1. **SCOPE**

1.1 **Description of Test**

The method described is used to determine the density of compacted asphalt mix specimens and the subsequent calculation of Marshall void characteristics.

1.2 **Application of Test**

The test and calculations may be used to evaluate the suitability of various asphalt-aggregate blends in the Marshall mix design method. The procedure may also be used for quality control, quality assurance, product acceptance and research testing, on lab prepared specimens and asphalt concrete cores.

1.3 **Units of Measure**

The units of measure are kg/m$^3$ for density and percent for Marshall air voids, Marshall voids in mineral aggregate and voids filled.

2. **APPARATUS AND MATERIALS**

2.1 **Equipment Required**

Scale capable of measuring up to 2 500 kg to an accuracy of 0.1 g and capable of weighing the sample on the scale and suspended in water beneath the scale.

A pail of water maintained at a constant level.

A fine wire mesh basket in which to place the specimen when weighing in water.

Apparatus to connect the wire mesh basket to the bottom of the scale.

Towel.
2.2 **Materials Required**

Marshall Mix Design specimens prepared in accordance with STP 204-8, PREPARATION OF MARSHALL COMPACTION SPECIMENS or asphalt concrete core specimens collected in accordance with STP 204-5, ASPHALT CONCRETE SAMPLES OBTAINED BY CORING.

3. **PROCEDURE**

3.1 **Sample Preparation**

All specimens will be allowed to reach a temperature of 20 to 30°C before conducting the test.

Specimens will be free of foreign materials such as seal coat, tack coat, foundation material, soil, paper or foil.

3.2 **Test Procedure**

3.2.1 For Specimens That Contain Moisture:

(a) Mass of Specimen in Water - immerse the specimen in a water bath at 25°C for 3 to 5 minutes then weigh in water. Designate this mass as C. If the temperature of the specimen differs from the temperature of the water bath by more than 2°C, the specimen shall be immersed in the water bath for 10 to 15 minutes.

(b) Measure the temperature of the water and if different from 25 ± 1°C, a correction to the bulk specific gravity to 25°C must be made in accordance with Section 4.1.

(c) Mass of Saturated Surface-Dry (SSD) Specimen in Air - surface dry the specimen by blotting quickly with a damp towel until all visible films of water are removed from the surface and then immediately weigh in air. Designate this mass as B. Note: Take care to avoid the evaporation of water from the voids in the specimen.

(d) Mass of Oven-Dry Specimen - oven dry the specimen to constant mass at 110°C ± 5°C (15 to 24 hours is usually sufficient). Allow the specimen
to cool to room temperature and weigh immediately in air. Designate this mass as A.

3.2.2 For Thoroughly Dry Specimens:

(a) Mass of Dry Specimen in Air - weigh the specimen after it has been standing in air at room temperature for at least 1 hour. Designate this mass as A.

(b) Mass of Specimen in Water - use the same procedure as described in 3.2.1 (a).

(c) Mass of Saturated Surface-Dry Specimen in Air - surface dry the specimen by blotting quickly with a damp towel and then weigh in air. Designate this mass as B.

4. RESULTS AND CALCULATIONS

4.1 Calculations

The Marshall Density in kilograms per cubic metre will be calculated by the following three steps:

4.1.1 Calculate the bulk specific gravity of the specimen as follows:

Bulk Specific Gravity of Mix = A/(B - C)

Where A = mass of the dry specimen in air, g
(B-C) = mass of the volume of water for the volume of the specimen at 25°C
B = mass of the saturated surface-dry specimen in air, g
C = mass of the specimen in water, g

4.1.2 The bulk specific gravity of the specimen at 25°C can be calculated from bulk specific gravity of the specimen measured at any other temperature as follows:

Bulk Specific Gravity @ 25°C = K x Bulk Specific Gravity Measured At Any Other Temperature.

Where K is determined from Table 1.
4.1.3 Calculate the Marshall Density of the specimen as follows:

Marshall Density = Bulk Specific Gravity x 997.0

Where 997.0 = density of water in kg/m³ @ 25°C (0.9970 g/cm³)

**TABLE 1**
Conversion Factor K for Various Temperatures

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>K Factor</th>
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</thead>
<tbody>
<tr>
<td>10</td>
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<tr>
<td>11</td>
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<td>18</td>
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<td>28</td>
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</tr>
<tr>
<td>29</td>
<td>0.998898</td>
</tr>
<tr>
<td>30</td>
<td>0.998599</td>
</tr>
</tbody>
</table>
The following formulae will be used to calculate air voids, voids in mineral aggregate and percent voids filled:

1. \[ \% \text{ Air Voids} = 100 \left[ 1 - \frac{\text{BSGM}}{\text{T.M.S.G.}} \right] \]

2. \[ \% \text{ Voids in Mineral Aggregate (VMA)} = 100 \left[ 1 - \frac{\text{BSGM}}{\left( 1 + \frac{\text{ASP}}{100} \right) \text{B.S.G.}} \right] \]

3. \[ \% \text{ Voids Filled} = \frac{\text{VMA} - \text{Air Voids}}{\text{VMA}} \times 100 \]

Where:
- M.D. = Marshall density, kg/m³
- T.M.S.G. = Theoretical maximum specific gravity corresponding to asphalt content from Marshall Mix Design (Form MR-71)
- B.S.G. = Bulk specific gravity of aggregate
- ASP = Asphalt content in percent by weight of dry aggregate
- VMA = Voids in mineral aggregate
- BSGM = Bulk Specific Gravity of Compacted Mix

5. References
   - ASTM D2726
   - ASTM D3203