Method of Test for

DETERMINATION OF SPECIFIC GRAVITY AND DENSITY CHARACTERISTICS
OF COMPRESSED ASPHALTIC MIXTURES
DOTD Designation: TR 304-11

I. Scope

A. This method of test is intended to determine the bulk specific gravity (G \text{mb}) and density characteristics of specimens of asphaltic mixtures made with low absorptive aggregates. Density characteristics include theoretical maximum specific gravity (G \text{mm}), % voids, density of mixture, % VMA, % VFA, and pavement density.

B. Reference Documents
   1. DOTD TR 300 – Determination of Bulk Specific Gravity of Aggregate and Mineral Filler for Asphaltic Mixtures.
   3. DOTD TR 327 – Theoretical Maximum Specific Gravity of Asphaltic Concrete Mixtures.
   4. AASHTO T 166 – Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens.

II. Apparatus

A. Balance – having a capacity of 2kg or more and sensitive to 0.1 g.
B. Basket or hanger device – No. 4 mesh basket or other approved, non-corrosive device for holding the specimen.
C. Water Bath – minimum 5-gal plastic or water tight, non-corrosive container filled with water, equipped with an overflow device to maintain a constant water level and capable of maintaining a water temperature of 77±1.8°F (25±1°C).
D. Oven – capable of maintaining a temperature of 125±5°F (52±3°C).
E. Suspension apparatus – a non-absorptive, non-corrosive device suitable for suspending the basket device from center of scale pan (Figure 1).
F. Absorptive material – for drying specimens.
G. Automatic Sample Drying Machine (Optional) – In accordance with ASTM D 7227 Figure 2.
H. Asphaltic Concrete Plant Report – DOTD Form No. 03-22-3085 (Figure 3).
I. Asphaltic Concrete Pavement Report – DOTD Form No. 03-22-3080 (Figure 4).
J. Personal Protective Equipment – thermal gloves, eye protection, apron, tongs and other tools for handling hot materials.

III. Health Precautions

Proper precautions are to be taken whenever hot materials or equipment must be handled. Use container holder or thermal gloves while handling hot containers. Wear eye protection while stirring and weighing heated materials due to possible shattering of particles. Dry contaminated materials under a vent to prevent exposure to fumes.

IV. Sample

The sample shall consist of one or both of the following:

A. Briquettes molded in accordance with DOTD TR 305 or AASHTO TP4.
B. Pavement cores taken in accordance with appropriate requirements.

V. Procedure

A. Clean the specimen by wiping it with absorptive material. Place the specimen in the oven set at 125±5°F
(52±3°C) and dry specimen to a constant mass. After constant mass is obtained, cool the specimen to room temperature at 77±1.8°F (25±1°C). Recently molded laboratory briquettes or specimens that have not been exposed to moisture do not require drying.

**Note 1:** Constant mass is defined as the mass at which further drying at 125±5°F (52±3°C) does not change the mass by more than 0.05 percent in subsequent weighings at two-hour intervals. Recently molded laboratory samples which have not been exposed to moisture do not require drying.

**Note 2:** Vacuum Drying Apparatus in accordance with ASTM D 7227 (such as Core Lock, Figure 2) may be used in place of manual drying method. Follow manufacturer’s procedure. Drying to constant mass for vacuum drying apparatus as defined in ASTM D 7227.

**B. Molded Briquette**

1. Determine the specific gravity of the molded briquette.
   a. Check balance for zero reading prior to weighing.

**Note 3:** Balances should be checked for zero prior to obtaining any weight.

b. Weigh the briquette in air to the nearest 0.1 g. Record on Asphaltic Concrete Plant Report as A.

c. Place briquette in basket device, immerse in water at 77±1.8°F (25±1°C) for 4±1 minutes, weigh to the nearest 0.1 g and record on the Asphaltic Concrete Plant Report as B. When weighing in water, no manipulation of the briquette or container is allowed. (See Figure 1)

d. Remove the specimen from the water. Damp-dry the specimen as quickly as possible by blotting with a damp towel. Immediately weigh the briquette to the nearest 0.1 g and record as the saturated surface dry mass, C.

e. Determine the bulk specific gravity of the briquette in accordance with Step VI.A.1 and record as D on the Asphaltic Concrete Plant Report.

2. Determine the density of the briquette in accordance with Step VI.A.2 and record as E on the Asphaltic Concrete Plant Report.

3. Determine the average theoretical maximum specific gravity, \(G_{\text{mm}}\), of the mixture in accordance with Step VI.A.3 and record as F on the Asphaltic Concrete Plant Report.

4. Determine the percent theoretical maximum specific gravity (%\(G_{\text{mm}}\)) in accordance with Step VI.A.4 and record as G on the Asphaltic Concrete Plant Report.

5. Determine the percent voids (\(V_a\)) in accordance with Step VI.A.5 and record as H on the Asphaltic Concrete Plant Report.

6. Determine the percent voids in mineral aggregate (%VMA) in accordance with Step VI.A.6 and record as J on the Asphaltic Concrete Plant Report.

7. Determine the percent voids filled with asphalt (%VFA) in accordance with Step VI.A.7 and record as K on the Asphaltic Concrete Plant Report.

**C. Pavement Core**

1. Determine the bulk specific gravity of the pavement core.
   a. Check balance for zero reading prior to weighing.

b. Weigh pavement core in air to the nearest 0.1 g and record as A on the Asphaltic Concrete Pavement Report.

c. Place pavement core in basket device, immerse in water at 77±1.8°F (25±1°C) for 4±1
minutes, weigh to the nearest 0.1 g and record as B on the Asphaltic Concrete Pavement Report. When weighing in water, no manipulation of the pavement core or container is allowed.

d. Remove the specimen from the water, damp-dry the specimen as quickly as possible by blotting with a damp towel and determine the surface dry mass as "C."

e. Determine the bulk specific gravity of the pavement core in accordance with Step VI.B.1 and record as P on the Asphaltic Concrete Pavement Report.

2. Record the average theoretical maximum specific gravity, determined in Step V.B.3, as G_{mm} on the Asphaltic Concrete Pavement Report.

3. Determine the % pavement density in accordance with Step VI.B.2 and record as PD on the Asphaltic Concrete Pavement Report.

4. Determine the average % pavement density for the lot in accordance with Step VI.B.3 and record as "Avg. Pavement Density for Lot" on the Asphaltic Concrete Pavement Report.

### VI. Calculations

#### A. Molded Briquette

1. Calculate the bulk specific gravity of the briquette, D, to the nearest 0.001 using the following formula:

\[
D = \frac{A}{C - B}
\]

where:

- \( A \) = wt. of briquette in air, g
- \( B \) = wt. of briquette in water, g
- \( C \) = wt. of SSD briquette

example:

\[
A = 1209.3 \\
B = 704.0 \\
C = 1210.2
\]

\[
D = \frac{1209.3}{1210.2 - 704.0} = \frac{1209.3}{506.2} = 2.38897
\]

2. Calculate the density of the mixture, E, to the nearest 0.1 (lb/ft³) using the following formula:

\[
E = D \times 62.4
\]

where:

- \( D \) = bulk specific gravity of briquette, \( G_{mb} \)
- 62.4 = constant

example:

\[
D = 2.389
\]

\[
E = 2.389 \times 62.4 = 149.074
\]

3. Calculate the average theoretical maximum specific gravity (G_{mm}), F, to the nearest 0.001 using the following formula:

\[
F = \frac{G_{mm1} + G_{mm2}}{2}
\]

where:

- \( G_{mm1} \) = first theoretical maximum specific gravity for the lot (determined in accordance with TR 327)
\( G_{\text{mm2}} = \) second theoretical maximum specific gravity for the lot (determined in accordance with TR 327)

\( 2 = \) constant (equals number of sample sets obtained per lot)

**Example:**

\[ G_{\text{mm1}} = 2.486 \]
\[ G_{\text{mm2}} = 2.494 \]

\[ F = \frac{G_{\text{mm1}} + G_{\text{mm2}}}{2} = \frac{2.486 + 2.494}{2} = 2.490 \]

4. Calculate the percent theoretical maximum specific gravity, \( G \), to the nearest 0.1\% using the following formula:

\[ G = \frac{D}{F} \times 100 \]

where:

\( D = \) bulk specific gravity of briquette, \( G_{\text{mb}} \)

\( F = \) average theoretical maximum specific gravity, \( G_{\text{mm}}, \) of the mixture

\( 100 = \) constant

**Example:**

\[ D = 2.389 \]
\[ F = 2.490 \]

\[ G = \frac{2.389}{2.490} \times 100 = 0.95943 \times 100 = 95.943 \]

\( G = 95.9\% \)

5. Calculate the percent voids (\( V_3 \)), \( H \), to the nearest 0.1\% using the following formula:

\[ H = 100 - G \]

6. Calculate the percent voids in mineral aggregate (\%VMA), \( J \), to the nearest 0.1\% using the following formula:

\[ J = 100 - \left( \frac{D \times P_s}{G_{\text{sb}}} \right) \]

where:

\( D = \) bulk specific gravity of briquette, \( G_{\text{mb}} \)

\( P_s = \) aggregate content, percent by total weight of mixture from JMF

\( G_{\text{sb}} = \) bulk specific gravity of the total aggregate from JMF

\( 100 = \) constant

**Example:**

\[ D = 2.389 \]
\[ P_s = 95.5 \]
\[ G_{\text{sb}} = 2.647 \]

\[ J = 100 - \left( \frac{2.389 \times 95.5}{2.647} \right) = 100 - 86.2 = 13.8\% \]

7. Calculate the percent voids filled with asphalt (\%VFA), \( K \), to the nearest whole percent using the following formula:

\[ K = \left( \frac{J - H}{J} \right) \times 100 \]
where:

\[ H = \text{percent voids} \]
\[ J = \% \text{voids in mineral aggregate} \]
\[ 100 = \text{constant} \]

example:

\[ H = 4.1 \]
\[ J = 13.8 \]
\[ K = \frac{(13.8 - 4.1) \times 100}{13.8} = 0.7029 \times 100 = 70.28 \]
\[ K = 70\% \]

B. Pavement Core

1. Calculate the bulk specific gravity, \( P \), of the pavement core to the nearest 0.001 using the following formula:

\[ P = \frac{A_c}{C_c - B_c} \]

where:

\( A_c = \) wt. of core in air, g
\( B_c = \) wt. of core in water, g
\( C_c = \) wt. of core (SSD), g

example:

\[ A_c = 737.5 \]
\[ B_c = 423.8 \]
\[ C_c = 739.4 \]
\[ P = \frac{737.5}{739.4 - 423.8} \]
\[ = \frac{737.5}{315.6} \]
\[ = 2.33681 \]
\[ P = 2.337 \]

2. Calculate the % pavement density, \( PD \), using the following formula:

\[ PD = \frac{P}{G_{mm}} \times 100 \]

where:

\( P = \) bulk specific gravity of pavement core, \( G_{mb} \)
\( G_{mm} = \) average maximum theoretical specific gravity for the lot
\[ 100 = \text{constant} \]

example:

\( P = 2.337 \)
\( G_{mm} = 2.490 \)
\[ PD = \frac{2.337}{2.490} \times 100 = 0.93855 \times 100 = 93.855 \]
\[ PD = 93.9\% \]

3. Calculate the average % pavement density for the lot, \( \text{Avg PD} \), using the following formula:

\[ \text{Avg PD} = \frac{\sum PD_n}{N} \]

where:

\( PD_n = \) % pavement density of each core for the lot
\( N = \) number of cores for the lot

example:

\( PD_1 = 93.9 \)
\( PD_2 = 93.9 \)
\( PD_3 = 96.0 \)
\( PD_4 = 95.7 \)
\( PD_5 = 93.7 \)
\( N = 5 \)
\[
\text{PD}_n = \frac{93.9 + 93.9 + 96.0 + 95.7 + 93.7}{5}
\]

\[
= \frac{473.2}{5}
\]

\[
= 94.640
\]

\[
\text{PD}_n = 94.6\%
\]

VII. Report

A. Report all bulk specific gravity and maximum theoretical specific gravity results to the nearest 0.001.

B. Report the following results to the nearest 0.1.

1. Percent Maximum Theoretical Specific Gravity
2. Percent Voids
3. Percent Voids in Mineral Aggregate (% VMA)
4. Density of Mixture
5. % Pavement Density

Note 4: Approved forms other than Asphaltic Concrete Plant and Pavement Reports may be used to report density characteristics.

VIII. Normal Test Reporting Time

Normal test reporting time is 2 days.
Figure 1
Molded Briquette Weighed In Water
Figure 2
Automatic Sample Drying Machine
### 2000 Specifications

**PLANT TEST PROPERITIES**

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
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<tbody>
<tr>
<td>Wt (Mass) in Air</td>
<td>320.4 lbs</td>
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<tr>
<td>Wt (Water) in Air</td>
<td>294.8 lbs</td>
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<tr>
<td>Difference</td>
<td>25.6 lbs</td>
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<tr>
<td>SSD Wt (Mass)</td>
<td>294.8 lbs</td>
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<tr>
<td>SSD Wt (Water)</td>
<td>283.0 lbs</td>
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<tr>
<td>Difference</td>
<td>11.8 lbs</td>
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<tr>
<td>Density</td>
<td>16.4 lbs/ft³</td>
</tr>
<tr>
<td>Theor Max Grd of Oil @ 12%</td>
<td>2.96%</td>
</tr>
<tr>
<td>Oil</td>
<td>2.96%</td>
</tr>
<tr>
<td>% Voids in Mix</td>
<td>37.4%</td>
</tr>
<tr>
<td>Voids in Mix</td>
<td>37.4%</td>
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<tr>
<td>% Voids, Vf</td>
<td>26.0%</td>
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<tr>
<td>% VPA</td>
<td>17.3%</td>
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**THEORETICAL MAXIMUM SPECIFIC GRAVITY**

<table>
<thead>
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<th>Value</th>
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<tbody>
<tr>
<td>% AC by Extraction</td>
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**THEORETICAL MAXIMUM SPECIFIC GRAVITY, Green "RICE"**

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<tr>
<td>Wt of Water</td>
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<tr>
<td>Diff</td>
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<tr>
<td>Green 1</td>
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<tr>
<td>Green 2</td>
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<tr>
<td>Green 3</td>
<td>15.2 lbs</td>
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<tr>
<td>Theor. Max. Sp. Gr</td>
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**GRADUATION OF EXTRACTED AGGREGATE**

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<th>Value</th>
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<tbody>
<tr>
<td>Dev</td>
<td>2 in. (50 mm)</td>
</tr>
<tr>
<td>% Coarse Passing</td>
<td>100%</td>
</tr>
<tr>
<td>% Fine Passing</td>
<td>100%</td>
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**AVERAGES**

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<th>Value</th>
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<tbody>
<tr>
<td>% AC</td>
<td>100.0%</td>
</tr>
<tr>
<td>% NA (NAC)</td>
<td>100.0%</td>
</tr>
<tr>
<td>% AC-NA-JMF</td>
<td>100.0%</td>
</tr>
<tr>
<td>% NA</td>
<td>100.0%</td>
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**Figure 3**

Asphaltic Concrete Plant Report