Round-Robin Study of Asphalt-Concrete Content by Ignition

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The National Center for Asphalt Technology (NCAT) has developed a test method to determine the asphalt content of hot-mix asphalt (HMA) mixtures by ignition. In the ignition method, an HMA sample is subjected to heat of 538°C (1,000°F) in a furnace to ignite and burn the asphalt cement (AC) from the aggregate. The difference in weight of the sample before and after is used to determine the asphalt content of the mixture. The aggregate recovered after ignition testing may then be used for gradation analysis. A round-robin study was completed by NCAT to determine the accuracy and precision of the ignition method. The round-robin test program is discussed, as well as the accuracy and precision values determined for the measured AC content and gradation using the ignition method. The results of the round-robin study indicate that the ignition method can measure the AC content of HMA mixtures with greater precision than solvent-extraction methods, without significantly affecting the gradation of the aggregate. This test method has shown excellent potential for replacing existing test methods for measuring asphalt content.

The National Center for Asphalt Technology (NCAT) has developed a test procedure to measure the asphalt content of hot-mix asphalt (HMA) mixtures by ignition. This test burns the asphalt cement (AC) from the mixture and provides information necessary to determine the AC content. Because the procedure is new, its accuracy and precision need to be determined.

OBJECTIVE

A study was undertaken to determine the accuracy and precision values for asphalt content determination by the ignition test method. The study was also intended to determine the accuracy and precision values for the measured gradation of the aggregate recovered after the asphalt was removed from the mix.

SCOPE

The round-robin study was performed according to ASTM C802 standard practice for conducting an interlaboratory test program to determine the precision of test methods for construction materials. A minimum of 10 participating laboratories is recommended by ASTM. NCAT chose 13 laboratories throughout the United States, including those of state departments of transportation, HMA producers, and FHWA.

Each laboratory was supplied with one NCAT asphalt content tester and two sets of sample baskets for testing. Four different HMA mixture types consisting of different aggregates, gradations, and asphalt contents were prepared at NCAT and sent to the participant laboratories for asphalt content determination and gradation analysis. The laboratories had no knowledge of the asphalt content or gradation of the HMA samples. A test procedure, instructions, and summary data sheets were sent to each laboratory along with the test samples. Each laboratory was asked to follow the test procedure provided and report the results to NCAT for analysis. The collected interlaboratory test data were analyzed, and the accuracy and precision values for the HMA properties were calculated using appropriate statistical methods.

INTERLABORATORY TEST PROGRAM

Material and Sample Preparation

HMA mixtures were prepared with four different types of aggregate and one type of AC. The materials used to prepare the HMA test samples were as follows: Aggregate 1 was gravel; Aggregate 2 was granite; Aggregate 3 was limestone; Aggregate 4 was traprock; and the AC grade was AC = 20. Calibration samples also were made with the same four aggregate types but were not mixed with AC. HMA samples were prepared with a known AC content and gradation, as listed in Table 1. Four different dense gradations and three different asphalt contents ranging from 5.0 to 6.0 percent were used in preparing the four HMA mixture types.

Each aggregate type was oven dried and then separated into individual sieve sizes to meet the desired gradation. The approximate batch weight of each sample was 1200 g (42 oz). Samples of each mix type were batched and a washed-sieve analysis was performed according to ASTM C136 and ASTM C117 to determine the true gradation. The average of these values (Table 1) provides the best measure of the true gradation of each mix type. The specific gravity and absorption of each aggregate blend are also shown in Table 1. The absorption values for the four aggregates were relatively low.

After the aggregate was batched, HMA samples were prepared by mixing the aggregate with the required amount of AC. The mixing equipment was conditioned with a "butter" mix of aggregate and AC before mixing the test samples. The butter mix uniformly coats the mixing equipment so that subsequent samples can be more completely removed from the equipment after mixing.

Sample Packaging

A container that could withstand heat from the hot samples and would allow easy removal of the sample at each of the participating laboratories was necessary for shipping the HMA samples to

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TABLE 1 Aggregate Type, Properties, Gradation, and AC Content for Mixes Used in Round-Robin Study

Aggregate	Gravel	Granite	Limestone	Traprock
Absorption, %	0.69	0.44	0.94	0.83
Bulk Specific Gravity	2.603	2.704	2.687	2.942
AC Content, %	6.00*	6.00*	5.00*	5.50*
Aggregate Gradation Sieve Size	Percent Passing			
19 mm (3/4 inch)	100.0	100.0	100.0	100.0
12.5 mm (½ inch)	97.3	97.7	97.4	97.0
9.5 mm (3/8 inch)	88.5	85.8	85.6	83.5
4.75 mm (No. 4)	71.6	66.8	61.4	57.0
2.36 mm (No. 8)	50.6	50.1	43.5	39.9
1.18 mm (No. 16)	35.7	36.0	30.8	29.1
600 microns (No. 30)	25.1	25.3	22.0	20.2
300 microns (No. 50)	15.3	16.1	14.6	13.6
150 microns (No. 100)	8.9	10.9	9.3	8.4
75 microns (No. 200)	6.0	7.7	6.7	5.3

*Aggregate was also provided with the same gradation, but with no asphalt cement for calibration.

each laboratory. Different types of containers were evaluated, and cardboard box with a waxlike coating on the inside was selected and obtained from the Menasha Corporation in Menasha, Wisconsin. This container could be heated without damage, and the coating minimized the amount of the sample that remained in the container. Samples were placed in the container for shipping immediately after preparation. Calibration samples (aggregate only) were placed in plastic ziplock bags for shipping. These samples could then be removed from the bags and placed in metal bowls for heating in an oven before ignition testing. Before sending the samples to each laboratory, each sample was weighed to confirm that correct total weight was provided in each container.

The samples were labeled according to the type of mix and were given a number representing either a calibration sample or an HMA sample. Mix types 1, 2, 3, and 4 were labeled A, B, C, and D, respectively. Samples 1 through 4 represented HMA samples and Samples 5 through 8 represented calibration samples. Figure 1 shows a shipping carton containing an HMA sample.

Equipment

Each laboratory was supplied with one asphalt content tester and two sets of sample baskets. The test equipment and sample baskets are shown in Figures 2 and 3.

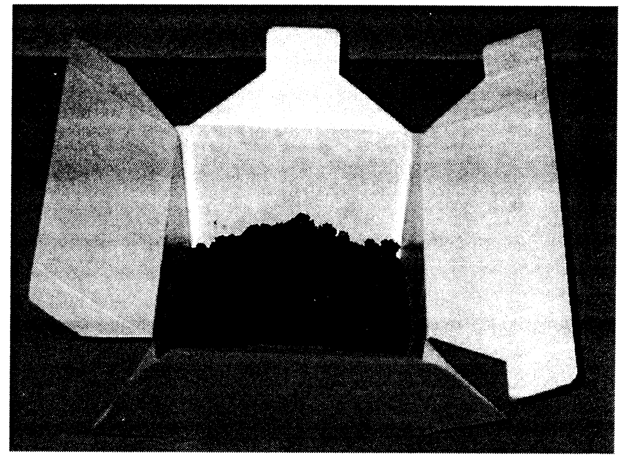

FIGURE 1 Shipping carton containing HMA test sample.

The tester consists of a muffle furnace with a built-in scale that continuously weighs a sample during a test. The unit measures and displays weight loss of a sample with a digital readout. A built-in printer prints the asphalt content result. The unit has a filter that is estimated to reduce by 90 percent the smoke produced during ignition of AC. An operator is only required to input the weight of a sample, the required test temperature, and the calibration factor before beginning the test. The furnace has an audible alarm that sounds when the test is finished, enabling an operator to perform other tasks while the test is in progress.

The sample baskets consist of two stainless steel No. 8 mesh trays, which are stacked on top of each other and placed on top of a flat stainless steel catch pan. An HMA test or calibration sample is divided into two equal portions, each of which is placed into a mesh tray. The two mesh trays are fastened to the catch pan with a safety strap and are inserted into the furnace.

Test Procedure

A test procedure for the interlaboratory test program was developed and provided to each participant. The procedure was developed for use solely with this study's test equipment. The test procedure was written so that an operator could perform the test easily in a step-by-step process and every laboratory would perform the test in an identical manner. Each laboratory was provided with two extra HMA samples to allow its operator to become familiar with the test procedure and to ensure that the equipment was functioning properly before testing of the round-robin samples was initiated.

Research at NCAT has indicated that the optimum temperature for ignition testing of most aggregates is 538°C (1,000°F) (*1–3*). Higher temperatures increase the loss of aggregate mass for some aggregates. Lower test temperatures can significantly decrease the amount of loss and excessively increase the test time. Therefore, the test procedure for the round-robin study used a test temperature of 538°C for the HMA samples to minimize loss of aggregate mass and test time. The samples were burned until the measured weight did not exceed 0.1 g (0.004 oz) for 3 consecutive min. The time required to achieve a constant weight was approximately 30 to 40 min. Dur-

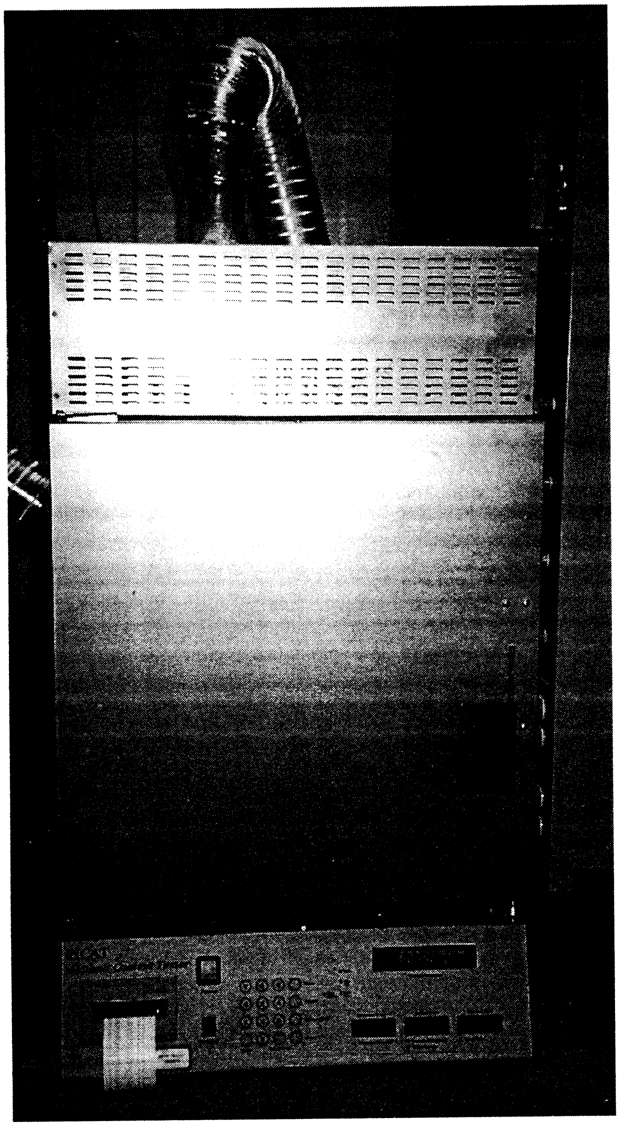

FIGURE 2 AC-content tester.

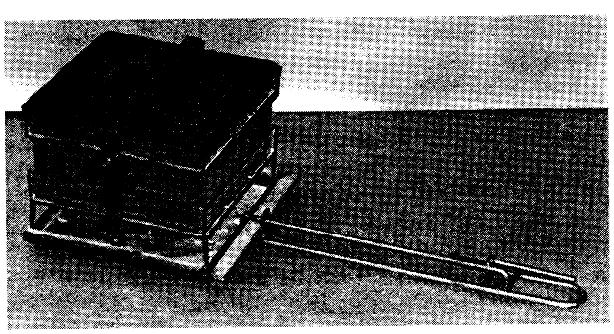

FIGURE 3 Test sample baskets.

ing testing of HMA samples the temperature inside the furnace increased approximately 40°C (72°F) to 578°C (1,072°F) after the AC ignited.

Most aggregates typically will experience some mass loss (usually less than 0.4 percent during ignition testing. As a result, the measured weight loss of HMA samples will consist of the weight loss of both the AC and the aggregate. Therefore, to increase accuracy, calibration samples (aggregate only) were burned to determine the amount of loss of aggregate mass for each aggregate type. The weight loss of calibration samples is usually approximately equal to that of HMA samples, as shown in Table 2. To subject the calibration samples to the same test conditions as the HMA samples, the test procedure called for burning calibration samples for 40 min at a test temperature of 578°C. The measured weight loss of HMA samples produced at an asphalt plant may also consist of moisture in the aggregate. Determination of the moisture content of the HMA may be required before ignition testing. Samples used for the round-robin study were manufactured in the laboratory with aggregate that was oven dried. Therefore, the round-robin test procedure did not include moisture-content determination.

Interlaboratory Testing Results

The results of the round-robin study were collected from each laboratory and analyzed for accuracy and precision according to ASTM C802 and ASTM C670. Data from 12 laboratories were used to determine the precision and accuracy of the test method. One of the 13 laboratories did not report any results. The measured AC content, percentage passing through the 4.75-mm (No. 4) sieve, and percentage passing through the 75-micron (No. 200) sieve for each laboratory are shown in Tables 2 through 4. A total of 15 samples from 8 laboratories were damaged before or during the test. ASTM C802 recommends making additional samples and collecting the missing data if the number of missing data from all the laboratories exceeds 1 percent of the total. Because missing data in this study was 7.8 percent of the 192 samples sent to round-robin participants and exceeded the minimum recommended percentage, additional samples were prepared and sent to the 8 laboratories. In all, 15 replacement samples were sent. The original damaged samples were discarded, and the replacement samples were tested and used in the analysis for accuracy and precision.

Table 2 indicates that all of the measured asphalt contents for the four repetitions of the four mixes are quite close to the true asphalt content of 6.0 percent. The greatest deviation from the true asphalt content was only 0.23 percent. No sample was discarded as an outlier.

Table 3 indicates that the measured percentage passing the 4.75-mm (No. 4) sieve for each test is quite close to the actual percentage passing as determined before the ignition test. The worst test result deviated 1.2 percent from the actual percentage passing. This amount of variability is acceptable.

Table 4 indicates there is more variability in the percentage passing the 75-micron (No. 200) sieve than in the percentage passing the 4.75-mm (No. 4) sieve. The worst test result for these samples deviated by 2.9 percent from the true percentage passing. It appears that 5 of the 16 test results from Laboratory 11 are in error. Although these five tests appear to be outliers, they were used to calculate precision and accuracy. Excluding the "bad" tests from Laboratory 11, the worst test result of the remaining 187 tests deviates from the actual gradation by 1.7 percent.

TABLE 2 Measured AC Content

Lab	Sample	Measured AC Content, % Mix 1	Mix 2	Mix 3	Mix 4
1	1	5.96	6.02	5.03	5.73
1	2	5.98	6.03	5.05	5.49
1	3	6.01	6.05	5.05	5.50
1	4	5.99	6.06	5.07	5.54
2	1	5.88	6.00	4.88	5.51
2	2	5.93	6.02	4.91	5.49
2	3	5.96	6.01	4.90	5.58
2	4	5.94	5.95	4.93	5.58
3	1	5.98	5.87	4.97	5.50
3	2	6.01	5.96	4.88	5.56
3	3	6.00	5.97	5.00	5.54
3	4	5.94	6.00	4.94	5.51
4	1	5.97	5.98	4.87	5.52
4	2	6.01	5.99	5.03	5.54
4	3	6.02	5.99	4.99	5.54
4	4	5.99	6.00	4.97	5.48
5	1	5.98	5.98	5.00	5.43
5	2	5.97	6.00	4.89	5.40
5	3	5.99	6.01	4.99	5.40
5	4	6.00	5.99	4.89	5.41
6	1	5.93	6.01	4.98	5.57
6	2	6.01	5.95	4.98	5.54
6	3	5.99	5.97	4.99	5.52
6	4	5.96	5.99	5.01	5.55
7	1	5.95	5.91	4.90	5.47
7	2	5.97	5.95	4.90	5.49
7	3	6.01	5.92	4.90	5.38
7	4	5.95	5.97	4.91	5.39
8	1	5.84	6.00	4.89	5.50
8	2	5.90	6.02	5.04	5.54
8	3	6.00	5.98	5.03	5.60
8	4	5.92	5.97	4.88	5.60
9	1	6.06	6.05	5.00	5.70
9	2	6.07	6.09	4.97	5.64
9	3	6.10	6.09	5.02	5.58
9	4	6.03	6.10	5.01	5.52
10	1	5.98	6.04	4.95	5.59
10	2	5.92	5.99	5.03	5.59
10	3	5.99	5.99	5.04	5.64
10	4	6.01	6.01	5.03	5.63
11	1	6.02	5.93	5.01	5.60
11	2	5.97	5.95	5.11	5.54
11	3	5.99	6.02	4.95	5.52
11	4	5.83	6.01	4.94	5.49
12	1	6.00	5.95	4.93	5.45
12	2	6.00	5.99	4.98	5.47
12	3	5.95	5.96	4.94	5.49
12	4	6.00	6.02	4.93	5.49
Average		5.98	5.99	4.97	5.53
True		6.00	6.00	5.00	5.50

TABLE 3 Measured Percentage Passing 4.75-mm Sieve

Lab	Sample	Measured Percent Passing 4.75 mm (No. 4) Sieve Mix 1	Mix 2	Mix 3	Mix 4
1	1	71.2	66.4	61.2	56.5
1	2	71.4	66.4	61.3	56.4
1	3	71.4	66.2	61.0	56.6
1	4	71.1	66.4	61.1	56.5
2	1	71.0	66.0	61.0	56.0
2	2	71.0	67.0	61.0	56.0
2	3	71.0	66.0	61.0	56.0
2	4	71.0	66.0	62.0	56.0
3	1	71.9	67.0	61.2	56.7
3	2	71.6	67.1	61.6	57.7
3	3	71.7	67.1	61.5	56.6
3	4	71.6	67.5	61.7	56.8
4	1	71.5	66.6	61.3	56.8
4	2	71.9	66.3	61.4	56.7
4	3	71.7	66.7	61.9	56.6
4	4	71.8	66.5	61.6	56.2
5	1	71.3	66.7	61.3	56.4
5	2	71.1	66.7	61.1	56.3
5	3	71.4	66.7	61.2	56.8
5	4	71.5	66.7	61.2	56.3
6	1	71.6	67.2	61.4	56.6
6	2	71.9	67.2	61.5	56.3
6	3	71.8	66.7	61.4	56.5
6	4	71.8	66.8	61.4	56.5
7	1	71.8	66.4	61.2	56.4
7	2	71.5	66.7	61.0	57.1
7	3	71.2	66.9	61.0	56.2
7	4	71.7	66.8	61.1	56.6
8	1	71.0	66.3	60.9	56.3
8	2	70.9	66.4	61.6	56.8
8	3	71.6	66.2	61.3	56.5
8	4	71.1	66.2	61.1	56.3
9	1	71.5	67.2	61.3	56.7
9	2	71.3	66.9	61.6	56.4
9	3	71.4	67.0	61.4	56.2
9	4	71.1	66.9	61.2	56.8
10	1	71.6	66.2	61.3	57.0
10	2	71.8	66.5	61.4	57.0
10	3	71.4	66.2	61.6	56.9
10	4	71.2	66.3	61.2	56.4
11	1	71.3	66.3	60.9	56.1
11	2	71.1	66.3	61.6	56.8
11	3	71.1	66.5	61.1	56.2
11	4	71.5	66.3	61.6	56.8
12	1	71.9	67.1	61.3	57.2
12	2	72.0	67.4	61.5	57.0
12	3	71.2	66.6	62.5	58.2
12	4	71.6	67.0	61.7	56.5
Average		71.5	66.6	61.4	56.6
Control		71.6	66.8	61.4	57.0

TABLE 4 Measured Percentage Passing 75-µm Sieve

Lab	Sample	Measured Percent Passing 75 micron (No. 200) Sieve			
		Mix 1	Mix 2	Mix 3	Mix 4
1	1	5.9	8.0	7.1	5.5
1	2	5.9	8.1	7.3	5.4
1	3	6.0	7.8	7.2	5.2
1	4	5.9	7.6	7.3	5.3
2	1	5.8	7.6	6.8	5.0
2	2	5.0	8.0	8.0	5.0
2	3	5.8	7.5	6.6	4.0
2	4	5.8	7.9	7.5	5.0
3	1	6.6	8.4	7.1	5.5
3	2	6.5	8.8	7.4	5.5
3	3	6.5	8.7	8.4	5.3
3	4	6.5	8.5	8.0	5.5
4	1	5.3	8.2	6.9	5.4
4	2	5.5	8.1	6.9	4.8
4	3	5.8	8.3	8.1	4.7
4	4	5.8	8.3	6.9	4.8
5	1	5.6	8.5	7.1	5.5
5	2	4.9	8.1	6.9	5.5
5	3	5.9	7.9	6.7	5.5
5	4	5.5	8.0	7.0	5.2
6	1	5.8	8.0	6.8	5.2
6	2	6.4	7.5	8.0	5.3
6	3	6.4	7.7	8.1	5.3
6	4	5.5	8.1	7.0	5.3
7	1	6.2	8.0	7.7	5.2
7	2	5.9	8.1	7.0	5.1
7	3	5.9	7.7	7.8	5.3
7	4	6.3	7.5	6.7	4.9
8	1	4.5	6.5	7.1	4.4
8	2	4.7	7.1	6.4	4.6
8	3	5.0	6.5	5.8	3.7
8	4	4.8	7.0	6.0	3.9
9	1	5.7	8.0	8.0	5.3
9	2	5.9	8.2	8.0	5.1
9	3	5.5	7.7	7.0	5.3
9	4	6.3	8.2	6.8	4.9
10	1	5.4	7.6	7.2	5.1
10	2	5.2	7.6	7.4	5.1
10	3	5.3	7.1	7.2	4.9
10	4	6.0	7.5	7.4	5.0
11	1	3.2	4.8	7.5	4.7
11	2	3.2	5.0	6.6	4.7
11	3	3.2	8.5	6.7	5.2
11	4	6.1	7.3	6.4	5.0
12	1	6.5	8.4	7.0	5.1
12	2	6.0	7.9	7.3	5.6
12	3	6.0	7.7	8.3	5.6
12	4	5.7	8.2	7.3	5.0
Average		5.6	7.7	7.2	5.1
Control		6.0	7.7	6.7	5.3

Statistical Analysis

Determination of Within- and Between-Laboratory Variances

The within- and between-laboratory variances were determined according to ASTM C802. The test for outliers and homogeneity of variance was not performed on the data for this study. All data were included in the analysis. The components of variance, variances, and standard deviations were also calculated according to ASTM C802.

Measured AC Content

Each laboratory conducted ignition testing for 16 HMA samples. Four replicates of four mixtures were tested for AC content determination. The measured asphalt contents for Mix 1 ranged from 5.83 to 6.07 percent. Mix 2–measured AC contents ranged from 5.87 to 6.10 percent. The true AC content for Mixes 1 and 2 was 6.00 percent. The true AC contents for Mixes 3 and 4 were 5.00 and 5.50 percent, respectively. The measured AC contents for Mix 3 ranged from 4.87 to 5.11 percent. Measured AC contents for Mix 4 ranged from 5.38 to 5.73 percent. The maximum difference between the true AC content and the measured AC content for the four mixes was 0.23 percent for Mix 4. For a total of 192 tests, the worst test result was 0.23 percent deviation from the true AC content.

The measured AC contents from each laboratory were averaged for each mixture type. The average measured AC contents are shown in Table 5. Each number shown is the average of 48 test results from 12 laboratories, each of which performed tests on 4 replicates of each mixture type.

As is presented in Table 5, the deviation of the measured AC content from the true AC content ranged from −0.03 to +0.03 percent. The overall average deviation of the measured AC content for the 192 samples tested was −0.02 percent. The low bias measured indicates that the AC content of HMA mixtures can be obtained with a high degree of accuracy using the ignition method.

The within- and between-laboratory standard deviations for the measured AC content are shown in Table 6 according to mix type. The symbols W/L and B/L represent the within-laboratory and between-laboratory components, respectively. The within-laboratory standard deviation ranged from 0.03 to 0.05 percent, with overall within-laboratory standard deviation being 0.04 percent. The between-laboratory standard deviation ranged from 0.05 to 0.08 percent. The average between-laboratory standard deviation was 0.06 percent. The solvent extraction method as specified by ASTM has been demonstrated to have standard deviations for within-laboratory and between-laboratory of 0.21 and 0.22 percent, respectively. Compared with the solvent extraction method, the ignition method has significantly lower standard deviations and therefore provides a higher degree of precision.

TABLE 5 Accuracy of Ignition Test for AC Content

Mix	"True" AC Content, %	Average Measured AC Content, %	Bias, %
1	6.00	5.98	-0.02
2	6.00	5.99	-0.01
3	5.00	4.97	-0.03
4	5.50	5.53	0.03

TABLE 6 Components of Variance, Variances, and Standard Deviations for AC Content

Mix	Component of Variance		Variance		Standard Deviation	
	W/L	B/L	W/L	B/L	W/L	B/L
1	0.0016	0.0010	0.0016	0.0026	0.0405	0.0513
2	0.0009	0.0012	0.0009	0.0021	0.0297	0.0460
3	0.0022	0.0014	0.0022	0.0036	0.0468	0.0595
4	0.0026	0.0032	0.0026	0.0059	0.0514	0.0766

Aggregate Gradation

Testing of aggregates at high temperatures will generally result in loss of aggregate mass. The test temperature for ignition testing was 538°C. The aggregate was recovered after testing and evaluated to determine if there was a significant change in gradation caused by the high test temperature. Accuracy and precision of the percentage passing the 4.75-mm (No. 4) and 75-μm (No. 200) sieves were determined.

The average percentage passing the 4.75-mm (No. 4) sieve for each mix is shown in Table 7. The bias for the four mix types ranged from −0.4 to 0.0 percent. The overall difference in percentage passing the No. 4 sieve after testing was −0.02. Because the difference between the true percentage passing and the measured percentage passing was quite low, the percentage passing the 4.75-mm sieve can be determined with a high degree of accuracy.

The within-laboratory and between-laboratory standard deviations for the percentage passing the 4.75-mm sieve are shown in Table 8. The within-laboratory standard deviations range from 0.22 to 0.34 percent. The between-laboratory standard deviations range from 0.31 to 0.42 percent. The overall within-laboratory and between-laboratory standard deviations were 0.27 and 0.37 percent, respectively.

The deviation of the measured percentage passing the 75-μm (No. 200) sieve from the true percentage passing for each mix is shown in Table 9. The bias ranges from −0.4 to 0.5 percent. The overall difference was −0.1 percent. The values for the within-laboratory and between-laboratory standard deviations are shown in Table 10. The within-laboratory standard deviations for the four mix types range from 0.26 to 0.57 percent. The between-laboratory standard deviations range from 0.43 to 0.82 percent. The overall within-laboratory standard deviation was 0.47. The overall between-laboratory standard deviation was 0.65 percent.

The precision statement for asphalt content and gradation were written according to ASTM C670. The precision value calculated is the acceptable range of two test results (ASTM D2S). The precision statements were not written for each mixture type but were calculated by taking an average of all four mixtures.

TABLE 7 Accuracy of Ignition Type for Percentage Passing 4.75-mm Sieve

Mix	"True" Percent Passing 4.75 mm Sieve	Average Measured Percent Passing 4.75 mm Sieve After Ignition Test	Bias, %
1	71.6	71.5	-0.1
2	66.8	66.6	-0.2
3	61.4	61.4	0.0
4	57.0	56.6	-0.4

TABLE 8 Components of Variance, Variances, and Standard Deviations for Percentage Passing 4.75-mm Sieve

Mix	Component of Variance		Variance		Standard Deviation	
	W/L	B/L	W/L	B/L	W/L	B/L
1	0.0496	0.0592	0.0496	0.1088	0.2227	0.3299
2	0.0519	0.1021	0.0519	0.1540	0.2278	0.3924
3	0.0794	0.0161	0.0794	0.0955	0.2817	0.3090
4	0.1183	0.0621	0.1183	0.1804	0.3440	0.4247

TABLE 9 Accuracy of Ignition Type for Percentage Passing 75-μm Sieve

Mix	"True" Percent Passing No. 200 Sieve	Average Measured Percent Passing No. 200 Sieve After Ignition Test	Bias, %
1	6.0	5.6	-0.4
2	7.7	7.7	0.0
3	6.7	7.2	0.5
4	5.3	5.1	-0.2

TABLE 10 Components of Variance, Variances, and Standard Deviations for Percentage Passing 75-μm Sieve

Mix	Component of Variance		Variance		Standard Deviation	
	W/L	B/L	W/L	B/L	W/L	B/L
1	0.2623	0.4064	0.2623	0.6687	0.5121	0.8177
2	0.3269	0.2937	0.3269	0.6205	0.5717	0.7877
3	0.2667	0.0708	0.2667	0.3375	0.5165	0.5809
4	0.0689	0.1153	0.0689	0.1842	0.2624	0.4291

Table 11 shows the precision statement for AC content, percentage passing the 4.75-mm (No. 4) sieve and percentage passing the 75-μm (No. 200) sieve. The within-laboratory (0.04) and between-laboratory (0.06) standard deviations are much lower than the 0.21 and 0.22 percent variability in standard deviations that result using the extraction test. There are no typical values for comparison of the variability of gradation because the samples tested in this study were prepared with aggregate that was batched to meet the design gradation.

The precision and bias statement developed here is for four aggregate types. These calculated numbers are expected to apply to most aggregates. However, aggregates might exist that have not been evaluated and that would not do as well in the test. Additional work is needed to verify these precision and bias numbers for a wide range of aggregate types.

CONCLUSIONS

- The ignition method can be used to accurately and quickly determine the AC content and gradation of HMA mixtures;
- Statistical analysis demonstrates that the ignition method can determine the asphalt content with greater precision than the solvent

TABLE 11 Precision Statement for AC Content and Percentages Passing 4.75-mm and 75-μm Sieves Determined by the Ignition Method

Test Property	Standard Deviation (1S)		Acceptable Range of Two Test Results (D2S)	
	W/L	B/L	W/L	B/L
Asphalt Content	0.04	0.06	0.11	0.17
Percent Passing 4.75 mm Sieve	0.27	0.37	0.8	1.1
Percent Passing 75 μm Sieve	0.47	0.65	1.3	1.8
Basis of Estimate: 4 replicates 4 materials 12 laboratories				

extraction method. The within-laboratory and between-laboratory standard deviations for AC content determined from the interlaboratory test program were 0.04 and 0.06 percent, respectively. Comparatively, the within-laboratory and between-laboratory standard deviations for AC-content determination by the solvent extraction method are 0.21 and 0.22 percent, respectively;

- The test procedure is simple and can be performed in approximately 30 min for 1200-g samples. An operator must be present to start the test but need not be present while the test is in progress;
- The ignition method is relatively inexpensive, with no associated costs for disposal of hazardous solvents;
- The recovered aggregate is free of AC and can be used for gradation analysis; and
- Smoke produced during ignition testing is significantly reduced by a filter.

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