TXDOT HIGH PERFORMANCE THIN OVERLAYS

Western Association of State Highways and Transportation Officials (WASHTO) – Materials and Construction Subcommittee
San Antonio, Texas
March 23, 2015
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Genesis of Thin Overlays

- Problem: Deficient performance life from conventional PM overlays
- Standard District Overlay Default: 2” D-GR TY C
  - Can’t afford premature failures and high long-term maintenance costs with limited future funding
- Re-examined our standard non-structural overlay practices for pavement preservation purposes
Genesis of Thin Overlays

- **Dense Graded Overlay Issues:**
  - Issues with raveling and failures due to segregation and low AC
  - Fatigue & Top Down Cracking
    - Due to premature aging and/or low AC

- **HMA/Base Modulus Ratios > 10:1**
  - Overly stiff mixtures due to recycled asphalt materials
  - Building in fatigue cracking to our pavement structures (16 to 20:1)
Genesis of Thin Overlays

- Goal: Develop a new strategy for PM overlays in the Austin District

  - Objective #1: Equal or better performance than current standard pavement preservation practices
    - Resist to rutting and cracking
    - Restore and improve ride
    - Restore and improve skid resistance

  - Objective #2: Less susceptible to premature distress
    - Less susceptible to segregation & premature aging

  - Objective #3: More cost-effective
    - Need to maximize every dollar
    - Cannot afford short service life
Genesis of Thin Overlays

- Austin District Thin Overlay Pilot Program (2007):
  - Locally available high quality aggregate with finer gradations
  - 70% Grade 5 Sandstone
  - 30% Screenings
  - PG 76-22
  - 1” Thin Overlay Mixture

Not everything is bigger in Texas
Genesis of Thin Overlays

- **First Mix Design:**
  - Density = 97.5%
  - AC = 6.7%
  - Hamburg = 20,000 passes @ 5.3 mm rut depth
  - Indirect Tensile = 123 psi.
  - Overlay Test = 453 cycles
Genesis of Thin Overlays – Test Section #1 (Ramming Plant)

- **Pavement Condition**
  - Severely fatigue and block cracked
  - Multiple failures
  - Crack widths $\leq 3/4”$

- **Construction: May 2007**
  - No repair to failures or fatigue areas
  - Heavy emulsion tack coat
  - Overlay directly on existing pavement
Genesis of Thin Overlays

- Truck Loading (May 2007 to August 2011)
  - Practically 100% Heavy Trucks (Haul trucks & Transports)
  - >4.5 million total tonnage (material and trucks) shipped in and out since overlay
  - No distress to date
Genesis of Thin Overlays – Test Section #2 (IH35 Frontage Rd.)

- ADT = 44,000
- High distressed
- Skid Number = mid 40’s
- Improved Ride – 35% improvement
- Five years until first crack seal
- Added Bonus: Quiet Ride Properties
  - Avg. = 94-98 dBA
  - PFC ~ 98 dBA
Genesis of Thin Overlays

- Evaluated Thin Overlay Pilot Program:
  - Objective #1: Equal or better performance than current standard pavement preservation practices
    - Improved Ride Quality (25-35% Improvement)
    - High Skid Resistance (mid 40s to mid 50s)
    - Noise Reduction (~98 dBA)
  - Objective #2: Less susceptible to premature distress
    - High AC; High Quality Aggregate
    - Balance Design
  - Objective #3: More cost effective: YES!!!
    - TOMs = $5.50 per SY
    - TY C = $7.20 per SY

- Full Implementation in FY 2008
Genesis of Thin Overlays

- Austin District:
  - 77 TOM projects
  - 413,000 tons or 1066 lane miles

- 10 Other Districts:
  - 25 projects
  - 177,000 tons or 476 lane miles
Austin District Guidelines on the Use of TOMs

- Pavement Selection Considerations
- Mix Design & Material Properties
- Keys to Successful Construction
Where can I use Thin Overlay Mixtures (TOMs)?

Answer: Thin overlays should be used on pavements:

- **Structurally sound** – Pavements needing extensive rehabilitation or requiring structural improvement should be avoided.
  - FPS 21 pavement design analysis predicts an overlay of 2” or less

- **Pavement Preservation** – Only requiring restoration of the surface wearing course properties, such as skid resistance, elimination of surface distresses, improve ride quality, reduce noise.
Pavement Selection Consideration for TOMs

- Pavement Evaluation – Need to do your homework!
- Network Level Structural Evaluation
  - Ground Penetrating Radar (GPR): Determine existing pavement thickness, including HMA and base course thickness
Pavement Selection Consideration for TOMs

- Pavement Evaluation – Need to do your homework!
- Network Level Structural Evaluation
  - Falling Weight Deflectometer (FWD): Pavement response to determine overall pavement capacity and subgrade support
Pavement Selection Consideration for TOMs

- Structural Condition Index (SCI)
- SCI is the ratio of existing structural capacity and required structural capacity for 20 year ESAL

\[
\text{SCI} = \frac{SN_{\text{eff}}}{SN_{\text{req}}}
\]

- \(SN_{\text{eff}} = f(\text{total thickness, FWD deflections})\)
- \(SN_{\text{req}} = f(20\text{-year ESALs, subgrade Mr})\)

- Thin Overlay option for SCI > 70
- Spot repair and Level-up for SCI = 70 – 80
Pavement Selection Consideration for TOMs

Average_SCI_Score
- Need MRhb
- Need LRhb
- Need PM
- Do Nothing
Pavement Selection Consideration for TOMs

Pavement Overlay Design Process
- Perform Overlay Design in FPS 21
- Use pavement section from GPR data
- Use subgrade support data from FWD data

TOMs okay if FPS 21 pavement design analysis predicts an overlay of 2” or less
Mix Design & Material Properties

- **Material Properties**
  - High Quality Aggregates
  - Polymer Modified Asphalt
    - PG 70-22 or 76-22
    - Typical Target AC TOM-C = 6.2 – 6.8%
    - Typical Target AC TOM-F = 6.8 – 7.4%
  - No Recycled Asphalt = No RAP or RAS
## Aggregate Quality Requirements

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coarse Aggregate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAC</td>
<td>Tex-499-A (AQMP)</td>
<td>A&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Deleterious material, %, Max</td>
<td>Tex-217-F, Part I</td>
<td>1.5</td>
</tr>
<tr>
<td>Decantation, %, Max</td>
<td>Tex-217-F, Part II</td>
<td>1.5</td>
</tr>
<tr>
<td>Micro-Deval abrasion, %</td>
<td>Tex-461-A</td>
<td>Note&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Los Angeles abrasion, %, Max</td>
<td>Tex-410-A</td>
<td>30</td>
</tr>
<tr>
<td>Magnesium sulfate soundness, 5 cycles, %, Max</td>
<td>Tex-411-A</td>
<td>20</td>
</tr>
<tr>
<td>Crushed face count&lt;sup&gt;3&lt;/sup&gt;, %, Min</td>
<td>Tex 460-A, Part I</td>
<td>95</td>
</tr>
<tr>
<td>Flat and elongated particles @ 5:1, %, Max</td>
<td>Tex-280-F</td>
<td>10</td>
</tr>
<tr>
<td><strong>Fine Aggregate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear shrinkage, %, Max</td>
<td>Tex-107-E</td>
<td>3</td>
</tr>
<tr>
<td><strong>Combined Aggregate</strong>&lt;sup&gt;4&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand equivalent, %, Min</td>
<td>Tex-203-F</td>
<td>45</td>
</tr>
</tbody>
</table>

1. Surface aggregate classification of “A” is required unless otherwise shown on plans.
2. Used to estimate the magnesium sulfate soundness loss in accordance with Section 347.2.1.1.2., “Micro-Deval Abrasion.”
3. Only applies to crushed gravel.
4. Aggregates, without mineral filler, or additives, combined as used in the job-mix formula (JMF).
### Master Gradation Limits (% Passing by Weight or Volume) and Volumetric Requirements

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Coarse (TOM – C)</th>
<th>Fine (TOM-F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 in.</td>
<td>100.0¹</td>
<td>100.0¹</td>
</tr>
<tr>
<td>3/8 in.</td>
<td>95.0 – 100.0</td>
<td>98.0 – 100.0</td>
</tr>
<tr>
<td>#4</td>
<td>40.0 – 60.0</td>
<td>70.0 – 95.0</td>
</tr>
<tr>
<td>#8</td>
<td>17.0 – 27.0</td>
<td>40.0 – 65.0</td>
</tr>
<tr>
<td>#16</td>
<td>5.0 – 27.0</td>
<td>20.0 – 45.0</td>
</tr>
<tr>
<td>#30</td>
<td>5.0 – 27.0</td>
<td>10.0 – 35.0</td>
</tr>
<tr>
<td>#50</td>
<td>5.0 – 27.0</td>
<td>10.0 – 20.0</td>
</tr>
<tr>
<td>#200</td>
<td>5.0 – 9.0</td>
<td>2.0 – 12.0</td>
</tr>
</tbody>
</table>

**Asphalt Binder Content², % Min**

<table>
<thead>
<tr>
<th></th>
<th>Coarse (TOM – C)</th>
<th>Fine (TOM-F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>6.0</td>
<td>6.5</td>
</tr>
</tbody>
</table>

**Design VMA³, % Min**

<table>
<thead>
<tr>
<th></th>
<th>Coarse (TOM – C)</th>
<th>Fine (TOM-F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>16.0</td>
<td>16.5</td>
</tr>
</tbody>
</table>

**Production (Plant-Produced) VMA³, % Min**

<table>
<thead>
<tr>
<th></th>
<th>Coarse (TOM – C)</th>
<th>Fine (TOM-F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>15.5</td>
<td>16.0</td>
</tr>
</tbody>
</table>

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1. Defined as maximum sieve size. No tolerance allowed.
2. Unless otherwise shown on the plans or approved by the Engineer.
## Mix Design & Material Properties

### Laboratory Mixture Design Properties

<table>
<thead>
<tr>
<th>Mixture Property</th>
<th>Test Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target laboratory-molded density, % (TGC)</td>
<td>Tex 207 F</td>
<td>97.5¹</td>
</tr>
<tr>
<td>Design gyrations (Ndesign for SGC)</td>
<td>Tex-241-F</td>
<td>50²</td>
</tr>
<tr>
<td>Hamburg Wheel test, passes at 12.5 mm rut depth for PG 70 mixtures</td>
<td>Tex-242-F</td>
<td>15,000 Min</td>
</tr>
<tr>
<td>Hamburg Wheel test, passes at 12.5 mm rut depth for PG 76 mixtures</td>
<td>Tex-242-F</td>
<td>20,000 Min</td>
</tr>
<tr>
<td>Tensile strength (dry), psi.</td>
<td>Tex-226-F</td>
<td>85-200</td>
</tr>
<tr>
<td>Overlay test, number of cycles</td>
<td>Tex-248-F</td>
<td>300 Min</td>
</tr>
<tr>
<td>Drain-down, %</td>
<td>Tex-235-F</td>
<td>0.20 Max</td>
</tr>
</tbody>
</table>

¹ The percentage of molded density is critical for ensuring the durability and performance of the mixture in various traffic conditions.

² The number of design gyrations is indicative of the mixture's resistance to repeated loads, which is crucial for structural integrity.

³ The Hamburg Wheel test results are essential for assessing the mixture's resistance to permanent deformation, ensuring it can perform well under heavy traffic.

⁴ Tensile strength is a measure of the mixture's ability to resist tearing and cracking, which is vital for its structural integrity.

⁵ Overlay tests provide insights into the mixture's performance under real-world conditions, ensuring it can withstand repeated loading without failure.

⁶ Drain-down values indicate the mixture's ability to retain its shape and integrity over time, crucial for long-term performance.

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![Laboratory Mixture Design Properties](image-url)
Balance Mix Design – Performance – Based

- Design material based on performance needs
- Low to Moderate ESALs with thin structure (i.e.: RM 32)
- High ESALs with significant structure (i.e.: IH-35)

Graph showing:
- 'Rut Depth (mm)' and 'Overlay (PassesX100)'

For High ESALs with significant structure:
- 6.5% AC Content
- Rut Depth (mm) = 6
- Overlay (PassesX100) = 10

For Low to Moderate ESALs with thin structure:
- 6.5% AC Content
- Rut Depth (mm) = 7
- Overlay (PassesX100) = 11
Keys to Successful Construction

- Preparation
  - Spot Repair: Isolated failures
  - Level-Up: Areas with greater than 120 in/mile
  - Milling: Recommend micromilling for smaller peak to valley
Keys to Successful Construction

- **BONDING IS CRITICAL**
- Bonding/Sealing Courses
  - Non-tracking Tack Coats
  - Spray Paver Underseal Membranes
  - Seal Coat Underseals
  - New Non-tracking Hot-Applied Asphalt
- Performance-based bonding course specification
Keys to Successful Construction

- Placement – Temperature
  - 1” Thin overlay cools twice the rate of a 1.5” mat

Figure 5. Severe Thermal Segregation in First Profile from CMHB-F.
Keys to Successful Construction

- **Placement Best Practices**
  - Use a shuttle buggy to maintain temperature
  - Use insulated truck and trapped
  - Place when ambient temp. 70° F or greater
    - WMA required 60 – 70° F ambient temp. but produce greater than 300° F. Compaction aid.
    - WMA additive also required for haul distances ≥ 40 miles.
  - IR-bar highly recommended
  - Tandem dual rollers close to the paver
  - No pneumatics
Acceptance Testing

- Too thin to measure in-place air voids accurately
- Require TxDOT water flow test (Tex-246-F) to ensure adequate density and impermeability.
  - Water flow should be greater than 120 seconds.
- Thermal segregation profile or use of the Pave-IR is critical to identify segregation which may lead to low density, permeability, and water infiltration
Long-Term Performance - TOMs

- “How are they performing?”
- Objectives from PM Overlays
  - **Safety**: Restore surface friction and resistance to skid in wet weather
  - **Durability**: Eliminate and prevent long-term surface distress (rutting/cracking)
  - **User Satisfaction** – improve ride quality and noise reduction
  - **Longevity**: Service life of 8 – 10 years with the least amount of routine maintenance as possible (crack seal, patching, strip seals, etc...)
Long-Term Performance - TOMs

- Long-term Skid Resistance Performance
  - Open-graded surface = Good Macro-texture = Good Skid Resistance
Long-Term Performance - TOMs

Long-Term Skid Resistance Performance (2008-2014)

Years in Service

- TOM_ALL
- PFC
- SMA
- D-GR TYC
Long-Term Performance - TOMs

Long-Term Distress Performance (2008-2014)

Avg. Distress Score vs. Years in Service

- Year 2: 99.2
- Year 3: 96.6
- Year 4: 95.8
- Year 5: 94.8
- Year 6: 91.0

~80.3% +/- 6
Noise Reduction – RM 12 OBSI Study

- Overall Level (dBA)

<table>
<thead>
<tr>
<th>Site</th>
<th>Before TOM (2/14/2012)</th>
<th>After TOM (9/10/2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A</td>
<td>109.6</td>
<td>96.0</td>
</tr>
<tr>
<td>Site B</td>
<td>109.3</td>
<td>96.4</td>
</tr>
<tr>
<td>Site C</td>
<td>109.3</td>
<td>97.8</td>
</tr>
<tr>
<td>Site D</td>
<td>109.1</td>
<td>95.9</td>
</tr>
<tr>
<td>Site E</td>
<td>109.0</td>
<td>95.6</td>
</tr>
<tr>
<td>Site F</td>
<td>109.2</td>
<td>96.0</td>
</tr>
<tr>
<td>AVG</td>
<td>109.3</td>
<td>96.3</td>
</tr>
</tbody>
</table>

Long-Term Performance - TOMs
Long-Term Performance - TOMs

- Objectives from PM Overlays:
  - **Safety**: High, sustainable surface friction over time
  - **Durability**: Distress scores over 90% over the last six years on average
  - **User Satisfaction** –
    - IRI improvement of at least 25% and up to 40% from pre-existing IRI
    - Well documented noise reduction
Long-Term Performance - TOMs

- Objectives from PM Overlays
  - **Longevity**: On average, a service life of 8 – 10 years could be projected with minimal routine maintenance
  - Initial Cost (12 month avg. low bid unit price):
    - 1” TOM = $6.80/SY
    - 1.5” D-GR TY D = $6.74/SY
    - 2” D-GR TY C = $7.92/SY
  - Austin District Cost Savings ~ $17 million
  - Statewide Annual Cost Savings ~ $9 million
- Life Cycle Cost Analysis (LCCA) – On-Going Analysis
  - Time to first crack seal for D-GR HMA with Recycled Asphalt = ~18-24 months
  - Time to first routine maintenance for TOM = ~4-5 years
Issues

High rate of oxidations of modified asphalts
  – REOBs/PPA
  – Over-stiffening leading to premature cracking and raveling

Aggregate supply
  – Industry recalibrating crushing fractions

Debonding issues
  – Non-tracking tack coats picking up during construction
  – Not allowing to set or spilling hot mix on the tack coat

Use in wrong applications
New Mixtures & Applications

- New Thinlay Mixtures

1” PFC-F

1” TOM-C

½ - ¾” Ultra-Thin (TOM-F)

OPEN GRADED (24% ) W

GAP

DENSE
New Mixtures & Applications

Districts Using TOM Mixes
New Mixtures & Applications

Districts with Ultra-Thin Sections
New Mixtures & Applications

- Ultra-Thin Overlays (Item 347 TOM-F)
- ¾” to ½” thickness
- When road is not a good candidate for seal coat
  - Good pavement condition
  - Lowest cost application
  - Turning movements
  - Improve skid resistance
  - Crack resistant level up layer

Thickness ½ inch to 5/8 inch

Hamilton Pool Road
Austin District
July 22nd 2013
New Mixtures & Applications

- ½ Ultra Thin (TOM-F) on Bleeding Seal Coats
- US 84 (Brownwood District) – First UT mix let outside of Austin
New Mixtures & Applications

- New Application: 1” PFC-F on Bleeding Seal Coats
- Loop 338 (Odessa District) – wet weather accidents

Water Flow = 9 seconds
New Mixtures & Applications

- New Application: TOM/CAM on CRCP
- US 59/IH 69
- ADT = 375,000 vpd @ 10% Truck
- Major freeway for Downtown Houston
New Mixtures & Applications

- All samples > 1000 cycles in OT

Rut depths after 20,000 wheel passes

3.8mm  2.7mm  2.8mm  2.6mm
New Mixtures & Applications

- US 59/ IH 69 (Houston District) – High Profile
QUESTIONS