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

Introduction
Test Day

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

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

Results
• www.cttp.org
• Letter & Certification

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
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
- \( X_{yz} \)
- \( X \) (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

\( G_b \) – SpG of the binder
\( Gmb \) – Bulk SpG of the mix
Terminology

Mix Design

- Determines the blend which will produce the required properties
- AASHTO R 35
- AASHTO M 323
- ArDOT Specifications

Field Testing (QC/QA)

- Determines compliance with ArDOT specifications based on the approved mix design

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

Relationships

\[ P_s + P_b = 100\% \]

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

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

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%*

### Terminology

**Specific Gravity / Density**

**Specific Gravity (G)**

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

**Density (D)**

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

*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

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
- $77 \, ^\circ F$

Field Testing
- $77 \, ^\circ F$ or $60 \, ^\circ F$
- $77 \, ^\circ F$ 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

Specific Gravity of Binder ($G_b$)

Determine the specific gravity needed for calculations.

$$G_{b60} = 1.028$$
Bulk SpG of Mixture \((G_{mb})\)

**Specific gravity of a compacted asphalt mixture**

- Used to determine the volumetric properties of compacted mix (gyratory specimens or cores) relative to the \(G_{mm}\)

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

\(A\) = dry mass
\(B\) = SSD mass
\(C\) = submerged mass

**Report all specific gravities to the nearest 0.001**

<table>
<thead>
<tr>
<th>Dry Mass</th>
<th>Submerged Mass</th>
<th>SSD Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>4556.7</td>
<td>2621.0</td>
<td>4563.5</td>
</tr>
</tbody>
</table>

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

2.346
Bulk SpG of Mixture \((G_{mb})\)

Determine the \(G_{mb}\) of the compacted specimen

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Mass</td>
<td>2327.2</td>
</tr>
<tr>
<td>Submerged Mass</td>
<td>1398.6</td>
</tr>
<tr>
<td>SSD Mass</td>
<td>2332.0</td>
</tr>
</tbody>
</table>

**Terminology**

- **Dry Mass**
- **Submerged Mass**
- **SSD Mass**

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

- \(A = \text{dry mass}\)
- \(B = \text{SSD mass}\)
- \(C = \text{submerged mass}\)

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

Determine the % absorption of the compacted specimen

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

Dry Mass = 4573.6 g \hspace{1cm} SSD Mass = 4585.1 g \hspace{1cm} Sub. Mass = 2633.0 g

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

0.59 %

Terminology

% Absorption (% Abs)

Determine the % absorption of the compacted specimen

Dry Mass = 4558.3 g
SSD Mass = 4571.0 g
Sub. Mass = 2631.2 g

Terminology
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**

<table>
<thead>
<tr>
<th>A</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1786.4</td>
<td>1048.7</td>
</tr>
</tbody>
</table>

\[ G_{mm} = \frac{1786.4}{(1786.4 - 1048.7)} = \frac{1786.4}{737.7} = 2.42158 \]

**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%

Terminology

% Compaction (Relative Density)

Determine the % compaction

\[
G_{mb} \text{ of Core} = 2.358
\]

\[
G_{mm} \text{ of Mix} = 2.502
\]
**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)
- **Stone**: (aggregate)

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

Volume of air pockets in a compacted asphalt mixture

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

<table>
<thead>
<tr>
<th>$G_{mb}$</th>
<th>96 %</th>
<th>$V_a$ = 4 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G_{mm}$</td>
<td>100 %</td>
<td>$V_a$ = 0 %</td>
</tr>
</tbody>
</table>

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

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

Find the reported % air voids

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

\[
V_a = 100\% - \left( \frac{2.363}{2.447} \times 100\% \right) = 100\% - 96.64896\% = 3.35104\%
\]

3.4 %

Terminology 39

---

% Air Voids ($V_a$)

Find the reported % air voids

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

\[
V_a = 100\% - \left( \frac{2.305}{2.413} \times 100\% \right) = 100\% - 96.64896\% = 3.35104\%
\]

Terminology 40
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**

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

Determine the \( G_{se} \) of the mixture

\[
P_b = 5.7 \%
\]

\[
G_{mm} = 2.413
\]

\[
G_b = 1.032
\]

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

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

**2.625**

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

Determine the \( G_{se} \) of the mixture

\[
P_b \quad 4.2 \%
\]

\[
G_{mm} \quad 2.555
\]

\[
G_{p60} \quad 1.032
\]

Terminology

\[
\begin{align*}
V_{MA} &= 100 \% - \left[ \frac{(G_{mb})(P_s)}{G_{sb}} \right] = V_{MAe} - V_{MACF} \\
V_{MAe} &= 100 \% - \left[ \frac{(G_{mb})(P_s)}{G_{se}} \right] 
\end{align*}
\]

Report % VMA to the nearest 0.1 %

Terminology
Voids in the Mineral Agg. (VMA)

Calculate the % VMA for the mixture

<table>
<thead>
<tr>
<th>Gmb</th>
<th>P</th>
<th>VMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.0%</td>
<td>1.8%</td>
</tr>
<tr>
<td>2</td>
<td>94.0%</td>
<td>2.612</td>
</tr>
</tbody>
</table>

Average Gmb 2.304

\[
VMA_e = 100\% - \left(\frac{(Gmb)(Ps)}{Gse}\right)
\]

\[
VMA = VMA_e - VMA_{CF}
\]

\[
VMA_e = 100\% - \left(\frac{(2.304)(94.0\%)}{2.612}\right) = 100\% - 82.916\% = 17.1\%
\]

\[
VMA = 17.1\% - 1.8\% = 15.3\%
\]

Terminology

Voids in the Mineral Agg. (VMA)

Calculate the % VMA for the mixture

<table>
<thead>
<tr>
<th>Gmb</th>
<th>P</th>
<th>VMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.6%</td>
<td>0.5%</td>
</tr>
<tr>
<td>2</td>
<td>2.635</td>
<td></td>
</tr>
</tbody>
</table>

Terminology
Volumetric Mix Design

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

Volumetric Mix Design

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

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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<tbody>
<tr>
<td>Optimum Asphalt Binder</td>
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<tr>
<td>VMA</td>
<td>14.5 %</td>
</tr>
<tr>
<td>VFA</td>
<td>73.1 %</td>
</tr>
<tr>
<td>Fines to Asphalt Ratio</td>
<td>0.99</td>
</tr>
<tr>
<td>Retained Stability</td>
<td>96.1 %</td>
</tr>
<tr>
<td>Nmax</td>
<td>205</td>
</tr>
</tbody>
</table>

Allowable Field Tolerances

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<th>Tolerance</th>
</tr>
</thead>
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<tr>
<td>Optimum Asphalt Binder</td>
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</tr>
<tr>
<td>Air Voids</td>
<td>3.0 % to 5.0 %</td>
</tr>
<tr>
<td>VMA</td>
<td>13.5 % to 16.0 %</td>
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Asphalt Binder: Hog Oil PG 76-22

APA Results: 1.055 mm

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<td>13.5 % to 16.0 %</td>
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<tr>
<td>5.000 mm or less</td>
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Volumetric Mix Design

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<td></td>
</tr>
<tr>
<td>5.000 mm or less</td>
<td></td>
</tr>
</tbody>
</table>
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

Volumetric Mix Design

Design Summary

<table>
<thead>
<tr>
<th>Mix Design #</th>
<th>HMA000-20</th>
<th>Mix Type</th>
<th>12.5 MM AGHM Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Asphalt Content %</td>
<td>6.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max Theor. SG (Gmm)</td>
<td>2.400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphalt Binder</td>
<td>PG 76-22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphalt Binder Source</td>
<td>Hog Oil Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixing Temp (F)</td>
<td>340</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compaction Temp (F)</td>
<td>310</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antistrip Source</td>
<td>HogGrip 976</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antistrip %</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Retained Stability</td>
<td>96.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loaded Wheel Test (LWT) Data (mm)</td>
<td>4.018</td>
<td>Spec Max = 8.000 mm</td>
<td></td>
</tr>
</tbody>
</table>

Page 3 of ArDOT Mix Design

Volumetric Mix Design
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

AR DOT 455A

Special Tests 58
**Water Sensitivity**

**Mix Design Requirement**
- Mix must retain $\geq 80\%$ of strength

**Field Requirement**
- Mix must retain $\geq 70\%$ of strength

**Special Tests**

**Stripping**

---

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

**Breaking Heads**
- Use Lottman head if stability $> 10,000\text{ lb}$

**Equipment**

- Standard
- Lottman
- 60
Water Sensitivity

Specimens
- (4) 6” Gyratory Specimens
  - Approximately 3 ¼” 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)

\[
\% \text{ Ret. Strength} = \frac{\text{Stability}_B}{\text{Stability}_A} \times 100\%
\]
Batching & Mixing Asphalt Mixtures

ARDOT 449A

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)  = 2,000</td>
</tr>
<tr>
<td>1/2&quot; Chip</td>
<td>33</td>
<td>(0.33)(10,000)  = 3,300</td>
</tr>
<tr>
<td>3/8&quot; Gravel</td>
<td>22</td>
<td>(0.22)(10,000)  = 2,200</td>
</tr>
<tr>
<td>Ind. Sand</td>
<td>18</td>
<td>(0.18)(10,000)  = 1,800</td>
</tr>
<tr>
<td>Nat. Sand</td>
<td>7</td>
<td>(0.07)(10,000)  = 700</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>Total = 10,000</td>
</tr>
</tbody>
</table>

Batching and Mixing 65
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%.

- 3/4" Chip: 35
- 1/2" Chip: 32
- Ind. Sand: 33

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

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
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.

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

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

\[ Binder\, Weight = 8472.7 - 7998.2 = 474.5\, g \]

Batching and Mixing

75

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.

Batching and Mixing

76
Mixing

Adjust to obtain the exact weight of binder

Mix thoroughly for at least 2 minutes

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
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

**AR DOT 449A**

Center for Training Transportation Professionals

AC Gauge Calibration
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 % |
| 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
BLANK Sample

Verify temperature of BLANK sample
• 200 – 300 °F

AC Gauge Calibration

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!

AC Gauge Calibration
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

Counts: 2910

Press ENTER

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

---

**AC Gauge Calibration**
**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

### 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
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

Ignition Oven Calibration
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>

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 Cnt

**Save sample remains for aggregate C_F**

---

Ignition Oven Calibration

<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 Cnt</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>

---

Binder Correction Factor

**Compare burned calibration samples**

- **If difference ≤ 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 %**

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

**Design P_b = 6.0 %**

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

- Average binder content values
  \[
  \text{Average} = \frac{6.16 + 6.26}{2} = 6.21 \%
  \]
- Subtract design \( P_b \)
  \[
  C_F = 6.21 \% - 6.00 \% = 0.21 \%
  \]

\[ C_F = 0.21 \% \]

Ignition Oven Calibration

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**Difference > 0.15 %**

- Sample 1 – 6.16 % @ 538 °C
- Sample 2 – 6.34 % @ 538 °C
- Sample 3 – 6.35 % @ 538 °C
- Sample 4 – 6.22 % @ 538 °C

**Design P_b = 6.0 %**

**Burn two more samples**

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

**Throw out high and low values and compute \( C_F \)**

\[
\text{Average} = 6.28 \%
\]

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

\[ C_F = 0.28 \% \]

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 $P_b = 5.3 %$

Sample 1  5.37 % @ 538 °C
Sample 2  5.40 % @ 538 °C
### Binder Correction Factor

<table>
<thead>
<tr>
<th>Determine the $C_F$</th>
<th>Design $P_b = 5.5%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>5.78 $%$ @ 538 °C</td>
</tr>
<tr>
<td>Sample 2</td>
<td>5.57 $%$ @ 538 °C</td>
</tr>
<tr>
<td>Sample 3</td>
<td>5.66 $%$ @ 538 °C</td>
</tr>
<tr>
<td>Sample 4</td>
<td>5.80 $%$ @ 538 °C</td>
</tr>
</tbody>
</table>

---

### Binder Correction Factor

<table>
<thead>
<tr>
<th>Determine the $C_F$</th>
<th>Design $P_b = 6.4%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>7.92 $%$ @ 538 °C</td>
</tr>
<tr>
<td>Sample 2</td>
<td>7.96 $%$ @ 538 °C</td>
</tr>
<tr>
<td>Sample 3</td>
<td>7.49 $%$ @ 482 °C</td>
</tr>
<tr>
<td>Sample 4</td>
<td>7.44 $%$ @ 482 °C</td>
</tr>
</tbody>
</table>
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

Ignition Oven Calibration 116

Aggregate Correction Factors

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 %

Ignition Oven Calibration 117
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

<table>
<thead>
<tr>
<th>Sieve Sizes</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>

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>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>41.8</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>
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</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>
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<tr>
<td>1/2&quot;</td>
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<td>-2.0</td>
<td></td>
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<tr>
<td>3/8&quot;</td>
<td>84.1</td>
<td>-1.8</td>
<td></td>
<td></td>
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<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>
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<td>-2.5</td>
<td></td>
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<td># 30</td>
<td>22.2</td>
<td>-2.7</td>
<td></td>
<td></td>
</tr>
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<td># 50</td>
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<td></td>
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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>
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

HMA Applications

Stations

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

Add or Subtract
• Drop “+” sign to easily convert distance to feet
  2579 ft
  - 1735 ft
  844 ft

• Replace “+” sign with a decimal point
  25.79 sta
  - 17.35 sta
  8.44 sta

• Carry units over like normal
  25 + 79
  - 17 + 35
  8 + 44
  (8 x 100) + 44 = 844 ft

HMA Applications
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)

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

\[
Weight (lb) = (tons)(2,000) \quad Area (yd²) = \frac{(length)(width)}{9}
\]

*Length and width measured in feet*

HMA Applications 128

Application Rate

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 129
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

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

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

\[
Weight (tons) = \frac{(Rate)(Area)}{2000} \quad \text{Area (yd}^2) = \frac{(length)(width)}{9}
\]

Rate measured in lb/yd^2 \quad \text{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

Quantity of Asphalt

Find the tons of asphalt needed to pave a 50’ x 300’ parking lot with an application rate of 160 lb/yd².
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 $\approx 6 - 12$ 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>55</td>
</tr>
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<td># 8</td>
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<td>17</td>
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<td># 100</td>
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<td>10</td>
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<tr>
<td># 200</td>
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</tr>
<tr>
<td>Pb</td>
<td>5.53%</td>
<td>4.75%</td>
<td>6.27%</td>
</tr>
</tbody>
</table>

Reducing

Reducing 149

Reducing

Reducing 150
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

- 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.)

1.16 ± 0.02° (internal angle)

30 ± 0.5 gyrations per minute
Mold Diameter Verification

Frequency
- Yearly or 80 hours

Verify inside dimensions
- Three-point Internal Bore Gauge
- Calib. 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 opp. end

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

Gyratory Compaction

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

Preparation

Reduce sample
• $115 \pm 5$ mm height
• $(4400 \text{ g} - 4800 \text{ g})$

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
**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)

Bulk Specific Gravity 169

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)

Bulk Specific Gravity 170
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 171

Calculation

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

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

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

Report \( G_{mb} \) to 0.001
Report \( \% \text{Abs} \) to 0.01 %

Bulk Specific Gravity 172
% Absorption Requirements

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

- If > 2 % absorption, rerun specimen
- AASHTO T 275 (Paraffin Coating)
- 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
(for use when specimens have more than 2 % absorption by AASHTO T 166)
Equipment

Scale
- Readable to 0.1 % of sample mass or better

Suspension Apparatus

Water Bath
- Equipped with an overflow outlet
- Maintain 77 ± 0.9 °F

Drying Apparatus
- Oven – 125 ± 5 °F
- Vacuum

Crock pot or other suitable device for heating paraffin wax

Procedure

Obtain the specific gravity of the paraffin at 77 ± 1.8 °F
- \( \approx 0.915 \)
- \( \frac{W_a}{W_a - (W + S)_{sub} + S_{sub}} \)

Heat paraffin wax to approximately 10 °F above the melting point
- 120 – 150 °F

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)
Procedure

Coat specimen on all sides with melted paraffin
Seal all surface voids
Cool at 77 ± 9 °F for at least 30 minutes

Procedure

Weigh specimen and record coated mass in air (D)
Prepare water bath
• Fill and allow to stabilize
• Tare out suspension apparatus
Immerse coated specimen in water bath
• Leave submerged for 4 ± 1 minute
Record submerged mass (E)
**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*

---

**Vacuum Sealing**

**AASHTO T 331**

*(for use when specimens have more than 2 % absorption by AASHTO T 166)*

---

**Bulk Specific Gravity**

179

180
**Equipment**

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

**Suspension Apparatus**

**Water Bath**
- Equipped with overflow
- Maintain 77 ± 1.8 °F

**Drying Apparatus**
- Oven – 125 ± 5 °F
- Vacuum

**Vacuum Chamber**
- Capable of reaching 5 mmHg in 60 seconds

**Plastic Sealing Bags**
- Thickness of 0.004 – 0.006 inches
- 14.75 – 15.5 in. opening

**Cushioned Sliding Plate**

**Calibration**

**Vacuum Chamber**
- Verify vacuum using vacuum gauge
- Every 3 months
- After repairs
- After relocation

**Vacuum Gauge**
- Range of at least 0 – 10 torr (mmHg)
- Must allow placement inside chamber
Procedure

Obtain bag correction factor (apparent specific gravity of bag)
- Manufacturer

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)

Inspect sealing bag for holes and record mass of bag

Place bag on sliding plate inside vacuum chamber

---

Procedure

Center specimen inside bag and on top of sliding plate
- Place smoothest side of specimen on the bottom

Smooth out wrinkles along the seal bar and obtain about 1 inch of bag overhang
Procedure

Seal specimen by closing and latching the lid
  • Wait until lid opens

Inspect seal, and bag for leaks

Within 60 seconds, submerge the sealed specimen in the water bath
  • Ensure bag is not rubbing on sides of water bath

Bulk Specific Gravity 185

Procedure

Record the submerged mass of the sealed specimen

Remove the sample from the water bath, cut open the bag, and record the weight of sample in air “C”
  • No more than a 0.08% loss or 0.04% gain is acceptable

Bulk Specific Gravity 186
Calculation

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

A = Initial dry mass of specimen
B = Calculated mass of dry sealed specimen
C = Final mass of specimen
E = Submerged mass of sealed specimen
F = Bag correction factor

*Report* \( G_{mb} \) to 0.001

Bulk Specific Gravity

---

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

Add ≈ 77 °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 ± 0.3 kPa
- 27.5 ± 2.5 mm Hg
- 15 ± 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

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

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
- \(325 \pm 25\, ^\circ\) F

Scale
- Readable to at least 0.1 g
- \(\geq 2\)-kg capacity

Thermometer
- Readable to the nearest 4 °F

Procedure

Record empty mass of 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 \(90 \pm 5\) minutes
- Determine net mass of sample
- Continue drying
- Check at \(30 \pm 5\) min. intervals until \(\leq 0.05\%\) change in mass
Procedure

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

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

\( M_p \) – previous measurement
\( M_n \) – newest measurement

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
**Calculation**

Determine the moisture content of the mixture

<table>
<thead>
<tr>
<th>Tare Weight</th>
<th>244.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Wt + Tare</td>
<td>1505.6</td>
</tr>
<tr>
<td>Dry Wt + Tare</td>
<td>1505.1</td>
</tr>
</tbody>
</table>

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

\[
M_i = 1505.6 - 244.0 = 1261.6 \quad M_f = 1505.1 - 244.0 = 1261.1
\]

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

0.04 %

Moisture Content 205

---

**Calculation**

Determine the moisture content of the mixture

<table>
<thead>
<tr>
<th>Tare Weight</th>
<th>356.8</th>
</tr>
</thead>
<tbody>
<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 206
Determination of Asphalt Content of Asphalt Mixtures by the Nuclear Method

ARDOT 449

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 ± 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 Gauge Field Testing

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

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% !
**Calculation**

Determine the reported binder content

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauge Reading (% AC)</td>
<td>6.20 %</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>0.07 %</td>
</tr>
</tbody>
</table>

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

**Reported \% Binder = 6.1 \%**

---

**Calculation**

Determine the reported binder content

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauge Reading (% AC)</td>
<td>5.29 %</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>0.03 %</td>
</tr>
</tbody>
</table>

AC Content
Determining the Asphalt Binder Content by Ignition Method

AASHTO T 308

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
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

Elapsed Time : 57:21
Sample Weight : 1838g
Weight Loss : 116.3g
Percent Loss : 6.32 %
Temp Comp : 0.16 %
Calib. Factor : 0.33 %
Calib. Asphalt Ctnt : 5.83 %
Filter Set Pt : 850°C
Chamber Set Pt : 538°C
**ArDOT Gradation**

Determined from the aggregate blend once the binder has been removed

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

**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

Dry to constant mass.
- Record mass after wash.
  - 0.1%

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

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

Sieve Analysis

Procedure (ARDOT 460)

Determine binder content
  • ARDOT 449

Reduce to an appropriate size

Record sample weight

Cool to ≈ 200 °F

Nominal Maximum Particle Size | Minimum Weight of Test Specimen
--- | ---
1/2" | 12.5 | 1500 g
3/4" | 19 | 2000 g
1" | 25 | 3000 g
1 1/2" | 37.5 | 4000 g
2 1/2" | 62.5 | 4000 g

Sieve Analysis 234
Procedure (ArDOT 460)

Cover sample with solvent, stir and soak

Repeat washing until solvent maintains its original color

Pour solvent over nested # 8 and # 200 sieves

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 %

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

ArkDOT 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

### Rolling Patterns

<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>
<td>1</td>
<td>Vib</td>
<td></td>
<td>140.2</td>
</tr>
<tr>
<td></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>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Static</td>
<td></td>
<td>145.3</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Static</td>
<td></td>
<td>144.7</td>
</tr>
<tr>
<td>Inter</td>
<td>1</td>
<td>Static</td>
<td></td>
<td>147.8</td>
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<tr>
<td></td>
<td>2</td>
<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>

**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
Sampling Asphalt Mixtures after Compaction (Obtaining Cores)

AASHTO R 67

Equipment

Core drilling machine
Diamond-edged core drill bit
Cooling agent
  • Water, ice, 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
% 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!*
Joint Densities

ARDOT Special Provision

ARDOT Specification

Requirements

• 6 inch cores
• Centered over joint
  • Butt Joints
  • Wedge
• Joint cores required for all surface courses
  • Taken only when both sides of the joint were formed
ARDOT Specification

**Final Surface Course**
- Lot - 12,000 linear ft
- Sublot – 3,000 linear ft
  - Excludes shoulder joints
  - 89 % - 96 % of Gmm
  - Use average of Gmm if material comes from two different sublots
- Lots with an average joint density of less than 88 % shall be sealed with PG 64-22

**Intermediate Surface Courses**
- Results will not be used for acceptance or pay
- Information only
- Cut cores on joint adjacent to density core locations

*Locations for final surface joint density cores will not match other density locations!*

---

**Random Numbers**

Sublot 3: Station 60 + 00 to 90 + 00 (3000 ft)

Random Number 0.64

Determine the station location required for testing.

\[(0.64)(3000 \text{ ft}) = 1920 \text{ ft} = 19 + 20 \text{ stations}\]

- 60 + 00
- + 19 + 20
- 79 + 20

79 + 20
In Place Density & % Compaction of ACHM Using a Nuclear Gauge

ArkDOT 461

Troxler 3430

- Keypad

<table>
<thead>
<tr>
<th>ON</th>
<th>YES</th>
<th>MA</th>
<th>PR</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>NO</td>
<td>STD</td>
<td>SPECIAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIME</td>
<td>DEPTH</td>
</tr>
</tbody>
</table>

(READY) 1 min
Depth: BS
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

Standard Check (Ratio Method)

Average last 4 counts

<table>
<thead>
<tr>
<th>Date</th>
<th>Density Standard (DS)</th>
<th>Moisture Standard (MS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 5th</td>
<td>2251</td>
<td>650</td>
</tr>
<tr>
<td>May 6th</td>
<td>2260</td>
<td>642</td>
</tr>
<tr>
<td>May 7th</td>
<td>2258</td>
<td>645</td>
</tr>
<tr>
<td>May 8th</td>
<td>2262</td>
<td>648</td>
</tr>
<tr>
<td>Average</td>
<td>2258</td>
<td>646</td>
</tr>
</tbody>
</table>

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

Determine Pass/Fail

Take new count

New Counts

<table>
<thead>
<tr>
<th>New Counts</th>
<th>Density Standard</th>
<th>Moisture Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>2234</td>
<td>638</td>
<td></td>
</tr>
</tbody>
</table>
**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

**Determine Pass/Fail**

**Average last 4 counts**

<table>
<thead>
<tr>
<th></th>
<th>DS</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 5th</td>
<td>2251</td>
<td>650</td>
</tr>
<tr>
<td>May 6th</td>
<td>2260</td>
<td>642</td>
</tr>
<tr>
<td>May 7th</td>
<td>2258</td>
<td>645</td>
</tr>
<tr>
<td>May 8th</td>
<td>2262</td>
<td>648</td>
</tr>
<tr>
<td>Average</td>
<td>2258</td>
<td>646</td>
</tr>
</tbody>
</table>

**Take new count**

<table>
<thead>
<tr>
<th>New Counts</th>
<th>Density Standard Count</th>
<th>Moisture Standard Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2234</td>
<td>638</td>
<td></td>
</tr>
</tbody>
</table>

**New Counts**

<table>
<thead>
<tr>
<th>New Counts</th>
<th>Density Standard Count</th>
<th>Moisture Standard Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2246</td>
<td>575</td>
<td></td>
</tr>
</tbody>
</table>

**Standard Check**

- **May 10th**
  - 2273 589
- **May 12th**
  - 2260 550
- **May 13th**
  - 2265 565
- **May 15th**
  - 2262 556

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 determine 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 $G_{mb}$

Core Correction Factors (CCF)

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

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

$$Core \ Density = (G_{mb}) \left(62.4 \ \frac{lb}{ft^3}\right)$$
**Core Correction Factor (CCF)**

Find core density

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

- Core \( G_{mb} = 2.301 \)
- Average (4) gauge WD readings
  - WD (1) = 145.6 pcf
  - WD (2) = 148.3 pcf
  - WD (3) = 147.2 pcf
  - WD (4) = 146.6 pcf
- Average = 146.9 pcf

Subtract average gauge WD from core density
- Keep track of sign

\[
CCF = \text{Core Density} - \text{Average WD}
\]
- \( CCF = 143.6 - 146.9 = -3.3 \)

**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>

\[ \text{Avg.} = \frac{5.8}{5} = 1.2 \]

**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

\[
JCF = + 1.2 \text{ pcf}
\]
Calculation (JCF)

Determine the job correction factor.

<table>
<thead>
<tr>
<th>Location</th>
<th>Gauge WD Reading</th>
<th>Core G&lt;sub&gt;mb&lt;/sub&gt;</th>
<th>JCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>143.3</td>
<td>141.5</td>
<td>142.8</td>
</tr>
<tr>
<td>2</td>
<td>140.5</td>
<td>139.8</td>
<td>138.4</td>
</tr>
<tr>
<td>3</td>
<td>141.5</td>
<td>142.8</td>
<td>140.3</td>
</tr>
<tr>
<td>4</td>
<td>139.5</td>
<td>137.2</td>
<td>140.0</td>
</tr>
<tr>
<td>5</td>
<td>138.2</td>
<td>139.3</td>
<td>140.1</td>
</tr>
</tbody>
</table>

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!*

Density JCF

271

Density Field Testing

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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

Density Field Testing

% 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.

\[
\text{Gauge WD} = 138.8 \text{ pcf} \\
\text{JCF} = +2.2 \text{ pcf} \\
G_{mm} = 2.422
\]

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

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

93.3 %

**Density Field Testing**

---

**Calculation (% Compaction)**

Determine the % compaction for the test location.

\[
\text{Gauge WD} = 139.3 \text{ pcf} \\
\text{JCF} = +3.5 \text{ pcf} \\
G_{mm} = 2.465
\]

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

\[
\% \text{ Comp} = \left( \frac{(139.3 + 3.5)}{(2.465 \times 62.4)} \right) \times 100\% = \frac{142.8}{151.1328} \times 100\% = 94.2828\%
\]
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

• 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

Density Field Testing

Report

ARDOT 461 – Section 5.5

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

Density Field Testing
## 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

<table>
<thead>
<tr>
<th>89</th>
<th>90</th>
<th>91</th>
<th>92</th>
<th>93</th>
<th>94</th>
<th>95</th>
<th>96</th>
<th>97</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="https://via.placeholder.com/15" alt="Star" /></td>
<td><img src="https://via.placeholder.com/15" alt="Star" /></td>
<td><img src="https://via.placeholder.com/15" alt="Star" /></td>
<td><img src="https://via.placeholder.com/15" alt="Star" /></td>
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<td><img src="https://via.placeholder.com/15" alt="Star" /></td>
<td><img src="https://via.placeholder.com/15" alt="Star" /></td>
<td><img src="https://via.placeholder.com/15" alt="Star" /></td>
</tr>
</tbody>
</table>

89.6 %

### 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

Density Field Testing

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**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**

**Lot**
- Lot = 3000 tons

**Sublot**
- Sublot = 750 tons

---

**Lot 1**

0   750    1500   2250   3000

---

**S1**  **S2**  **S3**  **S4**
**ArDOT Specifications**

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)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder Content</td>
<td>± 0.3 % (Mix Design)</td>
</tr>
<tr>
<td>Air Voids</td>
<td>3.0 % - 5.0 %</td>
</tr>
<tr>
<td>VMA</td>
<td>37.5 mm 11.0 % - 13.0 %</td>
</tr>
<tr>
<td></td>
<td>25.0 mm 12.0 % - 14.0 %</td>
</tr>
<tr>
<td></td>
<td>12.5 mm 13.5 % - 16.0 %</td>
</tr>
<tr>
<td></td>
<td>9.5 mm 14.5 % - 17.0 %</td>
</tr>
<tr>
<td>Gradation</td>
<td>See ArDOT Section 404.04</td>
</tr>
<tr>
<td>Field Density</td>
<td>92.0 % - 96.0 % or 90.0 % - 96.0 %</td>
</tr>
</tbody>
</table>

## ArDOT Specifications

### Field Compliance (ArDOT Section 404.04)

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

Compliance: 3.9 - 4.5, 3 - 5, 12.0 - 14.0, 92 - 96

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 300