Center for Training Transportation Professionals

Hot Mix Asphalt

Testing Technician

1

1

Course Overview

ARDOT Specifications

- Materials / Terminology
- Volumetrics / Calculations
- Sampling / Reduction
- Gyratory Compaction
- Gmb / Gmm
- Binder Content
- Compaction
- Quality Control / Quality Assurance

4

4

Test Day

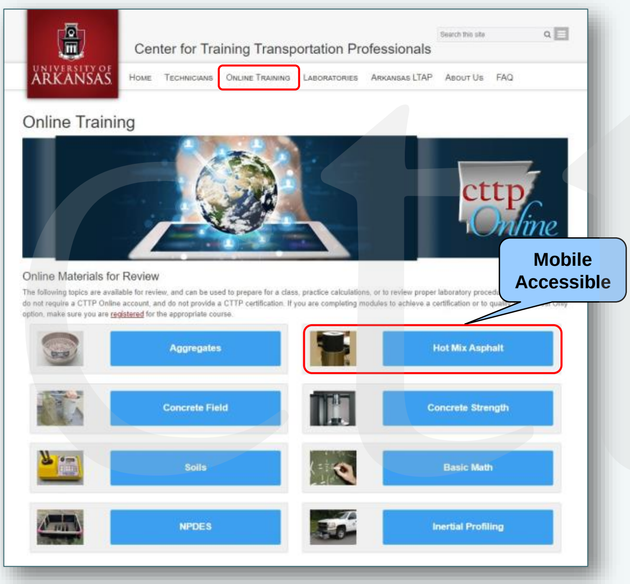
Written Exam
- ≈ 60 Questions
- Closed Book Exam
  - 2 Hour Time Limit
  - 70 % Overall Required to Pass

Results
- www.cttp.org
- Letter & Certification
- 5 Year Certification
- Basic Aggregates

Performance Exam
- 5 Exam Stations
  - Bulk SpG (Gmb)
  - Max SpG (Gmm)
  - Gyratory Compaction
  - Ignition Oven
  - AC Gauge
- 2 attempts

5

5



Help?

If you need help with mathematical calculations, just ask. Your instructor will be happy to assist you.

If you need further practice or assistance, please see our website www.cttp.org for online training.

- Modules
- Videos
- Practice Problems

6

6

Materials

Aggregate (stone) – granular material

Binder – an asphalt-based cement (Performance Graded)

Asphalt Mixture – Binder and aggregate combined

7

7

Mix Design vs Production

Mix Design

Combinations of aggregates and binder to determine optimum properties

- Volumetric
- Material quality
- Performance

Production

Ensure that the mix matches the design by performing regular checks of mix properties

- Specifications
- Tolerances
- Pay items

8

8

Aggregates

Nominal Maximum Aggregate Size (NMAS)
- Superpave – one size larger than the 1st sieve to retain >10%

Maximum Aggregate Size (MAS)
- Superpave – One size larger than NMAS

ARDOT mix designs based on NMAS
- Surface: 12.5mm (1/2"), 9.5mm (3/8")
- Binder: 25.0mm (1")
- Base: 37.5mm (1-1/2")

9

9

Aggregate Properties

Gradation
Angularity
Fractured faces
Flat/Elongated
Durability
Soundness

10

10

Aggregate Blend Gradation

11

11

Binder Properties

Temperature – Viscosity

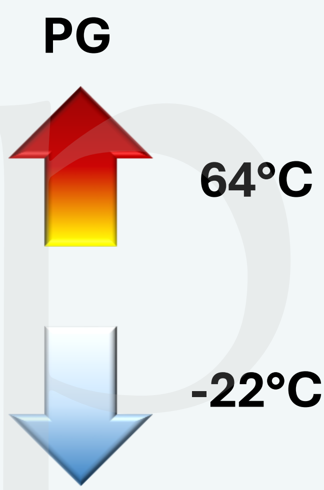
Climate & Traffic

Performance Graded

- PG 64-22
- PG 70-22
- PG 76-22

Mixing Temperature

Compaction Temperature



12

12

Performance Properties

Water Sensitivity
- Antistrip

Wheel Tracking Test
- Rutting Susceptibility

13

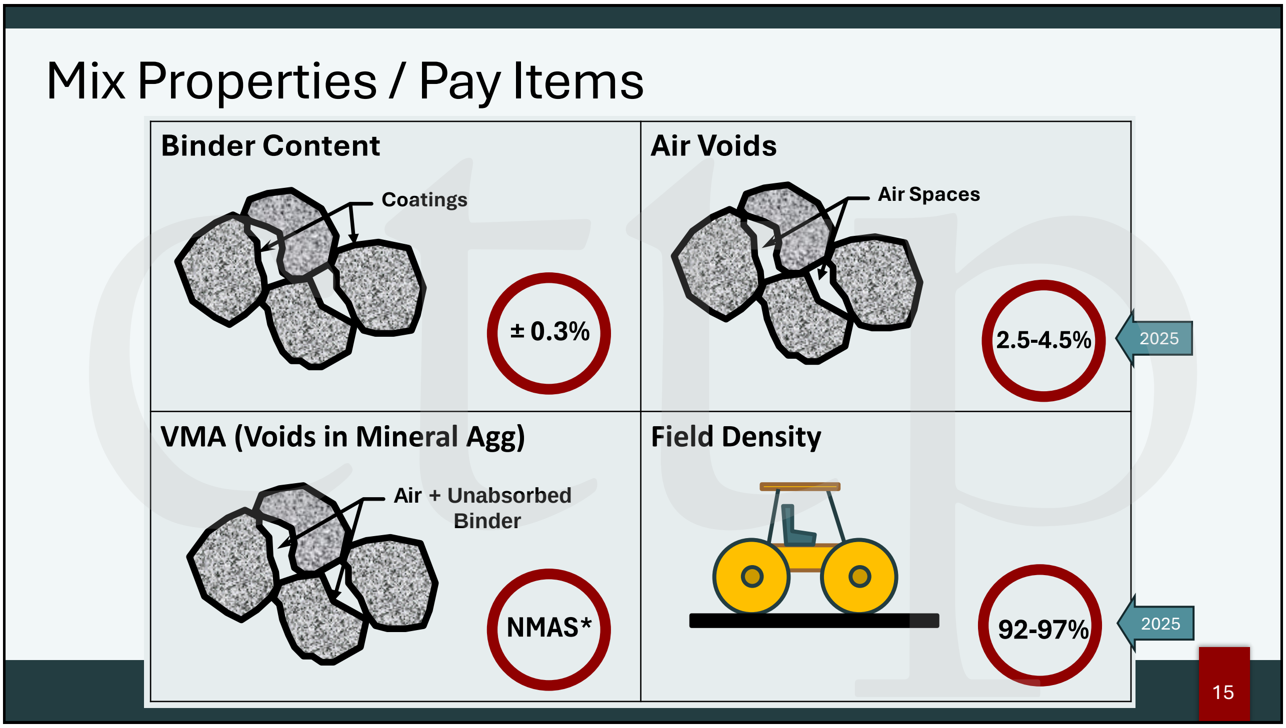
13

Balanced Mix Design

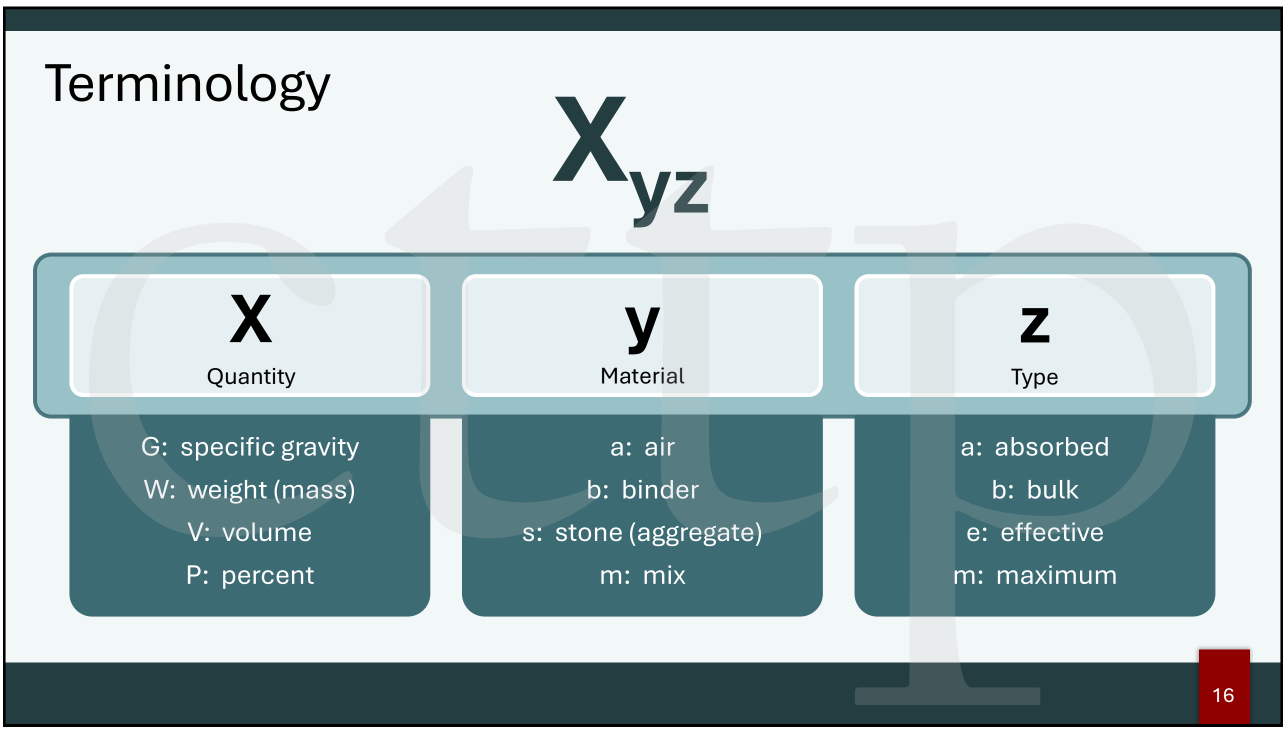
Rutting
Cracking

14

14


Mix Properties / Pay Items
Binder Content
Coatings
± 0.3%
Air Voids
Air Spaces
2.5-4.5%
2025
VMA (Voids in Mineral Agg)
Air + Unabsorbed Binder
NMAS*
Field Density
92-97%
2025
15

15


Terminology
Xyz
X
Quantity
y
Material
z
Type
G: specific gravity
W: weight (mass)
V: volume
P: percent
a: air
b: binder
s: stone (aggregate)
m: mix
a: absorbed
b: bulk
e: effective
m: maximum
16

16

Terminology

Term	Definition
Pb	
Gsb	
Pba	
Gmm	
Gse	

17

17

Percent Binder & Percent Stone

Agg Wt + **Binder Wt** = **Mix Wt**

$P_s + P_b = 100\ \%$

$$P_s = \frac{\text{Agg Wt}}{\text{Mix Wt}} \times 100 \qquad P_b = \frac{\text{Binder Wt}}{\text{Mix Wt}} \times 100 \qquad \text{Mix Wt} = \frac{\text{Agg Wt}}{P_s} \times 100$$

19

19

% Binder and % Stone

Determine the P_s if the P_b = 5.8 %

$P_s + P_b = 100$ %

$P_s = 100 - 5.8 = 94.2$

94.2 %

Report P_s & P_b to the nearest 0.1 %

20

20

% Binder and % Stone

Determine the P_s if the P_b = 6.1 %

$P_s + P_b = 100$ %

21

21

Specific Gravity of Binder (G_b)

Mix Design
- 77 °F

Field Testing
- Convert Gb from 60 °F to 77 °F
- Calculations use Gb_{77}

Conversion

$Gb_{77} = (Gb_{60})(0.9941)$

What is the Gb_{77} for binder with a $Gb_{60} = 1.024$?

$Gb_{77} = (1.024)(0.9941) = 1.01795...$

1.018

Report all specific gravities to the nearest 0.001

23

23

Specific Gravity of Binder (G_b)

Determine the specific gravity needed for calculations

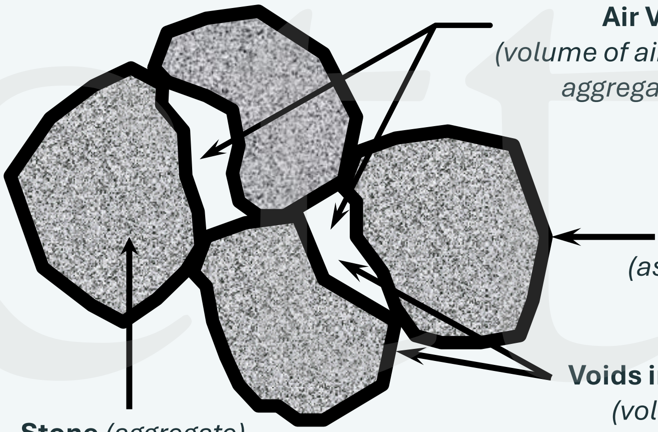
$Gb_{60} = 1.028$

$Gb_{77} = (Gb_{60})(0.9941)$

24

24

Terminology



26

26

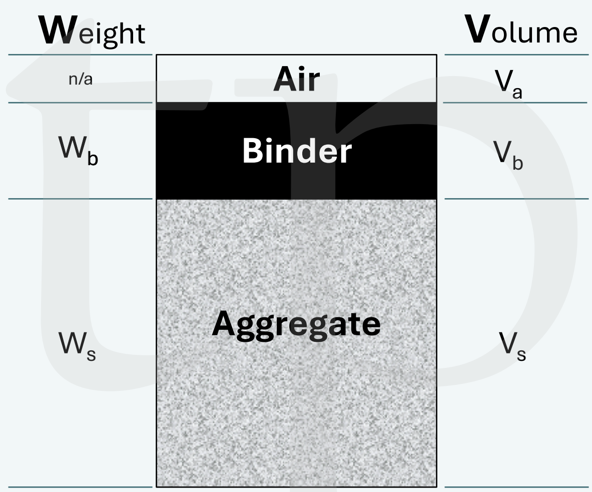
Mass – Volume Relationships

Aggregate
- Mass (wt)
- Volume

Binder
- Mass (wt)
- Volume

Air
- Volume

$$\textbf{Density} = \frac{\textbf{Weight}}{\textbf{Volume}}$$



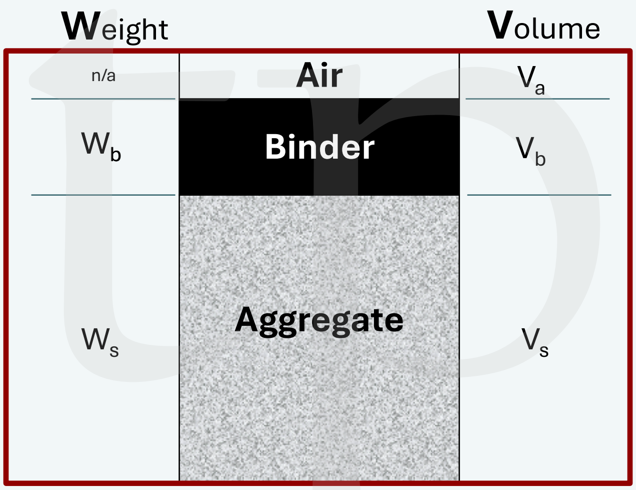
27

27

Bulk Specific Gravity of the Mix (Gmb)

Describes the density of the mix when compacted

- Will have some air voids



28

28

Calculation of Gmb

$$G_{mb} = \frac{A}{(B - C)}$$

A = Dry mass of specimen
B = SSD mass of specimen
C = Submerged mass of specimen

Report G_{mb} to 0.001

29

29

Calculation of Gmb

Determine the G_{mb} of the compacted specimen

Dry Mass	4456.7	A
Submerged Mass	2521.0	C
SSD Mass	4463.5	B

$$G_{mb} = \frac{A}{(B - C)}$$

$$G_{mb} = \frac{4456.7}{(4463.5 - 2521.0)} = \frac{4456.7}{1942.5} = 2.29431\ldots$$

2.294

30

30

Calculation of Gmb

Determine the G_{mb} of the compacted specimen

Dry Mass	4498.0	A
Submerged Mass	2496.3	C
SSD Mass	4502.0	B

$$G_{mb} = \frac{A}{(B - C)}$$

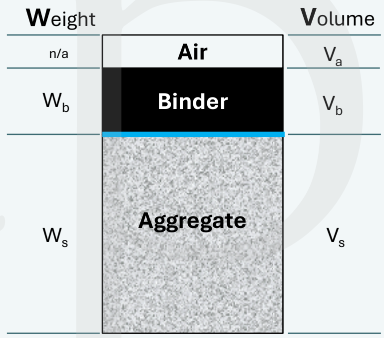
31

31

Calculation of Absorption

$$\% \text{ Abs} = \frac{(B - A)}{(B - C)} \times 100\ \%$$

A = Dry mass of specimen
B = SSD mass of specimen
C = Submerged mass of specimen



Report % Abs to 0.01 %

33

33

% Absorption (% Abs)

Determine the % absorption of the compacted specimen

Dry Mass	=	4571.6 g	**A**
Subm. Mass	=	2633.0 g	**C**
SSD Mass	=	4585.1 g	**B**

$$\% \text{ Abs} = \frac{(B - A)}{(B - C)} \times 100$$

$$\% \text{ Abs} = \frac{(4585.1 - 4571.6)}{(4585.1 - 2633.0)} \times 100 = \frac{13.5}{1952.1} \times 100\ \% = 0.69156...$$

0.69 %

34

34

% Absorption (% Abs)

Determine the % absorption of the compacted specimen

Dry Mass	= 3568.2 g
Subm. Mass	= 2016.1 g
SSD Mass	= 3577.9 g

$$\% \text{ Abs} = \frac{(B - A)}{(B - C)} \times 100$$

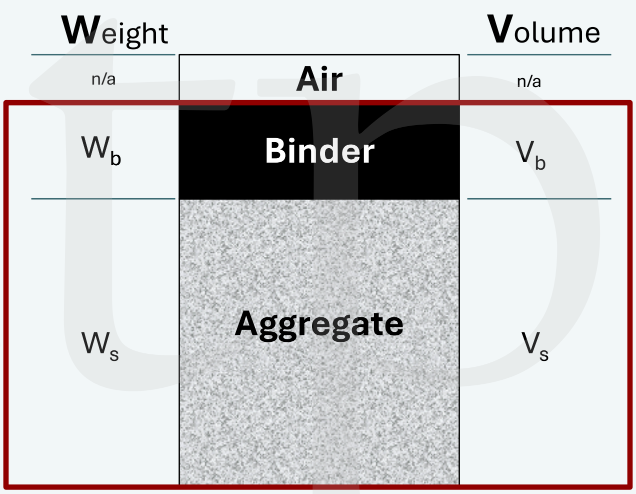
35

35

Theoretical Maximum Density of the Mix (Gmm)

Maximum Theoretical Specific Gravity of the Mixture (Gmm)

- “Rice” method
- Density of mixture with no air voids



37

37

Calculating Rice (Gmm)

Specific gravity of mixture with no air voids

- Used to determine relative density and % compaction
- Serves as a baseline value for maximum density

$$G_{mm} = \frac{A}{(A - C)}$$

A = dry mass
C = submerged mass

Report all specific gravities to the nearest 0.001

38

38

Calculating Gmm

Determine the G_{mm} of the asphalt mixture

Dry Mass	1796.4	A
Sub Mass (Bowl + S)	2348.7	C = 1048.7
Sub Mass (Bowl)	1300.0	

$$G_{mm} = \frac{A}{(A - C)}$$

$$G_{mm} = \frac{1796.4}{(1796.4 - 1048.7)} = \frac{1796.4}{747.7} = 2.40256...$$

2.403

39

39

Calculating Gmm

Determine the G_{mm} of the asphalt mixture

Dry Mass	2737.6
Sub Mass (Bowl + S)	2948.2
Sub Mass (Bowl)	1300.0

$$G_{mm} = \frac{A}{(A - C)}$$

40

40

% Density (based on Gmm)

Density of a mixture relative to a standard

- Maximum Theoretical Specific Gravity

$$\% \text{ Density} = \frac{G_{mb}}{G_{mm}} \times 100$$

Report % density to the nearest 0.1 %

42

42

% Density (based on Gmm)

Determine the % density

G_{mb} of Core 2.327
G_{mm} of Mix 2.434

$$\% \text{ Density} = \frac{G_{mb}}{G_{mm}} \times 100$$

$$\% \text{ Density} = \frac{2.327}{2.434} \times 100 = 95.6039...$$

95.6 %

43

43

% Density (based on Gmm)

Determine the % density

G_{mb} of Core 2.358
G_{mm} of Mix 2.512

$$\% \text{ Density} = \frac{G_{mb}}{G_{mm}} \times 100$$

44

44

% Air Voids (V_a)

Volume of air pockets in a compacted asphalt mixture

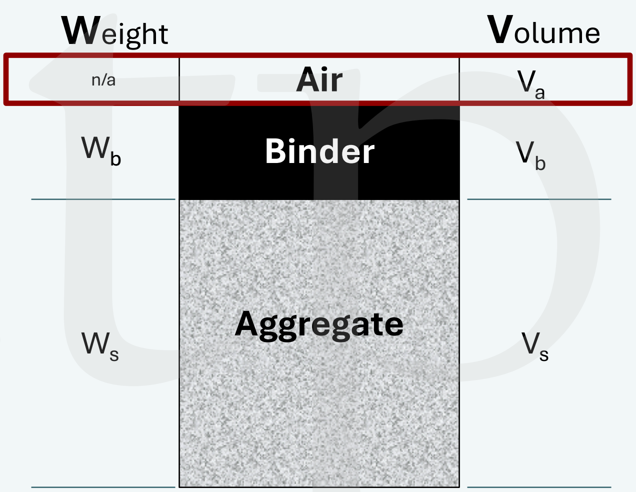
$$V_a = 100 - \% \text{ Density}$$

$$V_a = 100 - \left(\frac{G_{mb}}{G_{mm}} \times 100\right)$$

or

$$\left(1 - \frac{G_{mb}}{G_{mm}}\right) \times 100$$

Report % air voids to the nearest 0.1 %



46

% Air Voids (V_a)

Find the reported % air voids

G_{mb} 1	2.361	G_{mm}	2.447
G_{mb} 2	2.367		

Average G_{mb} 2.364

$$V_a = 100 - \left(\frac{G_{mb}}{G_{mm}} \times 100\right)$$

$$V_a = 100 - \left(\frac{2.364}{2.447} \times 100\right) = 100 - 96.608... = 3.3919...$$

3.4 %

47

% Air Voids (V_a)

Find the reported % air voids

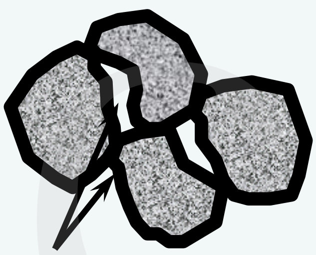
G_{mb} 1	2.309	G_{mm}	2.415
G_{mb} 2	2.303		

$$V_a = 100 - \left(\frac{G_{mb}}{G_{mm}} x\ 100\right)$$

48

48

Voids in the Mineral Aggregate (VMA)



Voids in the Mineral Aggregate (VMA)
(volume of air voids + volume of effective asphalt coating)

$$VMA = 100 - \left[\frac{(G_{mb})(P_s)}{G_{sb}}\right]$$

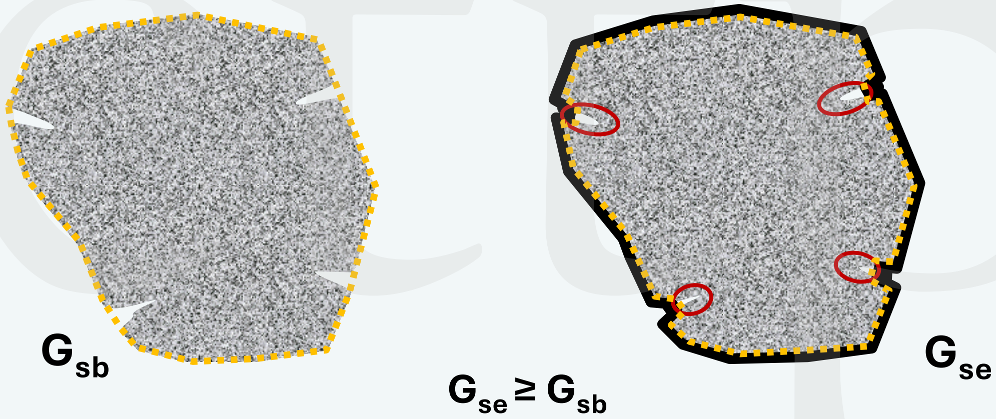
$$VMA_{eff} = 100 - \left[\frac{(G_{mb})(P_s)}{G_{se}}\right]$$

50

50

Effective Specific Gravity of Aggregate (G_{se})

Specific gravity of aggregate including the volume of pervious pore spaces not filled with asphalt



$G_{se} \geq G_{sb}$

51

51

Calculating Gse

$$\frac{P_s}{G_{se}} + \frac{P_b}{G_b} = \frac{100}{G_{mm}}$$

52

52

Calculating Gse

$$G_{se} = \frac{P_s}{\left(\frac{100}{G_{mm}} - \frac{P_b}{G_b}\right)}$$

Report all specific gravities to the nearest 0.001

53

53

Calculating Gse

Determine the G_{se} of the mixture

P_b	5.7 %
G_{mm}	2.413
$G_{b_{77}}$	1.032

$$G_{se} = \frac{P_s}{\left(\frac{100}{G_{mm}} - \frac{P_b}{G_b}\right)}$$

$P_s = 100 - 5.7 = 94.3$

$$G_{se} = \frac{94.3}{\left(\frac{100}{2.413} - \frac{5.7}{1.032}\right)} = \frac{94.3}{(41.4421... - 5.5232...)} = \frac{94.3}{35.9189...} = 2.62535...$$

2.625

54

54

Calculating Gse

Determine the G_{se} of the mixture

P_b	4.2 %
G_{mm}	2.555
$G_{b_{60}}$	1.032

$$G_{se} = \frac{P_s}{\left(\frac{100}{G_{mm}} - \frac{P_b}{G_b}\right)}$$

55

55

Voids in the Mineral Aggregate (VMA)

(VMA_{eff}) – (VMA) = VMA correction factor, or "VMA_{CF}"

$$VMA_{eff} = 100 - \left[\frac{(G_{mb})(P_s)}{G_{se}}\right]$$

$$VMA = VMAeff - VMA_{CF}$$

Voids in the Mineral Aggregate (VMA)
(volume of air voids + volume of effective asphalt coating)

Report % VMA to the nearest 0.1 %

57

57

Voids in the Mineral Aggregate (VMA)

Calculate the % VMA for the mixture

G_{mb} 1	2.345	P_b	4.1 %	VMA_{CF}	0.3 %
G_{mb} 2	2.343	P_s	95.9 %	G_{se}	2.588
Average G_{mb}	2.344				

$$VMA_{eff} = 100 - \left[\frac{(G_{mb})(P_s)}{G_{se}}\right]$$

$$VMA = VMA_{eff} - VMA_{CF}$$

$$VMA_{eff} = 100 - \left[\frac{(2.344)(95.9)}{2.588}\right] = 100 - 86.858... = 13.1$$

$$VMA = 13.1 - 0.3 = 12.8$$

12.8 %

58

58

Voids in the Mineral Aggregate (VMA)

Calculate the % VMA for the mixture

G_{mb} 1	2.425	P_b	4.4 %	VMA_{CF}	0.5 %
G_{mb} 2	2.431			G_{se}	2.635

$$VMA_{eff} = 100 - \left[\frac{(G_{mb})(P_s)}{G_{se}}\right]$$

$$VMA = VMA_{eff} - VMA_{CF}$$

59

59

ARDOT Mix Design

The mix design for the 25.0 mm ACHM Binder is accepted. Average verification results on this mix design are: Air Voids – 4.0 %; Gmb – 2.340; Height at Ndes – 115.2 mm. This mix design will be identified as HMA 684-25 for the Hogville, Inc. – Plant #1 in Fayetteville, AR.

Mix Design Properties

Optimum Asphalt Binder:	4.1 %	
Air Voids:	4.0 %	
VMA:	13.0 %	
VFA:	69.2 %	
Fines to Asphalt Ratio:	0.74	
Retained Stability:	94.1 %	
Ndes:	75	
Asphalt Binder:	HOG OIL PG 70-22	
APA Results:	1.951 mm	5.000 mm or less

Volumetric Mix Design

No.	Aggr. ID	Aggr. Name	Source	
1	75942	C Rock	Hogville Group, Hog Quarry	Fayetteville, AR
2	75861	5/8" Chips	Hogville Group, Hog Quarry	Fayetteville, AR
3	38850	1/4" Screenings	Hogville Group, Hog Quarry	Fayetteville, AR
4	22200	Man. Sand	Pork City Materials	Fayetteville, AR
5	02914	Sand	Hogville Group, Hog Quarry	Fayetteville, AR

Aggregates

Sieve Size	1	2	3	4	5	Job Mix	Control Points
50	100	100	100	100	100	100	100%
37.5	100	100	100	100	100	100	100%
25	72	100	100	100	100	100	90-100%
19	35	100	100	100	100	100	90% Max
12.5	11	89	100	100	100	93	
9.5	7	59	100	92	100	83	
4.75	4	7	90	55	100	59	
2.36	3	3	61	30	100	34	19-45%
1.18	2	3	37	17	99	22	
0.6	2	2	21	11	92	15	
0.3	2	2	11	7	63	8	
0.15	2	2	4	5	16	6	
0.075	1.8	2.0	3.3	4.7	13.2	4.8	1-7%
Cold Feed%	28	25	29	15	3		
Gsb	2.570	2.557	2.614	2.556	2.599		

Volumetric Mix Design

Design Summary

Mix Design #: HMA684-25 Mix Type: 25.0 MM ACHM Binder

Total Asphalt Content %:	4.1	Air Voids (Va):	4.0
New Asphalt Content %:	4.1	VMA:	13.0
Max. Theor. SG (Gmm):	2.437	VMA Corr. Factor:	0.3
Asphalt Binder:	PG 70-22	Gsb:	2.578
Asphalt Binder Source:	Hog Oil Company	Gse:	2.588
Mixing Temp (F):	330	Gb:	1.031
Compaction Temp (F):	305		
Antistrip Source:	HogGrip 975	Ni:	7
Antistrip %:	0.25	Ndes:	75
% Retained Stability:	94.1	Nmax:	115

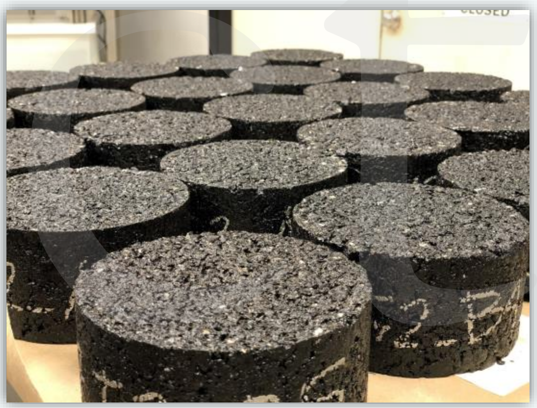
APA Results: 1.951 Spec Max = 5.000 mm

Mix Design Handout – p. 3 63

63

Mix Design

Volumetric Proportions

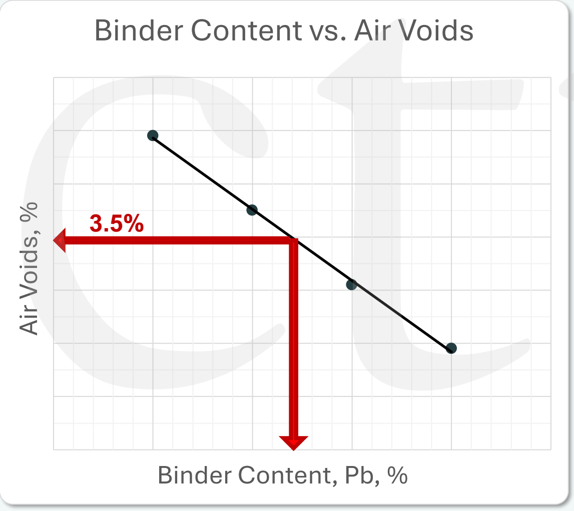


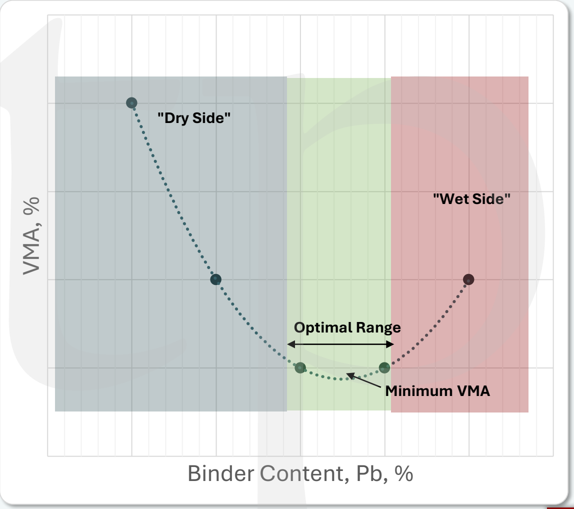
Performance

64

64

Volumetric Proportions





65

65

Performance – Moisture Sensitivity

Effects of water on strength of compacted mix
- 6" Marshall breaking head

Specimens in 2 groups
- Group A – control
- Group B – conditioned

Minimum Water Sensitivity Ratio = **80%**

SS-400-6: All ACHM mixes must contain liquid antistrip additive

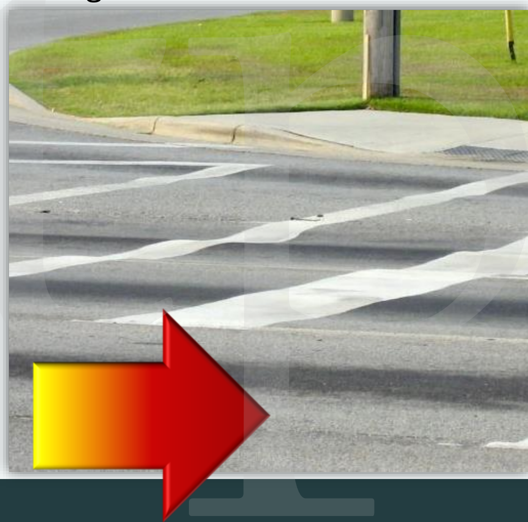
66

66

Pavement Distresses

Cracking

Rutting



67

67

Rutting – APA

Aging
- 2 hrs at Compaction Temp

Specimens
- 150 mm diameter
- 75 mm height
- 7 ± 1.0 % air voids
- 100 psi, 64 °C

Criteria
- Max of 5 or 8 mm @ 8000 cycles

68

68

Cracking Test – IDEAL-CT

Aging
- 2 hrs at Compaction Temp

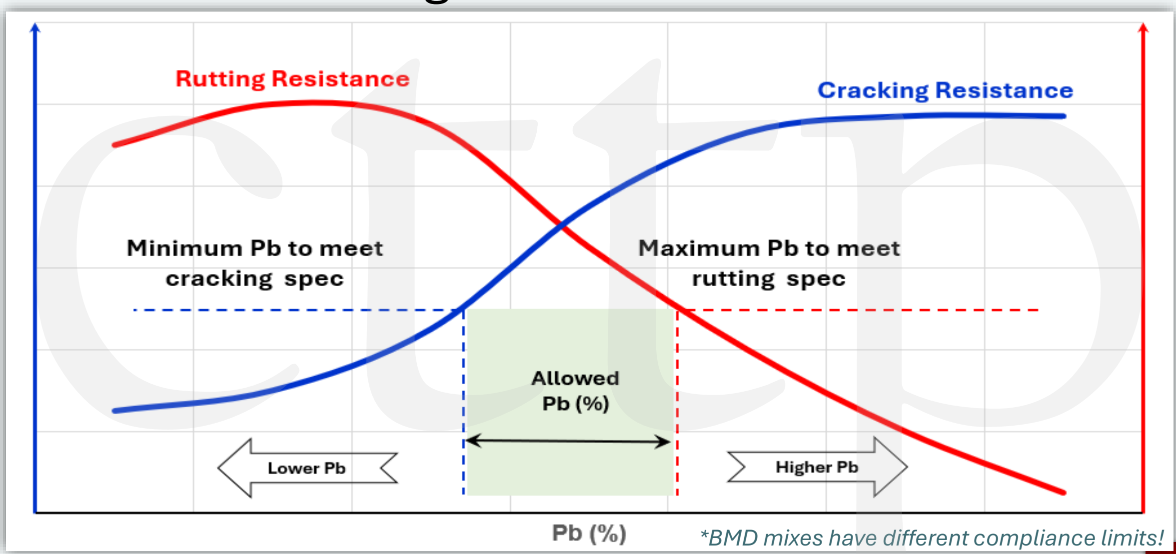
Specimens
- 3 specimens
- 150 mm diameter
- 62 mm height
- 7 ± 0.5 % air voids

Criteria
- Minimum CT Index = **75**

69

69

Balanced Mix Design



**BMD mixes have different compliance limits!*

70

70

Mix Design Verification

2024

Mix designs no longer have an expiration date.

A mix design that has not been used on an ARDOT project for the last 2 years is **INACTIVE**.

Mix designs with an expiration date may remain in production if they are not inactive.

A passing field verification may be submitted to Materials Division to be reactivated.

SS-400-4

71

71

Mix Design Verification

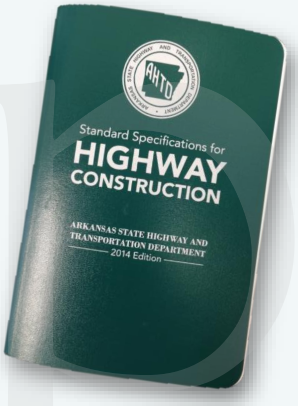
Required at the start of mix production or after an interruption of more than 120 days

Plant set up

- Mix Design Cold Feed %
- Optimum % Binder

Verify

- % Binder
- Gradation
- % Air Voids
- % VMA



SS-400-4

72

72

Verification Attempts

2 attempts allowed on ARDOT project

3 attempts allowed on non-ARDOT project

Max of 200 tons placed on ARDOT projects

Asphalt Content may not be changed until after verification of the mix design

73

73

Mix Verification on ARDOT Project

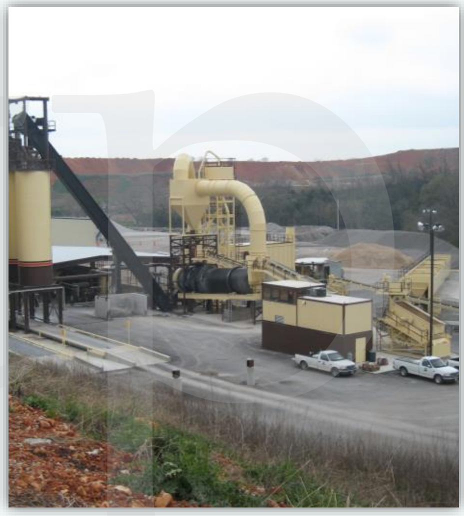
If 1st attempt doesn't verify	If 2nd attempt doesn't verify
Adjustments can ONLY be made to aggregate proportions	New mix design required
≤ 10 % limit per bin	
≤ 20 % limit total adjustment	

74

74

After Successful Verification

- Binder content shall be adjusted to obtain optimum binder content on mix design
- Binder content shall never be adjusted to lower than design value
- Can not make changes to binder content for control of a volumetric property
- All binder content changes must be reported to the Engineer in advance
- Contractor is allowed a 1-time field mix design



75

75

HMA Applications

cttp
Center for Training Transportation Professionals

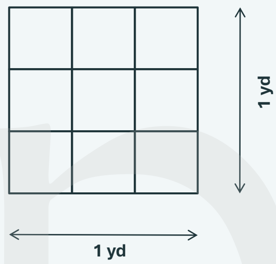
76

76

Conversions

1 ton — 2000 lbs

1 yd^2 — 9 ft^2



1 sta. — 100 ft

77

77

Stations

Station 50 + 80

- 50 stations + 80 feet
- (50 x 100) + 80 feet
- 5080 feet from start

Find the distance (ft) between station 17 + 35 and 25 + 79

- Drop "+" sign to convert distance to feet

$$\begin{array}{r} 2579 \text{ ft} \\ -\ 1735 \text{ ft} \\ \hline 844 \text{ ft} \end{array}$$

78

78

Application Rate

Describes the weight of asphalt needed to cover an area to produce the required thickness of pavement

- Checking the application rate ensures that the proper amount of asphalt is applied to the roadway

Application Rate (lb/yd^2)

$$\text{Weight (lb)} = \text{(tons)(2,000)}$$

$$\text{Area } (yd^2) = \frac{\text{(length)(width)}}{9}$$

$$\text{Rate} = \frac{\text{(tons)(18,000)}}{\text{(length)(width)}}$$

Length and width measured in feet

79

79

Application Rate

Find the application rate in lb/yd^2 for 700 tons of asphalt placed in an area 12’ wide by 4774’ long.

$$\text{Rate} = \frac{\text{(tons)(18,000)}}{\text{(length)(width)}}$$

$$\frac{(700)(18{,}000)}{(4{,}774)(12)} = \frac{12{,}600{,}000}{57{,}288} = 219.94\ldots$$

220 lb/yd^2

80

80

Application Rate

Find the application rate in lb/yd^2 for 1000 tons of asphalt placed from station 62 + 20 to station 101 + 67 and 16' wide

$$\text{Rate} = \frac{(\text{tons})(18{,}000)}{(\text{length})(\text{width})}$$

81

81

Quantity of Asphalt

The weight of asphalt mixture required to cover an area to a prescribed depth or application rate

- A typical assumption is that it takes approximately 110 pounds of asphalt mixture per square yard to produce a compacted pavement one inch thick

$$\text{Tons} = \frac{(\text{Rate})(\text{length})(\text{width})}{(18{,}000)}$$

$$\text{Weight (tons)} = \frac{(\text{Rate})(\text{Area})}{2000}$$

Rate measured in lb/yd^2

$$\text{Area (yd}^2\text{)} = \frac{(\text{length})(\text{width})}{9}$$

Length and width measured in feet

83

83

Quantity of Asphalt

Find the tons of asphalt needed to pave a 10 ft wide, 300 ft long drive with an application rate of 220 lb/yd^2

$$\text{Tons} = \frac{(\text{Rate})(\text{length})(\text{width})}{(18{,}000)}$$

$$\text{Tons} = \frac{(220)(300)(10)}{(18{,}000)} = \frac{660{,}000}{18{,}000} = 36.66\ldots$$

37 tons

84

84

Quantity of Asphalt

Find the tons of asphalt needed to pave a 50’ wide x 300’ parking lot with an application rate of 160 lb/yd^2

$$\text{Tons} = \frac{(\text{Rate})(\text{length})(\text{width})}{(18{,}000)}$$

85

85

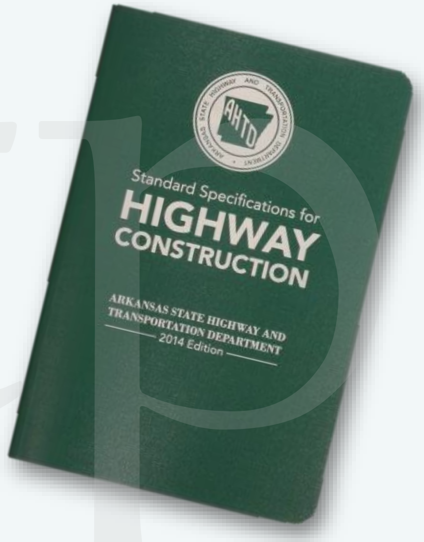
ARDOT Specifications

Standard Specifications & Errata
- Mix design and quality control requirements

Supplemental Specifications
- Changes to the Standard Specifications

Job Plans
- Mix design requirements and application rates

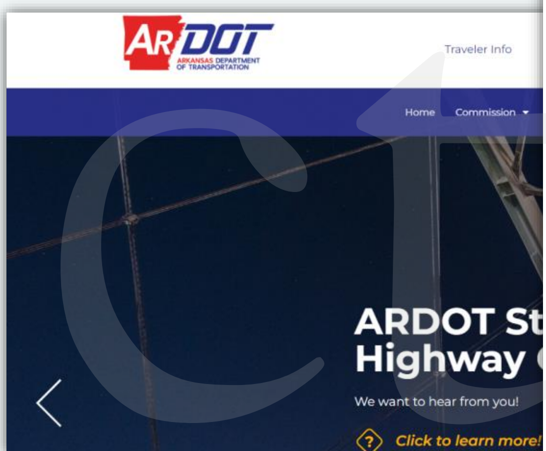
Special Provisions – Apply only to individual jobs
- Recycled Asphalt Shingles
- Warm Mix Asphalt
- PWL
- Joint Densities

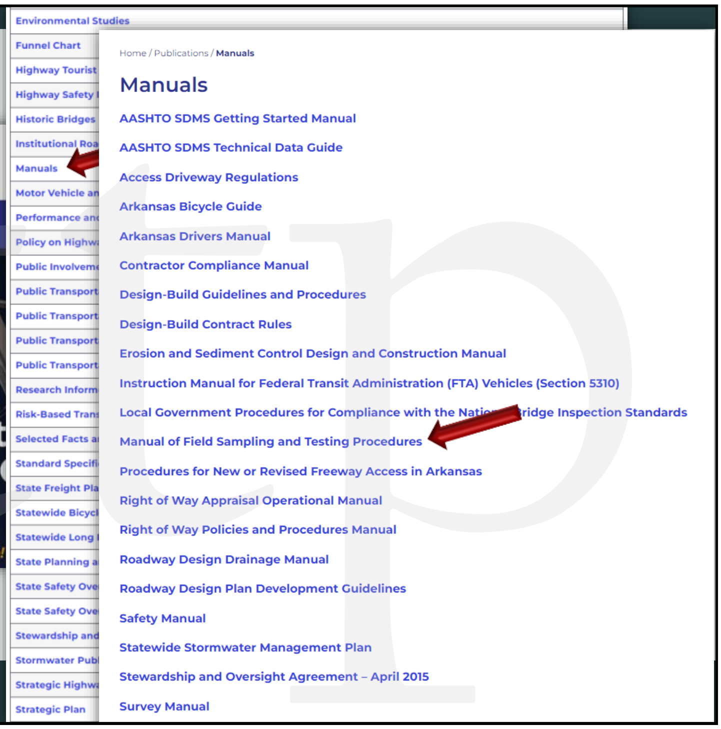


87

87

ARDOT Publications





88

Field Compliance Limits (ARDOT Table 410 – 1)

Property		Tolerance
Binder Content		± 0.3% (mix design)
Air Voids		2.5% - 4.5% (2025)
VMA	37.5 mm	11.0% - 13.5%
	25.0 mm	12.0% - 14.5%
	12.5 mm	14.0% - 16.5%
	9.5 mm	15.0% - 17.5%
Gradation	See ARDOT Section 404.04	
Field Density	92.0% - 97.0% or 90.0% - 97.0% (2025)	

89

89

Field Compliance Limits (ARDOT 404.04)

ARDOT Gradation	Sieve Size		Tolerance
Tolerances are applied to the Job Mix Formula (JMF)	1”	25.0 mm	± 7.0 %
	¾”	19.0 mm	± 7.0 %
	½”	12.5 mm	± 7.0 %
	#4	4.75 mm	± 7.0 %
	#8	2.36 mm	± 7.0 %
	#16	1.18 mm	± 4.0 %
	#30	0.60 mm	± 4.0 %
	#50	0.30 mm	± 4.0 %
	#100	0.15 mm	± 4.0 %

90

90

Specification Limits

ARDOT specification limits are absolute!

Observed or calculated values are not rounded for determination of compliance

- Compared directly with the limit
- Average values are rounded to same number of significant digits

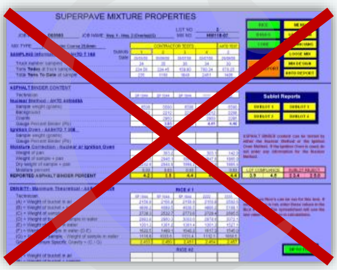
Any deviation outside limits is considered non-compliance

- Failing test

91

91

Submittals - SiteManager

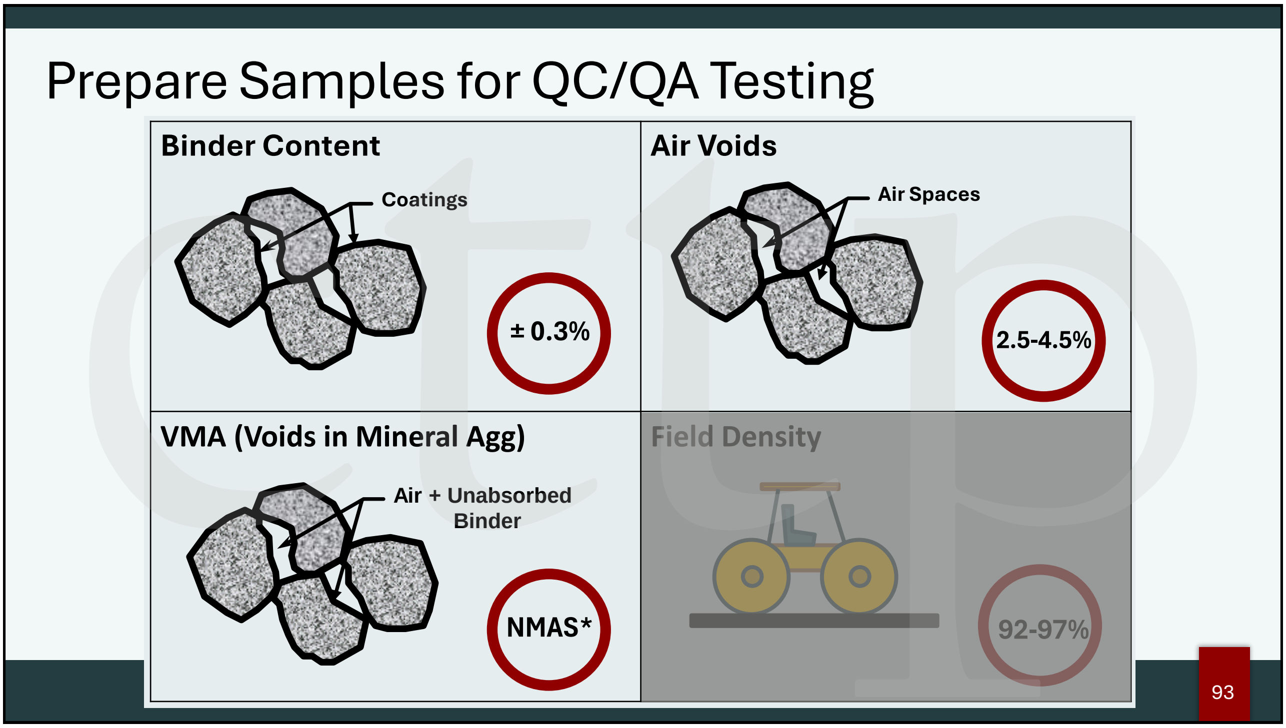


AASHTOWare

AASHTO

92

92

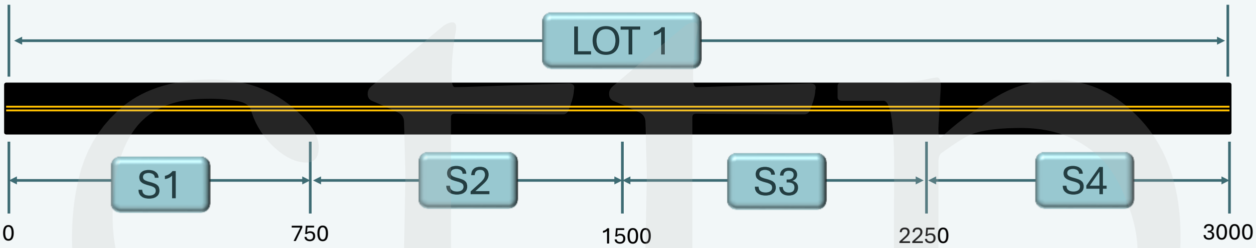

Prepare Samples for QC/QA Testing
Binder Content
Coatings
± 0.3%
Air Voids
Air Spaces
2.5-4.5%
VMA (Voids in Mineral Agg)
Air + Unabsorbed Binder
NMAS*
Field Density
92-97%
93

93


Quality Control / Quality Assurance
750 tons
Sublot 1
750 tons
Sublot 2
750 tons
Sublot 3
750 tons
Sublot 4
Lot = 3000 tons
94

94

Random Sampling - Tonnage



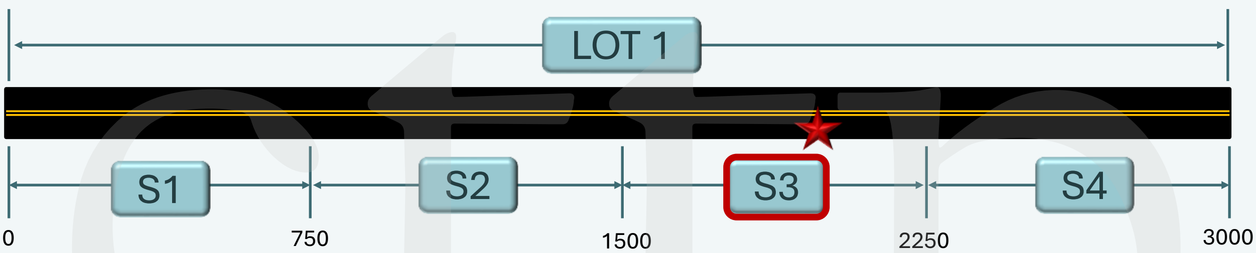
Step 1: Multiply random number (RN) by lot or sublot size

Step 2: Add previous tonnage

95

95

Random Sampling - Tonnage



Example: Lot 1, Sublot 3, RN = 0.64

750 x 0.64 = 480

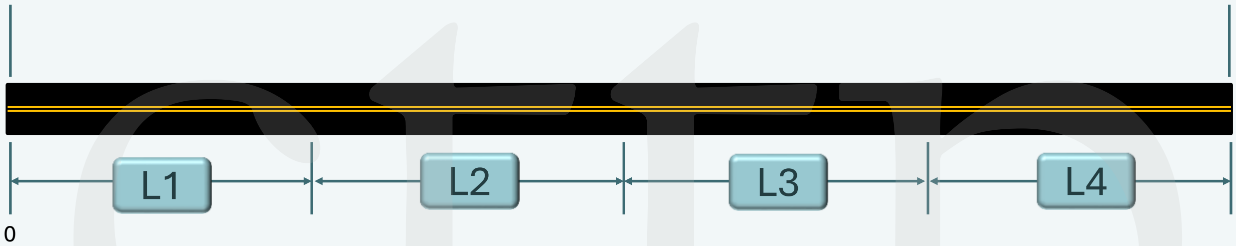
480 + 1500 = 1980

1980

96

96

Random Sampling - Tonnage



Example: Lot 4, RN = 0.38

97

97

Sampling Bituminous Mixtures

AASHTO R 97

cttp
Center for Training
Transportation Professionals

100

100

ARDOT Specifications

ARDOT 404.04 – Sampling shall be performed according to AASHTO R 97 and ARDOT 465

- Note 1: Samples shall be taken from trucks at the plant

101

101

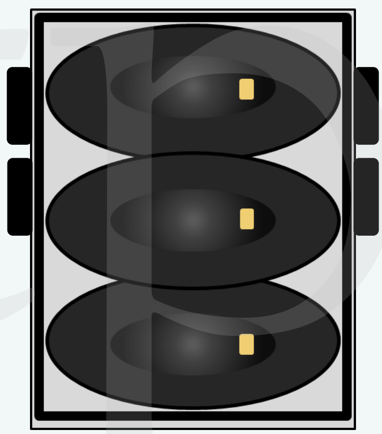
Transport Units

Visually divide truck bed into 3 or 4 equal sections

Remove 6-12” of topmost material

Obtain 1 portion from each section

Combine portions



102

102

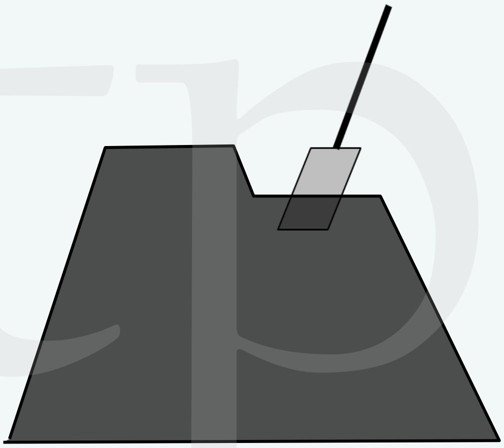
Transport Units

Avoid loss of larger aggregates from overfilling shovel

Avoid buildup of fines on shovel

Sample should look like the load sampled!

If not, get another sample from the same truck!



Windrow Sampling

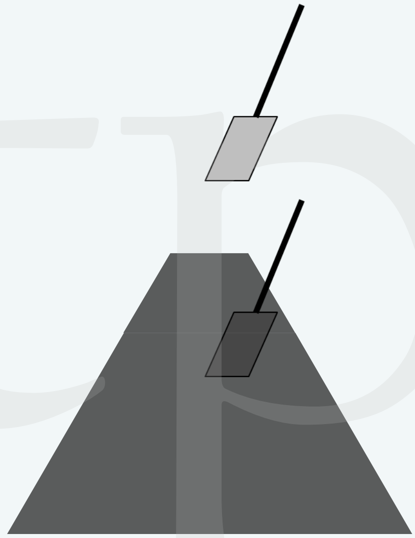
Visually divide the windrow unit into 3 approximately equal sections

- Avoid sampling in the beginning or end of a windrow unit
- Choose a sample location in each section

Windrow Sampling

Sample portions

- At each sample location, discard the top foot of windrow
- Fully insert shovel into the exposed surface
  - Vertically
- Roll back shovel and lift material
- Avoid material rolling off shovel
- Combine portions



105

105

Other Sampling Locations

Roadway (before compaction)

- Take samples behind paver, but in front of breakdown roller
- "Cookie Cutter"
- Plate

Used when asphalt is placed on grade or base material

Paver or MTD Hopper

- Remove top 6 – 10 inches of asphalt
- Take sample from center of hopper

  Stay at least 1.5' away from sides

Stockpiles

- Remove top 4 inches of asphalt

Always obtain a minimum of 3 portions

106

106

Transportation

Protect the sample

- Avoid contamination
- Prevent loss of material
- Maintain temperature

Labeling

- Job number
- Source of sample
  - Plant / mix design number
- Sample location
  - Tons
  - Lot / sublot

107

107

Reducing Samples of HMA to Testing Size

AASHTO R 47

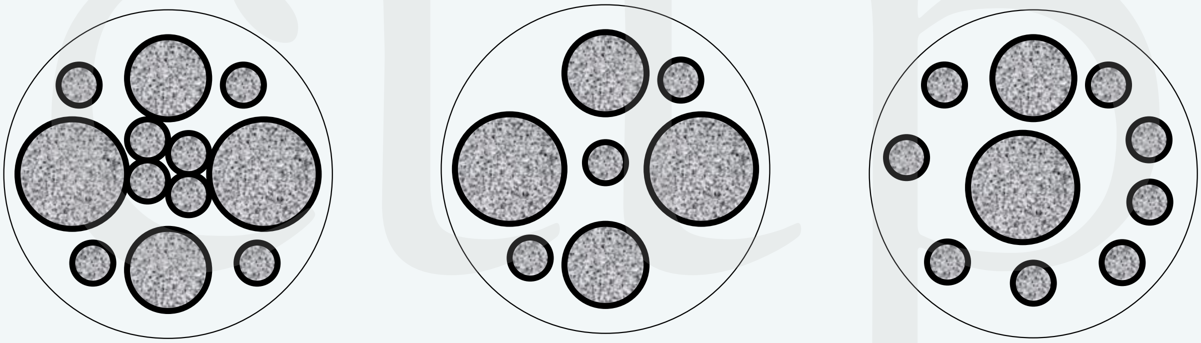
cttp
Center for Training
Transportation Professionals

108

108

Reducing Samples

Methods used to reduce samples in size while maintaining physical characteristics and size proportions



109

Reducing Samples

Gradation of a reduced HMA sample affects its volumetric properties

- Pb
- Gmm
- % Air Voids
- % VMA
- % Density

Sieve	Design	Coarse	Fine
¾”	100	100	100
½”	92	89	95
3/8”	81	78	84
# 4	52	49	55
# 8	30	27	33
# 16	20	17	23
# 30	16	15	18
# 50	13	11	15
# 100	9	8	10
# 200	5.2	4.2	6.2
Pb	**5.5 %**	**4.75 %**	**6.27 %**

110

Reducing Samples

Maintain Temperature

- Heat equipment up to maximum mixing temperature

Release Agents

- May be used to lightly coat equipment surfaces
  - Use only approved release agents
  - No solvents or petroleum-based products

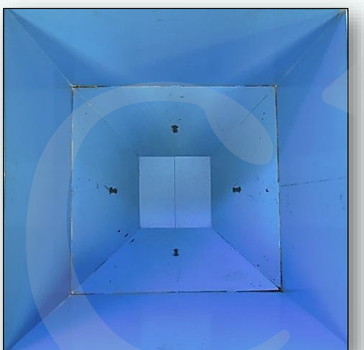
Methods

- Mechanical Splitter
  - Recommended for large samples
  - Type A
  - Type B
- Quartering Method
  - 2023 → Sectoring
- Incremental Method

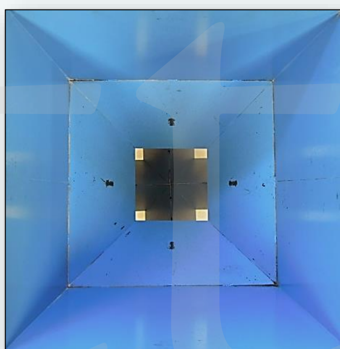
111

111

Type A Mechanical Splitter



Fill the hopper



Open the hopper

Collect diagonally opposite quarters

112

112

Type B Mechanical Splitter

Fill hopper or pan
- Evenly distribute

Open hopper at a controlled rate

Collect one side

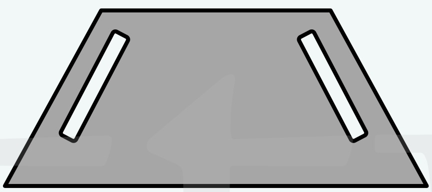
113

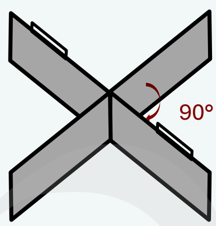
113

Quartering

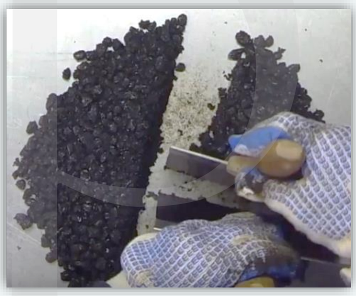
Straight Edge

Quartering Template





Place on nonstick surface
Mix well – turn pile 4+ times
Form conical pile and flatten
Separate into quarters using straightedge or template
Collect diagonally opposite quarters



114

114

Sectoring

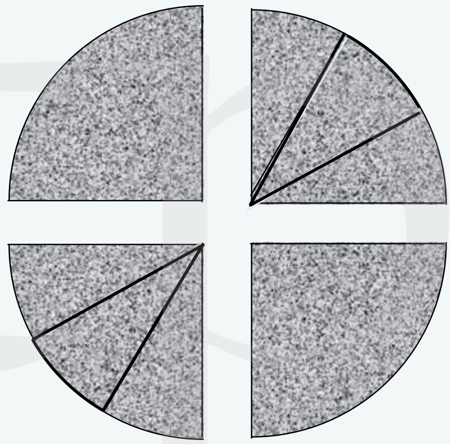
After Quartering:

Use a straightedge to obtain a sector
- Sector is from center to outer edge, "pie" slice

Drag sector away from quarter

Obtain equal size sector from the diagonally opposite quarter

Combine sectors



115

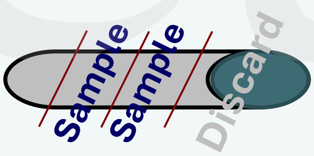
115

Incremental Method

Place sample on nonstick paper
- Mix well – turn pile 4+ times

Roll asphalt into cylindrical loaf
- Discard end quarter of loaf

Cut off (collect) desired sample sizes
- Remix and repeat as necessary

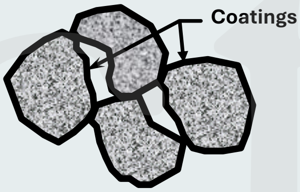


116

116

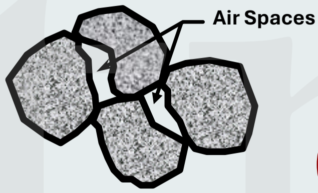
Prepare Samples for QC/QA Testing

Binder Content



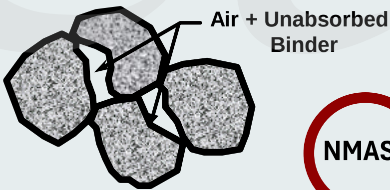
± 0.3%

Air Voids



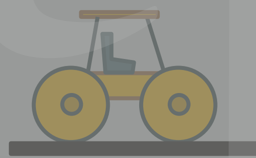
2.5-4.5%

VMA (Voids in Mineral Agg)



NMAS*

Field Density



92-97%

117

117

Prepare Samples for QC/QA Testing

Binder Content

- Nuclear AC Content
- Ignition Oven
- Moisture Content

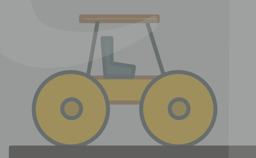
Air Voids

- Bulk Specific Gravity (Gmb)
- Max Specific Gravity (Gmm)

VMA (Voids in Mineral Agg)

- Bulk Specific Gravity (Gmb)
- Effective SpGr of Stone (Gse) (from Gmm)

Field Density



92-97%

118

118

Preparing HMA Specimens by Gyratory Compactor

AASHTO T 312

Center for Training Transportation Professionals

119

119

Gyratory Compaction - Equipment

Gyratory compactor

- Mold
- Bottom
- Top

Oven

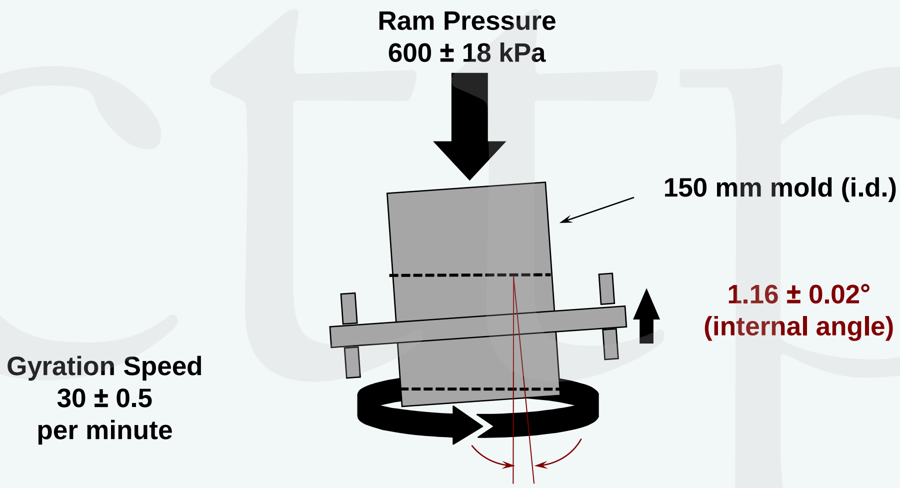
- Compaction temperature
- ± 5 °F

Thermometer

120

120

Gyratory Compactor Parameters



121

121

Compactor Preparation

Verify settings
- Angle & pressure
- Number of gyrations
  - Ndes shown on mix design

Lubricate bearing surfaces

Preheat molds and plates to compaction temperature
- At least 30 minutes
- Reheat at least 5 minutes between uses

122

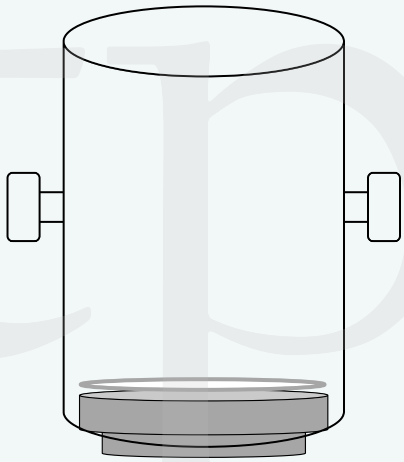
122

Preparation

Reduce sample
- 115 ± 5 mm height
- (4400 g – 4800 g)

Bring asphalt mixture to compaction temperature

Assemble mold
- Largest side of plate goes toward specimen
- Paper disk



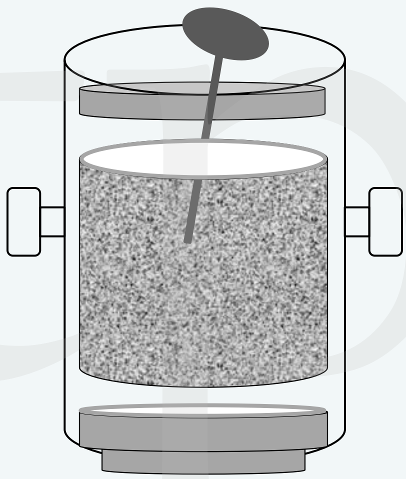
Procedure

Place asphalt mixture into mold in one lift
- Avoid segregation
- Level surface of HMA

Verify temperature
- Compaction temperature shown on mix design

Insert paper disk

Place top plate in mold if necessary



Gyratory Compaction Procedure

Load mold into compactor

Compact specimen

Remove mold from compactor

Gyratory Compaction Procedure

Extrude specimen from mold
- Cool tender specimens
- Extrude slowly

Remove paper disks

Cool to room temperature
- Compact at least 2 specimens

Mold Diameter Verification

Frequency
- Yearly or 80 hours

Verify inside dimensions
- 3-point bore gauge
- Calibrated master ring

Mold temperature
- 64 – 82 °F

Procedure
- Record 3 measurements at each height
  - 50 mm from wear end
  - 100 mm from wear end
  - 50 mm from opposite end

In-service mold diameters must be ≤ 150.2 mm

128

128

Gyratory Compactor Verification

Frequency
- Follow mfr. recommendations
- 12 month maximum

Verify
- Internal angle
- Pressure
- Rotation speed
- Height measurement

Additional Checks
- Change in location
- Repairs affecting calibration

Optional Check
- New season of mix designs

130

130

Bulk Specific Gravity of Compacted HMA Specimens

AASHTO T 166

Center for Training Transportation Professionals

132

132

Bulk Specific Gravity

Used to determine the volumetric properties of compacted mix

- Gyratory specimens or cores

133

133

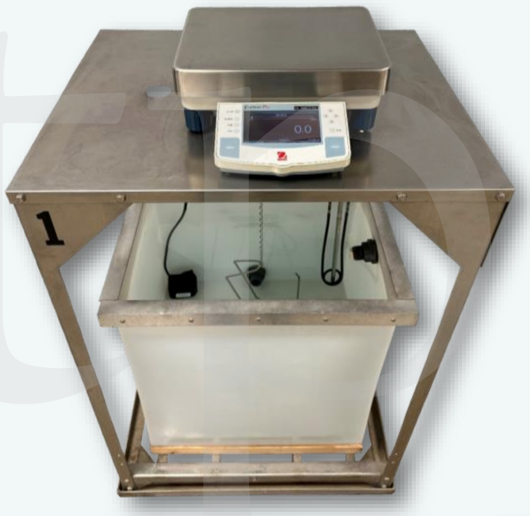
Bulk Specific Gravity - Equipment

Scale

- Readable to at least 0.1 % of sample mass
- Suspension apparatus (weigh-below)

Water bath

- Overflow device to maintain constant water level
- 77 ± 2 °F
- Agitator and heater (optional)



134

134

Bulk Specific Gravity – Method A

Remove any foreign material

Dry specimen to constant mass

- 2024 126 ± 5 °F
- Vacuum (≥ 2 cycles)

Cool to 77 ± 9 °F

Weigh specimen and record dry mass in air

135

135

Bulk Specific Gravity – Method A

Prepare water bath
- Fill and allow to stabilize
- Tare out suspension apparatus

Submerge specimen in water bath
- Leave submerged for **4 ± 1 minutes**

✏️ Record submerged mass

136

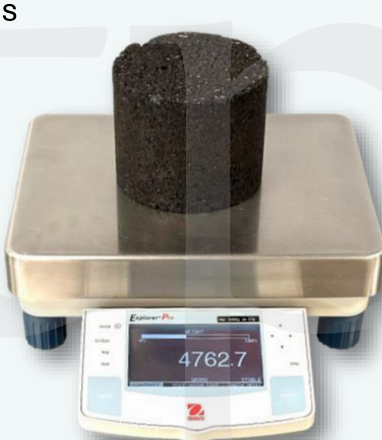
136

Bulk Specific Gravity – Method A

Remove specimen from water bath

Quickly bring to SSD with damp towel
- 15 seconds

Weigh specimen and record SSD mass ✏️



137

137

Calculation of Gmb and Absorption

$$G_{mb} = \frac{A}{(B - C)}$$

$$\% \text{ Abs} = \frac{(B - A)}{(B - C)} \times 100\ \%$$

A = Dry mass of specimen
B = SSD mass of specimen
C = Submerged mass of specimen

Report G_{mb} to 0.001, Abs to 0.01%

138

138

Bulk Specific Gravity – Method C (Rapid Test)

- Obtain submerged mass
- Obtain SSD mass
- Dry specimen at 230 ± 9 °F to constant mass
- Cool to room temperature
- Obtain dry mass

This method destroys the specimen but allows cores to be tested the same day

140

140

% Absorption Requirements

AASHTO T 166 is only applicable for samples that absorb 2 % or less water by volume

- If > 2 % absorption, rerun test
  - Dry to constant mass
  - AASHTO T 275 (Paraffin Coating)
  - AASHTO T 331 (Vacuum Sealing)

ARDOT Special Provision

- Longitudinal Joint Densities

Joint densities are susceptible to having more than 2 % absorption

141

141

Theoretical Maximum Specific Gravity

AASHTO T 209

cttp
Center for Training Transportation Professionals

142

142

The Rice Test (Gmm)

Influenced by the mixture
- Binder
- Stone
- Moisture

Influences pay
- % Air Voids
- % VMA
- % Density

143

Rice Test Equipment

Vacuum System

Water Bath & Scales

144

Sample Preparation

Plant-produced samples
- May be short-term conditioned at 135 ± 3 °C (275 ± 5 °F)
- Reduce samples to meet minimum size requirements

While still warm, separate sample
- ≤ ¼” in size (no fine clumps)
- Prevents trapped air between particles

Cool to room temperature

Sample Size

NMAS	Sample Size (minimum)
≥ 37.5 mm	4000 g
19 – 25 mm	2500 g
≤ 12.5 mm	1500 g

145

145

Rice Test Procedure

Tare bowl on the scale or record an empty mass

Place sample into vacuum bowl

Weigh vacuum bowl with sample

Record net mass of sample

146

146

Rice Test Procedure

Add 77 ° F water to completely cover the sample

- Sink floating particles
- Optional: Add 5-10 mL of diluted wetting agent
  - Aerosol OT

147

Rice Test Procedure

Remove trapped air by applying vacuum

- 2023 • 30 ± 5 mm Hg (4.0 ± 0.6 kPa)
- 2022 • 15 ± 1 minutes

Agitate vacuum bowl

- Mechanical shaker
- Vigorously shake every 2 minutes

148

Rice Test Procedure

Turn off table, pump, etc.

Release vacuum slowly

- ≤ 60 mm Hg/s (8 kPa/s)
- ~ 12 seconds

Prepare water bath

- Fill to overflowing
- Allow water level to stabilize
- Tare suspension apparatus

149

149

Rice Test Procedure

Submerge vacuum bowl + sample

- 77 ± 2 °F
- 10 ± 1 minutes

✏️ Record submerged mass of bowl + sample

Remove bowl from water bath

✏️ Record standardized mass of vacuum bowl

150

150

Calculation of Gmm

$$G_{mm} = \frac{A}{(A - C)}$$

A = Dry mass of sample
C = Submerged mass of sample

C = (bowl + sample) sub − (bowl)sub

Report all specific gravities to the nearest 0.001

151

151

Standardized Bowl Mass

Prepare water bath

Submerge empty vacuum bowl
- 77 ± 2 °F
- 10 ± 1 minutes

Record submerged mass of bowl
- Repeat 2 more times (3 total)
- **If within 0.3 g**, average 3 masses
- Record average mass

152

152

Bulk Specific Gravity of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens

AASHTO T 275

Center for Training Transportation Professionals

155

155

Paraffin Coating - Equipment

Scale
- Readable to 0.1 % of sample mass or better

Suspension Apparatus

Water Bath
- Overflow device to maintain constant water level
- 77 ± 0.9 °F
- Agitator and heater (optional)

Drying Apparatus
- Oven at 125 ± 5 °F
- Vacuum dryer

Crock pot or other suitable device for heating paraffin wax

156

156

Paraffin Coating - Procedure

Obtain the specific gravity of the paraffin at 77 ± 1.8 °F
- Manufacturer
- Approximately 0.915

Heat paraffin to about 10 °F above its melting point
- 120 – 150 °F

Dry specimen to constant mass
- 125 ± 5 °F
- Vacuum (≥ 2 cycles)

Cool to 77 ± 9 °F

Weigh specimen and record dry mass in air

157

157

Paraffin Coating - Procedure

Coat specimen on all sides with melted paraffin

Seal surface voids

Cool at 77 ± 9 °F for at least 30 minutes

158

158

Paraffin Coating - Procedure

✏ Weigh specimen and record coated mass in air

Prepare water bath

- Fill to overflowing
- Allow water level to stabilize
- Tare suspension apparatus

Submerge coated specimen in water bath for **4 ± 1 minutes**

✏ Record submerged mass

159

159

Paraffin Coating – Calculation

$$G_{mb} = \frac{A}{D - E - \left(\frac{D - A}{F}\right)}$$

A = Dry mass of specimen
D = Mass of coated specimen
E = Submerged mass of coated specimen
F = Specific gravity of paraffin at 77 °F

Report G_{mb} to 0.001

160

160

Bulk Specific Gravity of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing

AASHTO T 331

cttp
Center for Training Transportation Professionals

162

162

Vacuum Sealing - Equipment

Scale
- Readable to 0.1 % of sample mass or better
- Suspension apparatus

Water bath
- Overflow device to maintain constant water level
- 77 ± 0.9 °F
- Agitator and heater (optional)

Drying apparatus
- Oven or vacuum

Vacuum Chamber
- Reach 5 mm Hg in 60 seconds

Plastic sealing bags
- Thickness of 0.005 – 0.007 inch
- 2023 → 14.5 – 15.5 inch opening

Cushioned sliding plate

163

163

Vacuum Sealing - Procedure

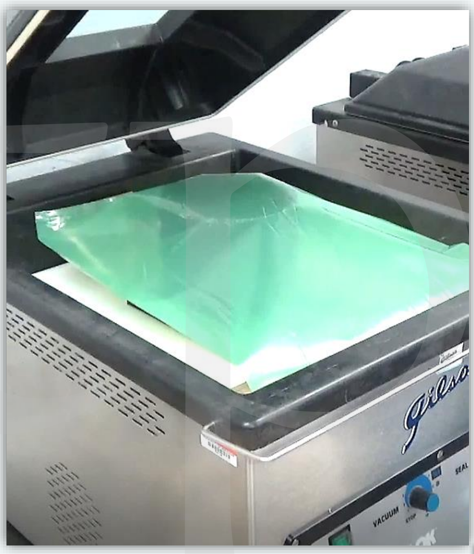
- Record bag correction factor
  - Apparent specific gravity of bag
    - Manufacturer
- Dry specimen to constant mass
  - 125 ± 5 °F
  - Vacuum (≥ 2 cycles)
- Cool to 77 ± 9 °F
- Weigh specimen and record dry mass in air
- Inspect sealing bag for holes, weigh and record bag mass
- Place bag on sliding plate inside vacuum chamber

164

164

Vacuum Sealing - Procedure

- Center specimen inside bag and on top of sliding plate
  - Place smoothest side down
- Place bag across seal bar
  - Smooth out wrinkles
  - Leave about 1 inch of overhang

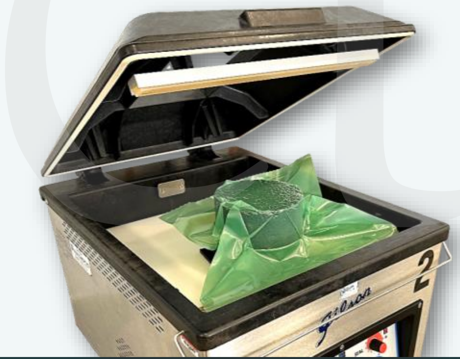


165

165

Vacuum Sealing - Procedure

Seal specimen
- Close lid and latch
- Wait for lid to open



Inspect bag and seal
- Repeat with new bag if loose or leak is noted

Within 60 seconds, submerge sealed specimen in water bath

Ensure bag is not touching sides of water bath
- Remove trapped pockets of air

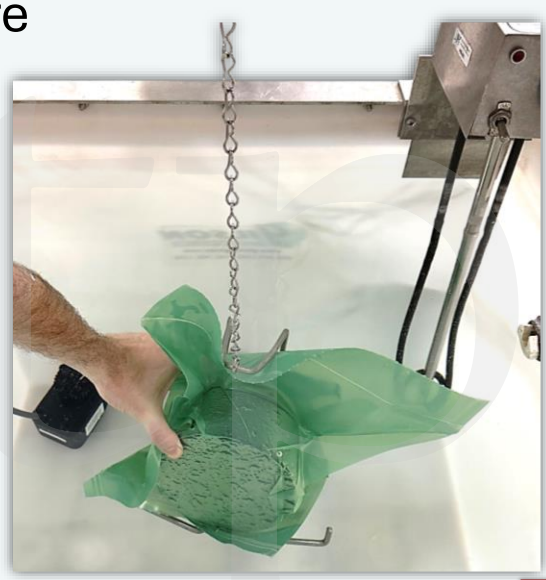
Vacuum Sealing - Procedure

Record submerged mass of sealed specimen

Remove sample from water bath

Cut open bag

Record final weight of sample in air
- Limited to 0.08 % loss or 0.04 % gain in weight



Vacuum Sealing – Calculation

$$G_{mb} = \frac{A}{C + B - E - \left(\frac{B}{F}\right)}$$

A = Initial dry mass of specimen
B = Mass of the bag
C = Final mass of specimen
E = Submerged mass of sealed specimen
F = Bag correction factor (apparent specific gravity)

Report G_{mb} to 0.001

168

168

Vacuum Sealing - Calibration

Vacuum chamber

- Verify vacuum using vacuum gauge
  - Every 3 months
  - After repairs
  - After relocation

Vacuum gauge

- Range of at least 0 – 10 mm Hg
- Must allow placement inside chamber

169

169

Moisture Content of Asphalt Mixtures by Oven Method

AASHTO T 329

Center for Training Transportation Professionals

171

171

Moisture Content - Equipment

Oven

- Mixing temperature or
- 325 ± 25 °F

Scale

- Readable to at least 0.1 g
- ≥ 2 kg capacity

Thermometer

2022
- Accurate to ± 3.6 °F (± 2 °C)

172

172

Moisture Content – Procedure

✏ Record empty mass of sample pan
- Include weight of liners

Place asphalt mixture in pan

✏ Measure and record temperature of the mix
- Distribute sample evenly in container

✏ Record mass of sample pan and moist test sample
- Determine initial mass of sample

Dry sample for 90 ± 5 minutes
- Determine mass of sample

Continue drying until ≤ 0.05 % change in mass
- Check at 30 ± 5 min. intervals

173

173

Moisture Content – Calculation

$$\% \text{ Change} = \frac{(M_p - M_n)}{M_n} \times 100$$

M_p – mass of previous measurement
M_n – mass of newest measurement

Cool to roughly the same temperature as initially recorded

✏ Weigh and record mass of sample pan and dry test sample
- Determine final dry mass of sample

174

174

Finding Constant Mass

1245.6 g

- Initial “wet” mass

1244.4 g

- 0.096 % change

More drying needed

1244.1 g

- 0.024 % change – final “dry” mass

<0.05, constant mass

175

175

Calculation

$$\%\,MC = \frac{(M_i - M_f)}{M_f} \times 100 = \frac{(W - D)}{D} \times 100$$

M_i = Initial mass of asphalt mixture (wet)
M_f = Final mass of asphalt mixture (dry)

Subtract tare weight of pan to get mixture weights!

Report moisture content to the nearest 0.01 %

176

176

Moisture Content – Calculation

Tare Weight = 356.8
Wet + Tare = 1355.7
Dry + Tare = 1354.8

W = 1355.7 – 356.8 = **998.9**

D = 1354.8 – 356.8 = **998.0**

$$\% MC = \frac{(W - D)}{D} \times 100$$

$$= \frac{(998.9 - 998.0)}{998.0} \times 100$$

= 0.09018…

0.09 %

177

177

Moisture Content – Calculation

Tare Weight = 243.8
Wet + Tare = 1505.7
Dry + Tare = 1505.2

$$\% MC = \frac{(W - D)}{D} \times 100$$

178

178

Determination of Asphalt Content by the Nuclear Method

ARDOT 449

Center for Training Transportation Professionals

181

181

Gauge Preparation

Place at least 30 feet from other sources of radiation

Keep area clear of hydrogenous materials
- Water
- Plastics
- Asphalt

Make sure chamber is clean and empty

Turn on gauge / warm up

Perform an 8 or 16 minute background count
- Daily or whenever gauge surroundings have changed

Record background count in a daily log
- Verify new background is within ± 1% of previous background count

182

182

Gauge Preparation

Activate the appropriate calibration

Set AC gauge test time for field testing
- 4, 8, or 16 minutes

Obtain a representative portion of asphalt mixture
- AASHTO R 97

Tare sample pan on scale or record empty weight

183

183

AC Gauge Field Testing

Place asphalt mixture in sample pan
- 2 lifts
    - Lightly tamp each lift
- Match calibration weight within ± 5 grams
- Level asphalt
    - Press down on leveling plate until asphalt surface is flush with top rim of pan
- Verify weight

184

184

AC Gauge Field Testing

Measure temperature

- Within ± 10 °F of calibration temp

Load sample pan into gauge

- Close door

Start test and move away 3 ft

Record counts and % AC (Pb)

- Average multiple tests

185

185

AC Gauge Field Testing

Determine moisture content AASHTO T 329 to the nearest 0.01 %

- Subtract reported moisture content from the AC gauge test result
- Round and report binder content to the nearest 0.1 %

Report binder content to the nearest 0.1% !

186

186

Asphalt Content by Nuclear Gauge

Pb from mix design = 4.1%
Pb measured by AC Gauge = 3.96 %
Moisture Content = 0.04 %

$P_b = 3.96 - 0.04 = 3.92$

3.9 %

Report P_b to the nearest 0.1 %

187

187

Asphalt Content by Nuclear Gauge

Pb from mix design = 4.1%
Pb measured by AC Gauge = 4.07 %
Moisture Content = 0.05 %

188

188

Calibration of Asphalt Content Gauge Troxler 3241-C

ARDOT 449A

Center for Training Transportation Professionals

191

191

AC Gauge Calibration

AC gauge measures “counts”

Calibration converts counts to Pb

Calibrations

- Gauge specific
- Mix design specific
- Should be done at the expected location of testing

192

192

AC Gauge Calibration Equipment

AC Gauge

Scale

- Readable to 0.1 g
- Capacity ≥ 12,000 g

Sample pan

Leveling plate

- 0.4” metal
- ½” plexiglass
- ¾” plywood

Thermometer

- 50 – 500 °F

193

193

Batching Requirements

Number of Points

- 4 batches heated to mixing temperature
- 8000 g of aggregate for each
  - Includes RAP/RAS

Batch weights are based on the mix design

Sieve Size	1	2	3	4	5	Job Mix	Control Points
19	100	100	100	100	100	100	100 %
12.5	74	100	100	100	100	95	90 – 100 %
9.5	47	91	100	100	99	87	90 % Max
4.75	5	21	96	94	80	54	
2.36	3	3	76	65	61	36	28 - 58 %
1.18	3	3	51	43	49	26	
0.6	3	3	32	25	41	18	
0.3	3	3	17	16	32	12	
0.15	2	2	8	14	22	8	
0.075	1.5	1.0	3.5	10.0	12.0	4.6	2 – 10 %
Cold Feed %	20	29	22	15	14		
Gsb	2.520	2.616	2.559	2.496	2.544		

194

194

Determine Calibration Weight

Prepare BLANK sample

- Zero pan on scale or record empty weight

Fill sample pan with the hot, dry, batched aggregate in 2 layers

- 1st layer
  - Fill pan about ½ full
  - Tamp aggregate and work corners
  - Drop pan 1" to settle aggregate
- 2nd layer
  - Add aggregate until just over full
  - Tamp aggregate and work corners

195

195

Determine Calibration Weight

Level top surface with straight edge

Record temperature (200 – 300 °F)

Determine net weight of aggregate to nearest whole gram

196

196

Determine Calibration Weight

Record – Record the net weight of aggregate.

Dump – Dump aggregate back into original pan with remaining aggregate. Remix by turning aggregate over a minimum of three times using a scoop.

Fill – Fill the sample pan a second time and record the net weight of aggregate.

Repeat – Repeat filling and weighing steps until two weights are within ± 25 g of each other.

Record – Record the last weight as the calibration weight.

Place – Place filled pan into oven to maintain temperature

The calibration weight is used for all remaining samples!

197

197

Calibration Samples

From Mix Design:
$Pb_{optimum}$ = 4.1 %

3 Required Binder Contents + Blank

- Based on the ARDOT mix design
- After mixing, place samples in oven to maintain temperature

Dry
0.0 %

Opt. -1 %
3.1 %

Optimum %
4.1 %

Opt. +1 %
5.1 %

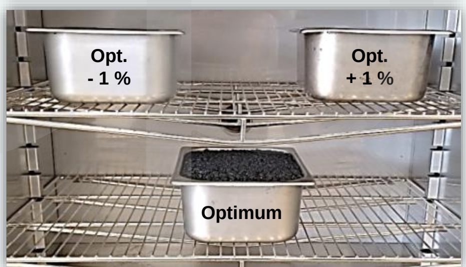
198

198

Calibration Samples

Prepare calibration pans

- Zero pan on scale
- Fill pan in 2 layers
  - Tamp lightly, work corners
  - Slightly overfill
- Match calibration weight within ± 5 g
- Compress with leveling plate
  - Verify weight
- Bring sample to calibration temp
  - 200 – 300 °F
  - Temp expected during field testing



199

199

BLANK Sample Counts

Set time to 16 minutes

Load BLANK sample and start test

- Record counts
  - Dry counts may be used to check for changes in aggregate during production

200

200

AC Gauge Calibration

Start a new calibration

- Three 16-minute counts
- Sample pan
- Gauge derived

Enter calibration weight

- Net weight

Enter the number of asphalt calibration samples

Measure the temperature of the asphalt mixture

Record calibration temperature

201

201

AC Gauge Calibration

Enter Pb for 1st sample

Load pan into gauge

- Start test
- Move away from gauge
  - At least 3 ft

Record counts

Counts : 2910

Press ENTER

Repeat process for all calibration points

202

202

AC Gauge Calibration

Record fit coefficient

- Must be at least 0.995

Review input data

- Screen or printer
- Record contants
  - A1, A2, A3

Record differences if necessary

Activate calibration

Store calibration

- Use mix design number

Example: HMA 684-25

- GAUGE READY -
1:00 PM 9/10
Time : 16 minutes
Calib# 68425

203

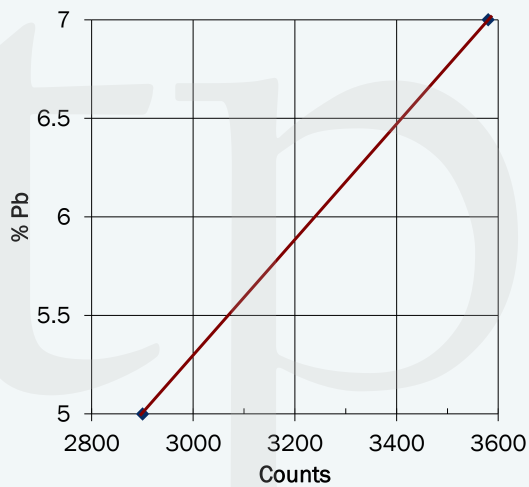
Fit Coefficient

2 point calibration

% AC	Counts	Difference
5.0	2900	0.000
7.0	3580	0.000

Fit coefficient = 1.000

ALWAYS – even if wrong



204

Fit Coefficient

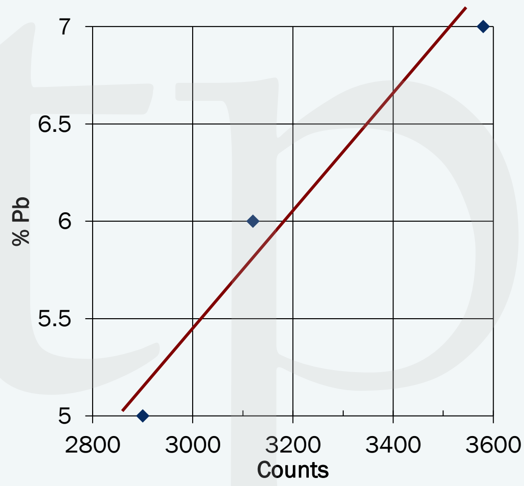
3 point calibration

% AC	Counts	Difference
5.0	2900	-0.017
6.0	3120	0.017
7.0	3580	-0.016

Fit Coefficient = 0.998

Straight line fit

ARDOT 449A requires 3 points



205

205

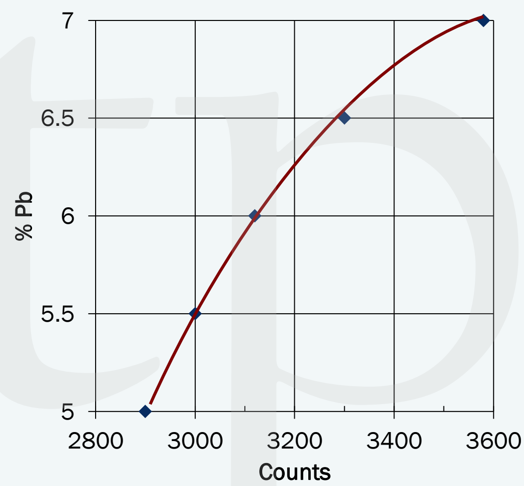
Fit Coefficient

3+ point calibration

% AC	Counts	Difference
5.0	2900	-0.002
5.5	3000	0.001
6.0	3120	-0.001
6.5	3300	0.001
7.0	3580	-0.002

Fit Coefficient ~ 0.999 or greater

Curved fit



206

206

Use Correct Calibration

Activate appropriate calibration during production for field testing

If > 120 days interruption of mix production has occurred, verify the mix calibration before use

- Prepare sample at design binder content
- Record date, mix design number, and test results

207

207

Determining Asphalt Binder Content by Ignition Method

AASHTO T 308

cttp
Center for Training Transportation Professionals

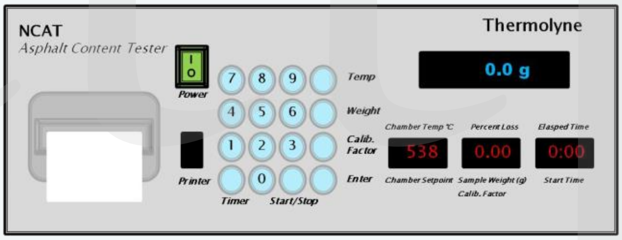
209

209

Ignition Oven Preparation

Mix Design

- Preheat ignition oven to calibration temperature
  - 538 °C or 482 °C
- Input appropriate binder content correction (calibration) factor

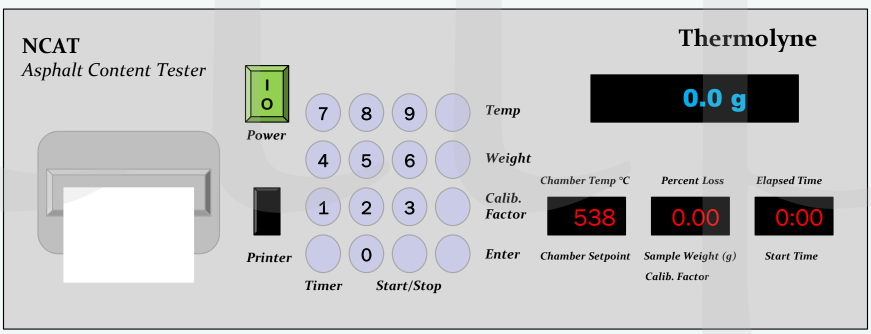


210

210

Ignition Oven Control Panel – Entering Data

Press item → Enter data → Press Enter quickly → Press again to Verify item



211

211

Ignition Oven – Sample Preparation

Obtain a representative asphalt sample according to AASHTO T 97

- Reduce using AASHTO R 47 to appropriate size

Use AASHTO T 329 to dry sample to constant mass

- Mixing temperature or 325 ± 25 °F

OR

Determine the moisture content using AASHTO T 329 and subtract from Pb

NMAS	Minimum Mass (g)*
# 4	1200 g
3/8"	1200 g
1/2"	1500 g
3/4"	2000 g
1"	3000 g
1 ½"	4000 g

*max = min + 500g

212

212

Ignition Oven Procedure

✏ Record the mass of the empty basket assembly

Place ½ of the sample into bottom basket

- Flatten and move sample away from basket edges

Repeat for other ½ of sample in top basket

Complete basket assembly

213

213

Ignition Oven Procedure

- Record mass of total basket assembly
  - Sample + basket assembly
- Calculate initial mass of asphalt sample
  - Net weight of sample
  - Input using oven panel
- Zero ignition oven scale
  - Press “0”

214

214

Ignition Oven Procedure

- Load basket assembly into oven
  - Maintain clearance on all sides
- Close and lock door
- Verify total mass
  - Within ± 5 g of recorded total assembly mass
- Press start

215

215

Ignition Oven Procedure

After burn

- Record binder content from the printed ticket (0.01 %)
- Subtract moisture content
- Report % binder to nearest 0.1 %

Cool sample

- Save for sieve analysis if needed

Elapsed Time :	57:21
Sample Weight :	1838g
Weight Loss :	84.4g
Percent Loss :	4.59 %
Temp Comp :	0.16 %
Calib. Factor :	0.37 %
Calib. Asphalt Ctnt	4.06 %
Filter Set Pt :	850 °C
Chamber Set Pt :	538 °C

216

216

Determining Correction Factors for the Ignition Oven

AASHTO T 308 – Annex A

cttp
Center for Training Transportation Professionals

219

219

Ignition Oven - Preparation

Obtain representative samples of binder and aggregate
- Oven dry aggregates

Batch according to job mix formula and $Pb_{optimum}$

Batch the asphalt mixture to meet the minimum mass requirements

Do not exceed minimum mass by more than 500g

NMAS	Minimum Mass (g)
# 4	1200 g
3/8”	1200 g
1/2”	1500 g
3/4”	2000 g
1”	3000 g
1 ½”	4000 g

**max = min + 500g*

220

220

Ignition Oven – Calibrations

Binder Correction Factor
- 2 samples
- Mix at design **optimum** binder content

Aggregate Correction Factor
- 1 sample
- Dry (no binder added)

221

221

Ignition Oven – Binder Correction Factor

Sample 1

Sample 2

Set calibration factor to 0.00 in ignition oven
Burn asphalt samples at 538 °C
Cool aggregate and save for further testing

222

222

Ignition Oven – Binder Correction Factor

Compare the measured binder contents from the printed tickets

- "Calibrated Asphalt Ctnt"

Elapsed Time:	37:12
Sample Weight:	1687g
Weight Loss:	78.4g
Percent Loss:	4.65%
Temp Comp:	0.14%
Calib. Factor:	0.00%
Calibrated Asphalt Ctnt	
	4.51%

Elapsed Time:	39:25
Sample Weight:	1682g
Weight Loss:	77.0g
Percent Loss:	4.58%
Temp Comp:	0.15%
Calib. Factor:	0.00%
Calibrated Asphalt Ctnt	
	4.43%

Are results within ± 0.15%?

4.51 – 4.43 = 0.08

223

223

Ignition Oven – Binder Correction Factor

IF the difference is within 0.15 %:

Average the two results

- Burn 1 4.51 %
- Burn 2 4.43 %

$$\text{Average} = \frac{(4.51 + 4.43)}{2} = 4.47$$

Subtract the actual binder content of the samples

- Samples mixed at 4.1 % ($Pb_{optimum}$ from mix design)

$$CF_{binder} = 4.47 - 4.10 = 0.37$$

0.37 %

Report the binder correction factor to the nearest 0.01 %

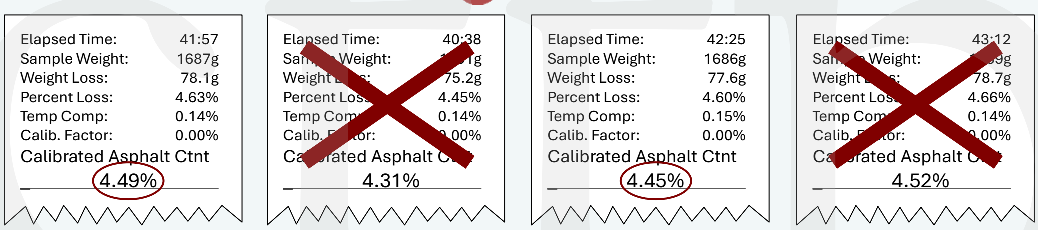
224

224

Ignition Oven – Binder Correction Factor

If the difference exceeds 0.15 %:

- Difference = 4.49 – 4.31 = 0.18



Calculate the correction factor

- Samples mixed at 4.1 % ($Pb_{optimum}$)

$$CF_{binder} = \frac{(4.49 + 4.45)}{2} = 4.47 - 4.10 = 0.37$$

0.37 %

225

225

Ignition Oven – Binder Correction Factor

If correction factor ≤ 1.0 % at 538 °C

- Report CF_{binder}

If correction factor > 1.0 % at 538 °C

- Start over but burn samples at 482 °C
- Report CF_{binder} even if > 1.0 % if established at 482 °C

If there is no improvement in CF_{binder} at 482 °C, use either CF / temperature

226

226

Binder Calibration – Problem 1

Determine CF_{binder}

Design P_b = 5.3 %

Sample 1	5.37 % @ 538 °C
Sample 2	5.40 % @ 538 °C

227

227

Binder Calibration – Problem 2

Determine CF_{binder}

Design P_b = 5.5 %

Sample 1	5.78 % @ 538 °C
Sample 2	5.57 % @ 538 °C
Sample 3	5.66 % @ 538 °C
Sample 4	5.80 % @ 538 °C

Diff. = 0.21 ✗

229

229

Binder Calibration – Problem 3

Determine CF_{binder}

Design Pb = 6.4 %

Sample 1	7.92 % @ 538 °C
Sample 2	7.96 % @ 538 °C

Diff. = 0.04 ✓

Average = 7.94

$CF_{Fbinder}$ = 7.94 – 6.40 = 1.54

C_F > 1.0 %

Sample 3	7.49 % @ 482 °C
Sample 4	7.44 % @ 482 °C

231

231

Ignition Oven – Aggregate Correction Factors

Use 3 aggregate samples
- (1) Dry aggregate sample
- (2) Burned samples

Record dry weights

Wash aggregate samples over #200 sieve
- Wetting agent required
  - Use enough soap to produce a small amount of suds

233

233

Ignition Oven – Aggregate Correction Factors

Perform sieve analysis for each sample
- Dry samples to constant mass
- Cool
- Record dry weight after wash
- Sieve samples
  - Report % passing to nearest 0.1 % for all sieves

234

234

Ignition Oven – Aggregate Correction Factors

Average % passing for the 2 burned samples

Sieve	Blank (True)	Burn # 1	Burn # 2	Average Burn (Measured)
1/2"	94.3	97.2	97.0	97.1
3/8"	85.9	87.6	87.8	87.7
# 4	54.3	55.8	56.0	55.9
# 8	36.7	37.9	37.5	37.7
# 16	26.1	29.5	29.7	29.6
# 30	17.7	18.8	19.0	18.9
# 50	11.9	12.6	12.8	12.7
# 100	8.5	9.0	8.6	8.8
# 200	4.6	4.9	5.1	5.0

235

235

Ignition Oven – Aggregate Correction Factors

Subtract the average burn from the blank sample

Sieve	Blank (True)	Burn # 1	Burn # 2	Average Burn (Measured)	ACF (True – Measured)
1/2"	94.3	97.2	97.0	97.1	-2.8
3/8"	85.9	87.6	87.8	87.7	-1.8
# 4	54.3	55.8	56.0	55.9	-1.6
# 8	36.7	37.9	37.5	37.7	-1.0
# 16	26.1	29.5	29.7	29.6	-3.5
# 30	17.7	18.8	19.0	18.9	-1.2
# 50	11.9	12.6	12.8	12.7	-0.8
# 100	8.5	9.0	8.6	8.8	-0.3
# 200	4.6	4.9	5.1	5.0	-0.4

236

236

Ignition Oven – Aggregate Correction Factors

Compare each ACF to the allowable difference

Sieve	Blank	Burn # 1	Burn # 2	Average Burn	ACF	Allowable Diff.
1/2"	94.3	97.2	97.0	97.1	-2.8	± 5 %
3/8"	85.9	87.6	87.8	87.7	-1.8	± 5 %
# 4	54.3	55.8	56.0	55.9	-1.6	± 5 %
# 8	36.7	37.9	37.5	37.7	-1.0	± 5 %
# 16	26.1	29.5	29.7	29.6	-3.5 ★	± 3 %
# 30	17.7	18.8	19.0	18.9	-1.2	± 3 %
# 50	11.9	12.6	12.8	12.7	-0.8	± 3 %
# 100	8.5	9.0	8.6	8.8	-0.3	± 3 %
# 200	4.6	4.9	5.1	5.0	-0.4	± 0.5 %

If any ACF > allowable, and if larger than #200, then ***use ALL ACF values***

If only #200 > allowable, ***use only #200 value***

237

237

Ignition Oven – Aggregate Correction Factors

Add the appropriate ACFs to the field test results and round

Sieve	Blank	Burn # 1	Burn # 2	Average Burn	ACF	Allowable Diff.	Field Test	Calc. % Pass	Report % Pass
1/2"	94.3	97.2	97.0	97.1	-2.8	± 5 %	97.2	94.4	94
3/8"	85.9	87.6	87.8	87.7	-1.8	± 5 %	88.3	86.5	87
# 4	54.3	55.8	56.0	55.9	-1.6	± 5 %	55.9	54.3	54
# 8	36.7	37.9	37.5	37.7	-1.0	± 5 %	37.8	36.8	37
# 16	26.1	29.5	29.7	29.6	-3.5 ★	± 3 %	29.5	26.0	26
# 30	17.7	18.8	19.0	18.9	-1.2	± 3 %	18.8	17.6	18
# 50	11.9	12.6	12.8	12.7	-0.8	± 3 %	12.6	11.8	12
# 100	8.5	9.0	8.6	8.8	-0.3	± 3 %	9.0	8.7	9
# 200	4.6	4.9	5.1	5.0	-0.4	± 0.5 %	5.2	4.8	4.8

\+ =

Whole #s

0.1%

238

238

Problem 1

Determine ACF values and which ones to apply

Sieve	Blank	Burn # 1	Burn # 2	Average Burn	ACF	Allowable Diff.
1/2"	100.0	100.0	100.0	100.0		± 5 %
3/8"	95.2	97.2	97.5	97.4		± 5 %
# 4	73.4	77.6	78.0	77.8		± 5 %
# 8	43.6	46.9	46.7	46.8		± 5 %
# 16	30.7	34.1	34.7	34.4		± 3 %
# 30	20.3	18.8	22.5	23.1		± 3 %
# 50	16.5	18.9	19.4	19.2		± 3 %
# 100	12.0	14.0	13.8	13.9		± 3 %
# 200	6.3	7.3	7.0	7.2		± 0.5 %

239

239

Problem 2

Determine ACF values and which ones to apply

Sieve	Blank	Burn # 1	Burn # 2	Average Burn	ACF	Allowable Diff.
1/2"	100.0	100.0	100.0	100.0		± 5 %
3/8"	93.4	97.2	95.2	96.2		± 5 %
# 4	68.9	70.2	69.7	70.0		± 5 %
# 8	45.6	46.9	46.2	46.6		± 5 %
# 16	28.4	30.6	30.1	30.4		± 3 %
# 30	19.5	20.2	21.1	20.7		± 3 %
# 50	14.3	17.2	16.3	16.8		± 3 %
# 100	9.8	10.7	11.0	10.9		± 3 %
# 200	4.5	5.1	4.8	5.0		± 0.5 %

241

241

Problem 3

Determine ACF values and apply as appropriate

Sieve	Blank	Burn # 1	Burn # 2	Average Burn	ACF	Allowable Diff.	Field Test	Calc. % Pass	Report % Pass
1/2”	100.0	100.0	100.0	100.0		± 5 %	100.0		
3/8”	97.4	97.2	98.9	98.1		± 5 %	96.5		
# 4	61.3	65.4	63.6	64.5		± 5 %	65.4		
# 8	38.5	40.1	41.0	40.6		± 5 %	38.1		
# 16	22.6	24.1	23.8	24.0		± 3 %	24.0		
# 30	19.4	19.7	19.9	19.8		± 3 %	20.5		
# 50	16.7	17.8	17.0	17.4		± 3 %	17.7		
# 100	12.3	14.1	13.8	14.0		± 3 %	13.9		
# 200	7.2	8.2	7.6	7.9		± 0.5 %	7.9		

243

243

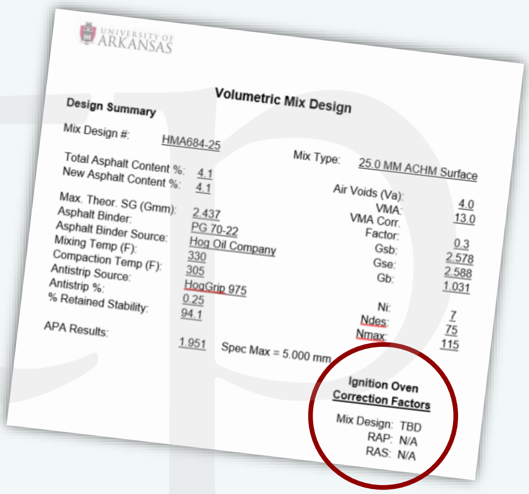
Ignition Oven Correction Factors

Correction Factors are mix-specific
- On mix design

Must be determined prior to acceptance testing

Repeat for changes to JMF
- >5% change in gradation

Aggregate correction factor is most critical for aggregates with a history of breakdown


UNIVERSITY OF ARKANSAS

Volumetric Mix Design

Design Summary

Mix Design #: HMA684-25
Mix Type: 25.0 MM ACHM Surface
Total Asphalt Content %: 4.1
New Asphalt Content %: 4.1
Max. Theor. SG (Gmm): 2.437
Asphalt Binder: PG 70-22
Asphalt Binder Source: Hog Oil Company
Mixing Temp (F): 330
Compaction Temp (F): 305
Antistrip Source: HogGrip 975
Antistrip %: 0.25
% Retained Stability: 94.1
APA Results: 1.951 Spec Max = 5.000 mm

Air Voids (Va): 4.0
VMA: 13.0
VMA Corr. Factor: 0.3
Gsb: 2.578
Gse: 2.588
Gb: 1.031
Ni: 7
Ndes: 75
Nmax: 115

Ignition Oven Correction Factors
Mix Design: TBD
RAP: N/A
RAS: N/A

245

245

Gradation Test

Determined from the aggregate blend after binder has been removed

- AASHTO T 30
  - Ignition Oven
- ARDOT 460
  - Solvent Wash

Mechanical Analysis of Extracted Aggregate

AASHTO T 30

cttp
Center for Training Transportation Professionals

Gradation Procedure (AASHTO T 30)

After cooling, record total weight of basket assembly

Calculate and record dry weight of aggregate
- Subtract weight of empty basket assembly

Wash aggregate over #200 sieve
- Use a wetting agent
- 2024 #8 or #16 cover sieve

Dry to constant mass

Record mass after wash
- 0.1 %

248

248

Gradation Procedure (AASHTO T 30)

Sieve sample
- Record weights retained
- Verify sum of individual weights are within 0.2 % of the mass after wash

Calculate % passing to the nearest 0.1 %

Apply appropriate aggregate correction factors

Report
- All sieves except #200 to the nearest whole number
- Report #200 sieve to the nearest 0.1 %

249

249

Solvent Wash and Sieve Analysis of Asphalt Concrete

ARDOT 460

cttp
Center for Training Transportation Professionals

250

250

Solvent Wash Procedure

Determine binder content
- ARDOT 449

Reduce to an appropriate size

Record sample weight

Cool to approximately 200 °F

NMAS (inches)	NMAS (mm)	Minimum Wt. of Test Specimen
½”	12.5	1500 g
¾”	19	2000 g
1”	25	3000 g
1 ½”	37.5	4000 g
2 ½”	62.5	4000 g

ARDOT 460

251

251

Solvent Wash Procedure

Cover sample with solvent
- Stir and soak

Pour solvent over nested #8 and #200 sieves

Repeat washing until solvent maintains its original color

Wash over # 200 sieve using water
- Liquid dish detergent may help remove oily residue

252

252

Solvent Wash Procedure

Return aggregate retained on sieves to container

Dry to constant mass
- Cool

Record dry weight after wash

Sieve sample
- Record weights

Calculate % passing

$$\textbf{Agg Wt} = \textbf{Mix Wt} \times \frac{P_s}{100}$$

Report
- All sieves except #200 to the nearest whole number
- Report #200 sieve to the nearest 0.1 %

253

253

Solvent Wash Calculation

Given an asphalt sample weighing 1853.4 g and a P_b of 6.2 %, find the weight of aggregate to be used in calculating a sieve analysis from a solvent wash

$$\text{Agg Wt} = \text{Mix Wt} \times \frac{P_S}{100}$$

$$P_S = 100 - 6.2 = 93.8$$

$$\text{Agg Wt} = 1853.4 \times \left(\frac{93.8}{100}\right) = (1853.4)(0.938) = 1738.489\ldots$$

1738.5 g

254

254

Solvent Wash Calculation

Given an asphalt sample weighing 3384.2 g and a P_b of 5.3 %, find the weight of aggregate to be used in calculating a sieve analysis from a solvent wash

$$\text{Agg Wt} = \text{Mix Wt} \times \frac{P_S}{100}$$

255

255

Batching & Mixing Asphalt Mixtures

ARDOT 449A

cttp
Center for Training Transportation Professionals

258

258

Batching

Forms precise gradation in the lab according to the mix design

Careful batching produces repeatable results!

Mix designs

Calibrations

Requirements
- % Binder
- Cold Feed %

259

259

Batching

Collect binder samples
- Manufacturer
- PG Grade

Collect representative stockpile samples
- Oven dry aggregates
- Fractionate if needed

Determine the size of sample to be batched
- See specification

Determine the number of "points" to be batched
- See specification

260

260

Batch Weights (Aggregate)

Determine the aggregate batch weights if the required total aggregate weight is 10,000 g

Aggregate		%			Weight
B Rock		28	(0.28)(10,000)	=	2,800
5/8" Chips		25	(0.25)(10,000)	=	2,500
1/4" Scrn.		29	(0.29)(10,000)	=	2,900
Man. Sand		15	(0.15)(10,000)	=	1,500
Sand		3	(0.03)(10,000)	=	300
Total	=	100	Total	=	10,000

261

261

Batch Weights (Aggregate)

Determine the aggregate batch weights if the required total aggregate weight is 8,000 g

Aggregate	%
3/4" Chip	30
1/2" Screen	28
1/4" Screen	25
Ind. Sand	17

262

262

Batch Weights (Mix)

Determine the batch weights if the desired mix weight is 1,700 g and the binder content is 6.0 %

Material		%			Weight
Binder		6.0	(0.06)(1,700)	=	102.0
			P_S = 100% − 6.0 % = 94.0 %		
Aggregate			(0.94)(1,700)	=	1,598.0
3/4" Chip		36	(0.36)(1,598)	=	575.3
1/2" Chip		40	(0.40)(1,598)	=	639.2
Ind. Sand		24	(0.24)(1,598)	=	383.5
Total	=	100	Total Agg	=	1,598.0

264

264

Batch Weights (Mix)

Determine the batch weights if the desired mix weight is 3,300 g and the binder content is 5.2 %

Material		%
Binder		5.2
Aggregate		
3/4" Chip		35
1/2" Chip		32
Ind. Sand		33
Total	=	100

265

265

Mixing

Preheat oven to mixing temperature

- Mix design

Heat aggregate to mixing temp

- 2 – 4 hours minimum
- May be heated overnight
- RAP/RAS not preheated with aggregate

Heat binder to mixing temperature

- 1 – 2 hours prior to mixing
- Do not heat overnight!

Preheat tools and mixing bucket

- Clean and/or "butter" mixing bucket
  - Prevents low binder content on the first mixed batch

268

268

Mixing

Zero mixing pot on scale

- Scale must be readable to 0.1 g

Add aggregate to mixing bucket

- Mix aggregate
- Form crater for binder

269

269

Mixing

Get aggregate weight

Calculate either:

- Mix weight **OR** binder weight

$$\text{Mix Wt} = \frac{\text{Agg Wt}}{P_s} \times 100$$

$$\text{Binder Wt} = \text{Mix Wt} - \text{Agg Wt}$$

Add binder to crater

270

270

Mixing

Determine the mix weight or binder weight for a sample if the Pb = 5.6 % and the measured weight of aggregate in the mixing bucket is 7998.2 g.

$$\text{Mix Wt} = \frac{\text{Agg Wt}}{P_s} \times 100$$

$$Ps = 100 - 5.6 = 94.4$$

$$\text{Mix Weight} = \frac{7998.2}{94.4} \times 100 = 8472.7$$

$$\text{Binder Weight} = 8472.7 - 7998.2 = 474.5$$

271

271

Mixing

Determine the mix weight or binder weight for a sample if the Pb = 4.4 % and the measured weight of aggregate in the mixing bucket is 4,995.0 g

$$\text{Mix Wt} = \frac{\text{Agg Wt}}{P_s} \times 100$$

272

272

Mixing

Adjust to obtain the exact weight of binder

Mix thoroughly for at least 2 minutes

274

274

Mixing

Empty mixing bucket

- Use hot spatula or spoon to scrape out all of the mixture
- Scrape tools

Place all scraped material into the sample container

275

275

Mixing

Verify mixing bucket is within ± 5 g of its initial weight

- If not, keep scraping!
- Reheat mixing pot if necessary

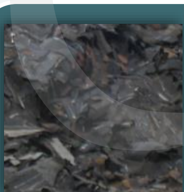
276

276

Mixing RAP / RAS

RAP

- Reclaimed Asphalt Pavement
- Add to aggregate 1 hour before mixing



RAS

- Recycled Asphalt Shingles
- Add to aggregate at time of mixing

Treated as aggregate portions

278

278

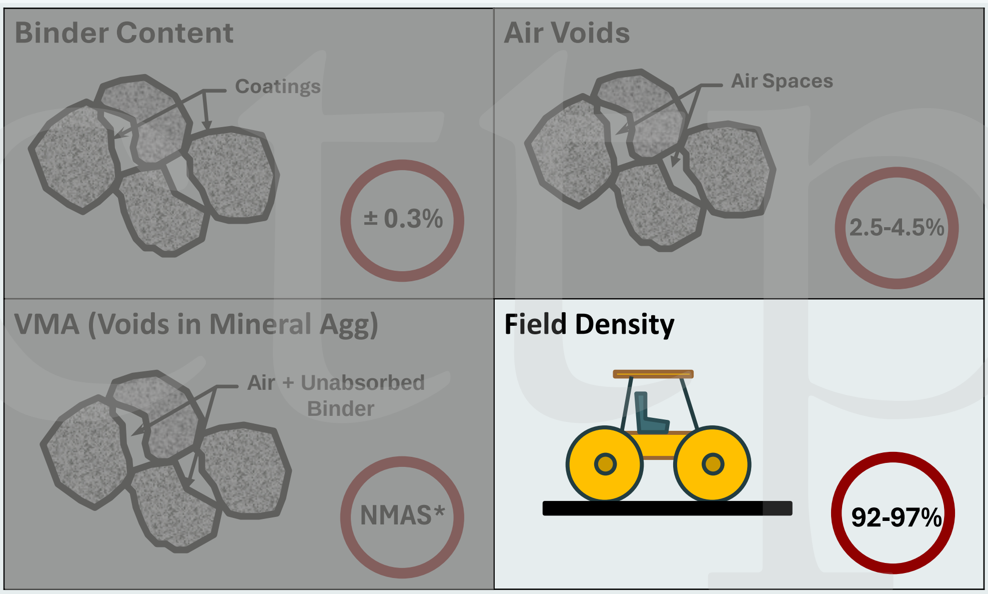
Compaction and Density

cttp
Center for Training
Transportation Professionals

279

279

Prepare Samples for QC/QA Testing



280

280

Compaction

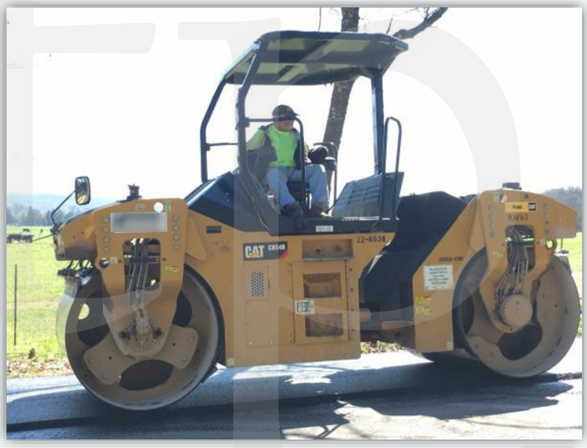
The MOST IMPORTANT factor affecting performance

- Compaction is a process
- Density is a measurement

Intelligent compaction

Best practices

- Stay close to the paver
- Angle drum when changing direction
- Never park roller on mat
- Start/stop slowly, vary location



281

281

Rollers

Steel wheel

- Breakdown – vibratory mode

- Finish – static mode

Pneumatic

- Intermediate
  - Knead particles

282

282

Rolling Pattern

ARDOT 410.08 – Rolling patterns are established at the beginning of placement for each mix design on a project

Equipment

- Nuclear density gauge
- Electromagnetic surface contact device
  - ASTM D7113

If the compaction method or equipment is changed, a new rolling pattern shall be established

283

283

Rolling Pattern

Pattern to achieve specified density

- Type or roller
- # vibratory passes
- # static passes

Take a 15 second wet density (WD) reading with gauge after every roller pass until no further increase in density

Take all readings at exact same location

284

284

Rolling Pattern

Choose only passes that increase density

Roller	Pass	Vibratory Static	WD Reading
Break	1	Vib	140.2
Dual	2	Vib	143.4
	3	Vib	146.5
	4	Static	147.0
	5	Static	145.3
	6	Static	144.7
Inter			
Rub	1	Static	147.8
	2	Static	148.1
	3	Static	147.2
	4	Static	147.2

Rolling Pattern:

- 3 vibratory passes with breakdown roller
- 1 static pass with breakdown roller
- 2 static passes with pneumatic roller

285

285

Sampling Asphalt Mixtures after Compaction (Obtaining Cores)

AASHTO R 67

cttp
Center for Training Transportation Professionals

286

286

Coring Equipment

Core drill

Diamond-edged drill bit

Cooling agent

- Water, ice, dry ice, liquid nitrogen

Retrieval device

Separation equipment

- Hammer and chisel
- Wet saw

287

287

Coring Procedure

Allow mat to cool

Cut core perpendicular to surface

- Use water or air while drilling
  - Reduces heat
- Apply constant, gradual pressure
- Drill to bottom of layer
  - Or slightly below

Remove core

- If damaged, cut another core within 6 inches of original

Label core

Fill hole with asphalt mixture

- Compact mixture
- Level with surface

288

288

Transporting Cores

Secure cores against jarring, rolling, or impact with any objects

- Newspaper
- Cylinder molds

Protect against extreme temperatures

- Insulated container

289

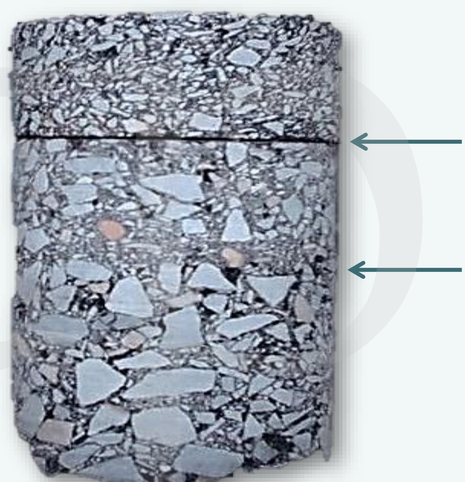
289

Separating Layers

Separate cores at the point of bonding

- Hammer and chisel
- Wet saw

Remove tack coats and bound gravel or dirt before testing



290

290

Density Specification (ARDOT)

Cut one core for every lot/sublot test

- Cut full depth cores
- 4” minimum diameter
- Label core

Standard Spec – 410.09

- Leveling and bond breakers
  - Thickness must be 3x NMAS

Do not sample within 1.5 feet of the edge (different for joint densities)

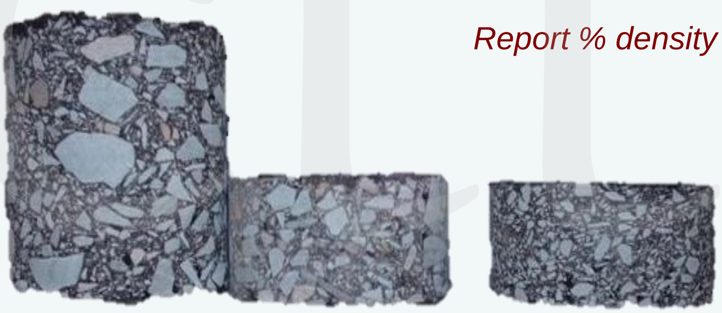
291

291

Density

$$\% \text{ Density} = \frac{G_{mb}}{G_{mm}} \times 100$$

Report % density to the nearest 0.1 %



292

292

Joint Density

ARDOT Special Provision

Center for Training Transportation Professionals

293

293

ARDOT Joint Density (SP)

Must cut 6" cores

Must use notched wedge unless milled or cutback (2025)

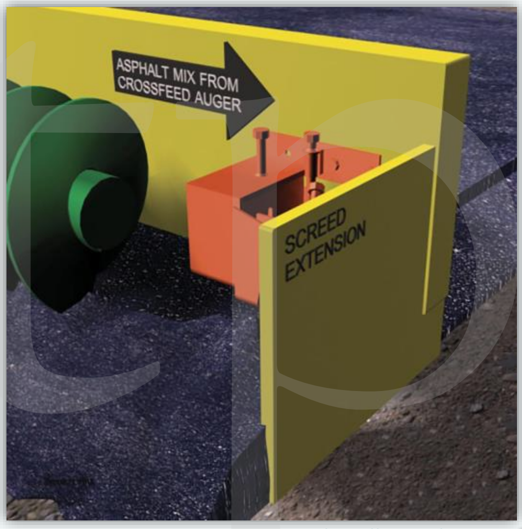
Final surface

- Lot = 40,000 linear feet (2025)
- Sublot = 10,000 linear feet (2025)
- 90% - 96% density (2025)
  - Use average Gmm
- If < 88% density, seal with PG 64-22

294

294

Notched Wedge Joint



https://transtechsys.com

295

295

Butt Joint

Cannot use Notched Wedge for milled or cutback joints

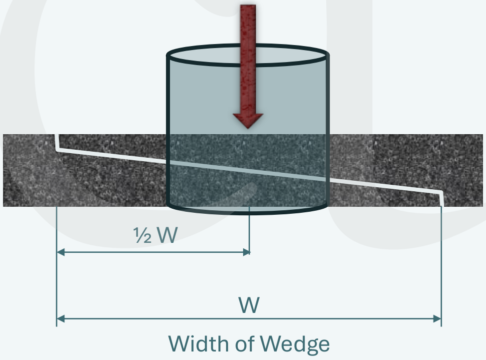
296

296

Center of the Joint

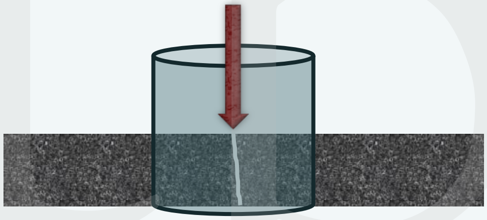
Notched Wedge Joints

- Centered over wedge width



Milled or Cutback Joint

- Centered over visible joint line



297

297

Notched Wedge Joint

Measure before the “hot” lane is placed

Inform the core drill operator

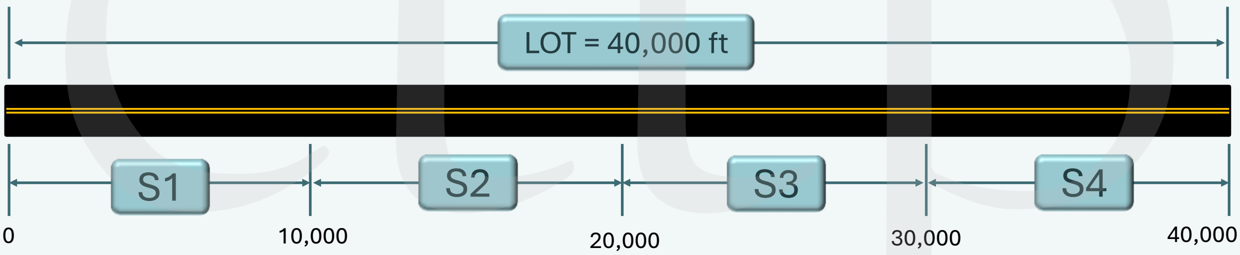
298

298

Joint Density Location

Only where joints are formed

- Centerline, lane lines
- Not shoulder



Joint density locations will not match mat density locations!

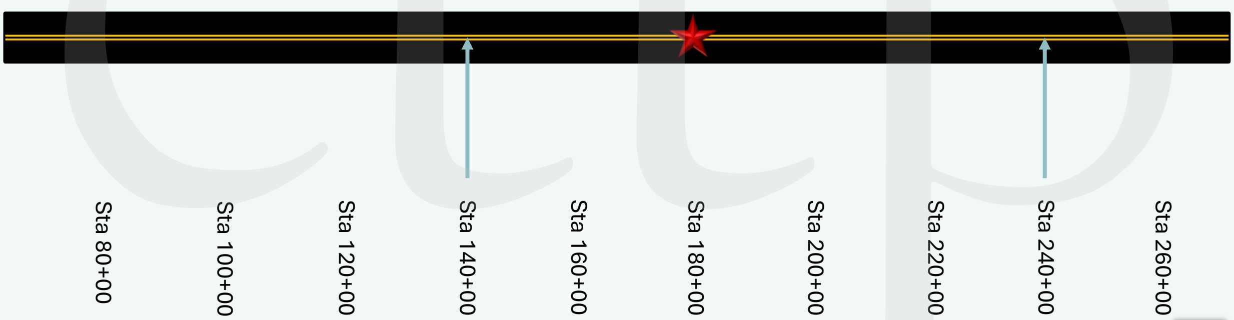
Joint Density Location

Sample between Sta. 140+00 to 240+00 and RN = 0.38

Determine the station location and Gmm required for testing

10,000 x 0.38 = 3800

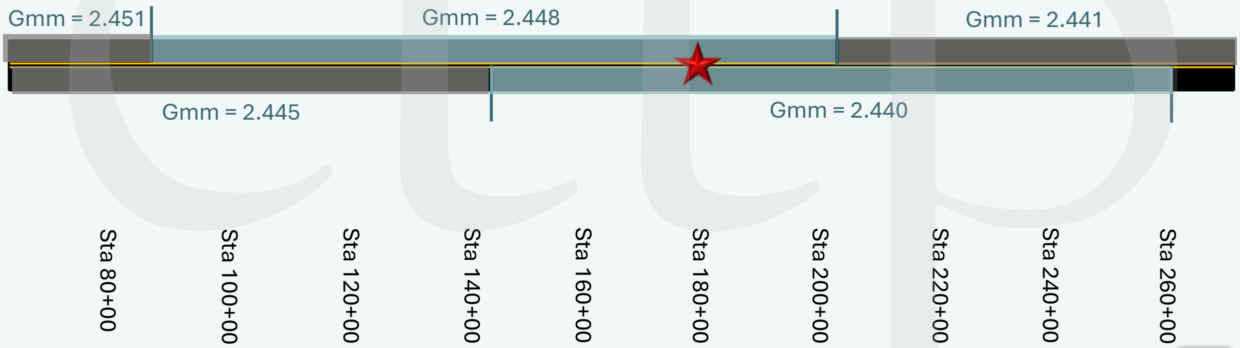
14,000 + 3800 = 17,800 (Sta 178+00)



Joint Density Location

$$\text{Gmm(avg)} = \frac{2.448 + 2.440}{2} = 2.444$$

Test at Sta. 178+00
Use Gmm value of 2.444



301

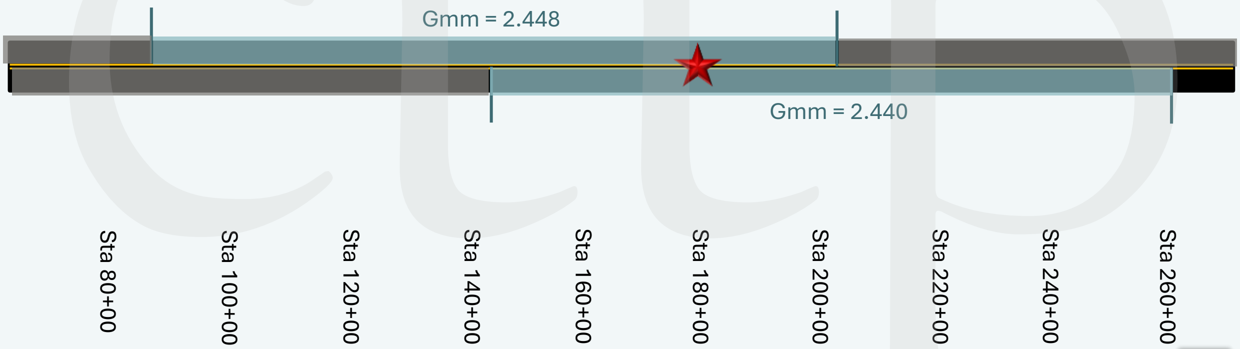
301

Joint Density Calculation

$$\text{\% Density} = \frac{2.229}{2.444} \times 100 = 91.2029...$$

Test at Sta. 178+00
Use Gmm value of 2.444
Gmb = 2.229

91.2% Density



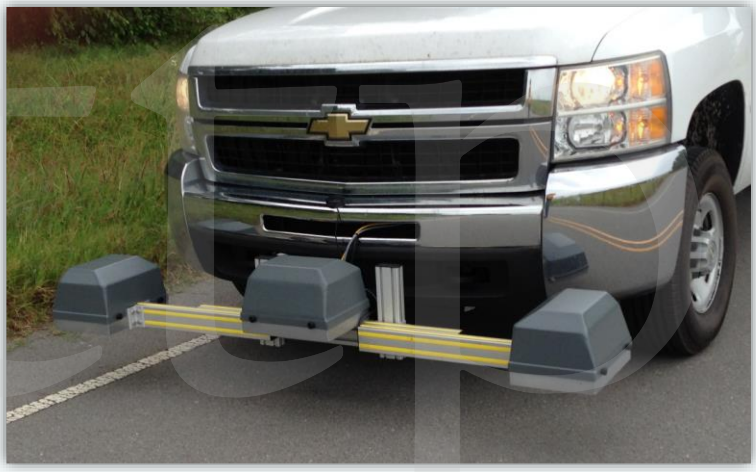
302

302

Inertial Profiling

International Roughness Index (IRI)
- Ride quality

Primary types
- Lightweight
- High-Speed



303

303

Quality

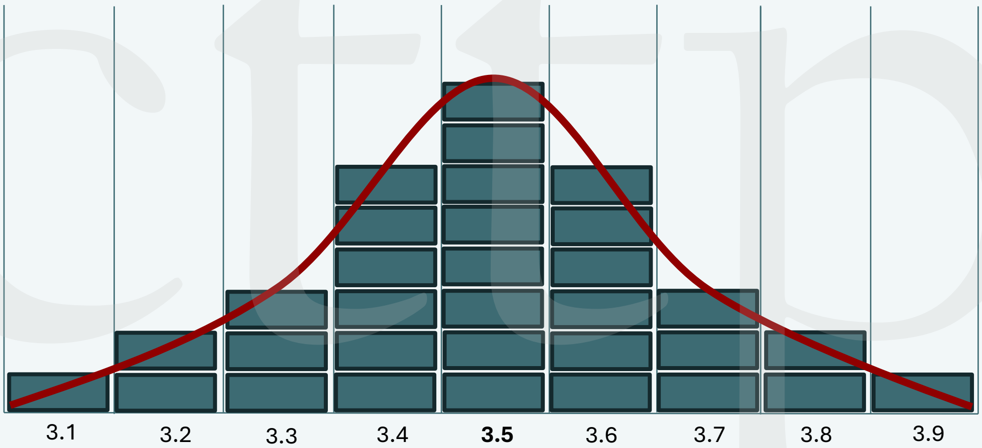
What defines quality?
What do we measure?
How good is good enough?
How often to test?

Variability in process
- Materials
- Procedure
- Construction

304

304

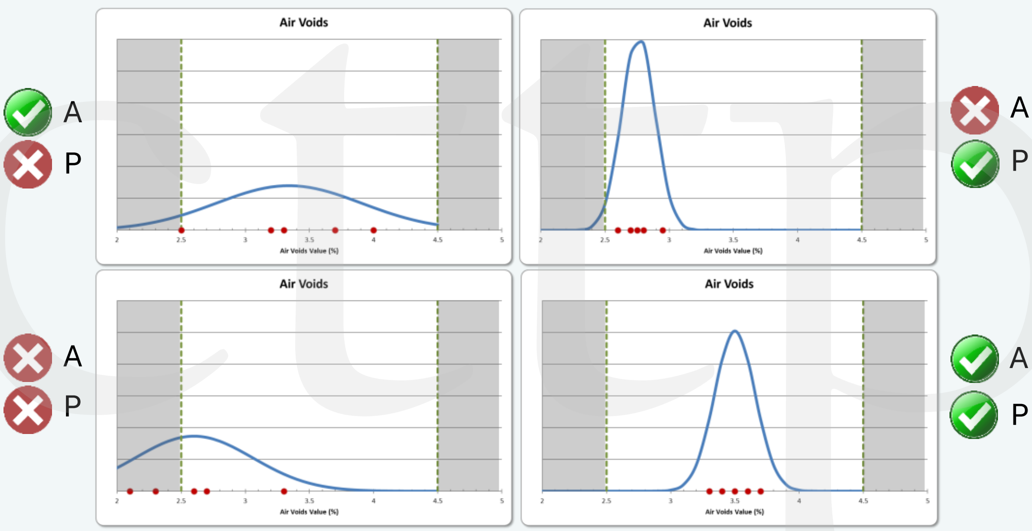
Frequency Diagram



305

305

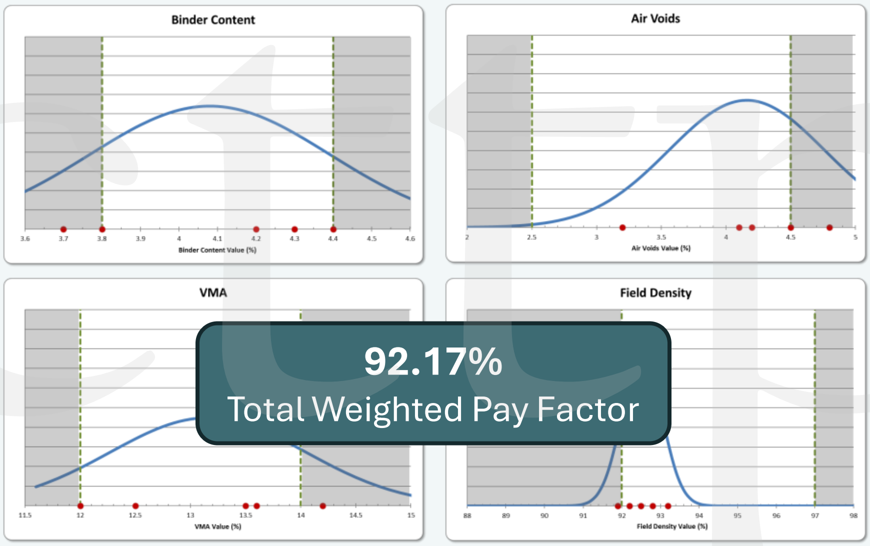
Percent Within Limits



306

306

Pay Factors



Binder Content: PWL = 65.14%
PF = 85.57%
(20%)

Air Voids: PWL = 69.60%
PF = 89.80%
(35%)

VMA: PWL = 73.63%
PF = 91.82%
(10%)

Field Density: PWL = 84.52%
PF = 97.26%
(35%)

92.17%
Total Weighted Pay Factor

307

307