ATT-36/95, VOID CALCULATIONS

1.0 SCOPE

This method describes the procedure for using the voids table and data sheets to determine the percent air voids, the percent voids filled with asphalt and the percent voids in the mineral aggregate of asphalt concrete cored and formed specimens.

2.0 EQUIPMENT

Voids Table (included with Mix Design)
Calculator

Data Sheets: Mix Moisture Content and Marshall Density Data, MAT 6-80, and Core Density, Extraction and Sieve Analysis, MAT 6-79, or ACP Density and Void Contents (MAT 6-40)

3.0 PROCEDURE

3.1 Dry Density and Asphalt Content

1. Determine the dry density of a core or a field formed Marshall specimen as directed in ATT-7, DENSITY, Immersion Method, Saturated Surface Dry Asphalt Concrete Specimens (or ATT-6 for Waxed Specimens).

2. Determine the corrected extraction asphalt content of the sample as directed in ATT-12, Part II, FILTERLESS EXTRACTION AND FILTERLESS CENTRIFUGE METHOD.

   If performing quality control testing, the nuclear asphalt content of the mix sample may replace the extraction asphalt content.

3.2 Void Contents

1. When performing quality assurance testing on ACP End Product Specification Contracts:

   a) For each core, use form MAT 6-79 to calculate the dry density (line "K") and the corrected extraction asphalt content (line "CC"). These two values are used to determine the core % Air Voids.
b) For field formed Marshall specimens, use form MAT 6-80 to calculate the average dry density of the two specimens compacted from the test series fresh mix sample.

Use form MAT 6-78 to calculate the average corrected extraction asphalt content of the cores obtained for that day of production. Record as Lot Average Asphalt Content (columns 34 to 36).

Use the lot average corrected extraction asphalt content and the test series average Marshall density to determine the % Air Voids and % VMA of the average density.

2. When performing quality control on ACP-EPS Contracts:
   a) Use the core dry density and the daily average nuclear or corrected extraction asphalt content to determine the ACP core void contents.
   b) For field formed Marshall specimens, calculate the average dry density of the two specimens compacted from the test series fresh mix sample.

Calculate the nuclear or the corrected extraction asphalt content of the test series fresh mix sample.

Use these values (lines "J" and "N" of form MAT 6-40) to determine the % Air Voids and % VMA of the Average Density.

3.2.1 Use of Voids Table

A table showing dry densities plotted against different asphalt contents is computed for every Mix Design. Upon approval of the Mix Design submitted by the Contractor's Consultant, two sets of void tables are produced, one is given to the Project Manager and the other is to be given to the Senior Materials Technologist.

Prior to using the table, ensure that the MST number, pit name and location are correct.

1. Locate on the tables the specimen's dry density in kg/m$^3$ as shown in Figure 1.

2. Proceed along the dry density line to where it intercepts the sample asphalt content and pick off the % air voids (the top number), the % voids filled with asphalt (the middle number), and the % voids in mineral aggregate (% VMA, the bottom number). Interpolate intermediate values.
FIGURE 1
3. Record the % Air Voids of the quality assurance core in line "N" of form MAT 6-79, as shown in Figure 2 below.

FIGURE 2
Record the void contents of the test series Marshall density on the last two lines of form MAT 6-80, as shown in Figure 3.

Record the void contents of the quality control core on lines "W", "X" and "Y" of data sheet MAT 6-40, as shown in Figure 4, column 1.

### Mix Moisture Content and Marshall Density Data

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Contract No.</th>
<th>Lot Number</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>99:08</td>
<td>6677/95</td>
<td>B</td>
<td>August 17, 1995</td>
</tr>
</tbody>
</table>

#### Mix Moisture Content

<table>
<thead>
<tr>
<th>Time Sample Placed in Oven</th>
<th>07:46</th>
<th>10:05</th>
<th>12:42</th>
<th>15:04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Sample Taken Out of Oven</td>
<td>12:03</td>
<td>14:10</td>
<td>16:55</td>
<td>19:16</td>
</tr>
<tr>
<td>Weight of Moist Sample + Pan</td>
<td>1745.1</td>
<td>1737.5</td>
<td>1670.2</td>
<td>1704.4</td>
</tr>
<tr>
<td>Weight of Dry Sample + Pan</td>
<td>1743.0</td>
<td>1734.9</td>
<td>1667.3</td>
<td>1701.1</td>
</tr>
<tr>
<td>Weight of Water A - B</td>
<td>2.1</td>
<td>2.6</td>
<td>2.9</td>
<td>3.3</td>
</tr>
<tr>
<td>Weight of Pan</td>
<td>646.3</td>
<td>655.1</td>
<td>646.3</td>
<td>655.1</td>
</tr>
<tr>
<td>Weight of Dry Sample B - D</td>
<td>1096.7</td>
<td>1079.8</td>
<td>1021.0</td>
<td>1046.4</td>
</tr>
</tbody>
</table>

F Moisture Content $\frac{100 \cdot C}{E}$

<table>
<thead>
<tr>
<th>%</th>
<th>0.19</th>
<th>0.24</th>
<th>0.28</th>
<th>0.32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot Average</td>
<td>0.26</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Marshall Density

<table>
<thead>
<tr>
<th>Test Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Number</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Original Sample Weight</td>
<td>g</td>
<td>1200.3</td>
<td>1199.8</td>
<td>1201.0</td>
<td>1199.6</td>
</tr>
<tr>
<td>DRY SAMPLE WEIGHT $\frac{100 \cdot C}{100 + F}$</td>
<td>g</td>
<td>1198.0</td>
<td>1197.5</td>
<td>1198.1</td>
<td>1196.7</td>
</tr>
<tr>
<td>Saturated Surface DRY WT.</td>
<td>g</td>
<td>1202.7</td>
<td>1201.9</td>
<td>1203.2</td>
<td>1201.6</td>
</tr>
<tr>
<td>Volume of Sample</td>
<td>cm³</td>
<td>509.4</td>
<td>508.3</td>
<td>510.0</td>
<td>510.5</td>
</tr>
<tr>
<td>Marshall Dry Density $\frac{100 \cdot H}{I}$</td>
<td>kg/m³</td>
<td>2352</td>
<td>2356</td>
<td>2349</td>
<td>2344</td>
</tr>
<tr>
<td>Lot Average</td>
<td>2352</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVERAGE MARSHALL DENSITY</td>
<td>kg/m³</td>
<td>2354</td>
<td>2347</td>
<td>2358</td>
<td>2350</td>
</tr>
<tr>
<td>% Air Void</td>
<td>%</td>
<td>3.8</td>
<td>3.9</td>
<td>3.6</td>
<td>3.9</td>
</tr>
<tr>
<td>% VMA</td>
<td>%</td>
<td>14.8</td>
<td>15.2</td>
<td>14.8</td>
<td>15.0</td>
</tr>
</tbody>
</table>

**Remarks**

Plant started up at 07:30 and shut down at 19:05

Checked by B. Good

**Note:** Transfer shaded areas to Lot Paving Report

**Figure 3**
3.2.2 Use of Data Sheet

If the voids table is not available, use MAT 6-40 data sheet for the void calculations as follows:

1. Transfer the test series average Marshall dry density or the dry density of the EPS core to line "J" of Mat 6-40 form.

2. Record on line "N" the sample asphalt content (as described in Section 3.2).

3. Pick off the Marshall design summary sheet, the Asphalt Relative Density, the Asphalt Ultimate Absorption and the Bulk Relative Density of Aggregate. Record these values in lines "K", "L", and "M" respectively, as shown in column 4 of Figure 4.

4. Determine the weight in kilograms of dry aggregate and asphalt in one cubic metre of mix using the following formulas:
   a) Calculate the Wt. of Dry Aggregate (line "O") in kg as follows:
      
      \[
      \text{Wt. of Dry Aggregate (kg)} = \frac{\text{Wt. of Dry Mix}}{\frac{\%\text{Asphalt Content in }\%}{100}} \times 100
      \]
      
      Therefore, the weight of dry mix in 1 m\(^3\) is the dry density of the mix (kg/m\(^3\)).
   
   b) Determine the Total Wt. of Asphalt (line "P") in kg as follows:
      
      \[
      \text{Wt. of Asphalt (kg)} = \text{Dry Density & Wt. of Dry Aggregate}
      \]
   
   c) Calculate the Wt. of Asphalt Absorbed (line "Q") in kg as follows:
      
      \[
      \text{Wt. of Asphalt Absorbed (kg)} = \frac{\text{Wt. of Dry Aggregate} \times \%\text{Asphalt Ultimate Absorption}}{100}
      \]
   
   d) Determine the Wt. of Effective Asphalt (line "R") in kg as follows:
      
      \[
      \text{Wt. of Effective Asphalt} = \frac{\text{Total Wt. of Asphalt & Wt. of Asphalt Absorbed}}{1000}
      \]

5. Calculate, to 3 decimal places, the volume of dry aggregate, asphalt and air in one cubic metre of mix using the following formulas:
   a) Calculate the Volume of Effective Asphalt (line "S") in m\(^3\) as follows:
      
      \[
      \text{Volume of Effective Asphalt (m}\text{\(^3\))} = \frac{\text{Wt. of Effective Asphalt}}{1000 \times \text{Asphalt Relative Density}}
      \]
b) Calculate the Volume of Aggregate (line “T”) in m³ using the formula:

\[
Wt. \text{ of Dry Aggregate} = \frac{1000 \times \text{Bulk Relative Density of Aggregate}}{\text{Wt of Dry Aggregate}}
\]
c) Calculate the Volume of Voids in the Mineral Aggregate (line "U") in m$^3$ as follows:

\[
\text{Volume of VMA (m}^3\text{)} = \text{Total Volume} \times 100\% - \text{Volume of Aggregate}
\]

Therefore, for 1 m$^3$ of mix: \(\text{Volume of VMA} = 1.000 - \text{Volume of Aggregate}\).

d) Determine the Volume of Air Voids (line "V") in cubic metres as follows:

\[
\text{Volume of VMA} \times \text{Volume of Effective Asphalt}
\]

6. Calculate the void contents of the specimen using the formulas:

a) Determine the % Air Voids (line "W") as follows:

\[
\text{Air Voids (\%)} \times \frac{\text{Volume of Air Voids}}{\text{Total Volume}} \times 100\%
\]

b) Calculate the % Voids Filled with Asphalt (line "X") as follows:

\[
\text{Voids Filled With Asphalt (\%)} \times \frac{\text{Volume of Effective Asphalt}}{\text{Volume of V.M.A.}} \times 100\%
\]

c)

Determine the Voids in the Mineral Aggregate (line "Y") in percent as follows:

\[
\text{VMA (\%)} \times \frac{\text{Volume of VMA}}{\text{Total Volume}} \times 100\%
\]

In this procedure, the Total Volume in steps (a) and (c) above is 1 m$^3$.

4.0 **HINTS AND PRECAUTIONS**

1. Make sure the Voids Table is the correct one. There is one computed for each mix design. Never use a table from another pit or a table for the same pit from an earlier design.

2. At the start of the job, use the data sheet to calculate the % air voids of the first few specimens and compare the data sheet results to the values obtained using the Table. If the difference between the two is greater than 0.1% further review of the design is necessary.

3. Whenever the asphalt cement type or grade changes from the one reported on the mix design, compare the relative densities of the two asphalt cements. If they vary by more than 0.010, new tables are required.

4. When using the data sheet, calculate the volumes shown on lines "S", "T", "U" and "V" to three decimal places.