DCT Testing for Bituminous Mixture Fracture Resistance

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Outline

• Introduction and background of fracture energy performance testing
• MnDOT previous efforts
  • Pooled-fund projects
  • 2013 implementation pilots
• Current work
• Future
• Summary
Why Performance Testing on Asphalt Mixtures?

• Thermal cracking is a major distress on MN pavement

• Binder specs are important...
  • But do not completely define actual mixture behavior

• Mixture performance testing provides specific information of material on roadway

• Needed to account for modifications
PG Binders and Cracking

• PG low temperature of -34C is common
  • Performance has been very good for the most part
• However, thermal cracking after 1-2 years with some -34C mixes has been observed
  • Not all PGLT -34 binders are equal
• Mixture $G_f$ relates to temperature performance
  • More discriminating than binder PG
What is the DCT?

- DCT=Disc-shaped Compact Tension test
- Low-temperature performance test for asphalt mixtures
- Pooled-Fund Studies recommended DCT for low-temperature fracture resistance
Disc-Shaped Compact Tension Test

- ASTM D7313-13
- Has existed for some time
- U of Illinois applied to HMA
- Test is run at low temperature
  - PGLT + 10C
  - LTPPBind PG Temp at 98% Rel. +10C
- Loading Rate based on CMOD
  - 0.0170 mm/sec
- Data acquisition
  - CMOD, Load

CMOD = Crack mouth opening displacement
Disc-Shaped Compact Tension Test

- Measures the fracture energy \( (G_f) \) of the mixture at specific temperature

\[ G_f = \frac{\text{Fracture Work}}{\text{Fracture Area}} \]

Fracture Area = Thickness * Length (initial ligament length)

\( G_f \) units: \( \text{J/m}^2 \)
Pooled Fund Projects – Findings 2004-2012

- Two separate projects
- Binder tests alone are insufficient
  - Critical need for an asphalt mixture specification
- Current specifications for LTC for both asphalt binders and mixtures are based on static creep tests and do not include a fracture test.
- Strongly recommended that selection of fracture resistant binders and mixtures be based on simple-to-perform true fracture tests.
Why was the DCT selected?

- Covered by ASTM procedure
- Follows procedure used for other materials (metals)
- CV of 10% observed for many of the tests
- Good correlation with field performance
Results from LTC Pooled-Fund Study
LTC Performance Specifications

- Based on traffic levels
- Limits based on:
  - Fracture energy tests @ +10C above 98% reliability Superpave low temperature PG (PGLT)
  - Low temperature cracking performance model (IlliTC)

<table>
<thead>
<tr>
<th>Project Criticality / Traffic Level</th>
<th>High (&gt;30M ESALs)</th>
<th>Medium (10-30M ESALs)</th>
<th>Low (&lt;10 M ESALs)</th>
</tr>
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<tbody>
<tr>
<td>Minimum DCT $G_f$</td>
<td>690</td>
<td>460</td>
<td>400</td>
</tr>
<tr>
<td>IlliTC Cracking Prediction (m/km)</td>
<td>&lt; 4</td>
<td>&lt; 64</td>
<td>Not required</td>
</tr>
</tbody>
</table>
DCT Pilot Project (2013)

• Develop and implement:
  • Decision system for non-compliant material
• Test procedure
  • Research → Production
• Equipment
• Training
Mix design pills submitted to UMD by contractor for DCT testing.

Minimum fracture energy of 400 J/m² met?

- **YES**: Production mix tested with DCT.
  - Test section paved with adjusted mix.
  - Mixture adjustments recommended, such as:
    - Increase binder content
    - Use harder, crushed quarry rock, etc.
    - Reduce RAP or RAS content

- **NO**: Mixture adjustments recommended.
  - Does production mix meet 400 J/m² requirement?
  - Did mixture adjustments improve fracture energy?
  - Did fracture energy change from mix design to production?
Possible Mixture Adjustments
Included in Special Provision

- Binder grade
  - Reduce low PG (-34 vs -28)
- Add or change polymer, modification
- Aggregate Gradation
  - Finer gradation
  - Increase binder content
- Aggregate source & crushing
  - Granite/taconite instead of limestone
  - Reduce RAP/RAS content
Projects

• 5 projects

• Variety of climates, binders, construction
  • D2 – TH 310, FDR + Overlay, 58-34
  • D3 – TH 371, Reconstruct, 64-34
  • Metro – TH 10, M & O, 64-28
  • D6 – TH 56, SFDR + Overlay, 58-34
  • D6 – TH 69, M & O, 58-28
Three mixes failed to meet min $G_f$ of 400 J/m$^2$ at mix design

Remaining two mixes did meet the min $G_f$

- Traffic level 4 designs (more crushed agg.)
- Polymer modified

A significant decrease in energy from mix design to standard production mix was observed

- Topic of current investigation
TH 56 – SPWEA340C, tested @ -24C
Note production decrease relative to mix design;
Adjustment made: 0.1% additional binder.
TH 310 – SPWEB340C, tested @ -30C
Note low value in first mix design;
Adjustment made: eliminate 20% RAP, stockpile feeds adjusted.
TH 10 – SPWEB440E, tested @ -24C
No adjustment made;
Note drop in fracture energy at mix production.
TH 69 – SPWEA440F, tested @ -24°C
No mix design data;
Adjustment made: reduce RAP from 30% to 20%, stockpile feeds adjusted.

![Graph showing Fracture Energy (J/m²) for various TH samples.](#)
TH 371 – SPWEB340B, tested @ -18C
No adjustment required;
Note drop in fracture energy at mix production;
Summary and Conclusions

- Mix designs must use same materials that will be used in production (esp. binder)
- Only two projects passed at mix design
  - Level 4 designs
  - Investigate further effects of higher percent crushing aggregate may create higher aggregate interlock, causing better cracking resistance.
- Significant drop in fracture energy from mix design to production was observed
  - Reasons outside of scope for this study, but are the subject of current work
Current Work

• “Round Robin” inter-laboratory repeatability study
  • Samples collected this fall, with testing to start this winter
• Participating labs include Braun, AET, UMD, and MnDOT
Current Work

- Study analyzing source of drop in fracture energy from mix design to production and placement
- Samples collected from 8 projects throughout the state
National Pavement Preservation

• **Partnerships**
  – MnROAD (North) / NCAT (South) Test Tracks
    • Offsite Low and High Volume Road Installations
    • Concrete and Asphalt Pavements
    • Includes Past/Current MnROAD Cells
  – FP² / National Center for Pavement Preservation
  – Government / Academia / Industry involvement

• **Getting Involved**
  – National Webinar Held – January 8th
  – March 2015 NCAT Planning Meeting
    • Direct input into the study
  – Pooled Fund posted jointly with NCAT
    • [http://www.pooledfund.org/Details/Study/496](http://www.pooledfund.org/Details/Study/496)
    • 2015 will use same study # (120K / year for 3-years)
Questions?

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