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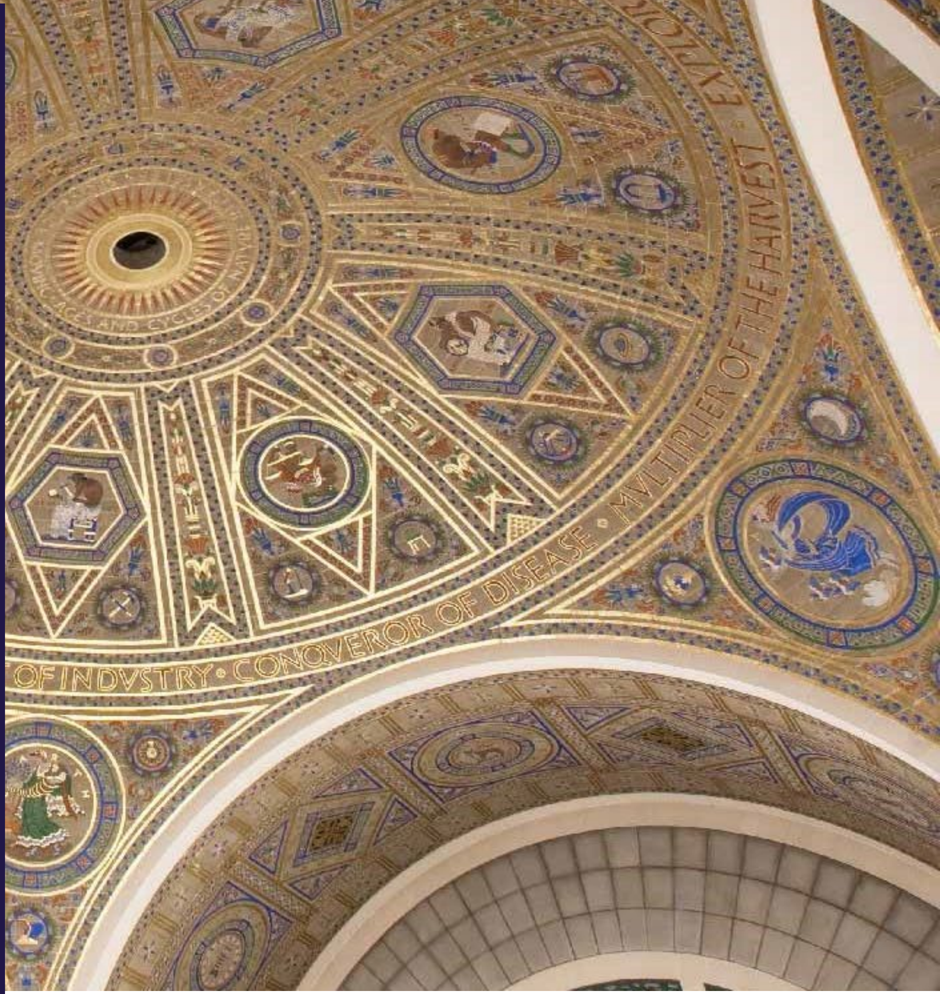
TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Asphalt Content of Recycled Mixes by Ignition Testing

February 28, 2024

11:00 AM – 12:30 PM



PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

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Purpose Statement

This webinar will present the work conducted by NCHRP to revise the current AASHTO T 308 test procedure to be able to incorporate mixes with high recycled materials content. Presenters will explore the effect of reducing the test temperature from 1,000 degrees Fahrenheit to 800 degrees Fahrenheit. Presenters will also share a new precision statement of the AASHTO procedure including recycle mixes.

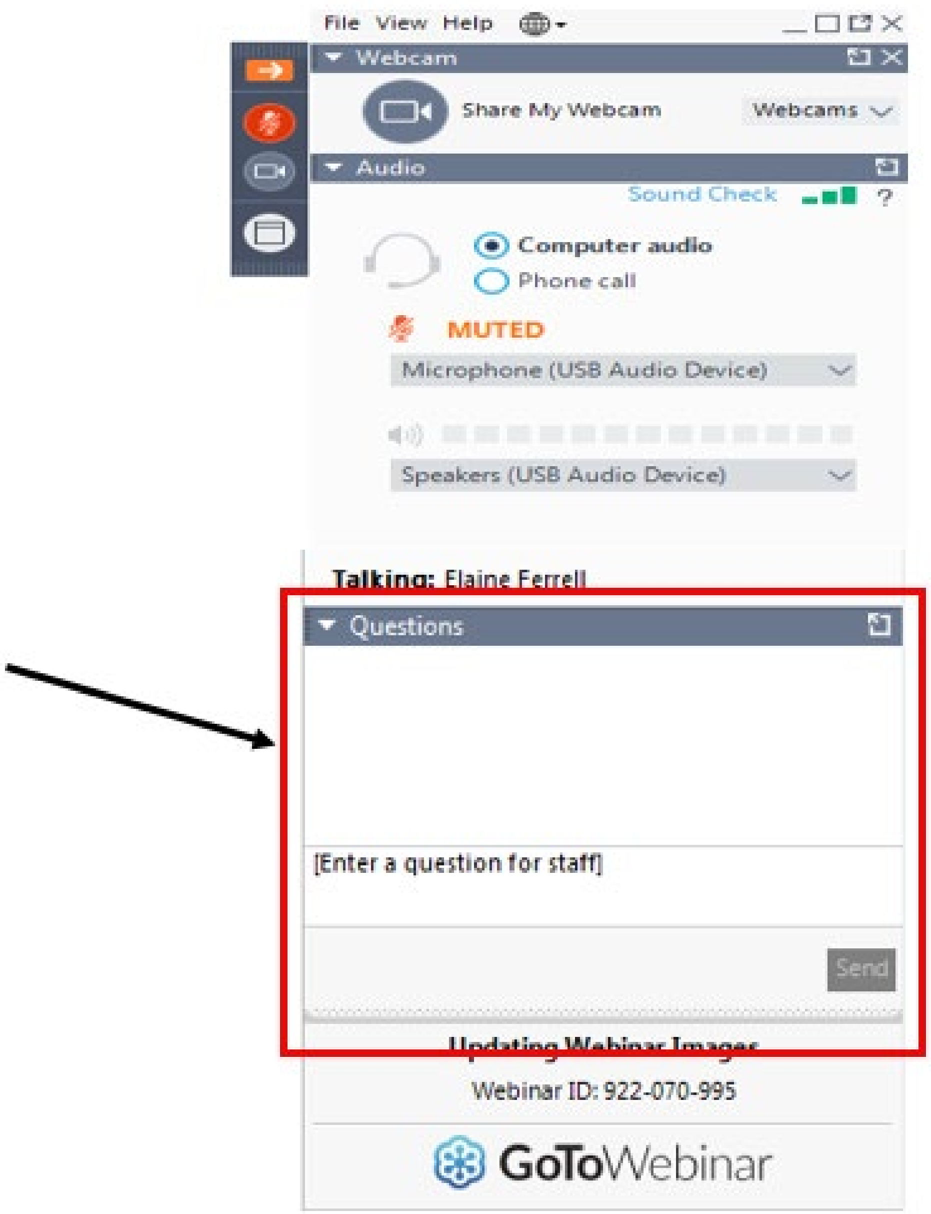
Learning Objectives

At the end of this webinar, you will be able to:

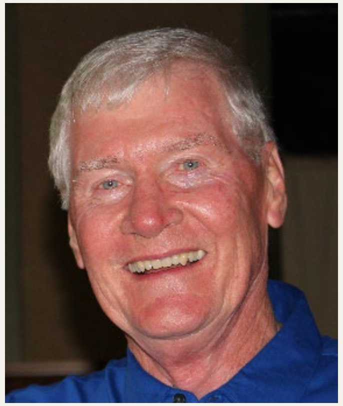
- Identify the current limitation of AASHTO T 308 for asphalt content determination of mixes with high recycled materials
- Make modifications to AASHTO T 308 procedure for more accurate asphalt content determination
- Apply the revised precision statement of AASHTO T 308

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today’s presenters



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NCHRP NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Asphalt Content of Recycled Mixes by Ignition Testing

NCHRP 09-56 and 09-56A

TRB Webinar
February 2024

National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

Agenda

- Background
  - Limitations of AASHTO T 308
  - Findings from NCHRP 9-56
- NCHRP 9-56A Study
  - Objectives
  - Experimental Plan
    - Evaluation of Laboratory-Produced RAP
    - Interlaboratory Study
    - Summary of Findings

Background

- Accurate determination of AC and aggregate gradation critical in control of asphalt mixture production
- Ignition method per AASHTO T 308 is widely used to determine AC and gradation

Basic Procedure AASHTO T 308:

- Oven used to burn asphalt off aggregate
- Procedure terminates when the weight of sample stabilizes-indicating no more binder in the mix
- Correction factor is used to account for the difference between actual binder content and ignition test results

The primary purpose of the correction factor (CF) is to determine the needed adjustment to convert the "measured" asphalt content to the "actual" asphalt content

Background

Two most common methods available for AC content determination: the ignition method (AASHTO T 308) and solvent extraction (AASHTO T 164)

Condition	Standard Deviation		Acceptable Range of Two Tests	
	T 308	T 164	T 308	T 164
Single Operator Precision: AC (%)	0.069	0.18	0.196	0.52
Multilaboratory Precision: AC (%)	0.117	0.29	0.33	0.81

Precision of the AASHTO T 308 is better than AASHTO T 164. The acceptable range of ignition method results is less than the acceptable range of the solvent extraction test

Limitations of AASHTO T 308

- Although the ignition method is straightforward and more precise than solvent extraction, there are still issues that need to be improved
  - Correction factors are needed
  - Some agencies and/or contractors share CFs between ignition units
  - Some regions of the country use aggregates that have relatively high and/or inconsistent CFs
  - CF of recycled materials is unknown

Issues Affecting Ignition Furnace CFs

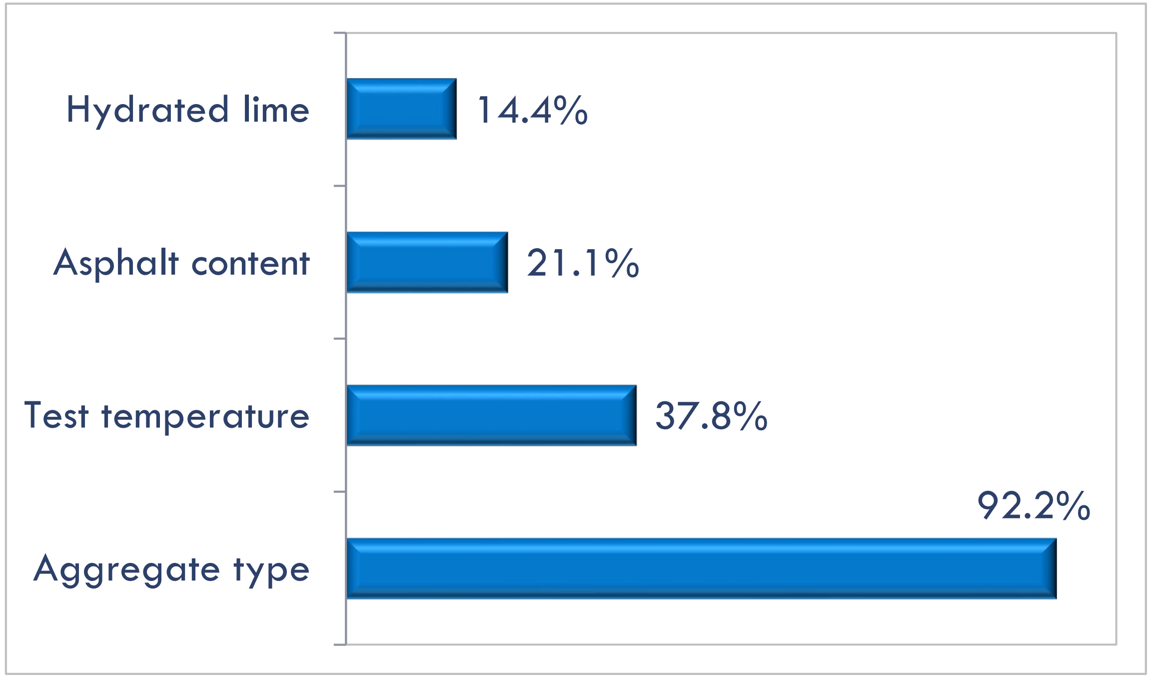
- Mass loss of aggregate during the test
- Temperature during test
- Type of furnace
- Use of lime, fibers, crumb rubber, RAP, etc
- Set up and maintenance of filters, exhaust set up, etc

Mass Loss of Aggregate During Test

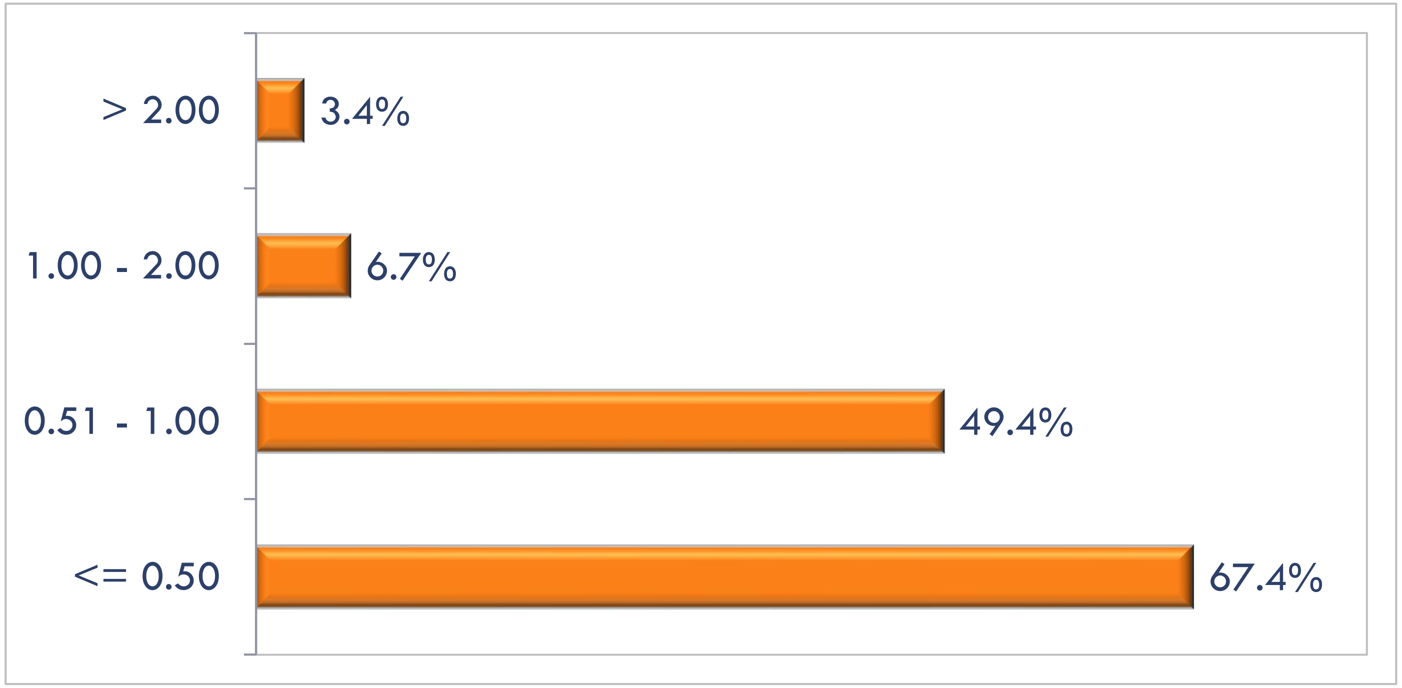
- Many aggregates only lose 0.2 to 0.3 percent mass during the test and these are not a significant problem
- Some aggregates lose up to 2 percent
  - Per AASHTO T 308 tests can be conducted at lower temperatures (900°F) to reduce the correction factor
  - Lower temperature results in less aggregate mass loss and longer test time

Issues Affecting Ignition Furnace CF

- 92.2% aggregate type significant, followed by test temperature, AC content, and use of hydrated lime
- Samples with higher AC/larger samples →more asphalt to burn → higher peak test temperature
- Other factors: RAP/RAS; length of vent pipe, 90° turns in vent pipe, cleanliness of oven, how baskets are loaded



Typical Asphalt Content CF Range

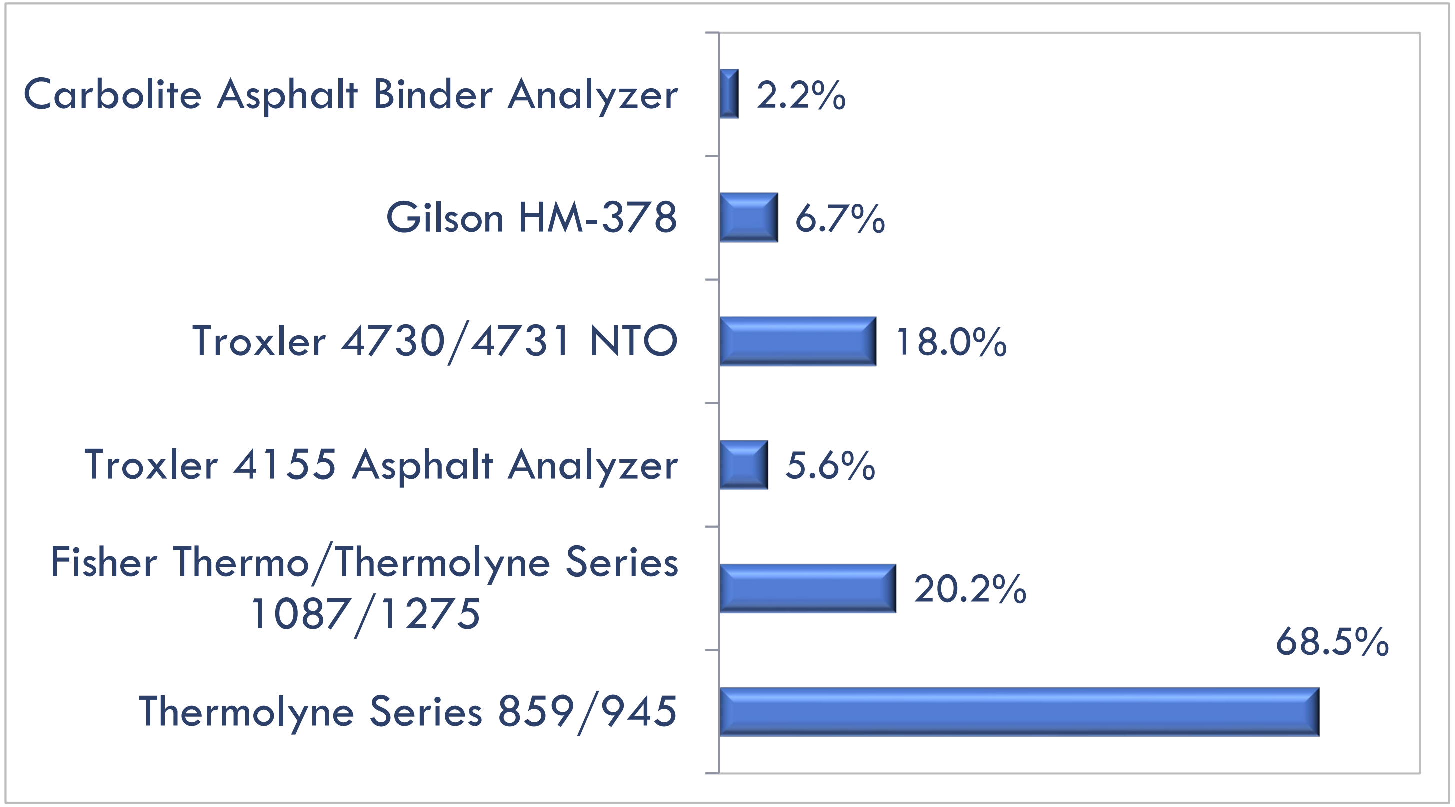


- Majority indicated CF <1
- Some agencies identified CF >1 is common
- Granite, gravel and limestone most common aggregates

Temperature During Test

- Many have adjusted the test temperature downward for high mass loss aggregate to reduce the CF
- Reducing test temperature will lower the CF
- However, if temperature is dropped too much the test time can be increased too much or all asphalt binder will not be removed during testing

Ignition Furnace Types



Type of Furnaces

- Several types of ignition equipment being used to measure asphalt content
- Most equipment has internal scales and automatic cutoff
- There is equipment that uses external scales but not often used

Use of Additives in Mix

- Additives such as lime, fibers, and crumb rubber affect the correction factor
- Some additives removed by burning during the ignition test. For example, we expect cellulose fiber to be removed from the mix by burning
- The use of lime often results in failure to remove all of the asphalt binder from the mix. For example, we often see aggregate after tests containing staining with asphalt residue

Filters and Exhaust need to be Properly Maintained

- Dirty filters will result in reduced airflow and affect the measured CF
- Follow instructions by AASHTO T 308 and equipment supplier for set up and maintenance of equipment including exhaust
- Moving equipment from one exhaust setup to another will likely change the CF

Sharing CFs between Furnaces

- CFs should be developed for each piece of equipment used
- Sharing correction factors is not good but is often done
- Sharing CFs (when small) may not generally affect results but this is a big problem when CFs are larger

Issues with Measuring Asphalt Content for Recycled Mixtures

- Raw materials are not available/not possible to determine CF
- How to know the effect of lime, if used, on measured asphalt content
- Ensure that moisture content is considered
  - Measure moisture in companion sample
  - Dry sample before testing
- Does RAP mix contain cellulose fibers, crumb rubber, or other combustible materials
- What is the variability of the RAP stockpile

NCHRP 9-56 Objectives

- Determine significant factors that affect the variability of CFs
- Evaluate the effect of sharing CFs between units
- Develop guidelines for the installation, operation, and maintenance of ignition furnaces to minimize the variability of CFs

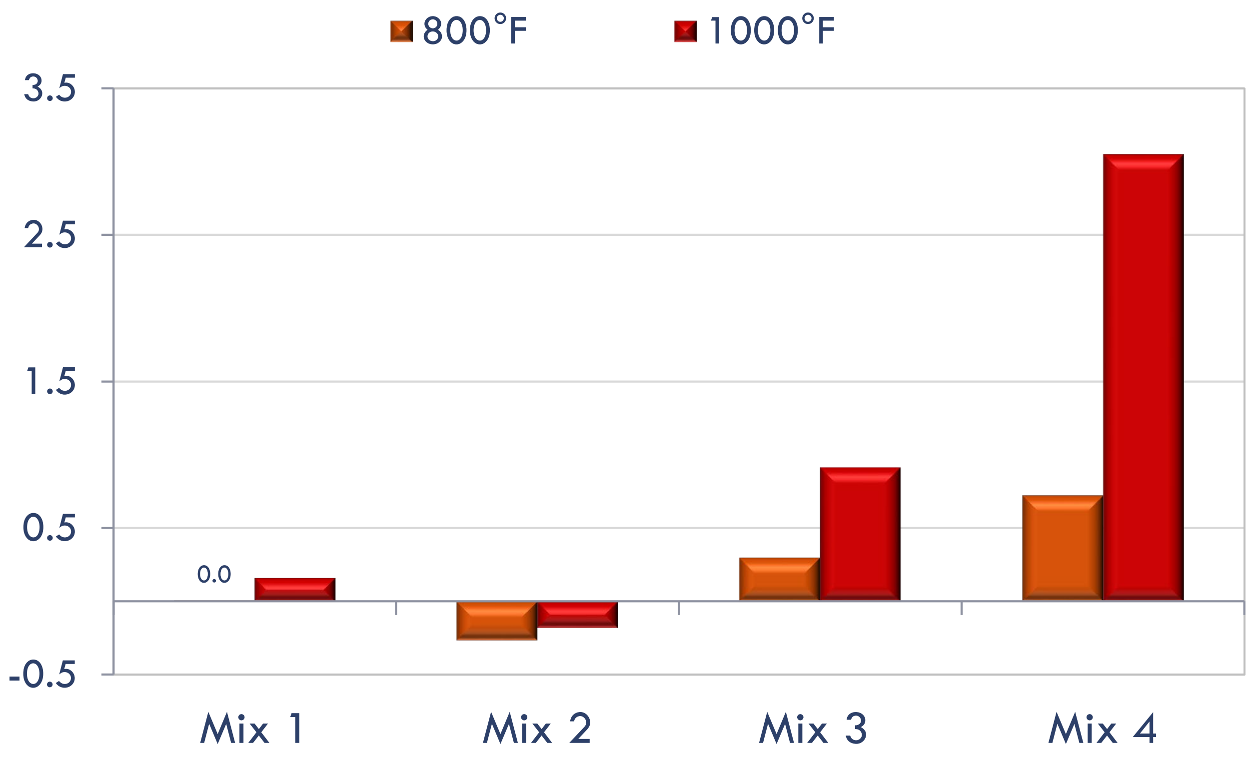
NCHRP 9-56 Key Finding

- Experiment to determine the sensitivity of the method concerning aggregate type, furnace type, test temperature, duct configuration, asphalt content, and sample mass

Aggregate/ Mix	Aggregate Description	Expected CF Range
1	Limestone and Granite (AL)	0.0 - 0.5
2	Limestone and Granite with 1% Lime (AL)	0.0 - 0.5
3	Limestone (MI)	0.5 - 1.0
4	Dolomite (AL)	1.0 - 3.0

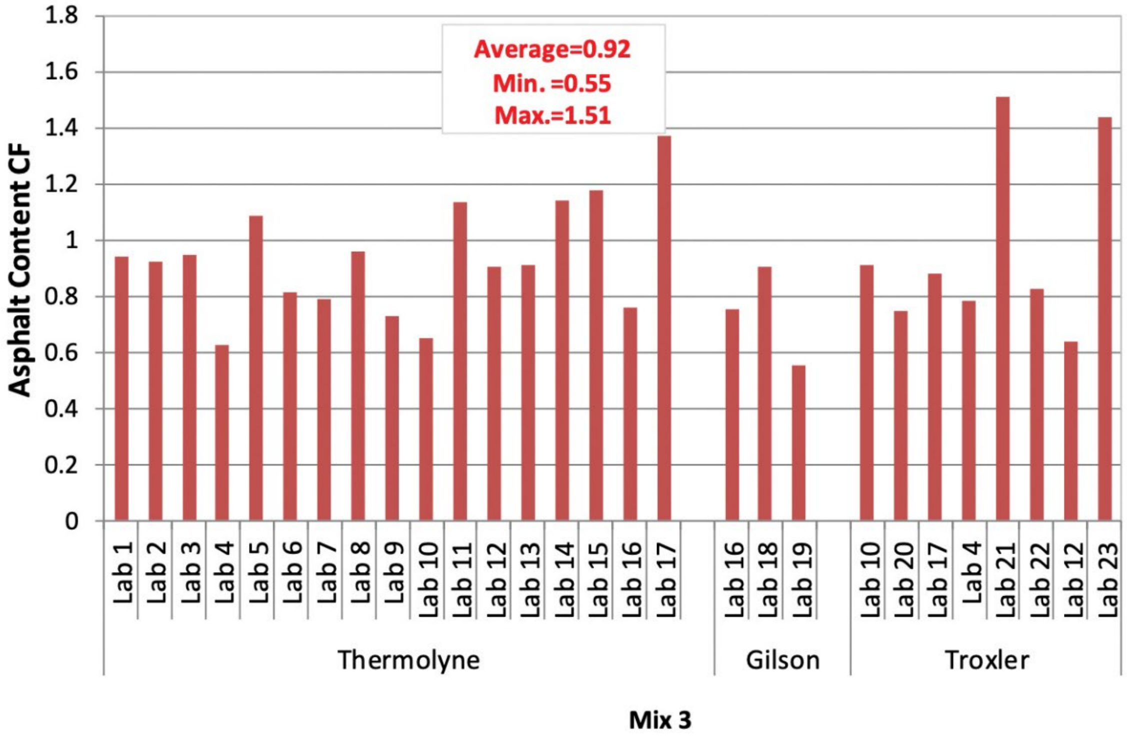
NCHRP 9-56 Key Finding

- From Sensitivity Study: The most significant factor was the test temperature



NCHRP 9-56 Key Finding

- *<u>From Interlaboratory study:</u>* CFs were significantly different for mixes even with same brand of furnace. It is not appropriate to use CF determined with one ignition furnace for tests conducted with another furnace



NCHRP 9-56 Key Finding

- *From Interlaboratory study:* Within-lab and between-lab precision depend on CF magnitude. Mixtures with high CFs have higher repeatability and reproducibility

Mix #	Actual AC%	Average Measured AC%	Average AC CF	Standard Deviation	
				W/L	B/L
1	5.2	5.32	0.12	0.097	0.117
2	5.2	4.97	-0.23	0.086	0.102
3	6.2	7.08	0.88	0.197	0.212
4	6.1	7.31	1.21	0.345	0.370
AASHTO T 308				**0.069**	**0.117**

NCHRP 9-56 Key Finding

- Results suggest that the precision statement in AASHTO T 308 was developed with low mass loss aggregates and may not apply to aggregates with higher mass loss
- Test conducted at 800°F significantly reduced asphalt CF, particularly for high mass loss aggregates

Findings

- Key product of this research is a Standard Practice for the Installation, Operation, and Maintenance of Ignition Furnaces (AASHTO R96-19)

Standard Practice for

Installation, Operation, and Maintenance of Ignition Furnaces

AASHTO Designation: R 96-19 (2023)[1]

AASHTO

First Published: 2019   Reviewed but Not Updated: 2023

Technical Subcommittee: 2c, Asphalt–Aggregate Mixtures

1. SCOPE

1.1. This standard practice is for the initial installation, operation, and maintenance of an ignition furnace for measuring the asphalt content of an asphalt mixture according to T 308. The aggregate recovered after ignition can be used for gradation analysis according to T 30.

1.2. Failure to properly install, operate, or maintain the ignition furnace may result in erroneous measurements, additional hazards, or both.

1.3. The values stated in SI units are to be regarded as the standard.

1.4. *This standard practice does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish safety and health practices along with determining the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- T 30, Mechanical Analysis of Extracted Aggregate
- T 308, Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

2.2. *Manufacturers' Manuals*:
- Carbolite Gero, Operating and Maintenance Instructions—Asphalt Binder Analyser
- Gilson Company, Inc., Operating Manual—Gilson Binder Ignition System HM-378
- ThermoFisher, Thermolyne National Center for Asphalt Technology (NCAT) Asphalt Content Tester Installation and Operation Manual
- Troxler Electronic Laboratories, Inc., Manual of Operation and Instruction—Troxler New Technology Oven (NTO) Asphalt Content Ignition Oven

3. FURNACE INSTALLATION

3.1. Prior to installing the furnace, read the manufacturer's manual.

3.2. *Locating the Ignition Furnace*:

NCHRP 9-56 Recommendations

NCHRP 9-56

- Reducing the test temperature from 1000°F to 800°F could translate into lower CFs and, potentially reduced within-labs and between-labs variability
- Conducting tests at 800°F for recycled mixes, could allow more accurate determination of AC content

NCHRP 9-56A

Project Objectives

- Evaluate the effect of reducing test procedure temperature to 800°F
- Determine variability of asphalt CFs for asphalt mixes containing high recycled material content (RBR >0.3) compared to those with virgin binder and aggregate only
- Conduct an interlaboratory study to establish a new precision statement for AASHTO T 308

Experimental Plan

- Evaluation of Laboratory-Produced RAP
- Evaluation of RAP and RAS Materials
- Interlaboratory Study including virgin and high recycled asphalt material (RAM) content

Evaluation of Laboratory Produced (Simulated) RAP

Objective: Evaluate effect of reducing test temperature and effect of aging to simulate RAP (AASHTO T 308 and AASHTO T 164)

Number of mixes	6
Test temperature	2 (800, 1000 °F)
Replicates	3
Aging condition	2 (unaged, short + long term aged)
Total Ignition Tests	72
Total Centrifuge Extractions	36

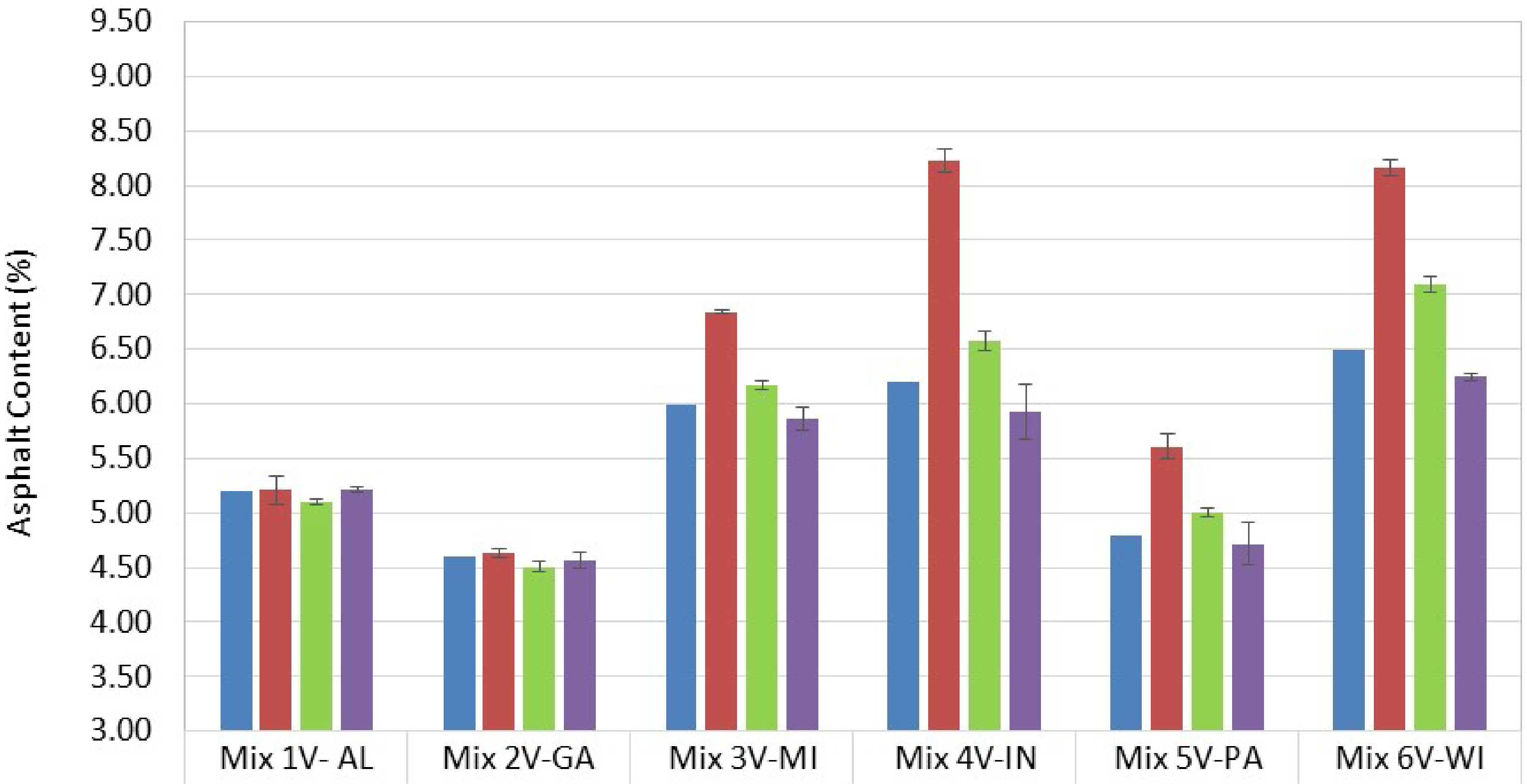
Mix Designs -Task 1-Virgin Mixes

Sieve Size (mm)	Mix 1V	Mix 2V	Mix 3V	Mix 4V	Mix 5V	Mix 6V
25.0	100.0	100.0	100.0	100.0	100.0	100.0
19.0	100.0	98.1	100.0	100.0	97.0	100.0
12.5	96.1	85.2	93.3	99.8	78.1	97.4
9.5	87.1	69.6	84.6	94.1	67.6	90.0
4.75	64.6	50.3	64.3	64.6	55.4	73.3
2.36	52.4	37.9	34.4	43.8	41.3	55.4
1.18	41.0	27.8	18.7	28.7	30.4	40.6
0.6	30.1	20.2	11.3	17.4	21.8	29.6
0.3	18.7	13.5	7.2	10.5	13.2	18.8
0.15	9.8	7.9	4.8	7.1	6.7	9.7
0.075	5.7	3.8	3.9	5.3	3.4	5.2
Aggregate Type	Limestone	Granite	Limestone	Dolomite	Sandstone	Limestone
NMAS, mm	12.5	19.0	12.5	9.5	19.0	9.5
Approximate CF	0 - 0.5	0.5 - 1.0	0.5 - 1.0	1.0 - 3.0	0.5 - 1.0	1.0-2.0
Aggregate Source	Alabama	Georgia	Michigan	Indiana	Pennsylvania	Wisconsin
Ndes, gyrations	60	65	80	100	100	75
Optimum AC	5.2	4.6	6.0	6.2	4.8	6.5
VMA	15.6	13.3	14.3	14.9	13.6	15.9
VFA	74.2	69.8	71.8	72.8	70.3	75
D/B Ratio	1.2	0.98	0.91	1.14	0.84	0.73
Absorption (%)	0.43	0.72	2.26	1.73	0.85	1.73

Main Selection Criteria

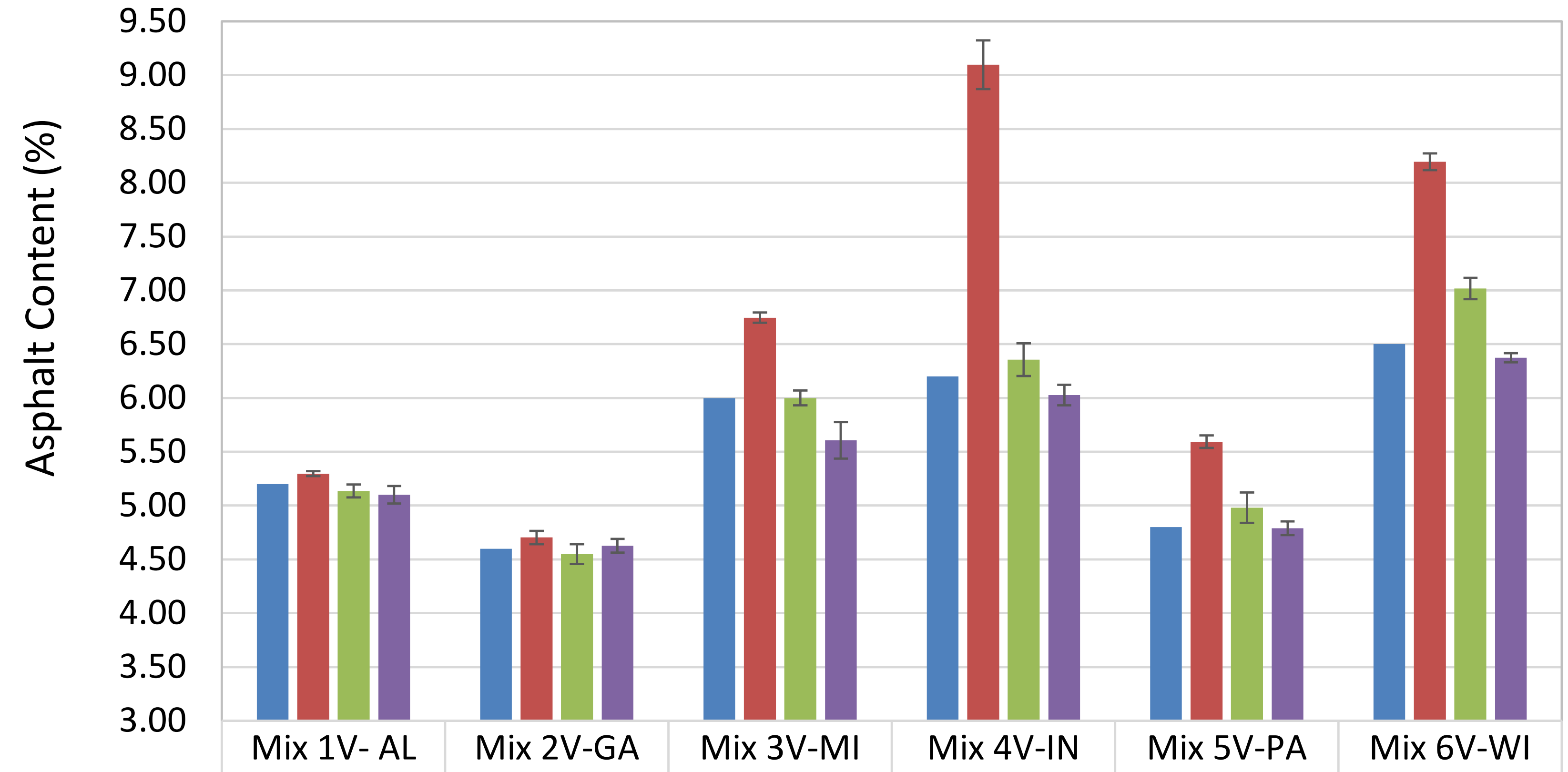
All used a PG 67-22

AC Results for Ignition and Extraction for Unaged Mixes



	Mix 1V- AL	Mix 2V-GA	Mix 3V-MI	Mix 4V-IN	Mix 5V-PA	Mix 6V-WI
Actual AC	5.20	4.60	6.00	6.20	4.80	6.50
Ignition 1000°F	5.21	4.63	6.84	8.23	5.61	8.17
Ignition 800°F	5.10	4.51	6.17	6.58	5.01	7.10
Centrifuge	5.21	4.56	5.87	5.93	4.72	6.25
Absorption	**0.43**	**0.72**	**2.26**	**1.73**	**0.85**	**1.73**

AC Results for Ignition and Extraction for Aged Mixes



	Mix 1V- AL	Mix 2V-GA	Mix 3V-MI	Mix 4V-IN	Mix 5V-PA	Mix 6V-WI
True AC	5.20	4.60	6.00	6.20	4.80	6.50
Ignition 1000°F	5.30	4.70	6.75	9.10	5.59	8.19
Ignition 800°F	5.14	4.55	6.00	6.36	4.98	7.02
Centrifuge	5.10	4.63	5.61	6.03	4.79	6.37
Absorption	**0.43**	**0.72**	**2.26**	**1.73**	**0.85**	**1.73**

Difference AC Content Ignition/Extraction and Actual AC

Mix #	AC Difference (Ignition-Actual)	AC Difference (Centrifuge-Actual)
Mix 1V	-0.06	-0.10
Mix 2V	-0.05	0.03
Mix 3V	0.00	-0.39
Mix 4V	0.16	-0.17
Mix 5V	0.21	-0.01
Mix 6V	0.53	-0.13

Mix with aggregate with highest absorption 2.26%

For the evaluation of RAP materials, no test provided consistently more accurate values, and the results were mix-dependent

Effect of Aging and Temperature Reduction on Simulated RAP

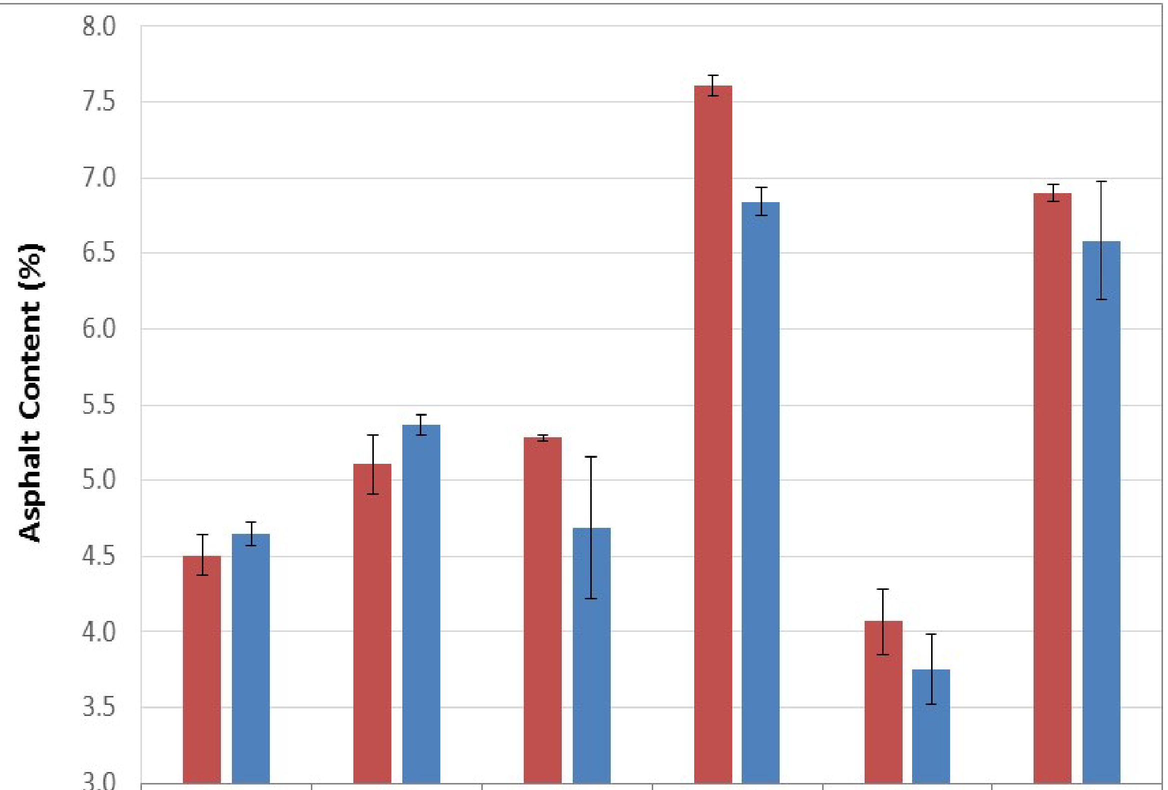
- Ignition and extraction results before and after aging showed no statistically significant difference
- Ignition test results at 800°F overestimate actual AC, but to a lesser degree than test at 1000°F
- Centrifuge extraction results yielded lower AC than actual values, especially for aggregates with high absorption
- For ignition tests, reducing temperature resulted in a lower CF for all mixes, except for mixes 1 and 2 which yielded negative CFs

Evaluation of RAP/RAS Materials

- Objective: Measured AC content of different sources of recycled materials using ignition tests at the proposed lower temperature (800°F), and also centrifuge extraction tests for comparison purposes

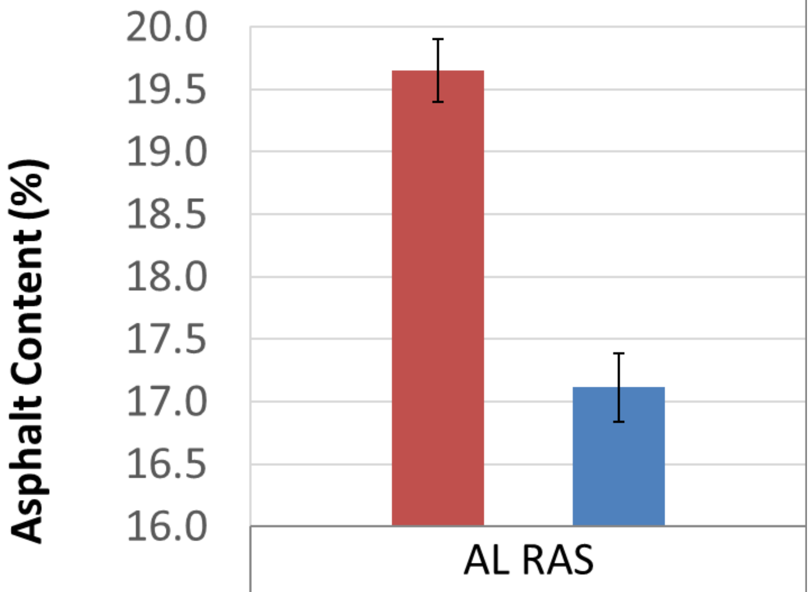
RAP/RAS Sources	6 RAP sources, 1 RAS source
Test Temperature	800°F
Replicates	3
Total Ignition Tests	18
Total Centrifuge Extractions	18

Recycled Materials AC Content



	AL	GA	MI	IN	PA	WI
Ignition	4.51	5.11	5.28	7.61	4.07	6.90
Centrifuge	4.64	5.37	4.69	6.84	3.75	6.58

RAP



	AL RAS
Igntion 800°F	19.65
Extraction	17.11

RAS

Recycled Materials

- Variability for recycled materials tends to be higher than that for virgin lab mixes
- Ignition tests yield higher asphalt content than extractions, except RAP1 and RAP2
- For the RAS material included in this study, difference between ignition results and extraction results was higher than 2%

Interlaboratory Study

<u>Objective:</u> Develop a revised precision statement for the test method in AASHTO T 308.

Laboratories	10 (8 with convection, 2 with infrared units)
Mixes	8 (4 virgin mixes + 4 mixes with high RAM) 1V, 1R, 3V, 3R, 5V, 5R, 6V, 6R
Samples per lab	16 raw material samples (2 per mix), and 16 asphalt mix samples (2 per mix)
Total Number of Samples	320

Development of Infrared Unit Burning Profile

- New Troxler burning profile equivalent to 800°F used for the Thermolyne unit was developed
- Profile proposed after several trials that involved tests conducted at the manufacturer’s lab and at the NCAT lab
- Preliminary evaluation with a limited number of labs to test profile
- New burning profile proved to be effective
- Infrared furnaces able to be included in Interlaboratory study

Mix Designs-High RAM Mixes

Sieve Size (mm)	Mix 1R	Mix 3R	Mix 5R	Mix 6R
25	100	100	100	100
19	100	100	98.6	100
12.5	95.5	94.4	89.6	97.6
9.5	84.2	88.5	80.9	91.3
4.75	55	71.5	51	73.8
2.36	41.9	43.8	34.9	58.1
1.18	33.3	28	26	45.5
0.6	24.3	19.1	19.4	33.2
0.3	15.1	11.4	12.5	19.3
0.15	7.8	6.9	6.9	10.4
0.075	4.1	4.9	3.7	6.8
NMAS, mm	12.5	12.5	19	9.5
Aggregate/RAM Source	Limestone	Limestone	Sandstone	Limestone
Ndes, gyrations	60	80	100	75
Optimum AC	5	5.8	5.1	5.8
VMA	14.6	14	13.7	14.2
VFA	72.5	71.3	70.9	71.8
D/B Ratio	0.96	1.11	0.87	1.09
Abs(%)	0.6	1.83	0.93	1.76
Recycled Binder Ratio	0.36	0.31	0.33	0.35
RAP Content (%)	20	38	45	30
RAS Content(%)	5	0	0	0

RBR ranged from 0.31-0.36

Interlaboratory Study

- Eight mixes, four virgin, and four high RAM mixes
- High RAM mixes developed at NCAT using virgin mixes
- Twelve laboratories were initially selected, but 2 had issues with their units and did not submit results
- Detailed instructions provided to labs to run ignition test at 800°F, and sieve analysis of residual aggregate per AASHTO T 30

Data Analysis

- Test results analyzed per ASTM E 691, and ASTM C802
- k and h statistics to evaluate consistency of results and possible outliers
  - **k=indicator of how laboratory variability compared with that of other labs**
  - **h=indicator of how laboratory average compared with that of other labs**
- Critical k and h values recommended in standard
- Each mix test results analyzed separately
- Pooled repeatability and reproducibility calculated

Data Analysis -Example

- Statistical Analysis of Interlaboratory Test Results for Mix 3V

Lab #	Optimum Asphalt Content	AC Sample 1	AC Sample 2	Average	s	d	h	k
Lab 1	4.8	4.85	5.07	4.96	0.156	0.052	0.47	2.22
Lab 2		4.75	4.69	4.72	0.042	-0.188	-1.70	0.61
Lab 3		4.82	4.66	4.74	0.113	-0.168	-1.52	1.62
Lab 4		4.90	4.93	4.91	0.021	0.007	0.07	0.30
Lab 5		5.05	5.09	5.07	0.028	0.162	1.47	0.40
Lab 6		4.92	4.93	4.93	0.007	0.022	0.20	0.10
Lab 7		4.95	4.89	4.92	0.042	0.017	0.16	0.61
Lab 8		4.94	4.97	4.96	0.021	0.052	0.47	0.30
Lab 9		4.98	4.92	4.95	0.042	0.042	0.38	0.61

$\bar{\bar{x}}$	Average of cell average	4.90		
$s_{\bar{x}}$	Standard deviation of cell averages	0.111	Critical h value	2.23
s_r	Repeatability standard deviation	0.070	Critical k value	2.41
s_L	Between lab standard deviation	0.099		
s_R	Reproducibility standard deviation	0.121		

New Precision Statement AASHTO T 308

Mix #	Actual AC	Measured (corrected) AC	Difference (Measured-Actual) in AC	s_r	s_R	r	R
Mix 1V	5.2	5.24	0.04	0.082	0.082	0.230	0.230
Mix 1R	5.0	4.92	-0.08	0.056	0.112	0.157	0.313
Mix 3V	6.0	6.05	0.05	0.106	0.106	0.298	0.298
Mix 3R	5.8	5.83	0.03	0.098	0.160	0.274	0.448
Mix 5V	4.8	4.90	0.1	0.070	0.121	0.196	0.339
Mix 5R	5.1	5.10	0.0	0.148	0.148	0.414	0.414
Mix 6V	6.5	6.62	0.12	0.046	0.225	0.129	0.630
Mix 6R	5.8	5.77	-0.03	0.164	0.164	0.459	0.459
Pooled Estimates				**0.073**	**0.146**	**0.203**	**0.410**
AASHTO T 308				**0.069**	**0.117**	**0.196**	**0.330**

Note: s_r=repeatability standard deviation, s_R=reproducibility standard deviation, r=repeatability acceptable range of two test results and R=reproducibility acceptable range of two test results.

Aggregate Gradation Analysis

- AASHTO T 308 specifies allowable sieving difference between gradation results and blank gradation results
- Average aggregate gradation for each sieve size per mix was calculated
- Aggregate CFs calculated by subtracting % passing for each sieve from % passing each sieve of a “blank” aggregate sample

Sieve	Allowable Difference
Sizes larger than or equal to 2.36mm	±5.0 percent
Sieve larger than 0.075mm and smaller than 2.36mm	±3.0 percent
Sizes 0.075mm and smaller	±0.5 percent

Aggregate Gradation Analysis

Sieve Size (mm)	Mix 1V			Mix 1 R		
	Blank Sample Gradation (% Passing)	Average Gradation (% Passing)	Aggregate Correction Factor (%)	Blank Sample Gradation (% Passing)	Average Gradation (% Passing)	Aggregate Correction Factor (%)
12.5	96.6	97.5	-0.9	96.0	96.5	-0.5
9.5	90.0	89.5	0.6	84.3	84.3	0.0
4.75	69.1	67.6	1.4	57.9	55.1	2.8
2.36	52.9	54.4	-1.5	46.2	41.7	4.5
1.18	41.2	42.2	-1.0	37.5	33.0	**4.5**
0.6	30.3	30.9	-0.6	28.1	25.2	2.9
0.3	19.1	19.5	-0.4	18.6	16.4	2.3
0.15	10.5	10.6	-0.1	10.5	9.2	1.3
0.075	6.2	6.3	-0.1	6.4	5.3	**1.1**
Sieve Size (mm)	**Mix 3V**			**Mix 3R**		
12.5	96.2	93.8	2.4	94.6	94.5	0.1
9.5	87.0	84.1	2.9	89.0	88.5	0.5
4.75	66.1	64.9	1.2	71.3	72.1	-0.8
2.36	37.2	37.6	-0.4	47.2	47.3	-0.1
1.18	22.3	23.0	-0.7	31.9	32.2	-0.3
0.6	14.8	15.8	-1.0	23.2	23.1	0.0
0.3	9.9	10.8	-0.9	15.1	14.9	0.2
0.15	6.8	7.1	-0.4	9.6	9.1	0.4
0.075	4.9	5.1	-0.2	7.0	6.4	**0.6**

Sieve Size (mm)	Mix 5V			Mix 5R		
	Blank Sample Gradation (% Passing)	Average Gradation (% Passing)	Aggregate Correction Factor (%)	Blank Sample Gradation (% Passing)	Average Gradation (% Passing)	Aggregate Correction Factor (%)
19	97.3	97.04	0.3	98.6	97.9	0.8
12.5	78.3	81.18	-2.9	93.0	88.7	4.3
9.5	67.4	71.81	-4.4	80.3	82.8	-2.5
4.75	53.1	57.91	-4.9	52.2	55.9	-3.6
2.36	40.8	43.88	-3.1	38.3	38.3	-0.1
1.18	30.1	32.74	-2.6	29.5	28.6	0.9
0.6	22.1	24.02	-1.9	22.6	21.8	0.9
0.3	13.9	15.16	-1.3	15.3	14.8	0.5
0.15	7.3	8.05	-0.8	8.5	8.5	0.0
0.075	3.6	4.20	-0.5	4.8	5.0	-0.1
Sieve Size (mm)	**Mix 6V**			**Mix 6R**		
12.5	95.2	97.2	-2.0	98.2	97.8	0.4
9.5	83.4	88.1	-4.6	92.3	91.8	0.5
4.75	66.2	70.9	-4.7	77.0	73.7	3.3
2.36	52.2	53.1	-0.9	61.3	56.9	4.5
1.18	40.1	38.8	1.3	48.3	43.7	**4.7**
0.6	31.4	29.2	2.2	36.5	32.2	**4.4**
0.3	22.9	21.1	1.8	22.7	19.6	3.0
0.15	14.6	13.9	0.7	13.4	11.7	1.7
0.075	6.3	6.2	0.1	7.7	6.7	**1.0**

Allowable differences were exceeded few time, limited sieve sizes

Findings

- Ignition results for virgin mixes with aggregates with low and high mass loss confirmed that reducing test temperature resulted in lower CFs
- Average standard deviation of tests at 1000°F was slightly higher (0.099), compared to results at 800°F (0.070)
- Centrifuge extraction yielded lower AC content than actual AC content; trend more pronounced for mixes with absorptive aggregates suggesting that CF may be needed for mixes with these aggregates

Findings

- A revised precision statement was developed with the inclusion of virgin and recycled mixes
- New precision values for the repeatability and reproducibility standard deviation were found to be 0.073 and 0.146; results suggested that virgin and recycled mixes do not require different precision statements
- Current AASHTO limits placed on aggregate gradations after ignition test conducted at 800°F are acceptable for virgin recycled mixtures

Recommendations

- Changes to AASHTO T 308 include: (1) change in the test temperature; and (2) a revised precision statement for asphalt content determination
- Evaluation with additional mixtures and RAP and RAS sources could be conducted in the future to refine the proposed precision statement

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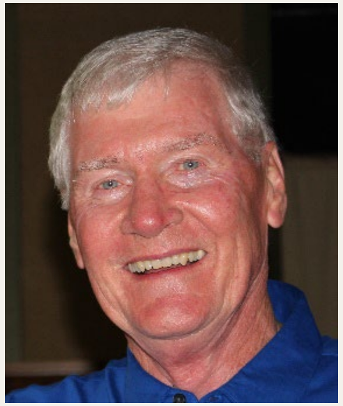
Thank you!

Courtesy of Timothy Ramirez

QUESTIONS?

Today's presenters



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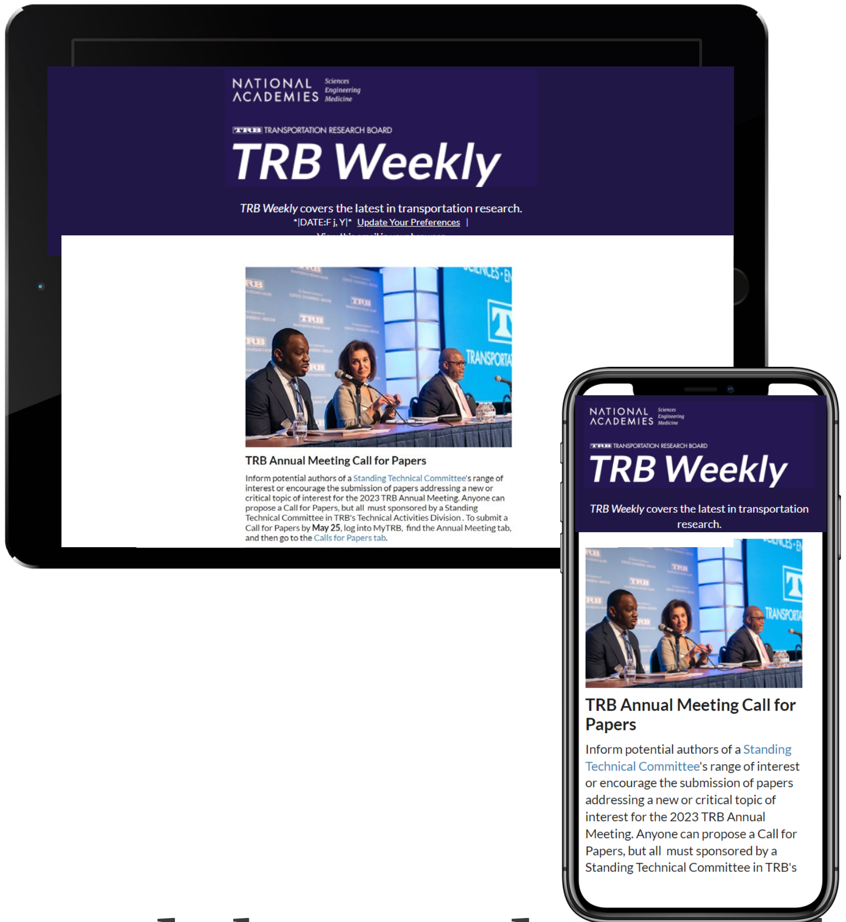

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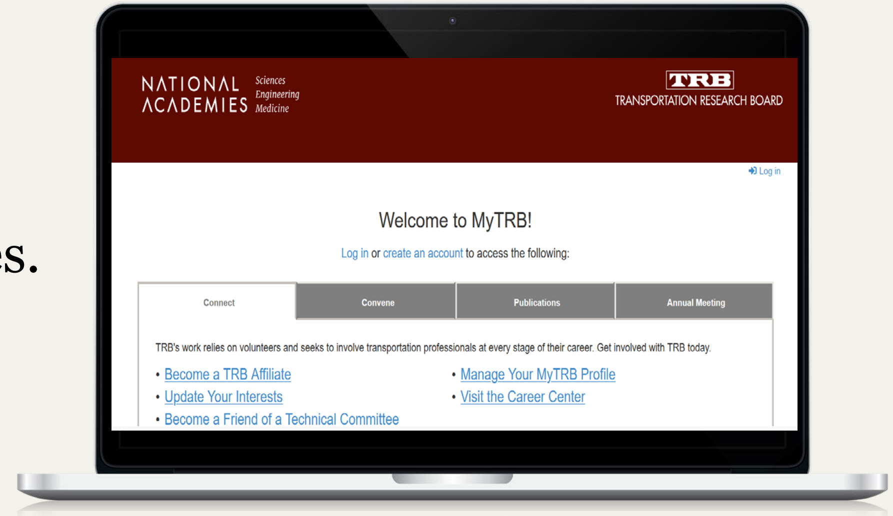

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