 minutes.

13.8 Remove the sample from the furnace after ignition and allow it to cool to approximately room temperature.

13.9 Measure and record the mass (M_A) of the sample after ignition to the nearest 0.1 gram.

13.10 Place the sample back into the furnace.

13.11 After the furnace reaches the set point temperature, heat the sample for at least 15 minutes.

13.12 Remove the sample from the furnace and allow it to cool to approximately room temperature.

13.13 Measure and record the mass (M_A) of the sample after ignition to the nearest 0.1 gram.

13.14 Repeat these steps until the change in measured mass (M_A) of the sample after ignition does not exceed 0.01 percent of the initial sample mass (M_B).

13.15 Record the last value obtained for (M_A) as the mass (M_A) of the sample after ignition.

13.16 Calculate the corrected asphalt content as follows:

$$\%AC = \frac{1 - \frac{M_A}{M_B} - C_F}{(1 - C_F)} * 100$$

where:
AC = measured asphalt content percent by mass of the oven-dry HMA sample.
M_A = total mass of aggregate remaining after ignition,
M_B = total mass of the HMA sample prior to ignition, and
C_F = calibration factor, obtained in Section 12 expressed as a fraction.

14. Report

14.1 The report shall include the following:

14.1.1 Date.

14.1.2 Identification of aggregate and mix type.

14.1.3 Test number.

14.1.4 Calibration data,

14.1.5 Mass of HMA sample before and after ignition (nearest 0.1 gram),

14.1.6 Measured asphalt content (nearest 0.01%), and

14.1.7 Aggregate gradation, if performed.

15. Precision and Bias

15.1 The single-laboratory standard deviation for asphalt content has been found to be 0.04%. Therefore, results of two properly conducted tests by the same operator on the same aliquot samples of HMA should not differ by more than 0.11% (Notes 11, 12 and 13).

15.2 The multi-laboratory standard deviation for asphalt content has been found to be 0.06%. Therefore, the results of two properly conducted tests from two different laboratories on HMA samples from the same batch should not differ by more than 0.17% (Notes 11, 12 and 13).

15.3 The bias for this test method is currently under development.

NOTE 11 - These numbers represent, respectively the (1S) and (D2S) limits as described in Recommended Practice ASTM C 670.

NOTE 12 - These precision statements are based on 4 aggregate types, 4 replicates, and 12 laboratories participating with no laboratory results deleted as outlying observations. All four aggregates had relatively low absorption values (water absorption values ranging from 0.5% to 0.8%).

NOTE 13 - These precision statements are applicable to Test Method A only, using laboratory prepared mixtures (not plant-mixed pavement samples). The precision of Test Method B has not been determined.

16. Keywords

16.1 asphalt content; ignition method; hot mix asphalt; asphalt paving mixtures

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