Hot Mix Asphalt Design
Marshall and Hveem

**Objective:**
- Develop an economical blend of aggregates and asphalt binders that meet design requirements
- Traditional mix design methods
  - Marshall
  - Hveem
- New
  - Superpave gyratory

**Requirements in Common**
- Sufficient asphalt binder 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**
- Developed by Bruce Marshall for the Mississippi Highway Department in the late 30's
- WES began to study it in 1943 for WWII
  - Evaluated compaction effort
    - No. of blows, foot design, etc.
    - Decided on 10 lb. hammer, 50 blows/side
    - 4% voids after traffic
- Initial criteria were established and upgraded for increased tire pressures and loads

**Automatic Marshall Hammer**
Marshall Mix Design

- Select and test aggregate
- Select and test asphalt binder
- Establish mixing and compaction temperatures
- Develop trial blends
- Heat and mix asphalt binder and aggregates
- Compact specimen (100 mm diameter)

Marshall Design Criteria

<table>
<thead>
<tr>
<th>Light Traffic</th>
<th>Medium Traffic</th>
<th>Heavy Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compaction</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>Stability N (lb.)</td>
<td>3336 (750)</td>
<td>5338 (1200)</td>
</tr>
<tr>
<td>Flow, 0.25 mm (0.1 in)</td>
<td>8 to 18</td>
<td>8 to 16</td>
</tr>
<tr>
<td>Air Voids, %</td>
<td>3 to 5</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Voids in Mineral Agg. (VMA)</td>
<td>Varies with aggregate size</td>
<td></td>
</tr>
</tbody>
</table>

Minimum VMA

- Acceptable VMA
- Deficient VMA
- Marginal VMA

Marshall Mix Design Tests

- Heights
  - 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
Target optimum asphalt binder content = average

Use target optimum asphalt binder content to check if these criteria are met

Target optimum asphalt binder content = the asphalt content at 4% air voids

The target stability is checked

Use target optimum asphalt binder 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
Hveem Mix Design Method

• Francis Hveem developed for California DOT in mid 1920's
• Limited use
  • Primarily in West coast states
• Addresses similar design considerations as Marshall
• Considers asphalt binder absorption by aggregate

Hveem Mix Design Method

• Selection and testing of aggregates
• Selection and testing of asphalt binders
• Centrifuge kerosene equivalent (CKE)
  • Surface capacity of aggregate
  • Estimate optimum asphalt binder content

Hveem Kneading Compactor

Hveem Stabilometer
Hveem Mix Design Method

Stability
Minimum

Air Voids, 
%

Asphalt Binder
Content, %

VMA
Minimum

Heavy traffic = 37 stability min.
Medium = 35 min.
Light = 30 min.

Asphalt Binder
Content, %

Step 1
Design Series

Step 2
Flushing

Step 3
Min. Stability

Step 4
Max. AC with 4% Voids

QUESTIONS?

Hveem Mix Design

- Advantages
  - Attention to voids, strength, durability
  - Kneading compaction similar to field
  - Strength parameter direct indication of internal friction component of shear strength

- Disadvantages
  - Equipment expensive and not easily portable
  - Not wide range in stability measurements