NCAT INNOVATIONS AND TECHNOLOGY

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Past Implementable Findings

- Materials – aggregates, polymers, additives
- Mixes – gradations, gyrations, balanced designs
- Structures – E, M-E, CR mix, rehabilitation
- Construction – WMA, increased density, tack
- Preservation – objective life cycle selection
2018 Track Research Focus

- Interlayers to reduce reflective cracking
- Performance optimized mixes (construction focus)
- Single pass full depth rapid reconstruction
- Thinlays and “ultra thinlays” for preservation
- Validation of laboratory cracking tests

Design, QC
REFLECTIVE CRACKING PREVENTION
GDOT Traditional Approach

• Traditional approach
  ▶ Single surface treatment (#7 stone)
  ▶ Not satisfactory
Treatments in 2012 Cycle

- N12: Double surface treatment with sand seal
- N13: Open-graded interlayer (OGI)
Treatments in 2018 Cycle

• **N12 Section**
  - GlasGrid
  - PETROMAT paving fabrics
  - Chip seal with 7# stone

• **N13 Section**
  - Chip seal with RAP
  - Rubber modified asphalt mix (3/4”)
  - Open-graded interlayer (OGI) (3/4”)
Research Objective

- Evaluate the long-term performance of different reflective cracking treatments
- Determine the most cost-effective approach to mitigate reflective cracking
Saw Cuts to Simulate Cracks

- Mill to 2.2 inch depth
- Deep cuts 1/8 inch wide
- Longitudinal cuts at 3 foot spacing
- Transverse cuts at 15 foot spacing
- Filled with sand to prevent healing
Saw Cut Pattern
Geosynthetic Interlayers
Chip Seals
Leveling Mix
OGI and Rubber Mix Interlayer
Overlay

9.5 mm NMAS Mix
Research Plan

- Determine percent of saw cut area with reflective cracks
- Measure rut depth on a routine basis
- Conduct cost-benefit analysis
Cracking

Percent of Saw Cut Area with Reflective Cracks

Equivalent Single Axle Loadings (ESALs) in Millions

- N12 Reflected Saw Cut
- N13 Reflected Saw Cut

OGI
Surf. Trmt.
Rutting

Rut Depth (mm) vs. Equivalent Single Axle Loadings (ESALs)

N12, Rut (mm) and N13 Rut (mm)
After 20 Million ESALs

- 50.5% of saw cuts have reflected through the OGI (N13) compared to only 6% in the Double Surface Treatment with a Sand Seal (N12)
- Cracking in both sections is low severity
- Additional dense-graded layer thickness in N12 may have affected performance
- N13 has less rutting than N12 (3 mm vs 7.8 mm)
THIN OVERLAYS FOR PAVEMENT PRESERVATION
Pavement Preservation (PG) Group Study

- Study life-extending and condition improving benefits of treatments under different conditions
  - Traffic
  - Climate
  - Initial condition
Thin overlay test sections

- ¾” thick overlay
  - Dense graded (virgin, RAP, RAS, ABR, HiMA)
  - UTBWC
  - OGFC (different tacks)

- Cold recycle (CIR, CCPR) + 1” thick overlay
Untreated sections

![Graph showing percentage of cracking vs age for untreated sections, with categories for good, fair, and poor conditions.]
50% RAP

5% RAS
11% RAP + 3% RAS
OGFC Thin Overlays
Cold Recycling + Thin Overlays
Cold climate performance
Preliminary findings

• Thin overlays effective in extending pavement life
• Performance strongly dependent on initial condition
THICK LIFT ASPHALT PAVING
Background – Thick Lift Paving

- Asphalt pavements typically built in series of lifts
  - Usually <3” thick
  - Tack between layers
  - Different mixes in each layer
  - Long work zones with traffic riding on intermediate layers and potential uneven lanes

- Due to traffic demands and work zone scheduling, SCDOT has been moving toward single, thick lift paving (5+ inches)
Thick Lift Paving Advantages

- Shorter work zones
  - Both time and distance
- No lift interfaces
  - Prevents interface shear failure
- No uneven lanes
- Open new pavement to traffic almost immediately
- Can be accomplished on any schedule
  - Off peak
- SCDOT aiming for greater depths (7+ inches)
Key Questions

• Cooling
  ➤ How long will it take thick mat to cool before opening it to traffic?

• Compaction
  ➤ Can density be achieved throughout pavement depth?

• Structural Response
  ➤ How does a thick lift pavement carry traffic relative to conventional multi-lift pavements?

• Performance
  ➤ How does a thick lift pavement perform relative to conventional multi-lift pavements?
Construction
Construction
Embedded Temp Probe During Paving
Temperature Monitoring
In Situ Cooling Curves

**8/22/2018 3:02 PM**
**Tair = 86F**

**8/23/2018 6:01 PM**
**Tair = 79F**

**8/24/2018 10:28 AM**
**Tair = 86F**
MultiCool Simulations
Measured vs Predicted Cooling Curves

8/22/2018 3:02 PM
Tair = 86F

8/23/2018 6:01 PM
Tair = 79F

8/24/2018 10:28 AM
Tair = 86F
Surface vs In Situ Monitoring

8/22/2018 3:02 PM
Tair = 86°F

8/23/2018 6:01 PM
Tair = 79°F

8/24/2018 10:28 AM
Tair = 86°F
Findings from Construction

- Time of day has strong influence on cooling rate
- MultiCool is most accurate over short durations & when ambient conditions are less variable
  - MultiCool needs some improvements
- Cooling may be significantly longer than measured at surface
  - Recommend simple thermocouple probe inserted at mid-depth to monitor in real-time
- Adequate in-place density was achieved
  - 95% $G_{mm}$
- Precision grinding needed to achieve acceptable IRI
Future Testing

- Falling Weight Deflectometer
- Strain and Pressure Measurements
- Performance
  - Ride, Rutting, Cracking
CRACKING RESEARCH
Cracking Group (CG) Experiment
MnROAD Test Sections
Asphalt Mixtures

<table>
<thead>
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<th>CELL NO</th>
<th>BINDER GRADE</th>
<th>ABR %</th>
<th>RAS</th>
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<td>30-40</td>
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<td>17</td>
<td>64S-22</td>
<td>20-30</td>
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<td>64S-22</td>
<td>15-25</td>
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<tr>
<td>23</td>
<td>64E-34²</td>
<td>10-20</td>
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</tbody>
</table>

All mixes are 12.5 mm NMAS
All mixes are $N_{\text{des}} = 80$ and target air voids = 4.0% except cell 19 which has $N_{\text{des}} = 100$ and target air voids = 3.0%

¹ Cell 22 limestone aggregate in mix
² Highly modified asphalt binder
Cracking Modes and Testing

- Types of cracking investigated
  - Low temperature
  - Top-down likely
  - Fatigue also possible

- PMLC testing
  - Low temp: DCT-MN and IDT Creep or SCB-MN
  - Intermediate temp: IFIT, OT, BBF
  - E*, TSR, Hamburg, loose mix, cores

- Sampling for other research studies
DCT Results

DCT Fracture Energy Results

Fracture Energy, J/m²

Test Section

16 17 18 19 20 21 22 23

LMLC Ave  PMLC Ave

National Center for Asphalt Technology
at Auburn University

54
Field Measurements
Field Measurements

Pictures taken from shoulder
- New cracking distress will be mapped and tabulated during next traffic closure
Test for QC/QA

• IDEAL-CT
  • Conducted on gyratory specimens compacted to a target height and air void level
  • Temperature conditioning for 2 hrs @ 25°C
  • Test with IDT load frame using monotonic load 50 mm/min
Indirect Tension Testing (TSR)

- Peak Load
- Fracture Energy
- Crack Rate

Index = Energy / Rate
Construction Quality Testing

Bennert 2018

![Construction Quality Testing Diagram](image)

- **Overlay Tester (cycles)**
- **APA Rutting (mm)**

- Test Data
- Test Data Trendline
- Proposed Pass/Fail

- NCHRP 9-33 HT-IDT Criteria
- Test Data Trendline
- Proposed Pass/Fail

- $R^2 = 0.89$
- $R^2 = 0.80$
Performance Optimized Construction Quality Testing & Mix Design Approval
Implementation takeaways

- Interlayers effective in preventing reflective cracking
- Thin overlays extend pavement life
- Thick lift paving is possible
- Quest for practical cracking test
- Simple unaged tests for construction quality (3 hrs)
THANKS!

Any questions?
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