Ultra-Thin Whitetopping (UTW) for Pavement Rehabilitation

Mike Byers
Executive Director, Indiana Chapter
American Concrete Pavement Association
ULTRA-THIN WHITETOPPING (UTW) FOR PAVEMENT REHABILITATION:

The State-of-the Practice

Purdue Road School
March 22, 2000
Ultra Thin Whitetopping: State-of-the-Practice

Ultra-Thin Whitetopping (UTW): The State-of-the-Practice
Mike Byers
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Ultra-Thin Whitetopping
The fastest growing overlay category
- Since 1992, more than 170 UTW projects have been constructed

UTW ≠ “Whitetopping”
- Whitetopping:
  - Well-established, proven pavement rehabilitation technique
- Ultrathin Whitetopping:
  - New technology
  - Trial and evaluation stage

UltraThin Whitetopping
Benefits of UTW
- Durable Surface—Eliminates Rutting
- Fast-Track Construction—Open 24 hours
- Reduces Interim Maintenance
- Competitive Cost
Benefits of UTW

- Traffic Loop Detector Protection
- Longer Construction Season
- Mini-slabs Precut for Utility Maintenance
- Light Reflective - Day and Night
- Environmentally Friendly

Key UTW Considerations

- Bond is critical.
- Slab size (Jointing) is important.
- Underlying asphalt thickness is important.
- Integrity & stiffness of underlying asphalt impacts UTW overlay performance

UTW - Bond is Key to Performance

When you test the bonding strength

- The bond within the asphalt fails before the bond between the asphalt and concrete fails.

The Concrete and Asphalt act as a composite system

Center Line of Stress
Ultra Thin Whitetopping: State-of-the-Practice

Bonding Effects on Edge Stress

<table>
<thead>
<tr>
<th>Unbonded</th>
<th>Bonded</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.49 Mpa (1230 psi)</td>
<td>2.90 Mpa (420 psi)</td>
</tr>
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75 mm Concrete, 100 mm AC, K = 61 Mpa/m, Ei = 27,500 Mpa, Eac = 2,758 MPa

Bonding Effects on Corner Stress

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<tr>
<td>8.49 Mpa (1230 psi)</td>
<td>2.90 Mpa (420 psi)</td>
</tr>
<tr>
<td>6.12 Mpa (890 psi)</td>
<td>3.68 Mpa (535 psi)</td>
</tr>
</tbody>
</table>

75 mm Concrete, 100 mm AC, K = 61 Mpa/m, Ei = 27,500 Mpa, Eac = 2,758 MPa

Short Joint Spacing

- Reduces effects of slab curling
- Acts as mini-paving blocks
- Aids in reduction of edge & corner stresses
- Compact slabs minimize joint movement

Ultra-Thin Whitetopping

Short joint spacing allows the slabs to deflect instead of bend. This reduces slab stresses to reasonable values.

Effects of AC Thickness

<table>
<thead>
<tr>
<th>50 mm (2&quot;) AC</th>
<th>100 mm (4&quot;) AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Stress</td>
<td>5.73 Mpa (830 psi)</td>
</tr>
<tr>
<td>AC Strain</td>
<td>$6.0 \times 10^{-4}$</td>
</tr>
<tr>
<td>Deflection</td>
<td>2.743 mm</td>
</tr>
</tbody>
</table>

Concrete Stress: 75 mm Concrete, K = 61 Mpa/m, Ei = 27,500 Mpa, Eac = 2,758 MPa

Construction Steps

- Core Existing Asphalt
- Mill and Clean
- Place finish and cure
- Early Saw
- Open to Traffic
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Construction Steps

- Mill Surface
- Placement using Slipform Paver
- Clean Surface
- Placement using Vibrating Screed

Construction Steps

- Finishing
- Early Saw
- Open to Traffic
- Cure

Mix Design

- Typical higher Cement Content
- Fast track type Construction
- Low Water / Cement Ratio
- Synthetic Fibers
- Current research evaluating conventional strength (4000 psi) concrete

UTW Interim Design Procedure

- New Engineering Bulletin for 1998
  - Conventional Whitetopping
    - Design
    - Construction
    - Performance
  - Ultra-thin Whitetopping
    - Design
    - Construction
    - Performance
UTW Design Procedures

- Based on the PCA Design Procedure
  - Fatigue in the concrete due to corner loading
  - Fatigue in the asphalt due to edge loading
- Information needed:
  - Flexural strength of concrete
  - Strength of subgrade support (k-value)
  - Asphalt pavement thickness after preparation
  - Asphalt pavement modulus
  - Weights, frequencies, and types of truck axles the pavement will carry
- Design tables show load carrying capacity for given thickness & joint spacing

Design Charts

- 4 Design Tables for Roads, Streets and Parking Areas
  - Light Residential Traffic (Cat. A), k = 27 MPa/m
  - Light Residential Traffic (Cat. A), k = 54 MPa/m
  - Collector and Minor Arterial Traffic (Cat. B), k = 27 MPa/m
  - Collector and Minor Arterial Traffic (Cat. B), k = 54 MPa/m
- 4 General Aviation Tables

Road and Street Design Example

- Traffic or Road Category
  - Minor Arterial
- Existing Pavement
  - Asphalt thickness—100 mm (4 in.)
  - subgrade/subbase k—27 MPa/m (100 psi)
- Trial Thickness
  - UTW thickness—75 mm (3 in.)
  - Flexural strength—4.8 MPa (700 psi)
  - Joint spacing—0.9 mm (3 ft)
- Design Capacity = 284 Thousand Trucks

Other Helpful Hints

- Maximum Joint Spacing
  - 12 to 15 times the concrete thickness
- Mix Design
  - Typical higher Cement Content
  - Fast track type Construction
  - Low Water / Cement Ratio
  - Synthetic Fibers
  - Use Thickened Edge End Panels

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- Traffic or Road Category
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City of Indianapolis - Bus Lanes

- Decided to try Ultra Thin Whitetopping to address problems having at bus stops.
- November 1997 - constructed 3 UTW sections at bus stops on Ohio Street
  - 2 @ 3 1/2" & 1 @ 4"
  - All high strength fiber reinforced
  - Bus stops out of service Saturday am opened Monday @ 6:00 am

DEPTH of ASPHALT:

- Cored each section to determine asphalt depth
- This information will help in concrete depth selection.

MILL OUT ASPHALT:

- Mill out each section to the designed depth (as close as possible)
- Concern about manholes

HANDLING MANHOLES

- Curb elevation varied
- Decided to place by hand
- Mix: high cement, super, double fibers
- Wanted to have 3,000psi in 24 hours

PLACING CONCRETE:
PLACING CONCRETE

BULL FLOATING & HAND FLOAT

TEXTURED FINISH

SAW CUT:
- Spacing determined by depth
  - 4" deep: 5'x5'
  - 3½" : 3'-4" x 3'-4"
  - must total to the 10' lane
- Used soft cut method
- Waited to cut before curing compound applied

SOFT CUT

CURE & PROTECTION:
- Cure:
  - White pigmented
  - Used power sprayer
  - Applied after saw cut.
- Protection:
  - used 2" Styrofoam to trap heat
  - some areas used insulating blankets
**PERFORMANCE:**

- All three sections are performing well
- City is satisfied with performance
- Looking for additional applications

**City of Indianapolis**

Existing UTW - Still Performing Well

**City of Indianapolis**

- If problem not corrected will reflect through when under traffic

In 1999 City of Indianapolis – Built six (6) Additional UTW Overlays

- Maryland Street
- Capital Avenue
- Ohio Street – 4 locations
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Performance Evaluation

- National study evaluating ten (10) UTW projects in United States
  - Some of first projects in U.S.
  - Concrete of similar mixture proportions
  - Relatively close proximity
  - Roads of similar use (except one)
  - Minimal traffic control during surveys

Performance Evaluation

- Pavement Condition Surveys using MICROPAVER Protocol:
  - Visual surveys to record distress
  - 18 of 19 Different Types of Distress with no deduct for joint sealant
    - Since all UTW projects surveyed are designed with no joint sealant, no deduction has been made for joint sealant condition
  - Degrees of Distress (Low, Med, Heavy)
  - Overall Rating from 0-100 (Pavement Condition Index)

Pavement Condition Index (PCI)

Numerical Rating from 0 to 100 --

- 85-100 Excellent
- 70-84 Very Good
- 55-69 Good
- 40-55 Fair
- 25-39 Poor
- 10-24 Very Poor
- 0-9 Failed

Indiana Chapter ACPA

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UTW Condition Survey

<table>
<thead>
<tr>
<th>Project</th>
<th>Yr. const</th>
<th>PCI('95)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belvoir Ave - Chattanooga, TN</td>
<td>1993</td>
<td>76</td>
</tr>
<tr>
<td>Green Street - Athens, TN</td>
<td>1994</td>
<td>85</td>
</tr>
<tr>
<td>Highway 56 - McMinnville, TN</td>
<td>1993</td>
<td>91</td>
</tr>
<tr>
<td>Concord Road - Knoxville, TN</td>
<td>1992</td>
<td>96</td>
</tr>
<tr>
<td>Cusick Street (out), Maryville, TN</td>
<td>1993</td>
<td>93</td>
</tr>
<tr>
<td>Cusick Street (in), Maryville, TN</td>
<td>1993</td>
<td>75</td>
</tr>
<tr>
<td>Weigh Station (app.)- No. Ga.</td>
<td>1993</td>
<td>95</td>
</tr>
<tr>
<td>Weigh Station (leave)- No. Ga.</td>
<td>1993</td>
<td>95</td>
</tr>
<tr>
<td>Wesley Chapel - Dekalb Co., GA</td>
<td>1993</td>
<td>85</td>
</tr>
<tr>
<td>Marbut Rd. - Dekalb Co., GA</td>
<td>1993</td>
<td>95</td>
</tr>
</tbody>
</table>

UTW Condition Survey
Conclusions

- 9 of 10 sections rate EXCELLENT
- Expected service
  - 8 to 12 years before PCI drops below GOOD
- 94% of cracking is low severity
  - Not effecting ride quality
- Approach and leave panels have disproportional amount of cracking

75% of all panel cracks have occurred in the end panels
- Impact loading from vehicles moving across the junction of the asphalt/concrete
- Vehicle loads across the concrete overlay's free edge
- Improper milling (not deep enough)

Suggest: Thickened edge for Ultra-thin Whitetopping

UTW Research in Progress

- ALF at FHWA's Turner Fairbanks Research Center
- Minnesota Test Road – MnRoad
- Indiana 's Joint Transportation Research Board

ALF – Turner Fairbanks

- Eight (8) one lane test sections
- 4 – 2 ½” & 4 – 3 ½” thickness
- Joint spacing @ 3', 4' & 6'
- 4 with fiber & 4 plain concrete
- All lanes built with 4000 psi concrete
- All test sections exhibited excellent performance – most exceeding predicted capacity.
- 3 ½" w/ 4' joints – ALF stopped @ 3,150,000 ESAL’s (2,000,000 predicted)
MnRoad
• UTW sections built October 1997
• Six (6) test sections on I-94 test road
• 3", 4" & 6" thickness
• Joint spacing: 4' x 4', 5' x 6', 10' x 12'
• 5 section use polypropylene fibers, 1 uses polyolefin fibers
• Except when closed to gather data, the sections have carried full interstate traffic since 1997.
• Minimal distress to date – No distress in 6" thick sections.

Indiana JTRP
• Two (2) test lanes under accelerated load facility
• 2 ½" & 4" thick sections
• Joint spacing @ 4' & 6'
• Testing just starting
• Two (2) field test sections planned as part of research project:
  • US 30
  • US 52

Summary
• UltraThin Whitetopping represents a new rehabilitation choice to address pavements with surface distress problems.

QUESTIONS??