Compaction of Tender HMA Mixtures

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Topics

- Definitions, causes of tender mixes
- Avoiding tender mixes
- Dealing with tender mixes in the field
Compaction is the process of mechanically reducing the volume of a mass of material.
Requirements for Compaction

• Workability
• Confinement
• Compactive effort

• Without all of these, a material can’t be compacted effectively
Factors affecting HMA Compaction

**Workability**
- Temperature
- Mixture volumetrics
  - VMA, $P_{be}$
- Mixture type/grading
  - Coarse, fine, large, small, gap-graded, open-graded
- Aggregate properties

**Confinement**
- Stability of underlying structure
- Friction/drag at the interface
- Internal friction
Compaction Equipment

• Screed unit
  – Weight of screed
  – External force applied to screed
  – Vibratory unit
    • 35 Hz (2100 VPM)

• Rollers
  – Vibratory steel-wheeled
  – Rubber-tired
  – Static steel-wheeled
What are “Tender Mixes?”

• Mixtures that are unstable during compaction
  – Excessive lateral and/or forward movement
  – Waves in the mat
  – Checking or cracking after roller passes

• This can occur at different stages of compaction
“Old” Tender Mixes

• Unstable over a wide range of temperatures
• Susceptible to deformation under traffic loading (scuffing, shoving, rutting)
• Most often seen in parking lots, light-duty paving

• Primary Cause: weak/unstable aggregate structure, usually due excessive rounded (uncrushed) particles-especially natural sand
Sand hump

![Graph showing sand hump][1]

[1]: Note: The graph shows the relationship between percent passing and sieve size raised to the 0.45 power. The red arrow indicates a point of interest on the graph. For more information, visit [asphaltinstitute.org](http://www.asphaltinstitute.org).
“New” Tender Mixes

• Can happen to mixes designed for high traffic
  – Particularly coarse-graded mixtures

• Usually occurs at an intermediate temperature (roughly between 260 and 200 F) after breakdown rolling

• Not readily apparent during mix design or production QC testing
Potential Mechanisms of Tender Mixes

- Sensitive gradation
  - VMA very sensitive to changes in asphalt binder content
  - Mixture is unstable after initial compaction until asphalt binder stiffens and shrinks
- Moisture remaining in mix
  - Contributes to lubrication
  - Emulsified into asphalt binder
- Slippage
VMA-Illustrated

Figure 3.01 Voids in the Mineral Aggregate (VMA) in a Compacted Mix Specimen

Note: For simplification, the volume of absorbed asphalt is not shown.
Design Aggregate Structure

Sieve Size, mm, raised to 0.45 power

Percent Passing

SMA

Fine graded

Coarse graded

We’re driven. www.asphaltinstitute.org
Bailey Definition: VMA vs. CA Volume

Avoid these areas if possible:

- High VMA or Voids
- Low Volume of CA

Biggest problem area:

- Fine
- Coarse
- SMA
Mix VMA Requirements
Voids in the Mineral Aggregate

<table>
<thead>
<tr>
<th>Nom Max Size, mm</th>
<th>Minimum VMA, %</th>
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<tr>
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<td>12.0</td>
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<tr>
<td>37.5</td>
<td>11.0</td>
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</tbody>
</table>

- VMA set on NMS, not on mixture surface area
- Some gradations/materials can have VMA that is very sensitive to changes in $P_{be}$

![Diagram showing VMA vs. % binder](chart.png)
Voids in the Mineral Aggregate

VMA criterion

Mix design

Effect of retained moisture

As produced

% binder
Significance

• Remember that VMA is calculated from test results measured at 77F ($G_{mb}$, $G_{mm}$)

• After breakdown rolling, the mixture is at much higher temperature
  – Asphalt binder occupies more than 7% more volume at 275F than at 77F!

• Sensitive mixtures after breakdown rolling can be effectively saturated and unstable, particularly if there is any moisture remaining
Correcting the Mixture

- Examine using Bailey parameters, stay within defined mixture types
- Use a sharp, angular, acid insoluble fine aggregate
- Evaluate the drying operations at the plant, including the drum flighting system
- Minimize moisture content of aggregates
What can be done in the field?

• If the mat is unstable-GET OFF OF IT!!!
  – Keep steel-wheeled rollers off until the mix has regained stability through cooling
  – Rubber-tire rollers using relatively low tire pressures can normally be used

• Check the surface condition, make sure that it is clean, properly tacked, and that the tack has broken and set (if emulsion)
  – Consider using a stiffer tack coat material
Other Possible Approaches

• Operate tandem vibratory rollers (strongly prefer to use the same make and size!) in echelon until tenderness is apparent

• Consider using rubber-tire as breakdown
  – Does not compact as efficiently as vibratory—could be advantageous under these conditions
  – More manipulation at bottom of mat for relatively thin lifts, possibly improving contact and friction at interface
  – Vibratory as intermediate—may not require separate finish rollers
Pneumatic Tire Manipulation

- Overlap manipulates mat under and between tire
- Tight finish resists moisture penetration
- Manipulation increased by lowering tire pressure
- Static force increased by high tire pressure
Reference: www.trb.org/news/