MICROCRACKING FOR CEMENT TREATED BASE - BRYAN

Darlene C. Goehl, P.E.

88th Annual Transportation Short Course
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Background Information

- TxDOT Research Project 0-4182(TTI),
  - Researcher, Tom Scullion
  - Looked at problems associated with Full Depth Recycling Projects,
    - Project Longitudinal Cracking on sections constructed on highly plastic soils
    - Bonding problems with fly ash treated bases
    - Excessive shrinkage cracking on cement stabilized bases
      - Reported on several sections, except in Bryan District
  - Question – Why no shrinkage cracking on Bryan District Projects?
Example Shrinkage Cracks
Research Project 0-4502

- TTI performed the research
- Researchers
  - Tom Scullion and Stephen Sebesta

- Purpose of project:
  - Evaluating the effectiveness of the microcracking concept.
    - When to stop rolling?
    - Is the slab cracked?
    - Is structure damaged?
Test Sites

- SH 47
- IH 45 Frontage Roads
- Riverside Campus Test Site
Test Site – SH 47

- Constructed Spring 2002
  - 14” CTB
  - 4” HMA
  - 5 sections,
  - all microcracked after 1 to 3 days cure
  - Minimal transverse cracking
Test Site – SH 47

- 12 ton vibratory roller
- 1 – 2 days after placement
- 2-3 mph
- High amplitude
- 2 – 4 passes
- Test after 2 passes
Test Site – IH 45 frontage Roads

- Outside Lanes constructed December 2004 (includes 200’ control)
  - TTI performed lab mix design (4% cement based on strength and moisture susceptibility)
  - TTI helped administer and monitor microcracking on outside lanes in December
- Inside Lanes constructed May 2005
- Structure:
  - 10” LTS
  - 14” CTB
  - 5” HMA
- During construction in December, noted longer than 3 days needed for CTB curing before initiation of microcracking
- Too early to evaluate long term performance (at time of Research) Still looks good with no shrinkage cracks observed in 2014.
Test Site – IH 45 frontage Roads

- Survey August 2005
  - No cracking; FWD SB OL-Backcalculation values very high

Microcracked after 4 Days Curing

200’ Control (not Microcracked)
Test Site - Riverside

- Constructed September 2003
- Sites with both 4 and 8% cement
- Treatments include:
  - Dry cure
  - Prime cure
  - Microcrack at 1, 2, and 3 days cure
  - Wet cured for 3 days
Test Site - Riverside

- Crack maps

Riverside Microcracking Test Facility

(0° to 350°)

- 4% Cement
  - Crack existing morning after placement
  - Crack appearing after treatment

- 8% Cement
  - Crack existing morning after placement
  - Crack appearing after treatment

Reference TxDOT Research 0-4502, Researcher, Tom Scullion w/ TTI
Test Site - Riverside

Crack Lengths with 4% Cement

<table>
<thead>
<tr>
<th></th>
<th>Cracking after Treatment</th>
<th>Total Cracking</th>
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<tbody>
<tr>
<td>Dry Cure</td>
<td></td>
<td>410</td>
</tr>
<tr>
<td>Prime Cure</td>
<td>310</td>
<td>300</td>
</tr>
<tr>
<td>Crack 1 Day</td>
<td>210</td>
<td>200</td>
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<tr>
<td>Crack 2 Day</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Crack 3 Day</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Moist Cure</td>
<td>350</td>
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</table>
Test Site - Riverside

Crack Lengths with 8% Cement

<table>
<thead>
<tr>
<th></th>
<th>Dry Cure</th>
<th>Prime Cure</th>
<th>Crack 1 Day</th>
<th>Crack 2 Day</th>
<th>Crack 3 Day</th>
<th>Moist Cure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack Length (ft) per 100 ft Road</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Cracking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cracking after Treatment</td>
<td></td>
<td></td>
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</table>

Reference TxDOT Research 0-4502, Researcher, Tom Scullion w/ TTI
Test Site - Riverside

Total Cracking of Riverside Test Sites

<table>
<thead>
<tr>
<th></th>
<th>Dry Cure</th>
<th>Prime Cure</th>
<th>Crack 1 Day</th>
<th>Crack 2 Day</th>
<th>Crack 3 Day</th>
<th>Moist Cure</th>
</tr>
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<tbody>
<tr>
<td>4% Cement</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8% Cement</td>
<td>400</td>
<td>500</td>
<td></td>
<td>300</td>
<td>300</td>
<td>400</td>
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</tbody>
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Reference TxDOT Research 0-4502, Researcher, Tom Scullion w/ TTI

September 26, 2014
Test Site – Riverside

Microcracking influence on Crack Severity

Wet Cured

Microcracked
FWD Results at Riverside

- 4 Percent Cement
- 8 Percent Cement

Backcalculated Base Modulus (ksi)

- Dry Cured
- Prime Cured
- Cracked @ Day 1
- Cracked @ Day 2
- Cracked @ Day 3
- Moist Cured
**Research Conclusions on Microcracking**

- For a given cement content, microcracking improves crack performance (length and severity).

- Greatest potential long-term benefit when combined with current lab mix designs (lowered strength targets).
  - The best performer at a higher cement content had over twice the amount of cracking as the best performer with the reduced strength target.
Research Conclusions on Microcracking

- With high cement contents, two microcracking sessions may be needed as suggested in European literature.
- Microcracking does not hurt the in-service base stiffness.
- In most conditions, perform microcracking with 3 passes after two days curing.
- When constructing in cooler seasons (avg daily temp <60 F), wait 4 days before microcracking.
Pamphlet guide to Microcracking (4502-P4) should be sent to Area and District Offices

Consider compilation of microcracking projects in Texas for long term performance assessment

Simpler, more rapid means to determine when rolling has achieved microcracking

– Instrumentation with accelerometers?
– PFWD may be an option
– Reportedly Geogauge modified and showing promising results in NCHRP study
**Research Information**

- [http://d2dtl5nlnpfr0r.cloudfront.net/tti.tamu.edu/documents/0-4502-P4.pdf](http://d2dtl5nlnpfr0r.cloudfront.net/tti.tamu.edu/documents/0-4502-P4.pdf)

**What Is Microcracking?**

The "block cracks" common to cement-treated base (CTB) initially present a cosmetic problem and result in negative public perception; however, these cracks can allow water into the pavement structure which will accelerate the rate of pavement deterioration. Combined with good lab design, microcracking can help alleviate the severity of cracking in CTB and therefore help improve the perceived quality of TxDOT projects and extend the project life.

Microcracking is the application of several vibratory roller passes to a CTB after a short curing stage, typically after one to three days, to create a fine network of cracks. Microcracking is one technique to help reduce the risk of cracks in the CTB reflecting through the pavement surfacing.

The goal of microcracking is to form a network of fine cracks and prevent the wider, more severe cracks from forming.

**NEED MORE INFORMATION?**

The oldest TxDOT project incorporating microcracking involved SH 47 near Bryan, Texas. Complete details can be obtained from the lab engineer in charge:

**Durango Goehl, P.E.**
Texas Department of Transportation
(979) 774-6099
dgoehl@dot.state.tx.us

Texas Transportation Institute researcher evaluating microcracking included:

**Robert Sabotta**
(979) 458-8194
rsabotta@tamu.edu

**Tom Scullion, P.E.**
(979) 845-9910
t.scullion@tamu.edu

Complete project details are available in Technical Report TxDOT Project 0-4502:

- **Microcracking Stabilized Bases during Construction to Minimize Shrinkage**

Published: August 2006
What Are the Benefits of Microcracking?
Microcracking reduces the severity of shrinkage cracking problems in CTB. Compared to resist curing alone, microcracking improves the performance of CTB by reducing the crack width, reducing the total crack length, or both. Through these mechanisms, microcracking reduces the risk of reflective cracking through the surface layer.

What Does a Microcracked CTB Look Like?
Upon introduction to the microcracking concept, most pavement personnel fear microcracking will rubble or powder the base. Contrary to this fear, a properly microcracked CTB looks no different than an ordinary CTB. Typically, no visual changes are detectable in the base immediately after microcracking. On rare occasions, some visible hairline cracks may appear. However, use of some type of stiffness testing device, such as the falling weight deflectometer (FWD), is typically the only method to definitively detect a change in the base after microcracking.

How and When Should Microcracking Be Performed?
After placement and satisfactory compaction of the CTB according to the applicable bid item, the base should be moist cured by sprinkling for 12-72 hours before microcracking. If performing construction during winter months when average daily temperatures are below freezing, the base should be moist cured for at least 96 hours before microcracking. Microcracking should be performed on the same (or equivalent tonnage) steel wheel vibratory roller used for compaction. A minimum 12-ton roller is recommended. Typically three full passes (one pass is down and back) with the roller operating at maximum amplitude and traveling approximately 2 to 3 mph will satisfactorily microcrack the section. After satisfactory completion of microcracking, the base should be moist cured by sprinkling to a total cure time of at least 72 hours from the day of placement.

What to Look for During the Microcracking Process
Inspect the microcracking operation and look for:
1. Satisfactory completion of three full passes that achieve 100 percent coverage.
2. Signs of cracking in the CTB. Although new cracks are rarely observed (often times some transverse cracking will have already taken place during the moist-curing stage), hairline cracks imparted by the roller occasionally may be visible. If available, the FWD can be used to ensure adequate completion of microcracking by testing every station immediately after completion of the three microcracking passes. The average base modulus as back-calculated from the FWD should be reduced at least 30 percent by microcracking. If using a PPWD for controlling microcracking, target a 40 percent reduction in average base modulus.
3. Signs of detrimental damage to the CTB. If properly designed and cured, microcracking should not damage the CTB. However, if the base appears to start to break up excessively at the surface, stop microcracking and use a static roller until a satisfactory surface finish is obtained.
4. Satisfactory completion of continued moist curing to an age of at least 72 hours from the day of placement.
**Bryan District Implementation**

- **Application of Microcracking:**
  - Cement Stabilized Base – Road or Plant Mixed
  - Use General Notes
  - Do not require if opening to traffic at the end of the construction day
  - Example General Notes:
    - After compaction the finished cement treated base shall be kept wet for a period of 24 to 48 hours. During this time, but not sooner than 24 hours, the finished course shall be rolled with a vibratory roller to induce microcracking. The vibratory roller shall be type C with a static weight equal to or more than 12 tons and the vibratory drum shall be not less than 20 inches wide. The roller shall travel at a speed of 2 mph, vibrating at maximum amplitude, and make 2 to 4 passes with 100% coverage exclusive of the outside 1 foot of the surface crown, unless otherwise directed by the Engineer. Additional passes may be required to achieve the desired crack pattern as directed by the Engineer. The Contractor shall notify the District Laboratory 72 hours before the microcracking begins at xxx-xxx-xxxx. After completion of the microcracking, the section shall be cured for a period of 48 hours. Curing shall be as described in Item 276.
Bryan District Implementation

- Important Information to have a successful Microcracked Base
  - Determine optimum stabilizer content based on unconfined compressive strength and moisture susceptibility.
  - Timing to perform microcracking 2-3 days after compacting unless the average ambient temperature is $<60^\circ$F, the increase to 4 days.
  - Equipment, typically same vibratory roller used for compaction (12 Ton or larger)
  - Try 3 passes (down and back) unless have FWD to test before and after. With FWD look for 50% reduction in backcalculated modulus before stop rolling.
Other TxDOT Districts that have used micro-cracking

**FM 3436 Houston District**

8 Years old  8 inch  3%  Cement Micro-crack + 2 inch HMA

Excellent Performance  No significant cracks
The Dominican Republic microcracks all of its highways

Microcracking based on TTI Research ($2B under construction)

Other Agencies using Microcracking
- Caltrans
- New Zealand
- Zambia DOT
- Utah DOT

3.5 years old – Micro-cracked
FDR  No cracks
Excellent condition

AutoPista Del Coral
Dominican Republic 2012  120 km

Reference TxDOT Research 0-4502, Researcher, Tom Scullion w/ TTI
During the period from 48 to 72 hours after compaction, microcrack the surface by applying 3 single passes of a 12-ton vibratory steel drum roller at maximum amplitude travelling from 2 to 3 mph, regardless of whether asphaltic emulsion has been applied.

UC- Davis  2014
Initiating an HVS test program on Microcracking
Items 275 and 276

Microcracking. When shown on the plans, maintain moisture content of the finished cement treated base for a period of 24 to 48 hr. During this time, but not sooner than 24 hr., roll the finished course with a vibratory roller to induce microcracking. The vibratory roller shall be in accordance with Item 210, “Rolling,” with a static weight equal to or more than 12 tons and the vibratory drum shall be not less than 20 inches wide. The roller shall travel at a speed of 2 mph, vibrating at maximum amplitude, and make 2 to 4 passes with 100% coverage exclusive of the outside 1 ft. of the surface crown, unless otherwise directed by the Engineer. Additional passes may be required to achieve the desired crack pattern as directed. Notify the Engineer 24 hours before the microcracking begins.
Questions