Course Overview

Refresher Info

Sampling / Reduction

Design / Volumetrics
  • ARDOT Specifications
  • Calibrations

Gyratory Compaction

Gmb / Gmm
  • % Air Voids
  • % VMA

% Binder
  • AC Gauge
  • Ignition Oven

% Compaction
  • Cores
  • Nuclear Density
Test Day

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

Results
- www.cttp.org
- Letter & Certification

Performance Exam
- 6 Exam Stations
  - Gyratory Compactor
  - Bulk SpG (Gmb)
  - Max SpG (Gmm)
  - Ignition Oven
  - AC Gauge
  - Density Gauge

Conversions

1 ton = 2000 lb
1 yd² = 9 ft²
1 station = 100 ft
Terminology

Terms and formulas relating to mix design and acceptance testing for asphalt mixtures and pavements

Binder – An asphalt-based cement produced from petroleum residue with or without modifiers (AR PG Grades 64-22, 70-22, 76-22)

Aggregate – A granular material (sand, crushed stone or gravel, steel slag). May refer to an individual aggregate type or to the blend of several different aggregates

Asphalt Mixture – Binder and aggregate combined
Terminology

Nominal Maximum Aggregate Size (NMAS)
- Superpave: One size larger than the first sieve that retains more than 10% aggregate

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

The NMAS is the designated size of an ARDOT asphalt mix design
- (9.5 mm, 12.5 mm, 25.0 mm, 37.5 mm)

Terminology

$X \_{xyz}$

- $X$: (quantity)
- $y$: (material)
- $z$: (type)

- $G$: specific gravity
- $W$: weight (mass)
- $V$: volume
- $P$: percent
- $a$: air
- $b$: binder
- $s$: stone (agg)
- $m$: mix
- $a$: absorbed
- $b$: bulk
- $e$: effective
- $m$: maximum

$G_0$ – SpG of the binder
$G_{mb}$ – Bulk SpG of the mix
## Terminology

<table>
<thead>
<tr>
<th><strong>Mix Design</strong></th>
<th><strong>Field Testing (QC/QA)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Determines the blend which will produce the required properties</td>
<td>Determines compliance with ARDOT specifications based on the approved mix design</td>
</tr>
<tr>
<td>AASHTO R 35</td>
<td></td>
</tr>
<tr>
<td>AASHTO M 323</td>
<td></td>
</tr>
<tr>
<td>ARDOT Specifications</td>
<td></td>
</tr>
</tbody>
</table>

Terminology is separate from field testing. However, many terms and calculations are the same!

## Relationships

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agg Wt. + Binder Wt. = Mix Wt.</strong></td>
<td>$P_s + P_b = 100%$</td>
</tr>
</tbody>
</table>

\[
P_s = \frac{Agg\ Wt}{Mix\ Wt} \times 100\% \\
P_b = \frac{Binder\ Wt}{Mix\ Wt} \times 100\%
\]

*The % binder is based on the total mix weight*
Relationships

What is the $P_s$ if the $P_b = 5.6\ %$?

$$P_b + P_s = 100\ %$$

$$P_s = 100\ % - 5.6\ % = 94.4\ %$$

*Report $P_s$ & $P_b$ to the nearest 0.1 %*

---

Specific Gravity / Density

Specific Gravity ($G$)

- Relative density to water
- How many times lighter or heavier than water an object is

Density ($D$)

$$D = (G)(62.4\ \text{lb/ft}^3)$$

*Report density to the nearest 0.1 pcf*
Specific Gravity / Density

If an asphalt mixture has a specific gravity of 2.428, what is the density (lb/ft³) of the mixture?

\[ D = (G)(62.4 \text{ lb/ft}^3) \]

\[ D = (2.428)(62.4) = 151.5072 \]

151.5 lb/ft³

Terminology

Specific Gravity / Density

If an asphalt core has a specific gravity of 2.335, what is the density (lb/ft³) of the core?
Specific Gravity of Binder ($G_b$)

**Mix Design**
- 77 °F

**Field Testing**
- 77 °F or 60 °F
- 77 °F is used for all calculations

**Conversion**

\[ G_{b77} = (G_{b60})(0.9941) \]

What is the $G_{b77}$ for binder with a $G_{b60} = 1.025$?

\[ G_{b77} = (1.025)(0.9941) = 1.01895 \]

1.019

*Report all specific gravities to the nearest 0.001*

Terminology 18

---

Specific Gravity of Binder ($G_b$)

Determine the specific gravity needed for calculations.

\[ G_{b60} = 1.028 \]
**Bulk SpG of Mixture (G\textsubscript{mb})**

**Specific gravity of a compacted asphalt mixture**
- Used to determine the volumetric properties of compacted mix (gyratory specimens or cores) relative to the G\textsubscript{mm}

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

A = dry mass  
B = SSD mass  
C = submerged mass

*Report all specific gravities to the nearest 0.001*

**Terminology**

---

**Bulk SpG of Mixture (G\textsubscript{mb})**

**Determine the G\textsubscript{mb} of the compacted specimen**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Mass</td>
<td>4556.7</td>
<td>A</td>
</tr>
<tr>
<td>Submerged Mass</td>
<td>2621.0</td>
<td>C</td>
</tr>
<tr>
<td>SSD Mass</td>
<td>4563.5</td>
<td>B</td>
</tr>
</tbody>
</table>

\[
G_{mb} = \frac{4556.7}{(4563.5 - 2621.0)} = \frac{4556.7}{1942.5} = 2.34579
\]

*2.346*

**Terminology**
Bulk SpG of Mixture ($G_{mb}$)

Determine the $G_{mb}$ of the compacted specimen

- **Dry Mass**: 2327.2
- **Submerged Mass**: 1398.6
- **SSD Mass**: 2332.0

% Absorption (% Abs)

The percentage of water absorbed by the specimen based on the volume of the specimen

- If $G_{mb}$ is determined using AASHTO T 166 and the absorption of the specimen is > 2 %, the test results for $G_{mb}$ are not valid and an alternative test method must be used (AASHTO T 275 or AASHTO T 331)

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

- **A** = dry mass
- **B** = SSD mass
- **C** = submerged mass

Report % absorption to the nearest 0.01 %
% Absorption (% Abs)

Determine the % absorption of the compacted specimen

\[
\% Abs = \frac{(B - A)}{(B - C)} \times 100\% \\
\]

\[
\% Abs = \frac{(4585.1 - 4573.6)}{(4585.1 - 2633.0)} \times 100\% = \frac{11.5}{1952.1} \times 100\% = 0.5891\% \\
\]

0.59 %

Terminology

26

% Absorption (% Abs)

Determine the % absorption of the compacted specimen

Dry Mass = 4558.3 g
SSD Mass = 4571.0 g
Sub. Mass = 2631.2 g
Max. Theor. Sp. Gr. of Mixture ($G_{mm}$)

Specific gravity of an asphalt mixture with no air voids
- Used to determine the relative density and % compaction of compacted asphalt mixtures

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

A = dry mass
C = submerged mass

Report all specific gravities to the nearest 0.001

Terminology

Max. Theor. Sp. Gr. of Mixture ($G_{mm}$)

Determine the $G_{mm}$ of the asphalt mixture

<table>
<thead>
<tr>
<th>Component</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Mass</td>
<td>1786.4</td>
</tr>
<tr>
<td>Sub Mass (Bowl + S)</td>
<td>2348.7</td>
</tr>
<tr>
<td>Sub Mass (Bowl)</td>
<td>1300.0</td>
</tr>
</tbody>
</table>

$$C = 1048.7$$

$$G_{mm} = \frac{A}{(A - C)} = \frac{1786.4}{(1786.4 - 1048.7)} = \frac{1786.4}{737.7} = 2.42158$$

2.422

Terminology
Max. Theor. Sp. Gr. of Mixture ($G_{mm}$)

Determine the $G_{mm}$ of the asphalt mixture

- Dry Mass: 2833.3
- Sub Mass (Bowl + S): 2961.1
- Sub Mass (Bowl): 1301.2

% Compaction (Relative Density)

Density of a mixture relative to a standard
- Maximum Theoretical Density or Specific Gravity

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

- $G_{mb}$: 96 %
- $G_{mm}$: 100 %

Report % compaction to the nearest 0.1 %
% Compaction (Relative Density)

Determine the % compaction

\[
\% \text{Compaction} = \frac{G_{mb}}{G_{mm}} \times 100 \%
\]

\[
\% \text{Compaction} = \frac{2.329}{2.428} \times 100 \% = 95.92257 \%
\]

95.9 %

--

% Compaction (Relative Density)

Determine the % compaction

\[
\begin{align*}
G_{mb} \text{ of Core} & = 2.358 \\
G_{mm} \text{ of Mix} & = 2.502
\end{align*}
\]

--
**Terminology**

- **Air Voids** ($V_a$): Volume of air between coated aggregate particles
- **Binder**: (asphalt cement)
- **Voids in the Mineral Aggregate** (VMA): (volume of air voids + volume of effective asphalt coating)

**% Air Voids ($V_a$)**

Volume of air pockets in a compacted asphalt mixture

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

$G_{mb}$
96 %

$V_a = 4\%$

$G_{mm}$
100 %

$V_a = 0\%$

$$V_a = 100\% - \left( \frac{G_{mb}}{G_{mm}} \times 100\% \right) \text{ or } \left( 1 - \frac{G_{mb}}{G_{mm}} \right) \times 100\%$$

*Report % air voids to the nearest 0.1 %*
% Air Voids ($V_a$)

Find the reported % air voids

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

\[
V_a = 100\% - \left( \frac{2.365}{2.447} \times 100\% \right) = 100\% - 96.64896\% = 3.35104\%
\]

3.4 %

Terminology

% Air Voids ($V_a$)

Find the reported % air voids

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

\[
V_a = 100\% - \left( \frac{2.305}{2.413} \times 100\% \right) = 100\% - 96.39879\% = 3.60121\%
\]

3.6 %

Terminology
Effective Sp. Gr. Of the Agg. \((G_{se})\)

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

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

Report all specific gravities to the nearest 0.001

**Terminology**

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P_b)</td>
<td>5.7 %</td>
</tr>
<tr>
<td>(G_{mm})</td>
<td>2.413</td>
</tr>
<tr>
<td>(G_b)</td>
<td>1.032</td>
</tr>
</tbody>
</table>

\[
P_s = 100 \% - 5.7 \% = 94.3 \%
\]

\[
G_{se} = \frac{94.3}{(\frac{100}{2.413} - \frac{5.7}{1.032})} = \frac{94.3}{(41.442 ... - 5.523 ...)} = \frac{94.3}{35.9189} = 2.62536
\]

2.625

**Terminology**
Effective Sp. Gr. Of the Agg. (G_{se})

Determine the G_{se} of the mixture

\[ P_b = 4.2\% \]
\[ G_{mm} = 2.555 \]
\[ G_{p60} = 1.032 \]

Voids in the Mineral Agg. (VMA)

Volume of air voids and effective asphalt coating in an asphalt mixture

\[ VMA = 100\% - \left[ \frac{(G_{mb})(P_s)}{G_{sb}} \right] = VMA_e - VMA_{CF} \]

\[ VMA_e = 100\% - \left[ \frac{(G_{mb})(P_s)}{G_{se}} \right] \]

Report % VMA to the nearest 0.1 %

Terminology
Voids in the Mineral Agg. (VMA)

Calculate the % VMA for the mixture

G\text{mb} 1 \quad 2.305 \quad P_b \quad 6.0 \% \quad \text{VMA}_{\text{CF}} \quad 1.8 \%

G\text{mb} 2 \quad 2.303 \quad P_s \quad 94.0 \% \quad G_{\text{se}} \quad 2.612

Average G_{\text{mb}} \quad 2.304

\begin{align*}
VMA_e &= 100 \% - \frac{(G_{\text{mb}})(P_s)}{G_{\text{se}}} \\
VMA &= VMA_e - VMA_{\text{CF}}
\end{align*}

\begin{align*}
VMA_e &= 100 \% - \left( \frac{2.304 \times 94.0 \%}{2.612} \right) = 100 \% - 82.916 \% = 17.1 \%

VMA &= 17.1 \% - 1.8 \% = 15.3 \%
\end{align*}

Terminology

Voids in the Mineral Agg. (VMA)

Calculate the % VMA for the mixture

G\text{mb} 1 \quad 2.425 \quad P_b \quad 4.6 \% \quad \text{VMA}_{\text{CF}} \quad 0.5 \%

G\text{mb} 2 \quad 2.431 \quad \quad G_{\text{Se}} \quad 2.635

Terminology
Volumetric Mix Design

Relationships between ArDOT asphalt mix designs and field acceptance testing and quality control

ArDOT ACHM Mix Designs are approved for a period of 5 years provided that the mix design produces satisfactory results during production and placement.
Volumetric Mix Design

Mix Design Number: HM000 – 20  Exp. Date: 1/1/2025

Mix Design Properties

- Optimum Asphalt Binder: 5.4 %
- Air Voids: 4.0 %
- VMA: 14.5 %
- VFA: 73.1 %
- Fines to Asphalt Ratio: 0.99
- Retained Stability: 96.1 %
- Nmax: 205

Allowable Field Tolerances

- 5.1 % to 5.7 %
- 3.0 % to 5.0 %
- 13.5 % to 16.0 %

Asphalt Binder: Hog Oil PG 76-22

APA Results: 1.055 mm

5.000 mm or less

Page 1 of AnDOT Mix Design

Volumetric Mix Design

<table>
<thead>
<tr>
<th>No.</th>
<th>Appr_ID</th>
<th>Appr_Name</th>
<th>Source</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hog1000</td>
<td>1/2 Chip</td>
<td>Silt</td>
<td>Fayetteville, AR</td>
</tr>
<tr>
<td>2</td>
<td>Hog5000</td>
<td>3/8 Chip</td>
<td>Silt</td>
<td>Fayetteville, AR</td>
</tr>
<tr>
<td>3</td>
<td>Hog1750</td>
<td>3/8 Gravel</td>
<td>Silt</td>
<td>Fayetteville, AR</td>
</tr>
<tr>
<td>4</td>
<td>Hog2000</td>
<td>Ind. Sand</td>
<td>Silt</td>
<td>Fayetteville, AR</td>
</tr>
<tr>
<td>5</td>
<td>Hog2000</td>
<td>Screenings</td>
<td>Silt</td>
<td>Fayetteville, AR</td>
</tr>
</tbody>
</table>

Size: 1 2 3 4 5

Job Mix: 100 %

Control Points

<table>
<thead>
<tr>
<th>9.0</th>
<th>47</th>
<th>90</th>
<th>100</th>
<th>99</th>
<th>93</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5</td>
<td>47</td>
<td>90</td>
<td>100</td>
<td>99</td>
<td>97</td>
</tr>
<tr>
<td>10.0</td>
<td>47</td>
<td>90</td>
<td>100</td>
<td>100</td>
<td>97</td>
</tr>
<tr>
<td>11.0</td>
<td>47</td>
<td>90</td>
<td>100</td>
<td>99</td>
<td>97</td>
</tr>
<tr>
<td>12.0</td>
<td>47</td>
<td>90</td>
<td>100</td>
<td>99</td>
<td>97</td>
</tr>
</tbody>
</table>

Volumetric Mix Design

<table>
<thead>
<tr>
<th>Size: 1 2 3 4 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>190 100 100 100 100</td>
</tr>
<tr>
<td>12.5 74 100 100 100 100</td>
</tr>
<tr>
<td>9.5 47 91 100 100 99</td>
</tr>
<tr>
<td>4.75 5 21 96 94 94</td>
</tr>
<tr>
<td>2.36 3 3 76 65 61</td>
</tr>
<tr>
<td>1.18 3 3 51 43 40</td>
</tr>
<tr>
<td>0.6 3 3 32 25 41</td>
</tr>
<tr>
<td>0.3 3 3 17 16 32</td>
</tr>
<tr>
<td>0.15 2 2 8 14 22</td>
</tr>
</tbody>
</table>

Cold Feed %: 20 29 22 15 14

Page 2 of AnDOT Mix Design

Volumetric Mix Design
Volumetric Mix Design

Design Summary

<table>
<thead>
<tr>
<th>Mix Design #:  HMA000-20</th>
<th>Mix Type: 12.5 MM AC HM Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Asphalt Content %</td>
<td>6.4</td>
</tr>
<tr>
<td>Air Voids (Ve)</td>
<td>4.0</td>
</tr>
<tr>
<td>VMA</td>
<td>14.7</td>
</tr>
<tr>
<td>VMA Corr. Factor</td>
<td>1.6</td>
</tr>
<tr>
<td>Maximum Theor. SG (Gmm)</td>
<td>2.400</td>
</tr>
<tr>
<td>Asphalt Binder</td>
<td>PG 76-22</td>
</tr>
<tr>
<td>Asphalt Binder Source</td>
<td>Hog Oil Company</td>
</tr>
<tr>
<td>Mixing Temp (F)</td>
<td>340</td>
</tr>
<tr>
<td>Compaction Temp (F)</td>
<td>310</td>
</tr>
<tr>
<td>Antistrip Source</td>
<td>HogGrip 975</td>
</tr>
<tr>
<td>Antistrip %</td>
<td>0.25</td>
</tr>
<tr>
<td>Spec Max = 8.000 mm</td>
<td></td>
</tr>
<tr>
<td>% Retained Stability</td>
<td>96.1</td>
</tr>
</tbody>
</table>

Loaded Wheel Test (LWT) Data (mm) = 4.618

Page 3 of ArDOT Mix Design

ArDOT Special Tests

Tests required at the start of production for a new mix design and in the event of a 120 day or more interruption in mix production

- Field Verification SS-400-4 11-16-17
- Maximum of 200 tons to be placed on an ArDOT project during verification
- Production on non-ArDOT projects may be used for mix verification
Field Verification of ACHM

Plant Set
- Mix Design %
- Cold Feed %
- Optimum % Binder

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

After Verification
- No changes allowed on binder feed
- Aggregate proportion adjustments may be made
  - \( \approx 5\% \) per bin limit
  - \( 10\% \) total adjustment
- Changes may be submitted as a field design to the Resident Engineer

Special Tests 57

Test Method for Water Sensitivity for Compacted Bituminous Mixtures

ARDOT 455A

Special Tests 58
Water Sensitivity

Mix Design Requirement
• Mix must retain ≥ 80% of strength

Field Requirement
• Mix must retain ≥ 70% of strength

Special Tests

Water Sensitivity

When
• Once during 1st three days of production
• After a 90 day interruption of production

Breaking Heads
• Use Lottman head if stability > 10,000 lb

Equipment

Standard Lottman

Special Tests
Water Sensitivity

Specimens
• (4) 6” Gyratory Specimens
• Approximately 3 ¾” high (95 mm)
• ≈ 1000 g less than full size specimen
• Compact to \(N_{\text{des}}\) gyrations

Special Tests

Group A (Control)
• Submerge in water bath for 30 – 40 minutes
• 140 ± 1.8 °F
• Remove from water and immediately break
• 30 seconds
• Record stability (lb) and flow (0.01 in)

Group B (Conditioned)
• Within 24 hours, vacuum for 1 hour @ 30mm Hg
• Submerge in 140 °F water bath for 24 hours
• Remove from water and immediately break
• 30 seconds
• Record stability (lb) and flow (0.01 in)

\[
\% \text{ Ret. Strength} = \frac{\text{Stability}_B}{\text{Stability}_A} \times 100\%
\]

Special Tests
Batching & Mixing Asphalt Mixtures

Batching is used to blend aggregates and binder together in a controlled manner to produce specific properties or duplicate a mix design. Careful batching produces repeatable results!

Mix Designs

Calibrations
- Ignition Oven
- AC Gauge

Requirements
- % Binder
- Cold Feed %
Preparation

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

Batch Weights (Aggregate)

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

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>%</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot; Chip</td>
<td>20</td>
<td>(0.20)(10,000)</td>
</tr>
<tr>
<td>1/2&quot; Chip</td>
<td>33</td>
<td>(0.33)(10,000)</td>
</tr>
<tr>
<td>3/8&quot; Gravel</td>
<td>22</td>
<td>(0.22)(10,000)</td>
</tr>
<tr>
<td>Ind. Sand</td>
<td>18</td>
<td>(0.18)(10,000)</td>
</tr>
<tr>
<td>Nat. Sand</td>
<td>7</td>
<td>(0.07)(10,000)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
Batch Weights (Aggregate)

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

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot; Chip</td>
<td>30</td>
</tr>
<tr>
<td>1/2&quot; Screen</td>
<td>28</td>
</tr>
<tr>
<td>1/4&quot; Screen</td>
<td>25</td>
</tr>
<tr>
<td>Ind. Sand</td>
<td>17</td>
</tr>
</tbody>
</table>

Batching (Mix)

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

<table>
<thead>
<tr>
<th>Material</th>
<th>%</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder</td>
<td>6.0</td>
<td>(0.06)(1,700)  = 102.0</td>
</tr>
<tr>
<td>Aggregate</td>
<td>94.0</td>
<td>(0.94)(1,700)  = 1,598.0</td>
</tr>
<tr>
<td>3/4&quot; Chip</td>
<td>36</td>
<td>(0.36)(1,598)  = 575.3</td>
</tr>
<tr>
<td>1/2&quot; Chip</td>
<td>40</td>
<td>(0.40)(1,598)  = 639.2</td>
</tr>
<tr>
<td>Ind. Sand</td>
<td>24</td>
<td>(0.24)(1,598)  = 383.5</td>
</tr>
<tr>
<td><strong>Total Agg</strong></td>
<td></td>
<td><strong>1,598.0</strong></td>
</tr>
</tbody>
</table>
Batching (Mix)

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4” Chip</td>
<td>35</td>
</tr>
<tr>
<td>1/2” Chip</td>
<td>32</td>
</tr>
<tr>
<td>Ind. Sand</td>
<td>33</td>
</tr>
</tbody>
</table>

Mixing

Batch out # of points required
- Include “butter batch” if needed

Preheat aggregate and binder in oven to mixing temperature
- Place binder in oven ≈ 1-2 hours prior to mixing

Preheat tools and mixing bucket
- Clean and/or “butter” mixing bucket
- Buttering prevents a low binder content in the first mixed batch
Mixing

Zero “buttered” mixing pot
• Scale must be readable to the nearest 0.1 g

Add aggregate to mixing pot
• Mix aggregate
Form a crater for the binder

Batching and Mixing

Mixing

Determine the weight of aggregate in the bucket

Determine the total 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

Batching and Mixing
Mixing

Determine the total mix weight or binder weight for a calibration point if the Pb = 5.6 % and the measured weight of aggregate in the mixing pot is 7,998.2 g.

\[ P_s = 100\% - 5.6\% = 94.4\% \]

\[ \text{Mix Weight} = \frac{7998.2}{94.4\%} \times 100\% = 8472.7 \text{ g} \]

\[ \text{Binder Weight} = 8472.7 - 7998.2 = 474.5 \text{ g} \]

Mixing

Determine the total mix weight or binder weight for a calibration point if the Pb = 4.4 % and the measured weight of aggregate in the mixing pot is 7,995.0 g.
Mixing

Adjust to obtain the exact weight of binder

Mix thoroughly for at least 2 minutes

Batching and Mixing

Empty mixing pot into a sample container
- Use a spatula or spoon to scrape out all asphalt mixture
- Scrape tools

Place all scraped out asphalt mixture into the sample container

Verify mixing pot weight is within ± 5 g of its initial weight
- If not, re-scrape until mixing pot weight is within tolerance
- Reheat mixing pot if necessary

Batching and Mixing
Mixing RAP/RAS

Remove heated aggregate sample from oven
Add unheated RAP
Place sample back into oven for 1 hour at the mixing temperature
Remove sample from oven and add RAS
Add binder and mix thoroughly

RAP – reclaimed asphalt pavement
RAS – reclaimed/recycled asphalt shingles

Calibration of Asphalt Content Gauge Troxler 3241 - C

ARDOT 449A
AC Gauge Calibration

An AC gauge calibration establishes a calibration curve that correlates count values detected by the gauge to the % binder in the asphalt mixture.

In field testing, the gauge compares the calibration curve to the field test counts and returns the appropriate % binder.

Calibrations

- Gauge specific
- Mix design specific

Calibrations should be done at the expected location of testing
### Equipment

**AC Gauge**
- Sample Pans (3+)
- Scoop
- Scale
  - Readable to 0.1 g
  - Capacity ≥ 12,000 g
- Thermometer
  - 50 – 500 °F

**Leveling Plate**
- ≥ 3/4” Plywood
- ≥ 1/2” Plexiglass
- ≥ 0.4” Metal Plate

---

### Batching Requirements

**Number of Points**
- 4 points minimum
- 8000 g aggregate
  - Includes weight of RAP and RAS

**Required Binder Contents**

| Dry Batch | 0 %  | 0 %  |
| Design    | - 1 %| 5.2 %|
| Design Optimum | 6.2 %| 6.2 %|
| Design + 1 % | 7.2 %|     |

*Example: Opt. Pb = 6.2 %*
AC Gauge Location

Place gauge at least 30 feet from other radiation sources

Keep area around gauge free of hydrogenous material
  • Water
  • Asphalt / Mixtures
  • Plastics

Gauge Preparation

Turn on gauge and allow to warm up

Make sure chamber is clean and empty
  • Keep chamber door closed during operation

Run a 16 minute background count
  • Record counts
  • Verify count is within ± 1% of previous background
Determination of Calib. Weight

Prepare BLANK Sample
- Zero sample pan on scale or record empty weight

Fill sample pan with the batched, hot, dry aggregate in 2 layers
- 1st Layer
  - Add aggregate until pan is ≈ half full
  - Tamp aggregate and work corners with scoop or spoon
  - Drop pan ≈ 1 inch onto hard surface to settle aggregate

- 2nd Layer
  - Add aggregate until just over full
  - Tamp aggregate and work corners

Level the top surface with a straight edge
Determine the net weight of aggregate to the nearest whole gram
Verify temperature of BLANK sample
• 200 – 300 °F

Determination of Calib. Weight

1. Record net weight of aggregate.
2. Dump aggregate back into original pan with remaining aggregate. Remix by turning aggregate over a minimum of three times using scoop.
3. Fill pan a second time and record net weight of aggregate.
4. Repeat filling and weighing steps until two weights are within ± 25 g of each other.
5. Record the last weight as the calibration weight.

This is the calibration weight used for all remaining samples!
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

Calibration Samples

Prepare Calibration Pans
- Zero pan on scale
- Fill pan in two layers
  - Tamp lightly and work corners
  - Slightly overfill pan on top lift
- Match calibration weight within ± 5 grams
- Compress mixture with leveling plate until even with pan rim
  - Verify weight
- Bring samples to desired calibration temperature
  - 200 – 300 °F
Calibration

Start a new calibration
- 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 the calibration temperature

AC Gauge Calibration

Enter 1st % AC and load pan into AC Gauge
- Start test
- Move away at least 3 feet

Record counts

Counts : 2910
Press ENTER

Repeat process for all calibration points

AC Gauge Calibration
Calibration Data

Record fit coefficient
- Must be at least 0.995 or greater

Review input data
- Screen or printer
- Record constants
  - A1, A2, and A3
  - Record differences if necessary

Activate calibration
Store calibration
- Use mix design number
  Example: HMA 192-19

Gauge is now calibrated and ready for use

Fit Coefficient

2 Point Calibration

<table>
<thead>
<tr>
<th>% AC</th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>2900</td>
</tr>
<tr>
<td>7.0</td>
<td>3580</td>
</tr>
</tbody>
</table>

Fit Coefficient = 1.000
ALWAYS – even if wrong
Fit Coefficient

3 Point Calibration

<table>
<thead>
<tr>
<th>% AC</th>
<th>Counts</th>
<th>Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>2900</td>
<td>-0.017</td>
</tr>
<tr>
<td>6.0</td>
<td>3120</td>
<td>0.017</td>
</tr>
<tr>
<td>7.0</td>
<td>3580</td>
<td>-0.016</td>
</tr>
</tbody>
</table>

Fit Coefficient ≈ 0.998
Straight line fit

AC Gauge Calibration

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3+ Point Calibration

<table>
<thead>
<tr>
<th>% AC</th>
<th>Counts</th>
<th>Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>2900</td>
<td>-0.002</td>
</tr>
<tr>
<td>5.5</td>
<td>3000</td>
<td>0.001</td>
</tr>
<tr>
<td>6.0</td>
<td>3120</td>
<td>-0.001</td>
</tr>
<tr>
<td>6.5</td>
<td>3300</td>
<td>0.001</td>
</tr>
<tr>
<td>7.0</td>
<td>3580</td>
<td>-0.002</td>
</tr>
</tbody>
</table>

Fit Coefficient ≈ 0.999
or greater
Curved Fit

AC Gauge Calibration

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Determining the Asphalt Binder Content of HMA by the Ignition Method

AASHTO T 308

Ignition Oven Calibration

Establishes correction factors for binder content and aggregate breakdown

Correction factors are mix design and ignition oven specific
• > 5% change in mixture proportions requires a new calibration

Equipment
• Ignition oven
• Basket assembly
• Scale
  • Readable to 0.1 g
Sample Preparation

All samples are laboratory batched to the JMF using oven dried aggregate
• AASHTO T 30

Mix all samples using the optimum % binder from the mix design

Samples may not exceed the minimum mass by more than 500 g

<table>
<thead>
<tr>
<th>NMAS</th>
<th>Minimum Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td># 4</td>
<td>1200 g</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>1200 g</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>1500 g</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>2000 g</td>
</tr>
<tr>
<td>1&quot;</td>
<td>3000 g</td>
</tr>
<tr>
<td>1 1/2&quot;</td>
<td>4000 g</td>
</tr>
</tbody>
</table>

Ignition Oven Calibration

Binder Correction Factor

Turn ignition oven on and input required data
• Set chamber temperature to 538 °C
• Set calibration factor to 0.00

Allow oven to reach chamber set point temperature

Batch and mix 2 samples at the mix design optimum asphalt binder content
Binder Correction Factor

Burn both samples

Record binder content from the printed ticket
  • Calib. Asphalt Cntn

Save sample remains for aggregate $C_F$

<table>
<thead>
<tr>
<th>Elapsed Time</th>
<th>57:21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Weight</td>
<td>1838g</td>
</tr>
<tr>
<td>Weight Loss</td>
<td>116.3g</td>
</tr>
<tr>
<td>Percent Loss</td>
<td>6.32%</td>
</tr>
<tr>
<td>Temp Comp</td>
<td>0.16%</td>
</tr>
<tr>
<td>Calib. Factor</td>
<td>0.00%</td>
</tr>
<tr>
<td>Calib. Asphalt Cntn</td>
<td>6.16%</td>
</tr>
<tr>
<td>Filter Set Pt</td>
<td>850 °C</td>
</tr>
<tr>
<td>Chamber Set Pt</td>
<td>538 °C</td>
</tr>
</tbody>
</table>

Ignore Oven Calibration

Binder Correction Factor

Compare burned calibration samples

If difference $\leq 0.15\%$
  • Compute a correction factor ($C_F$)

If difference $> 0.15\%$
  • Burn two more samples @ 538 °C
  • Throw out high and low values
  • Compute a correction factor ($C_F$)

$C_F$ is the difference between the actual and average measured binder content

Report binder correction factors to the nearest 0.01 %
**Binder Correction Factor**

**Difference ≤ 0.15 %**  
Design $P_b = 6.0 \%$

- Sample 1 – 6.16 % @ 538 °C  
- Sample 2 – 6.26 % @ 538 °C  

**Compute a correction factor ($C_F$)**

- Average binder content values

\[
Average = \frac{6.16 + 6.26}{2} = 6.21 \%
\]

- Subtract design $P_b$

\[
C_F = 6.21 \% - 6.00 \% = 0.21 \%
\]

$C_F = 0.21 \%$

**Ignition Oven Calibration**

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---

**Binder Correction Factor**

**Difference > 0.15 %**  
Design $P_b = 6.0 \%$

- Sample 1 – 6.16 % @ 538 °C  
- Sample 2 – 6.34 % @ 538 °C  

**Burn two more samples**

- Sample 3 – 6.35 % @ 538 °C  
- Sample 4 – 6.22 % @ 538 °C  

**Throw out high and low values and compute $C_F$**

\[
Average = 6.28 \% \quad C_F = 6.28 \% - 6.00 \% = 0.28 \%
\]

$C_F = 0.28 \%$

**Ignition Oven Calibration**

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Binder Correction Factor

If Correction Factor ≤ 1.0 % (538 °C)
• Report $C_F$

If Correction Factor > 1.0 % (538 °C)
• Start over but burn samples at 482 °C
• Report $C_F$ even if > 1.0 % if established at 482 °C
• If there is no improvement in the $C_F$ at 482 °C, you may use the $C_F$ from the higher temperature

Ignition Oven Calibration

Binder Correction Factor

Determine the $C_F$
Design $P_b = 5.3 \%$

<table>
<thead>
<tr>
<th>Sample</th>
<th>$C_F$ @ 538 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>5.37 %</td>
</tr>
<tr>
<td>Sample 2</td>
<td>5.40 %</td>
</tr>
</tbody>
</table>

Ignition Oven Calibration
### Binder Correction Factor

Determine the $C_F$

<table>
<thead>
<tr>
<th>Sample</th>
<th>Value</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>5.78 %</td>
<td>538 °C</td>
</tr>
<tr>
<td>Sample 2</td>
<td>5.57 %</td>
<td>538 °C</td>
</tr>
<tr>
<td>Sample 3</td>
<td>5.66 %</td>
<td>538 °C</td>
</tr>
<tr>
<td>Sample 4</td>
<td>5.80 %</td>
<td>538 °C</td>
</tr>
</tbody>
</table>

Design $P_b = 5.5 \%$

---

### Binder Correction Factor

Determine the $C_F$

<table>
<thead>
<tr>
<th>Sample</th>
<th>Value</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>7.92 %</td>
<td>538 °C</td>
</tr>
<tr>
<td>Sample 2</td>
<td>7.96 %</td>
<td>538 °C</td>
</tr>
<tr>
<td>Sample 3</td>
<td>7.49 %</td>
<td>482 °C</td>
</tr>
<tr>
<td>Sample 4</td>
<td>7.44 %</td>
<td>482 °C</td>
</tr>
</tbody>
</table>

Design $P_b = 6.4 \%$

---

Ignition Oven Calibration
Aggregate Correction Factors

Batched/Burnt Samples
- (1) “Blank” Sample
  - Unburned, dry aggregate batch
- (2) Burnt Ignition Oven Samples
  - Remaining aggregate from calibration samples

Wash samples over # 200 sieve
- Use wetting agent

Sieve samples
- Report % passing to the nearest 0.1 % for all sieves

Compute the aggregate correction factor (ACF) for each sieve
- Calculate average gradation for burned samples
- Subtract average gradation from “blank” gradation

\[ ACF = Blank - Avg.\ Burn \]

Report aggregate correction factors to the nearest 0.1 %
Application of ACF

Determine required application of aggregate correction factors

- If any sieve (except #200) exceeds the allowable difference
- Apply correction factors to all sieves

- If only the #200 sieve exceeds the allowable difference
  - Apply only the #200 correction factor

Round and report sieve analysis

**Ignition Oven Calibration**

**Sieve Sizes**

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Allow. Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td># 8 &amp; Up</td>
<td>± 5.0%</td>
</tr>
<tr>
<td>&gt; # 200 &amp; &lt; #8</td>
<td>± 3.0%</td>
</tr>
<tr>
<td># 200</td>
<td>± 0.5%</td>
</tr>
</tbody>
</table>

**Application of ACF**

Find the ACF and which ones need to be applied.

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Blank</th>
<th>Burn #1</th>
<th>Burn #2</th>
<th>Avg. Burn</th>
<th>ACF</th>
<th>Allowable Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>0.0</td>
<td>± 5 %</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>95.2</td>
<td>97.2</td>
<td>97.0</td>
<td>97.1</td>
<td>-1.9</td>
<td>± 5 %</td>
</tr>
<tr>
<td># 4</td>
<td>75.4</td>
<td>77.6</td>
<td>77.8</td>
<td>77.7</td>
<td>-2.3</td>
<td>± 5 %</td>
</tr>
<tr>
<td># 8</td>
<td>43.8</td>
<td>46.4</td>
<td>45.2</td>
<td>45.8</td>
<td>-2.0</td>
<td>± 5 %</td>
</tr>
<tr>
<td># 16</td>
<td>30.0</td>
<td>34.1</td>
<td>33.5</td>
<td>33.8</td>
<td>-3.8</td>
<td>± 3 %</td>
</tr>
<tr>
<td># 30</td>
<td>20.7</td>
<td>22.5</td>
<td>22.0</td>
<td>22.3</td>
<td>-1.8</td>
<td>± 3 %</td>
</tr>
<tr>
<td># 50</td>
<td>16.5</td>
<td>18.9</td>
<td>17.4</td>
<td>18.2</td>
<td>-1.7</td>
<td>± 3 %</td>
</tr>
<tr>
<td># 100</td>
<td>12.0</td>
<td>14.0</td>
<td>13.7</td>
<td>13.9</td>
<td>-1.9</td>
<td>± 3 %</td>
</tr>
<tr>
<td># 200</td>
<td>6.5</td>
<td>7.2</td>
<td>7.0</td>
<td>7.1</td>
<td>-0.6</td>
<td>± 0.5 %</td>
</tr>
</tbody>
</table>

**Ignition Oven Calibration**
## Application of ACF

Find the ACF and which ones need to be applied.

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Blank</th>
<th>Burn #1</th>
<th>Burn #2</th>
<th>Avg. Burn</th>
<th>ACF</th>
<th>Allowable Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
<td>± 5 %</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>94.3</td>
<td>97.2</td>
<td>96.5</td>
<td>96.9</td>
<td></td>
<td>± 5 %</td>
</tr>
<tr>
<td># 4</td>
<td>70.6</td>
<td>73.4</td>
<td>74.1</td>
<td>73.8</td>
<td></td>
<td>± 5 %</td>
</tr>
<tr>
<td># 8</td>
<td>.418</td>
<td>43.0</td>
<td>44.2</td>
<td>43.6</td>
<td></td>
<td>± 5 %</td>
</tr>
<tr>
<td># 16</td>
<td>32.5</td>
<td>33.1</td>
<td>33.9</td>
<td>33.5</td>
<td></td>
<td>± 3 %</td>
</tr>
<tr>
<td># 30</td>
<td>21.0</td>
<td>23.6</td>
<td>23.0</td>
<td>23.3</td>
<td></td>
<td>± 3 %</td>
</tr>
<tr>
<td># 50</td>
<td>15.7</td>
<td>17.8</td>
<td>17.1</td>
<td>17.5</td>
<td></td>
<td>± 3 %</td>
</tr>
<tr>
<td># 100</td>
<td>11.4</td>
<td>12.0</td>
<td>12.3</td>
<td>12.2</td>
<td></td>
<td>± 3 %</td>
</tr>
<tr>
<td># 200</td>
<td>5.6</td>
<td>6.1</td>
<td>6.3</td>
<td>6.2</td>
<td></td>
<td>± 0.5 %</td>
</tr>
</tbody>
</table>

Ignition Oven Calibration

## Field Gradation

Calculate the % passing for the field gradation

- Add ACF
- Round

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Sieve Analysis</th>
<th>ACF</th>
<th>Calculated % Passing</th>
<th>Reported % Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>100.0</td>
<td>0.0</td>
<td>100.0</td>
<td>100</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>97.2</td>
<td>-2.3</td>
<td>94.9</td>
<td>95</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>88.3</td>
<td>-3.5</td>
<td>84.8</td>
<td>85</td>
</tr>
<tr>
<td># 4</td>
<td>56.1</td>
<td>-2.4</td>
<td>53.7</td>
<td>54</td>
</tr>
<tr>
<td># 8</td>
<td>39.5</td>
<td>-4.0</td>
<td>35.5</td>
<td>36</td>
</tr>
<tr>
<td># 16</td>
<td>29.0</td>
<td>-3.6</td>
<td>25.4</td>
<td>25</td>
</tr>
<tr>
<td># 30</td>
<td>20.4</td>
<td>-2.0</td>
<td>18.4</td>
<td>18</td>
</tr>
<tr>
<td># 50</td>
<td>13.7</td>
<td>-1.0</td>
<td>12.7</td>
<td>13</td>
</tr>
<tr>
<td># 100</td>
<td>9.1</td>
<td>-0.8</td>
<td>8.3</td>
<td>8</td>
</tr>
<tr>
<td># 200</td>
<td>5.8</td>
<td>-0.6</td>
<td>5.2</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Ignition Oven Calibration
Field Gradation

Calculate the % passing for the field gradation

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Sieve Analysis</th>
<th>ACF</th>
<th>Calculated % Passing</th>
<th>Reported % Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>100.0</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>93.2</td>
<td>-2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>84.1</td>
<td>-1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td># 4</td>
<td>52.5</td>
<td>-2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td># 8</td>
<td>43.0</td>
<td>-2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td># 16</td>
<td>31.6</td>
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<td># 30</td>
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<td>-2.7</td>
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<td># 50</td>
<td>14.7</td>
<td>-1.0</td>
<td></td>
<td></td>
</tr>
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<td># 100</td>
<td>11.8</td>
<td>-1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td># 200</td>
<td>5.2</td>
<td>-0.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ignition Oven Calibration

HMA Applications
Unit Conversions

Length
- 1 yard = 3 feet

Area = length x width
- 1 yd² = 9 ft²

Station
- 1 station = 100 feet

Station 50 + 63
- 50 stations + 63 feet
- (50 x 100) + 63 feet
- 5063 feet from start

Stations

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

Add or Subtract
- Drop “+” sign to easily convert distance to feet
- Replace “+” sign with a decimal point
- Carry units over like normal
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/yd²)

\[
Rate = \frac{(tons)(18,000)}{(length)(width)}
\]

\[Weight\ (lb) = (tons)(2,000)\quad Area\ (yd^2) = \frac{(length)(width)}{9}\]

Length and width measured in feet

HMA Applications

Find the application rate in lb/yd² for 700 tons of asphalt placed in an area 12’ wide by 4774’ long.

\[
Rate = \frac{(tons)(18,000)}{(length)(width)}
\]

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

220 lb/yd²

HMA Applications
Application Rate

Find the application rate in lb/yd² for 1000 tons of asphalt placed from station 62 + 20 to station 101 + 67 and 16’ wide.

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.

\[ Tons = \frac{(Rate)(length)(width)}{18000} \]

\[ Weight \ (tons) = \frac{(Rate)(Area)}{2000} \]

\[ Area \ (yd^2) = \frac{(length)(width)}{9} \]

Rate measured in lb/yd²  Length and width measured in feet
Quantity of Asphalt

Find the tons of asphalt needed to pave a 10’ wide, 300 ft long drive with an application rate of 220 lb/yd².

\[
Tons = \left( \frac{(Rate)(length)(width)}{18,000} \right)
\]

\[
Tons = \left( \frac{(220)(300)(10)}{18,000} \right) = \frac{660,000}{18,000} = 36.67
\]

37 tons
Sampling
Bituminous
Paving Mixtures

AASHTO R 97

ARDOT Specifications

ARDOT 404.04: Sampling shall be performed according to AASHTO R 97 (formerly AASHTO T 168) and ARDOT 465

• Note 1: Samples shall be taken from trucks at the plant
Transport Units

Visually divide truck bed into 3 or 4 equal sections

Remove ≈ 6 – 12 in of topmost material

Obtain one portion from each of the newly exposed areas

Combine portions
Transport Units

Avoid loss of larger aggregates from overfilling shovel

Avoid buildup of fines on shovel

Sample should look like load sampled

Windrow

Visually divide the windrow unit into ≈ 3 equal sections

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

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 out
  - Avoid material rolling off the shovel
- Combine portions

Other Locations

Roadway (before compaction)
- Take samples behind paver and 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 in. of asphalt
- Take sample from the center of hopper
  - Stay ≥ 1.5’ away from sides

Stockpiles
- Remove top 4 in. of asphalt

Always obtain a minimum of 3 portions from different areas
Transportation

- Avoid contamination
- Prevent loss of material
- Maintain temperature

Labeling
- Job number
- Source of sample
  - Plant
  - Mix design number
- Sample location
  - Tons
  - Lot and sublot

Reducing Samples of HMA to Testing Size

AASHTO R 47
Reducing Samples

Methods used to reduce samples in size while maintaining the same physical characteristics as the original sample.

The gradation of a reduced HMA sample affects its volumetric properties:
- $P_b$
- $G_{mm}$
- % Air Voids
- % VMA
- % Compaction

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Design</th>
<th>Coarse</th>
<th>Fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>92</td>
<td>89</td>
<td>95</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>81</td>
<td>78</td>
<td>84</td>
</tr>
<tr>
<td># 4</td>
<td>52</td>
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<td># 8</td>
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<td>11</td>
<td>15</td>
</tr>
<tr>
<td># 100</td>
<td>9</td>
<td>7.5</td>
<td>10</td>
</tr>
<tr>
<td># 200</td>
<td>5.2</td>
<td>4.2</td>
<td>6.2</td>
</tr>
</tbody>
</table>

$P_b$ 5.53% 4.75% 6.27%
Reduction Methods

Maintain Temperature
• May heat equipment up to the 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 of Reduction
• Mechanical Splitter
  • Recommended for large samples
  • Type A
  • Type B
• Quartering Method
• Incremental Method

Type A Mechanical Splitter

Fill the hopper
Open the hopper
Collect diagonally opposite quarters
Type B Mechanical Splitter

Fill hopper or pan
- Evenly distribute

Open hopper at a controlled rate

Collect one side

Quartering

Straight Edge

Quartering Template

Place sample on nonstick surface
Mix well by turning the pile over at least 4 times
Form a conical pile and flatten
Separate into quarters using template or straightedges
Collect diagonally opposite quarters
Incremental Method

Place sample on nonstick paper
  - Mix well by turning pile over at least 4 times

Roll asphalt into a cylindrical loaf
  - Discard end 1/4 of loaf

Cut off (collect) desired sample sizes
  - Re-mix and re-roll as necessary

Preparing HMA Specimens by Gyratory Compactor

AASHTO T 312
Equipment

Gyratory Compactor
- Mold
- Bottom
- Top

Oven
- Thermostatically controlled to ± 3 °C (≈ 5 °F)

Thermometer

SGC Compaction Parameters

- Ram Pressure: 600 ± 18 kPa
- 150 mm mold (i.d.)
- 30 ± 0.5 gyrations per minute
- 1.16 ± 0.02° (internal angle)
Mold Diameter Verification

**Frequency**
- Yearly or 80 hours

**Verify inside dimensions**
- Three-point Internal Bore Gauge
- Calib. Master Ring

**Procedure**
- Record 3 measurements at each height
  - 50 mm from wear end
  - 100 mm from wear end
  - 50 mm from opp. end

**Mold Temperature**
- 64 – 82 °F

*All measurements must be ≤ 150.2 mm for in-service molds*

Gyratory Verification

**Frequency**
- Follow manufacturer’s recommendations
  - 12 month maximum

**Verify**
- Internal Angle
- Pressure
- Rotation Speed
- Height Measurement

**Additional Checks**
- Physical movement
- Repairs which affect calibration

**Optional Check**
- New season of mix designs
Preparation

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

Lubricate bearing surfaces

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

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

Procedure

Load mold into compactor

Compact specimen

Remove mold from compactor
Procedure

Extrude specimen from mold
- Cool tender specimens partially before extruding

Remove paper disks

Allow specimens to cool to room temperature
- Compact at least 2 specimens

Gyratory Compaction

Bulk Specific Gravity of Compacted HMA Specimens

AASHTO T 166

Bulk Specific Gravity
**Equipment**

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

**Water Bath**
- Overflow device to maintain a constant water level
- 77 ± 1.8 °F
- Agitator and heater (optional)

---

**Method A Procedure**

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

Cool to 77 ± 9 °F

Weigh specimen and record dry mass in air (A)
Method A Procedure

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

Immerse specimen in water bath
- Leave submerged for 4 ± 1 minute

Record submerged mass (C)

Method A Procedure

Remove specimen from water bath

Quickly bring specimen to SSD with a damp towel
- 15 seconds

Weigh specimen and record SSD mass (B)
Method C Rapid Test Procedure

Obtain submerged mass (C)

Obtain SSD mass (B)

Dry specimen at 230 ± 9 °F to constant mass and cool to room temperature

Obtain dry mass (A)

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

Bulk Specific Gravity

Calculation

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

\[ \% \ Abs = \frac{(B - A)}{(B - C)} \times 100 \]

A = Dry mass of specimen

B = SSD mass of specimen

C = Submerged mass of specimen

Report \( G_{mb} \) to 0.001

Report \( \% \ Abs \) to 0.01 %
% Absorption Requirements

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

- If > 2 % absorption, rerun specimen using AASHTO T 275 (Paraffin Coating) or AASHTO T 331 (Vacuum Sealing)

Paraffin Coating

Vacuum Sealing

% Absorption Requirements

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

- If > 2 % absorption, rerun specimen using AASHTO T 275 (Paraffin Coating) or AASHTO T 331 (Vacuum Sealing)

ARDOT Special Provision

• Longitudinal Joint Densities 1-17-19

Joint densities are susceptible to having more than 2 % absorption
Paraffin Coating

AASHTO T 275

Vacuum Sealing

AASHTO T 331
Theoretical Maximum Specific Gravity and Density

AASHTO T 209

Influenced by the composition of the mixture
- Binder
- Stone
- Moisture

Influences “pay”
- % Air Voids
- % VMA
- % Compaction
Sample Preparation

Plant-Produced Samples
- Dry sample to constant mass at 221 ± 9 °F
- Dry until less than 0.1 % loss

While warm, separate the sample to a loose state
- Prevents trapped air between the particles
- No fine clumps > 1/4 inch in size

Cool sample to room temperature

Procedure

Zero bowl on scale or record empty mass

Place sample into vacuum bowl

Weigh vacuum bowl with sample

Record net mass of sample
**Procedure**

Add $\approx 77 \, ^\circ\, F$ water to completely cover sample
- Sink floating particles
- Optional: Add 5 – 10 mL of diluted wetting agent

**Procedure**

Remove trapped air by applying vacuum
- $3.7 \pm 0.3 \, kPa$
- $27.5 \pm 2.5 \, mm \, Hg$
- $15 \pm 2 \, minutes$

Agitate vacuum bowl at least every 2 minutes
Procedure

Release vacuum slowly
  • Do not exceed 8 kPa/s or 60 mmHg/s

Prepare water bath
  • Fill to overflowing
  • Allow water level to stabilize
  • Tare out suspension apparatus

Procedure

Submerge vacuum bowl with sample in water bath
  • 77 ± 2 °F
  • Suspend for 10 ± 1 minute

Record submerged mass of vacuum bowl with sample

Remove vacuum bowl with sample from water bath
Standardization

Fill water bath and allow to stabilize

Immerse empty vacuum bowl in water at 77 ± 2 °F
  • 10 ± 1 min

Record submerged mass of vacuum bowl
  • Repeat process 2 more times
  • If the variation of the 3 masses is within 0.3 g, use the average of the 3 masses for the submerged mass of bowl

Calculation

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

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

\[ C = (\text{bowl + sample})_{sub} - (\text{bowl})_{sub} \]

Report all specific gravities to the nearest 0.001
Moisture Content of Asphalt Mixtures by Oven Method

AASHTO T 329

Equipment

Oven
- Mixing temperature or
- 325 ± 25 °F

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

Thermometer
- Readable to the nearest 4 °F
**Procedure**

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

Place asphalt mixture into pan

Measure and record the temperature of the asphalt mixture
- Distribute sample evenly in container

Record mass of sample pan and moist test sample
- Determine initial mass of sample (net wet weight)

Dry sample for 90 ± 5 minutes
- Determine net mass of sample
- Continue drying
- Check at 30 ± 5 min. intervals until ≤ 0.05% change in mass

**Moisture Content**

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

\( M_p \) – previous measurement
\( M_n \) – 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 (net dry weight)

**Moisture Content**
Calculation

\[ \% MC = \frac{(M_i - M_f)}{M_f} \times 100 \% \]

\( M_i \) = 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*

### Moisture Content

\( M_i = 1505.6 - 244.0 = 1261.6 \)
\( M_f = 1505.1 - 244.0 = 1261.1 \)

\[ \% MC = \frac{(1261.6 - 1261.1)}{1261.1} \times 100 \% = \frac{0.5}{1261.1} \times 100 \% = 0.03964 \% \]

0.04 %
Calculation

Determine the moisture content of the mixture

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tare Weight</td>
<td>356.8</td>
</tr>
<tr>
<td>Wet Wt + Tare</td>
<td>1808.7</td>
</tr>
<tr>
<td>Dry Wt + Tare</td>
<td>1798.1</td>
</tr>
</tbody>
</table>

Moisture Content 195

Determination of Asphalt Content of Asphalt Mixtures by the Nuclear Method

ARDOT 449

AC Content 198
Gauge Preparation

**Set-up**
- Place gauge at least 30 feet from other sources of neutron radiation
- Keep area around gauge clear of hydrogenous materials
  - Water
  - Plastics
  - Asphalt

**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 $\pm 1\%$ of previous background count

---

**Gauge Preparation**

**Activate the appropriate calibration**
- If an interruption of mix production of more than 120 days has occurred, verify the mix calibration before use
  - Prepare sample at the design binder content
  - Record date, mix design number, and test results

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

**Obtain a representative portion of asphalt mixture**
- AASHTO R 97
AC Gauge Field Testing

Place asphalt mixture into sample pan

- 2 lifts
  - Lightly tamp each lift (including corners)
- Match calibration weight within ± 5 grams
- Press down on levelling plate until asphalt surface is level with the top rim of pan
  - Verify weight

AC Content 201

Measure Temperature

- Test sample at ± 10 °F of calibration temperature

Load sample pan into gauge

- Close door

Start test

- Move away ≈ 3 feet

Record counts and % AC (asphalt binder content)

- Average multiple tests

AC Content 202
AC Gauge Field Testing

Determine the moisture content of the sample using AASHTO T 329 to the nearest 0.01%

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

Report binder content to the nearest 0.1%!

\[
\text{AC Content} \quad 203
\]

Calculation

Determine the reported binder content

\[
\begin{align*}
\text{Gauge Reading (\% AC)} & = 6.20 \% \\
\text{Moisture Content} & = 0.07 \%
\end{align*}
\]

\[
\text{Calc. \% Binder} = 6.20 \% - 0.07 \% = 6.13 \%
\]

\[
\text{Reported \% Binder} = 6.1 \%
\]

\[
\text{AC Content} \quad 204
\]
Calculation

Determine the reported binder content

Gauge Reading (% AC)  5.29 %
Moisture Content  0.03 %
Entering Data

To enter data: Press item desired, enter data, and press <ENTER> quickly. Verify data entered by pressing item again (should display correct value in window).

Ignition Oven Preparation

Preheat ignition oven to calibration temperature
- Input chamber temperature for binder content correction factor
  - 538 °C or 482 °C

Input appropriate binder content correction factor (calibration factor)
Sample Preparation

Obtain a representative asphalt sample according to AASHTO T 97
  • Reduce using AASHTO R 47 to appropriate size

Oven dry sample to constant mass at 230 ± 9 °F

OR

Determine the moisture content using AASHTO T 329

Procedure

Record the mass of the empty basket assembly

Place 1/2 of the sample into the bottom basket and remaining portion into the top basket
  • Flatten and move sample away from basket edges
  • Complete assembly
Procedure

Record mass of total basket assembly
  • Basket assembly and sample

Calculate the initial mass of the asphalt sample
  • Input initial mass into ignition oven

Zero ignition oven scale

Procedure

Load basket assembly into oven
  • Maintain clearance

Close and lock door

Verify the total mass
  • Scale reading must be within ± 5 g of the recorded total basket assembly mass

Start test
Procedure

After Burn
- Record binder content (calib. asphalt ctnt) from the printed ticket (0.01 %)
- Subtract moisture content
- Report % binder to the nearest 0.1 %

Cool sample
- Save for sieve analysis if needed

Ignition Oven

<table>
<thead>
<tr>
<th>Elapsed Time</th>
<th>57:21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Weight</td>
<td>1838g</td>
</tr>
<tr>
<td>Weight Loss</td>
<td>116.3g</td>
</tr>
<tr>
<td>Percent Loss</td>
<td>6.32%</td>
</tr>
<tr>
<td>Temp Comp</td>
<td>0.16%</td>
</tr>
<tr>
<td>Calib. Factor</td>
<td>0.33%</td>
</tr>
<tr>
<td>Calib. Asphalt Ctnt</td>
<td>5.83%</td>
</tr>
<tr>
<td>Filter Set Pt</td>
<td>850 °C</td>
</tr>
<tr>
<td>Chamber Set Pt</td>
<td>538 °C</td>
</tr>
</tbody>
</table>

ArDOT Gradation

Determined from the aggregate blend once the binder has been removed

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

Sieve Analysis
Mechanical Analysis of Extracted Aggregate

AASHTO T 30

Procedure (AASHTO T 30)

After cooling, record the total weight of aggregate and basket assembly.

Wash aggregate over the # 200 sieve using a wetting agent.

• #10 or # 16 cover sieve

Calculate and record the dry weight of aggregate.

Dry to constant mass.

• Subtract weight of empty basket assembly

• Record mass after wash

• 0.1%
Procedure (AASHTO T 30)

Sieve sample
• Record weights
• Verify the sum of the 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%

Solvent Wash and Sieve Analysis of Asphalt Concrete

ARDOT 460
Procedure (ArDOT 460)

Determine binder content
  • ArDOT 449

Reduce to an appropriate size

Record sample weight

Cool to ≈ 200 °F

<table>
<thead>
<tr>
<th>Nominal Maximum Particle Size</th>
<th>Minimum Weight of Test Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>(inches)</td>
<td>(mm)</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>12.5</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>19</td>
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<tr>
<td>1&quot;</td>
<td>25</td>
</tr>
<tr>
<td>1 1/2&quot;</td>
<td>37.5</td>
</tr>
<tr>
<td>2 1/2&quot;</td>
<td>62.5</td>
</tr>
</tbody>
</table>

Procedure (ArDOT 460)

Cover sample with solvent, stir and soak

Repeat washing until solvent maintains its original color

Wash over the # 200 sieve with water
  • Liquid dish detergent may help to remove the oily residue

Pour solvent over nested # 8 and # 200 sieves
Procedure (ARDOT 460)

Return aggregate retained on sieves to container

Dry to constant mass
  • Cool
  • Record dry weight after wash

Sieve sample
  • Record weights

Calculate % passing

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

\[
\text{Dry Wt of Agg} = \text{Mix Wt} \times \frac{P_s}{100} \quad \text{(before wash)}
\]

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.

\[
\text{Dry Wt of Agg} = \text{Mix Wt} \times \frac{P_s}{100}
\]

\[
P_s = 100 \% - 6.2 \% = 93.8 \%
\]

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

**1738.5 g**
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.

Compaction

External forces are used to reposition aggregate particles into a more closely spaced arrangement thereby increasing the density of the pavement.
Intelligent Compaction

Intelligent compaction uses modern vibratory rollers with an integrated measurement system, an onboard computer reporting system, Global Positioning System (GPS) based mapping, and optional feedback control. The precise location of the roller, its speed, and number of passes over a given location are mapped using GPS. Sensors are mounted in the drums to monitor applied compaction effort, frequency, and response of the pavement. Temperature instrumentation allows the user to monitor surface temperature. Feedback can alert operator when additional roller passes are required.
ArDOT Specifications

410.08 - Rolling patterns are established at the beginning of placement of 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

Procedure

A rolling pattern establishes the number and type of roller passes required to achieve the specified density

- Take a 15 second WD reading with gauge after every roller pass until WD reading decreases
- Take all readings at the exact same location

Rolling Pattern

- Type of roller
- Number of vibratory passes
- Number of static passes
Procedure

Choose only the passes which increase density

Rolling Pattern

- 3 vibratory passes with the breakdown roller
- 1 static pass with the breakdown roller
- 2 static passes with the rubber tire roller

<table>
<thead>
<tr>
<th>Roller</th>
<th>Pass</th>
<th>Vibratory</th>
<th>Static</th>
<th>WD Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Break</td>
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<td>Vib</td>
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<td>140.2</td>
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<tr>
<td>Dual</td>
<td>2</td>
<td>Vib</td>
<td></td>
<td>143.4</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Vib</td>
<td></td>
<td>146.5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Static</td>
<td></td>
<td>147.0</td>
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<td>Static</td>
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<tr>
<td>Inter</td>
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<td>Static</td>
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<td>147.8</td>
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<tr>
<td>Rub</td>
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<td>Static</td>
<td></td>
<td>148.1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Static</td>
<td></td>
<td>147.2</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Static</td>
<td></td>
<td>147.2</td>
</tr>
</tbody>
</table>

Sampling Asphalt Mixtures after Compaction (Obtaining Cores)

AASHTO R 67

Center for Training Transportation Professionals
Equipment

Wet-core drilling machine
Diamond-edged core drill bit
Cooling agent
• Water, dry ice, or liquid nitrogen
Retrieval device
Separation equipment
• Hammer and chisel
• Wet saw

Procedure

Allow asphalt mat to cool prior to coring
Cut core perpendicular to asphalt surface
• Use water or air while drilling to minimize heat caused by friction
• Apply constant, gradual pressure
• Drill to bottom of layer or just slightly below

Remove core
• If core is damaged, obtain a new core within 6 inches of the original location

Label core
Fill hole with asphalt mixture
• Compact mixture
• Level with surface
Transportation

Secure cores against jarring, rolling, or impact with any objects
- Newspaper
- Cylinder molds

Protect against extreme temperatures
- Insulated container

Separation

Separate cores at the point of bonding
- Hammer and chisel
- Wet saw

Remove tack coats and bound gravel or dirt before testing
Separation

Cores

% Compaction

AASHTO T 166

\[ \% \text{Comp} = \frac{G_{mb}}{G_{mm}} \times 100\% \]
**ArDOT Specifications**

Cut one core for every lot or sublot test
- Cut cores full depth
- 4” minimum diameter
- Label core

**SS-410-3**
- Levelling & Bond Breakers
- Thickness must be 3 x NMAS

*ArDOT 465 Section 5.1.3.1: Do not sample for density within 1.5 feet of the mat’s longitudinal joint or edge. Does not apply to joint densities!*

---

**In Place Density & % Compaction of ACHM Using a Nuclear Gauge**

*ArDOT 461*

---

**Density Standard Count**
Troxler 3430

• Keypad

(READY) 1 min
Depth : BS

ON
YES

OFF
NO

MA
PR

STD
SPECIAL

TIME
DEPTH
START
ENTER

Density Standard Count

Standard Count

Run Daily
• Used to determine if the gauge is functioning properly
• Adjusts for source decay and background radiation

Block Site Selection
• Dry, flat asphalt surface
• ≥ 10’ from large objects
• ≥ 60’ from any radioactive sources

Run Standard Count
• Place gauge on block
• Rod in “Safe” position
• Press <Standard>
• Move away ≈ 3 feet

Density Standard Count

244

245
Standard Check (Ratio Method)

Determine Ratios

- Density (± 1 %)
  - Ratio = 0.99 – 1.01
  - 2234 / 2258 = 0.9893
  - 2258 / 2234 = 1.0107

- Moisture (± 2 %)
  - Ratio = 0.98 – 1.02
  - 638 / 646 = 0.9876
  - 646 / 638 = 1.0125

Standard Check (Range Method)

Compute Ranges

- Density (± 1 %)
  - Range = 2258 x 0.01 = ± 22
  - 2258 - 2234 = 24

- Moisture (± 2 %)
  - Range = 646 x 0.02 = ± 12
  - 646 - 638 = 8
Standard Check

<table>
<thead>
<tr>
<th>Date</th>
<th>DS</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 10th</td>
<td>2273</td>
<td>589</td>
</tr>
<tr>
<td>May 12th</td>
<td>2260</td>
<td>550</td>
</tr>
<tr>
<td>May 13th</td>
<td>2265</td>
<td>565</td>
</tr>
<tr>
<td>May 15th</td>
<td>2262</td>
<td>556</td>
</tr>
</tbody>
</table>

New Counts: 2246, 575

Determine if the new density and moisture standard counts pass or fail.

Failing Standard Count

Re-run standard count
- Check set-up

Establish a new average
- Run 4 new standard counts
- Run new standard count and compare to new average
  - Pass – proceed to testing
  - Fail – repair gauge

Gauge must pass standard counts before use in the field.
Job Correction Factor (JCF)

Eliminates gauge errors
- Surface voids
- Base irregularities

Mix design and job location specific
- Must be determined on each project site

JCF is applied to test results prior to calculating the % compaction for each test location

Core Correction Factor (CCF)

- Test Strip
  - (5) random locations

- Each Location
  - (4) gauge WD readings
  - 1 minute
  - Fill voids of rough surfaces with dry sand
  - Cut (1) core
  - Determine $G_{mb}$

Take readings within 1 foot of core

Direction of Paving
Core Correction Factors (CCF)

Determine each core’s bulk specific gravity ($G_{mb}$)

Convert each $G_{mb}$ to a core density

\[ \text{Core Density} = (G_{mb}) \left( \frac{62.4 \text{ lb}}{ft^3} \right) \]

Find core density

Core $G_{mb}$: 2.301

Average (4) gauge WD readings

Subtract average gauge WD from core density

- Keep track of sign

\[ CCF = \text{Core Density} - \text{Average WD} \]

\[ -3.3 \text{ pcf} \]
Job Correction Factor (JCF)

Average (5) core correction factors

<table>
<thead>
<tr>
<th>Core</th>
<th>CCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+ 2.2</td>
</tr>
<tr>
<td>2</td>
<td>+ 2.0</td>
</tr>
<tr>
<td>3</td>
<td>+ 1.8</td>
</tr>
<tr>
<td>4</td>
<td>- 0.5</td>
</tr>
<tr>
<td>5</td>
<td>+ 0.3</td>
</tr>
</tbody>
</table>

Avg. = 5.8/5 = 1.2

Application of JCF

- If JCF < 1.0
  - Do not use JCF
  - Read density directly from gauge
- If JCF > 1.0
  - Add JCF to all wet density readings before calculating % compaction

JCF = + 1.2 pcf

Calculation (JCF)

Determine the job correction factor.

<table>
<thead>
<tr>
<th>Location</th>
<th>Gauge WD Reading</th>
<th>Core G_mb</th>
<th>JCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>143.3 141.5 142.8 140.6</td>
<td>2.312</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>140.5 139.8 138.4 140.0</td>
<td>2.285</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>141.5 142.8 140.3 140.7</td>
<td>2.310</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>139.5 137.2 140.0 138.8</td>
<td>2.251</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>138.2 139.3 140.1 140.5</td>
<td>2.277</td>
<td></td>
</tr>
</tbody>
</table>

Density JCF
Preparation

Set gauge parameters
- Time – 1 minute
- Depth – backscatter

3 Random test locations
- Dry and flat
- Fill Voids of rough surfaces with dry sand if used when establishing the JCF

Test at same time interval (laydown to test) as JCF

_ArDOT 461 Section 4.2: Do not make tests within 1.5 feet of the asphalt mat’s edge. Does not apply to joint densities!

Field Testing

Place gauge on asphalt mat with source rod aligned with the direction of paving
- Stabilize gauge

Lower rod to BS position

Start test
- Move away ≈ 3 ft

Safe Rod

Record Data
- WD reading
- Station and offset

Lay-down
% Compaction (Gauge)

Calculation
- Add JCF to WD reading
- Divide by the maximum density
- Multiply result by 100

\[
\% \text{Comp} = \frac{(WD + JCF)}{(G_{mm} \times 62.4)} \times 100 \%
\]

Report % compaction to the nearest 0.1 %

Density Field Testing

Calculation (% Compaction)

Determine the % compaction for the test location.

| Gauge WD | 138.8 pcf | JCF | + 2.2 pcf | % \text{Comp} = \frac{(WD + JCF)}{(G_{mm} \times 62.4)} \times 100 \%
| G_{mm} | 2.422 |

% \text{Comp} = \frac{(138.8 + 2.2)}{(2.422 \times 62.4)} \times 100 \% = \frac{141.0}{151.1328} \times 100 \% = 93.2954 \%

93.3 %

Density Field Testing
Calculation (% Compaction)

Determine the % compaction for the test location.

\[
\begin{align*}
\text{Gauge WD} & \quad 139.3 \text{ pcf} \\
\text{JCF} & \quad + 3.5 \text{ pcf} \\
G_{mm} & \quad 2.465 \\
\end{align*}
\]

Report

Test Locations (3)
- Station #
- Offset
  - Include from left or right side of pavement
  - % Compaction

Reported Result (1)
- According to ArDOT 461 (Sections 5.4 – 5.6)
**Report**

**ARDOT 461 – Section 5.4**  
Spec: 92 – 96

- Report the average of all compaction tests if:
  - A. At least 2 of the 3 are ≥ 92.0 and ≤ 96.0 % and any remaining result is not more than 2 % above or below the specification limits

- B. All are above or below the specification limits and no result is more than 2 % above or below the limits

---

**Report**

**ARDOT 461 – Section 5.4**  
Spec: 92 – 96

- C. If all are outside specification limits (different directions) and none are more than 2 % out:
  
  **Add arithmetic differences between test and closest limit**
  
  **Average the sum, and add or subtract from limit closest to two tests**

  - 92.0 – 90.6 = 1.4
  - 92.0 – 91.3 = 0.7
  - 96.3 – 96.0 = 0.3
  
  \[
  \frac{(1.4 + 0.7 + 0.3)}{3} = 0.8
  \]
  
  \[
  2.4 \div 3 = 0.8
  \]
  
  \[
  92.0 - 0.8 = 91.2 \%
  \]
Report

ARDOT 461 – Section 5.5  Spec: 92 – 96

- If (2) are outside specification limits (same side), and one is within the specification limits:
  - Average only the (2) non-complying results

\[
\frac{91.2\% + 91.8\%}{2} = 91.5\%
\]

Density Field Testing 270

Report

ARDOT 461 – Section 5.6  Spec: 92 – 96

- If (1) of the results are more than 2% outside the specification limits
  - Report this (1) result for the test

\[
89.6\%
\]

Density Field Testing 271
Report

Sublot Compliance / Rejection

- If a density result for a sublot is 2% or more outside compliance limits:
  - Two (2) additional tests will be performed by ArDOT
  - If the sublot already contains both contractor and ArDOT test results, then only one (1) additional test will be performed
  - If the average of the three (3) tests is within ±2% of the specification limit, the sublot will be accepted and the average is the official result of the sublot

ArDOT Specifications

Standard Specifications & Errata
- Mix design and quality control requirements

Supplement Specifications
- Changes to the Standard Specifications

Job Plans
- Mix design requirements and application rates

Special Provisions – Apply only to individual jobs
- Submission of Hot Mix Acceptance Test Results
- Recycled Asphalt Shingles
- Warm Mix Asphalt
- PWL
- Joint Densities
ARDOT Specifications

ARDOT
- Lot = 3000 tons

Contractor
- Sublot = 750 tons

ARDOT specification limits are considered absolute limits!

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 non-compliance
- Failing test
**ArDOT Specifications**

**ArDOT Pay Items**
- % Binder
- % Air Voids
- % VMA
- % Compaction

---

**ArDOT Specifications**

**Field Compliance (ArDOT Table 410-1)**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Binder Content</strong></td>
<td>± 0.3 % (Mix Design)</td>
<td></td>
</tr>
<tr>
<td><strong>Air Voids</strong></td>
<td>3.0 % - 5.0 %</td>
<td></td>
</tr>
<tr>
<td><strong>VMA</strong></td>
<td>37.5 mm</td>
<td>11.0 % - 13.0 %</td>
</tr>
<tr>
<td></td>
<td>25.0 mm</td>
<td>12.0 % - 14.0 %</td>
</tr>
<tr>
<td></td>
<td>12.5 mm</td>
<td>13.5 % - 16.0 %</td>
</tr>
<tr>
<td></td>
<td>9.5 mm</td>
<td>14.5 % - 17.0 %</td>
</tr>
</tbody>
</table>

**Gradation**
See ArDOT Section 404.04

**Field Density**
92.0 % - 96.0 % or 90.0 % - 96.0 %
**ArDOT Specifications**

**Field Compliance (ArDOT Section 404.04)**

<table>
<thead>
<tr>
<th>ArDOT Gradation</th>
<th>± 7.0 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1” (25.0 mm)</td>
<td></td>
</tr>
<tr>
<td>Tolerances</td>
<td>± 7.0 %</td>
</tr>
<tr>
<td>3/4” (19.0 mm)</td>
<td></td>
</tr>
<tr>
<td>1/2” (12.5 mm)</td>
<td></td>
</tr>
<tr>
<td>(Tolerances are</td>
<td>± 7.0 %</td>
</tr>
<tr>
<td>applied to the</td>
<td></td>
</tr>
<tr>
<td>job mix formula)</td>
<td>± 4.0 %</td>
</tr>
<tr>
<td># 4 (4.75 mm)</td>
<td></td>
</tr>
<tr>
<td># 8 (2.36 mm)</td>
<td></td>
</tr>
<tr>
<td># 16 (1.18 mm)</td>
<td></td>
</tr>
<tr>
<td># 30 (0.60 mm)</td>
<td></td>
</tr>
<tr>
<td># 50 (0.30 mm)</td>
<td></td>
</tr>
<tr>
<td># 100 (0.15 mm)</td>
<td></td>
</tr>
</tbody>
</table>

**ArDOT Specifications**

![Superpave Mixture Properties Table](image)

**ArDOT Specifications**

280

281
**Standard Pay**

Determine which (if any) of the pay items will result in a pay deduction or rejection of the lot.

<table>
<thead>
<tr>
<th>Test</th>
<th>% Binder</th>
<th>% Air Voids</th>
<th>% VMA</th>
<th>% Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sublot 1</td>
<td>4.2</td>
<td>2.5</td>
<td>12.5</td>
<td>92.2</td>
</tr>
<tr>
<td>Sublot 2</td>
<td>3.8</td>
<td>3.3</td>
<td>11.2</td>
<td>91.9</td>
</tr>
<tr>
<td>Sublot 3</td>
<td>4.4</td>
<td>3.2</td>
<td>12.9</td>
<td>91.0</td>
</tr>
<tr>
<td>Sublot 4</td>
<td>4.6</td>
<td>4.0</td>
<td>12.2</td>
<td>93.1</td>
</tr>
<tr>
<td>Lot</td>
<td>4.5</td>
<td>3.7</td>
<td>12.8</td>
<td>91.8</td>
</tr>
<tr>
<td>Average</td>
<td>4.30</td>
<td>3.34</td>
<td>12.32</td>
<td>92.00</td>
</tr>
<tr>
<td>Compliance</td>
<td>3.9 - 4.5</td>
<td>3 - 5</td>
<td>12.0 - 14.0</td>
<td>92 - 96</td>
</tr>
</tbody>
</table>

*25.0 mm Mix Design  Optimum Pb = 4.2 %*

---

**Percent Within Limits (PWL)**

An alternative method of determining compliance and calculating pay based on:

- Specifications limits
- Variability in test data

Used for jobs let by ARDOT under a special provision for new construction projects and jobs with full depth reconstruction.

PWL analysis is performed only on lots which contain 3 or more test results.
Total Pay Factor < 80 = “Remove and Replace”
105% Pay Possible

Pay & PWL

**PWL**

- PWL: 62.74
- PF_{PAB}: 86.37 (20%)
- PWL: 62.53
- PF_{VMA}: 86.27 (10%)

**PWL**

- PWL: 70.95
- PF_{PAV}: 90.48 (35%)
- PWL: 50.00
- PF_{PC}: 80.00 (35%)

Total Pay Factor < 80 = “Remove and Replace”
105% Pay Possible

Pay & PWL
284

**PWL**

- Average Air Voids

Pay & PWL
285
2020

PWL

PWL – Percent Within Limits (Good)

<table>
<thead>
<tr>
<th>% Air Voids</th>
<th>LSL = 3 %</th>
<th>USL = 5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sublot 1</td>
<td>4.0 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 2</td>
<td>4.2 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 3</td>
<td>3.8 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 4</td>
<td>3.9 %</td>
<td></td>
</tr>
<tr>
<td>Lot</td>
<td>4.1 %</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>4.00 %</td>
<td></td>
</tr>
</tbody>
</table>

PWLₜ = 100.00  PFₚₐᵥ = 105.00

Non-PWL = 100 % Pay

Pay & PWL
### PWL

**PWL – Percent Within Limits (Fair)**

<table>
<thead>
<tr>
<th>% Air Voids</th>
<th>LSL = 3 %</th>
<th>USL = 5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sublot 1</td>
<td>4.8 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 2</td>
<td>5.2 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 3</td>
<td>4.2 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 4</td>
<td>4.6 %</td>
<td></td>
</tr>
<tr>
<td>Lot</td>
<td>4.0 %</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>4.56 %</td>
<td></td>
</tr>
</tbody>
</table>

PWL\textsubscript{T} = 81.23      \text{PF\textsubscript{PAV}} = 95.62

Non-PWL = 100 % Pay

Pay & PWL 290

---

### PWL

**PWL – Percent Within Limits (Fair)**

<table>
<thead>
<tr>
<th>% Air Voids</th>
<th>LSL = 3 %</th>
<th>USL = 5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sublot 1</td>
<td>3.3 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 2</td>
<td>5.2 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 3</td>
<td>4.2 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 4</td>
<td>4.6 %</td>
<td></td>
</tr>
<tr>
<td>Lot</td>
<td>4.0 %</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>4.26 %</td>
<td></td>
</tr>
</tbody>
</table>

PWL\textsubscript{T} = 85.09      \text{PF\textsubscript{PAV}} = 97.55

Non-PWL = 100 % Pay

Pay & PWL 291
### PWL

**PWL – Percent Within Limits (Poor)**

<table>
<thead>
<tr>
<th>% Air Voids</th>
<th>LSL = 3 %</th>
<th>USL = 5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sublot 1</td>
<td>2.6 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 2</td>
<td>3.2 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 3</td>
<td>3.1 %</td>
<td></td>
</tr>
<tr>
<td>Sublot 4</td>
<td>4.5 %</td>
<td></td>
</tr>
<tr>
<td>Lot</td>
<td>2.8 %</td>
<td></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>3.24 %</strong></td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{PWL}_T = 61.33 \quad \text{PF}_{PAV} = 85.67 \]

Non-PWL = 100 % Pay

Pay & PWL 292