Impact of Asphalt Mixture Design and Construction on Density and Durability of Asphalt Pavements

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- Coastal Bridge
Durable Pavement

- Title 23 Code of Federal Regulations
  - Part 626.3 Policy.
- “Pavement shall be designed to accommodate current and predicted traffic needs in a safe, **durable**, and cost effective manner.”
Durable

... able to exist for a long time without significant deterioration in quality or value.”
## Approaches to Achieve Durable Pavement

### Mixture Design
- BMD concept
- Additives
- Engineered Materials
- ...

### Construction
- Increased Density
- WMA
- I.C.
- Tack Coat
- Long. Joints
- Thermal Segregation
- ...

Asphalt Mixture Design

• Volumetrics
  – Voids in the Total Mix, $V_{TM}$
  – Voids in the Mineral Aggregate, $V_{MA}$
  – Voids Filled with Asphalt, $V_{FA}$

• Densification
  – Stages during lab compaction process
Asphalt Mixture Design: Concern

- Optimum asphalt binder content
  - Quantity
  - NOT QUALITY
  - Aged Binders
    - Replace virgin binder
    - RAP and/or RAS

Reduce Durability

VOLUME

Total Volume

asphalt

aggregate

Mass

Total Mass

air
**Durable Pavement -- Louisiana BMD**

- **Volumetric and Performance Mixture Testing**
  - Rutting (**AASHTO T 324**): LWT test (50°C, Wet)
  - Cracking (**ASTM 8044**): SCB test (25°C)
Durable Pavement -- Construction

- **Tack Coat Best Practices**
  - Select and apply *proper tack coat material type, rate, full coverage and performance testing*
Durable Pavement -- Construction

- Tack Coat Best Practices
  - Select and apply proper tack coat material type, rate, full coverage and performance testing

sections with ISS > 40 psi were associated with sections that have lower number of cracks
Durable Pavement -- Construction

- Longitudinal Joint Best Practices
  - Specification and construction
Durable Pavement -- Construction

- Thermal Segregation
  - Specification and construction
Durable Pavement – Construction
Semi-Circular Bend Test Results, 25°C

- Reduced thermal segregation increases density
- Improve SCB Jc

[Bar chart showing average Jc values for different temperatures and VTM values: VTM=6% and VTM=9%]
Durable Pavement -- Construction

- **In-place density**
  - Influence pavement performance

- **Pavement are constructed to a specified In-place density**
  - achieved by means of roller compaction
  - % of mixture maximum specific gravity (%Gmm)
  - Typical target
  - 92% - 93% of Gmm, 8% - 7% VTM

- **Significant advancement**
  - Improve pavement density

https://www.forconstructionpros.com
Durable Pavement -- Construction

- 1% increase in field density (1% less air voids) is reported to increase asphalt pavement service-life 10+% 
- Improve pavement performance by 5 to 25% 
  - annual savings of $1.75 to $8.75 billion 
- Cost 
  - Increase in-places density vs. operation, maintenance, and road user cost 
- Increase in-place density targets 
  - enhanced mixture durability 
  - Increase pavement service life 

Aschenbrener, T., ETG Presentation, April 27, 2016
Durable Pavement – Construction
Density vs. fatigue life

Average Reduction in Fatigue Life for 1% increase in Air Voids

Aschenbrener, T., ETG Presentation, April 27, 2016
Durable Pavement – Construction

Density vs. Rutting

Average Increase in Rut Depth for 1% increase in Air Voids

- AL 2010: 22.7%
- WT rc: 10.9%
- WT f/f+c: 7.3%
- WT rc: 66.3%
- WT oc: 9.6%
- WT f/f+: 11.5%

Aschenbrener, T., ETG Presentation, April 27, 2016
Durable Pavement -- Construction

Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Aschenbrener, T., ETG Presentation, September 13, 2017
Effect of Increased Asphalt Pavement Density on Its Durability

Objective

- Evaluate effects of increasing initial in-place density of asphalt pavements on their potential field performance
  - Identify methodology for achieving increased in-place density of asphalt pavements with minimal additional costs and without damaging the aggregate structure,
  - Construct a demonstration pavement section that includes a control section (meeting the current minimum density requirement) and a test section (having an average of 1.5% increased in-place density),
  - Evaluate volumetric properties of laboratory and field asphalt samples, and
  - Evaluate laboratory performance characteristics of laboratory and field asphalt samples
Effect of Increased Asphalt Pavement Density on Its Durability

Scope

- Overlay rehabilitation project
- US Route 190 in Livingston Parish, Louisiana

- State Project No. H.009549
  - Route: US 190, Walker, LA
  - Total Project Length: 5.69 miles

- Design Life: 3.9 million ESALs for 20 years
- Overlays placed: 2” Level-2 BC and 2” Level-2 WC
Effect of Increased Asphalt Pavement Density on Its Durability

Scope

- Three test sections
  - Each is ~ 4000 ft
- Control section
- Two sections with increased in-place density
  - WMA chemical additive (Evotherm) on binder and wearing course layers
  - Increase asphalt binder content
    » 0.2%
- Each test section
  - Wearing and Binder course layers
Effect of Increased Asphalt Pavement Density on Its Durability

Scope

• Density
• High temperature Performance
  • Loaded Wheel Tracking Test
    • AASHTO T-324
  • Rutting
• Intermediate temperature Performance
  • Semi Circular Bend Test
  • Cracking
  • ASTM D8044
• Dynamic Modulus Test
  • IDT mode
Effect of Increased Asphalt Pavement Density on Its Durability

Scope

- Three test sections
  - Each is ~ 4000 ft
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Effect of Increased Asphalt Pavement Density on Its Durability

Test Sections

- Evotherm WMA: Evotherm WMA additive BC and WC
- Plus-AC HMA: 0.2% Increased asphalt content BC and WC
- Control HMA: Conventional Superpave asphalt BC and WC
Effect of Increased Asphalt Pavement Density on Its Durability

Construction Timeline

- Evotherm WMA BC
- Evotherm WMA WC
- Plus-AC HMA BC
- Plus-AC HMA WC
- Control HMA BC
- Control HMA WC
## Effect of Increased Asphalt Pavement Density on Its Durability

### Asphalt Mixture Design

<table>
<thead>
<tr>
<th>Mixtures</th>
<th>Control HMA</th>
<th>Evotherm WMA</th>
<th>Plus AC HMA</th>
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<tbody>
<tr>
<td></td>
<td>BC</td>
<td>WC</td>
<td>BC</td>
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<tr>
<td><strong>Design Volumetrics</strong></td>
<td></td>
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<tr>
<td>%Design AC</td>
<td>4.8</td>
<td>5.0</td>
<td>4.9</td>
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<tr>
<td>VMA</td>
<td>14.3</td>
<td>14.6</td>
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<tr>
<td>VFA</td>
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<tr>
<td>VTM</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>%RAP</td>
<td>23.8</td>
<td>19.1</td>
<td>23.8</td>
</tr>
<tr>
<td>%WMA Add.</td>
<td>0.0</td>
<td>0.0</td>
<td>0.7</td>
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</tbody>
</table>
Effect of Increased Asphalt Pavement Density on Its Durability
Night Paving
Field Density – QA Cores

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th>Control</th>
<th>Evotherm</th>
<th>Plus AC</th>
<th>Control</th>
<th>Evotherm</th>
<th>Plus AC</th>
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</thead>
<tbody>
<tr>
<td>%Gmm Binder Course</td>
<td>96.1</td>
<td>96</td>
<td>95.1</td>
<td>94.7</td>
<td>95.5</td>
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<tr>
<td>%Gmm Wearing Course</td>
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<td></td>
<td>95.5</td>
</tr>
</tbody>
</table>
Semi-Circular Bend Test Results, 25°C

ASTM D8044

BC: 23.8% RAP
WC: 19.1% RAP

STA: Plant produced mixture
LTA: 5 days, 85°C
Semi-Circular Bend Test Results, 25°C

**ASTM D8044**

**Mixture Type**
- **Binder Course**
- **Wearing Course**

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**Mixtures**
- **STA:** Plant produced mixture
- **LTA:** 5 days, 85°C

**BC:** 23.8% RAP  **WC:** 19.1% RAP
Summary

- Test sections were successfully constructed
  - Ascertain effect of increased density on pavement performance

- Preliminary results
  - ~ 1% decrease in VTM
  - Achieved 95.5 %Gmm
    » WMA Evotherm Additive in WC

- Mixture with increased %AC showed higher laboratory cracking resistance as compared to control mixture
  - SCB Jc