Asphalt Concrete Mix Design
Hot Mix Asphalt Concrete (HMA) Mix Designs

• Objective:
  – Develop an economical blend of aggregates and asphalt that meet design requirements

• Historical mix design methods
  – Marshall
  – Hveem

• New
  – Superpave gyratory
Mix Design Objectives

• Sufficient asphalt to ensure a durable pavement
• Sufficient stability under traffic loads
• Sufficient air voids
  – Upper limit to prevent excessive environmental damage
  – Lower limit to allow room for initial densification due to traffic
• Sufficient workability
MARSHALL MIX DESIGN

Specimen size 102 x 64 mm
Marshall Mix Design

• Developed by Bruce Marshall for the Mississippi Highway Department in the late 1930’s
  • No. of blows,
  • Decided on 10 lb.. Hammer, 50 blows/side
  • 4% voids after traffic
• Initial criteria were established and upgraded for increased tire pressures and loads
Marshall Mix Design

- Select and test aggregate
- Select and test asphalt cement
  - Establish mixing and compaction temperatures
- Develop trial blends
  - Heat and mix asphalt cement and aggregates
  - Compact specimen (102 mm diameter)

bit. = 4%
bit. = 4.5%
bit. = 5%
bit. = 5.5%
bit. = 6%

(Just an example)
Mixing / Compaction Temps

Viscosity, Pa s

Temperature, C

Compaction Range

Mixing Range
## Marshall Design Criteria

<table>
<thead>
<tr>
<th></th>
<th>Light Traffic ESAL $&lt; 10^4$</th>
<th>Medium Traffic $10^4 &lt; ESAL&lt; 10$</th>
<th>Heavy Traffic ESAL $&gt; 10^6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compaction</td>
<td>35</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Stability N (lb.)</td>
<td>3336 (750)</td>
<td>5338 (1200)</td>
<td>8006 (1800)</td>
</tr>
<tr>
<td>Flow, 0.25 mm (0.1 in)</td>
<td>8 to 18</td>
<td>8 to 16</td>
<td>8 to 14</td>
</tr>
<tr>
<td>Air Voids, %</td>
<td>3 to 5</td>
<td>3 to 5</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Voids in Mineral Agg. (VMA)</td>
<td></td>
<td></td>
<td>Varies with aggregate size</td>
</tr>
</tbody>
</table>

These criteria can slightly vary between various regions.
Minimum VMA Requirements
Marshall Mix Design Tests

- Heights of samples
  - Used to correct stability measurements
- Bulk specific gravity of compacted sample
- Maximum specific gravity of loose mix
- Stability and flow
  - 60°C water bath (30 to 40 minutes)
  - 50 mm/min loading rate
  - Max. load = uncorrected stability
  - Corresponding vertical deformation = flow
Marshall Design Use of Data
Asphalt Institute Procedure

Air Voids, %

Stability

Unit Wt.

Asphalt Content, %

Asphalt Content, %

Asphalt Content, %

Target optimum asphalt content = average
Use target optimum asphalt content to check if these criteria are met.
Marshall Design Use of Data
NAPA Procedure

Air Voids, %

Asphalt Content, %

Target optimum asphalt content = the asphalt content at 4% air voids
The target stability is checked
Use target optimum asphalt content to check if these criteria are met.
Marshall Design Method

• **Advantages**
  – Attention on voids, strength, durability
  – Inexpensive equipment.
  – Easy to use in process control/acceptance.

• **Disadvantages**
  – Impact method of compaction
  – Does not consider shear strength
  – Load perpendicular to compaction axis