AGGREGATE BLENDING, ABSORPTION, & SPECIFIC GRAVITY

Topics to be Covered

- Aggregate specific gravities
- Gradations
- Blending stockpiles

Specific Gravity Tests for Aggregates

- Two tests are needed
  - Coarse aggregate (retained on the 4.75 mm sieve)
  - Fine aggregate (passing the 4.75 mm sieve)

Apparent Specific Gravity, $G_{sa}$

\[ G_{sa} = \frac{\text{Mass of Aggregate, oven dry}}{\text{Volume of aggregate}} \]

Bulk Specific Gravity, $G_{sb}$

\[ G_{sb} = \frac{\text{Mass of aggregate, oven dry}}{\text{Vol of agg, + surface voids}} \]

Surface Voids

Vol. of water-perm. voids
**Effective Specific Gravity, \( G_{se} \)**

\[
G_{se} = \frac{\text{Mass, dry}}{\text{Effective Volume}}
\]

- **Volume of water-perm. voids not filled with asphalt**
- **Absorbed asphalt**

Effective volume = volume of solid aggregate particle + volume of surface voids not filled with asphalt

**Water Absorption**

- **Surface Voids**
  - SSD weight - Oven dry weight
  - Oven dry weight

**Coarse Aggregate Specific Gravity**

- **ASTM C127**
  - Dry aggregate
  - Soak in water for 24 hours
  - Decant water
  - Use pre-dampened towel to get SSD condition
  - Determine mass of SSD aggregate in air
  - Determine mass of SSD aggregate in water
  - Dry to constant mass
  - Determine oven dry mass

**Calculations**

- \( G_{ab} = A / (B - C) \)
  - A = mass oven dry
  - B = mass SSD
  - C = mass under water
- \( G_{a,SSD} = B / (B - C) \)
- \( G_{ea} = A / (A - C) \)
- Water absorption capacity, %
  - Absorption % = \([B - A] / A \) * 100
### Coarse Aggregate Specific Gravity

**Calculations - Example Problem**

- **Given:**
  - Mass oven dry - 3625.5 (A)
  - Mass SSD - 3650.3 (B)
  - Mass under Water - 2293.0 (C)

- **Apparent Specific Gravity - \( G_{sa} \)**
  
  \[
  \frac{3625.5}{(3625.5 - 2293.0)} = 2.721
  \]

- **Bulk Specific Gravity - \( G_{sb} \)**
  
  \[
  \frac{3625.5}{(3650.3 - 2293.0)} = 2.671
  \]

- **Absorption, %**
  
  \[
  \frac{(3650.3 - 3625.5)}{2293.0} = 0.68 \%
  \]
**Fine Aggregate Specific Gravity**

**Calculations**

\[ G_{sb} = \frac{A}{(B + S - C)} \]

- \( A \) = mass oven dry
- \( B \) = mass of pycnometer filled with water
- \( C \) = mass pycnometer, SSD aggregate and water
- \( S \) = mass SSD aggregate

\[ G_{sb,SSD} = \frac{S}{(B + S - C)} \]

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

- Water absorption capacity, %
  - Absorption % = \( \frac{[(S - A) / A] \times 100}{100} \)

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**Example Problem**

Given

\( A = \) mass oven dry = 498.9
\( B = \) mass of pycnometer filled with water = 666.5
\( C = \) mass pycnometer, SSD aggregate and water = 982.3
\( S = \) mass SSD aggregate = 500.1

- \( G_{sb} = \frac{498.9}{(666.5 + 500.1 - 982.3)} = 2.707 \)
- \( G_{sb,SSD} = \frac{500.1}{(666.5 + 500.1 - 982.3)} = 2.714 \)
- \( G_{sa} = \frac{498.9}{(666.5 + 498.9 - 982.3)} = 2.726 \)

Water absorption = \( \frac{[(500.1 - 498.9) / 498.9] \times 100}{100} = 0.24 \% \)

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**Aggregate Gradation**

- Distribution of particle sizes expressed as percent of total weight
- Determined by sieve analysis

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**Types Of Gradations**

- **Open graded**
  - Few points of contact
  - Stone on Stone contact
  - High permeability
- **Well graded**
  - Good interlock
  - Low permeability
- **Gap graded**
  - Lacks intermediate sizes
  - Good interlock
  - Low permeability
Superpave Aggregate Gradation

Percent Passing vs. Design Aggregate Structure

- Restricted zone
- Control points
- Nominal maximum size
- Maximum size

Sieve Size (mm) Raised to 0.45 Power

Superpave Mix Size Designations

<table>
<thead>
<tr>
<th>Superpave Designation</th>
<th>Nom Max Size (mm)</th>
<th>Max Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0 mm</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>12.5</td>
<td>19</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>9.5</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Blending of Aggregates

- **Reasons for blending**
  - Obtain desirable gradation
  - Single natural or quarried material not enough
  - Economical to combine natural and process materials

Definitions

- **Nominal Maximum Aggregate Size**
  - One size larger than the first sieve to retain more than 10%

- **Maximum Aggregate Size**
  - One size larger than nominal maximum size

Superpave Mix Size Designations

Blending of Aggregates

- **Numerical method**
  - Trial and error
  - Basic formula
Blending of Aggregates

\[ P = Aa + Bb + Cc + ... \]

- Where:
  - \( P \) = % of material passing a given sieve for the blended aggregates
  - \( A, B, C, ... \) = % material passing a given sieve for each aggregate
  - \( a, b, c, ... \) = Proportions (decimal fractions) of aggregates to be used in blend

<table>
<thead>
<tr>
<th>Material</th>
<th>Aggregate No. 1</th>
<th>Aggregate No. 2</th>
<th>Blend</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Used</td>
<td>% Passing</td>
<td>% Batch</td>
<td>% Passing</td>
<td>% Batch</td>
</tr>
<tr>
<td>3/8</td>
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<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td>No. 4</td>
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<td>100</td>
<td>80 to 100</td>
<td>100</td>
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<td>No. 8</td>
<td>30</td>
<td>100</td>
<td>65 to 100</td>
<td>100</td>
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<td>88</td>
<td>40 to 80</td>
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<td>No. 30</td>
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<td>10 to 65</td>
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<td>7 to 40</td>
<td>100</td>
</tr>
<tr>
<td>No. 100</td>
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<td>3 to 20</td>
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<tr>
<td>No. 200</td>
<td>0</td>
<td>10</td>
<td>2 to 10</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ P_{no.4} = (0.50 \times 90) + (0.50 \times 100) = 95.0 \]

Combined Specific Gravity

\[ G_{sb} = \frac{P_A + P_B + P_C}{G_A + \frac{P_B}{G_B} + \frac{P_C}{G_C}} \]

- Where: \( P_A, P_B, \) and \( P_C \) = percent by mass of each aggregate in blend
- \( G_A, G_B, \) and \( G_C \) = Bulk Specific Gravity of each aggregate

Example Problem

\[ G_{sb} = \frac{(P_A + P_B + P_C)}{G_A + \frac{P_B}{G_B} + \frac{P_C}{G_C}} \]

- \( P_A, P_B, \) and \( P_C \) = percent by mass of each aggregate in blend
- \( G_A, G_B, \) and \( G_C \) = Bulk Specific Gravity of each aggregate

Questions ?

- Example Problem -

\[ G_{sb} = \frac{(P_A + P_B + P_C)}{G_A + \frac{P_B}{G_B} + \frac{P_C}{G_C}} \]

Based on the information given:

- \( P_A = 50% \)
- \( G_A = 2.695 \)
- \( P_B = 25% \)
- \( G_B = 2.711 \)
- \( P_C = 25% \)
- \( G_C = 2.721 \)

\[ G_{sb} = \frac{(50 + 25 + 25)}{2.695 + \frac{25}{2.711} + \frac{25}{2.721}} = 2.765 \]

Keeping roads good with asphalt paving materials

http://www.cp2info.org/canter