Concrete Overlays & Intersection

Concrete Intersection Guidelines
Step-by-step Instructions to Designing and Reconstructing Intersections with Concrete
The Problem . . .
The Problem . . .
Intersections and wheel paths that hold water are problem areas.
Three Major Areas

- Design
- Construction
- Traffic Control
Design Consideration

- Complete reconstruction or inlay
- Concrete intersection construction limits
- Thickness design
- Subgrade and subbase requirements
- Jointing detail
- Concrete materials
- Concrete to asphalt transitions
Concrete Resurfacing

General Types
Concrete Overlay History

- Bonded Overlays
  (1913 Warsaw St. Toledo, OH)

- Unbonded Overlays
  (1916 Grand River Ave. Wayne County, MI)

- Whitetopping (1918 S. 7th St. Terre Haute, IN)

- Ultra-Thin Whitetopping (1991 Landfill Access Road near Louisville, KY)

Bellefontaine, Ohio, 1891
Outer Loop Recycling & Disposal Facility, Louisville, KY
First UTW Project

Mix Requirements
3500 psi in 24 hrs.
3 LBS./C.Y. (ASTM 1018)
Air: 4% - 7%
Crushed Stone
28 Day Strength: 7000 - 8000 psi

Sawed Full Depth
Continuity Break

4 Panels To Be Sawed In 2' Squares

NATIONAL FLEXCRETE EXPERIMENTAL PROJECT
Louisville, Kentucky
3.5- in. – 6 months
2 - in. – 6 months
First UTW Research Findings

- Recycling Center - Louisville, KY
  - Two 275 ft test sections
    - 3.5 in. thickness – 6x6 ft. joint spacing
    - 2 in. thickness – 2x2 & 6x6 ft joint spacing
  - Used fast-track paving
  - Milled existing asphalt
- Identified bond as key
- Identified joint spacing as key
- Overall found promising
Iowa State Highway 21

In-service Road Tests and Performance
Iowa Highway 21

- 7.2 Mile State Highway Research Project
- 65 Different Test Sections
  - 2, 4, 6, 8 inch thickness
  - 2, 4, 6, 12 feet joint spacing
  - with and without fibers
- Constructed overlay 1994
- Monitoring by Iowa State University
- Traffic 1090 ADT (13% trucks)
Iowa Highway 21 Findings

- Bond was achieved and retained over time
- Surface distresses were minimal over the first ten years
- UTW overlays eliminate rutting
- Surface preparation should include milling or other adequate cleaning methods
- Investigation of the asphalt should be accomplished to determine removal depth prior to UTW overlay
- Fiber reinforcement is recommended to retain continuity of the slab in case cracking occurs
MN Whitetopping Research

- Mn/Road built in 1997
- 3-6 inches
- Two mixes - polyolefin fibers; polypropylene fibers
- As of 2002, 4.7 Million ESALs – 6 in. no distress
- 3 in. has cracking deterioration along long. joints

Keep Joints out of Wheelpaths!
Complete reconstruction or inlay

- First question is full or partial replacement
  - Full replacement allows for utility updates
  - However is a longer construction process
  - The WSDOT has had success with full weekend replacement
  - Complete replacement approximately 72 hours
  - Most common partial replacement is a UTW inlay
  - Milling of 2 to 4 inches of asphalt
  - UTW has special construction considerations for material selection, and jointing
What is the existing pavement cross-section?

- Existing Pavement
- What level of pavement distress
- Bond or No Bond
Ultra-Thin Whitetopping

Since 1990, over 300 UTW projects have been constructed.
Ultra-Thin Whitetopping

Since 1990 about 1 million SY placed – It is not experimental anymore
UTW Use by State - 2002

The map shows the distribution of UTW (Unemployment Tax Work) use across different states in 2002. States are color-coded to indicate the range of UTW use per state. The color key includes:
- Black: 0
- Yellow: 6 - 10
- Light Green: 1
- Orange: 11 - 20
- Light Blue: 2 - 5
- Red: 21 - 40
- Pink: >60

Alaska and Hawaii are also shown on the map.
Mechanics of Composite Section

Unbonded

Neutral Axis

Bonded
Bonding
The Key to UTW
UTW vs. "Whitetopping"

- **Whitetopping:**
  - Well-established
  - Proven pavement rehabilitation technique

- **Ultra-Thin Whitetopping:**
  - Incorporates new technology
  - Seeing increased use nationwide
General Design Considerations

Conventional

- Pavement condition influences support value
- Pre-overlay repair needs
- Site factors
  - Traffic control
  - Shoulders
  - Clearances

UTW

- Detailed evaluation
  - Requires 3 in. asphalt (min.)
- Traffic evaluation
- Replacement areas
  - Won’t bond well to new asphalt
- Joint spacing
- Thickness restraint factors
  - Curb & gutter, etc.
Surface Preparation Considerations

**Conventional**
- No effort to Bond
  - No cleaning
  - No muss no fuss
- Place directly on existing surface unless…
  - Rutting >1 in., then consider benefit of milling
    - Cross slope adjustments
    - Avoiding leveling course

**UTW**
- Make effort to bond
  - Mill after patching
  - Milling depth depends on distress, thickness of asphalt
- Air blast or power broom
- Allow to dry
Whitetopping Overlays

- Joint depth ($D/3$) for conventional whitetopping
- Adjust if ruts over 1 inch
Jointing Considerations

Conventional
- Typical spacing: 21 x T
- Same load transfer as new construction
  - Dowel bars
  - Tie bars
- Do not skew
  - Found to be of no value where dowels are used
- Saw depth is important

UTW
- Typical spacing 12 to 15 x T
- Keep longitudinal joints away from wheel paths
  - Mn/Road lesson!
- No dowel bars or tiebars
- Do not skew
- Early-entry sawing a must
Short joint spacing allows the slabs to deflect instead of bend. This reduces slab stresses to reasonable values.
Concrete Mixture Considerations

**Conventional**
- Typical state specifications

**UTW**
- Typically fast–track
- Typically includes fibers
- Higher strengths used for constrained designs
## Concrete Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Standard (per cubic yard)</th>
<th>Fast Track (per cubic yard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement (Type I)</td>
<td>564 lbs.</td>
<td>708 lbs.</td>
</tr>
<tr>
<td>Cement (Type III)</td>
<td></td>
<td>(658 lbs.)</td>
</tr>
<tr>
<td>Fly Ash</td>
<td></td>
<td>(50 lbs.)</td>
</tr>
<tr>
<td>Coarse Aggregate *</td>
<td>1750 lbs.</td>
<td>1425 lbs.</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>1250 lbs.</td>
<td>1350 lbs.</td>
</tr>
<tr>
<td>Water:Cement Ratio</td>
<td>0.45 max.</td>
<td>0.42</td>
</tr>
<tr>
<td>Water Reducer</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Air Entrainer **</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

* Maximum top size coarse aggregate 0.75 - 1.0 in.
** Air content 6% + 1.5%
Key Intersection Issues

- Minimal disruption
  - Open until actual paving
  - Reconstruction not desirable due to cost/time
  - Completed minimal amount of time
    - “Fast Track” Concrete

- Vertical limitations
  - Overhead and other vertical restrictions
  - Meet existing entrances
  - Minimal thickness system

- Other Issues
  - Manholes (in-place pavement structures)
  - Cannot use bonded system due to concrete condition
Concrete Intersection Construction Limits

- Based on level of pavement deterioration
- Replacement of both physical and functional areas
- At busy intersection the functional area may extend well beyond the physical area because of slow moving maneuvering vehicles
- Functional area needs to include all rutted areas
- Major arterial legs may extend back 200 to 500 feet from crosswalk
- Minor arterial approximately 50 to 100 feet
Design Considerations

Area Definitions:

Physical Area

Functional Area

Note: Physical area carries the combined traffic from both roadways thickness design must account for both
I.D. Problem Intersections
Thickness Design

- Many choices in pavement thickness design
  - 1993 AASHTO Guide for Design of Pavement Structures
  - ACPA as the WinPAS Design Program
  - PCA Design Procedure
  - New StreetPave Software January 2005
Pavement Depth
Subgrade and Base requirements

- Subgrade is the natural ground the pavement rests
  - Uniform
  - Compactable
  - Drainable

- Base is the layer of material between the subgrade and pavement
  - Granular, Cement Treated, other

- Overlays utilizes the existing pavement as a base
  - Concrete k-value 450
  - Asphalt k-value 350
<table>
<thead>
<tr>
<th>Overlay Classification 20-Year, 4-Lane</th>
<th>Support Composite k-value</th>
<th>Concrete Flexural Strength</th>
<th>Concrete Thickness (Joint Spacing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbonded, Major Arterial (80%, 15%, 1000 ADTT, 2%)</td>
<td>450</td>
<td>600</td>
<td>7” (12’x12’)</td>
</tr>
<tr>
<td>Unbonded Major Arterial (80%, 15%, 2500 ADTT, 2%)</td>
<td>450</td>
<td>750</td>
<td>7” (12’x12’)</td>
</tr>
<tr>
<td>Whitetopping Major Arterial (80%, 15%, 1000 ADTT, 2%)</td>
<td>350</td>
<td>600</td>
<td>7” (12’x12’)</td>
</tr>
<tr>
<td>Whitetopping Major Arterial (80%, 15%, 2500 ADTT, 2%)</td>
<td>350</td>
<td>750</td>
<td>7” (12’x12’)</td>
</tr>
<tr>
<td>UTW</td>
<td>350</td>
<td>900</td>
<td>3.5 inches (4’x4’)</td>
</tr>
</tbody>
</table>
Jointing Detail
Jointing

Purpose:

• Control natural transverse & longitudinal cracking from internal slab stresses.
• Divide pavement into construction lanes or increments.
• Accommodate slab movements.
• Provide load transfer.
• Provide uniform sealant reservoir.
The Three Basic Joint Types

**Transverse Joints**
- Doweled: 1 ¼ - 1 ½ in dia.
- Smooth Dowel
- D/4 - D/3 Sealant
- Reservoir ⅛ - ⅜ in (typ.)
- Undoweled: D/4 - D/3 Sealant
- Reservoir ⅛ - ⅜ in (typ.)
- Smooth Face (Butt Joint)
- 1 ¼ - 1 ½ in dia.
- Smooth Dowel

**Longitudinal Joints**
- Doweled: Expansion Joint
- 1.0 in. max.
- Smooth Dowel: 1 ¼ - 1 ½ in dia.
- Reservoir ⅛ - ⅜ in (typ.)
- Contraction: Deformed Tie Bar
- Butt Joint
- Smooth Face: Butt Joint
- Keyway
- Keyed

**Isolation / Expansion Joints**
- Expansion Cap: 1.0 in. max.
- Thickened Edge Expansion Joint
- 1.2D Filler
- Thickened Edge: 6D to 10D
- Isolation Joint: Manhole, Inlet, Building, etc.
Joint Spacing & Depth

- **Granular Base**
  - Spacing - 24 x T
  - Saw Depth - T/4

- **Stabilized Base**
  - Spacing - 21 x T
  - Saw Depth - T/3
  - Bond Breaker??

Contraction Joints
Boxing Out Fixtures

Square
- Isolation joint
- Reinforcing bars recommended to hold cracks tight

Diagonal
- Isolation joint

Circular
- Isolation joint

Square with Fillets
- Isolation joint

None
- Isolation joint around perimeter

Telescoping Manhole
- No boxout or isolation joint necessary

Inlet - None

Inlet - Round
Street and Intersection Jointing Layout:
Keys to Good Performance
Intersection Joint Layout

- Develop a jointing plan
  - Bird’s eye view
- Follow the steps
- Be practical!
Concrete to Asphalt Transition

Saw cut face

10 - 15 ft. (typical)

5 ft. min.

Thickened Edge
Concrete to Asphalt Transition

Ultra-thin Overlay (D< 4 inches)

Saw cut face

T + 3 in.

L = Standard Length between joints (4 to 5 ft.)
Concrete to Asphalt Transition

Conventional Whitetopping (D > 4 inches)

- No. 4 Deformed bar (first three joints)
- Saw cut face
- 6-10 ft. (typical)
- 1.2 D (6 in. min.)
- 5 ft. (min.)

Diagram showing layers:
- AC SURFACE
- AC BASE
- Concrete to Asphalt Transition
Construction Considerations

- Removal of existing pavement
- Preparing the grade
- Setting forms
- Placing in-pavement structures
- Other details prior to placing concrete
- Placing, finishing, and texturing the concrete
- Curing the concrete
- Saw cutting the pavement
- Sealing/Filling joints
- Opening to traffic
Removing the existing pavement

- Pavement Removal
  - Cold Milled
  - Bull Dozer
  - Front End Load
- Removed using dump trucks
Other Details Prior to Placing Concrete

- Reinforcing steel
  - Dowel Bars
  - Tie Bars

- Box out for in pavement structures

- Traffic loops
Placing, Finishing, and Texturing the Concrete
Placing, Finishing, and Texturing the Concrete
Curing the Concrete

- White Pigmented Curing Compound
  - Conventional Paving 200 sq.ft./gal.
  - Fast Track Paving 150 sq.ft./gal.
  - UTW 100 sq.ft./gal
Saw cutting the pavement
Sealing/Filling joints

Purpose: Reduce infiltration of water and incompressible
Traffic Management Issues

- Traffic control options
  - Complete closure
  - Partial closure
  - Construction under traffic
  - Complete closures during limited time periods

- Construction staging procedures
  - Construction by lane
  - Construction by quadrant
Traffic Management
Construction Phasing Options:

Construction Under Traffic - by Lane

Phase 1
Phase 2
Phase 3
Phase 4
Traffic Management
Construction Phasing Options:

Construction Under Traffic - by Quadrant

Phase 1

Phase 2

Phase 3

Phase 4
Prior to Construction
Stage 1
Stage 3
Construction Under Closure
Innovations

Stamped Crosswalks UTW
Sheridan, WY
Combination Stamped & Colored

- Contrasting Colors
- Aids with disabilities
- Textured and Colored Borders
- Colored smooth interior
Other Applications

- Concrete Inlays
  - Bus Stops
  - Turn Lanes
  - Any Stopping Area
Additional Information

- Contact Louisiana Chapter
- ACPA visit www.pavement.com
Thank You
Various Examples
Unbonded Overlay Project 1997

- Access to Local Businesses Crucial
- 9-inch widening built first
- 7,200 square yard overlay built in one Saturday
Enterprise Drive, Allen Park, MI

- Original pavement built in 1950’s
- 9-inch mesh reinforced
- 6-inch unbonded overlay
- 9-inch plain concrete widening
- Joint Spacing - 10 feet
Enterprise Drive
Oakwood to S. Dearborn, 6"
Enterprise Drive, Allen Park
Enterprise Drive, Allen Park
Enterprise Drive
Oakwood to S. Dearborn, 6 in., January 2003
Unbonded Overlay Performance

- Very Good
- Can be expected to perform for 20-30+ years.
  - Most failures are due to the use of inadequate separation layers.
Combination

- What you can do when the existing pavement is composed of both concrete and asphalt

- Combining UTW & Unbonded Overlay Technology
Brick Exposed, South Leg
Tuesday 6/05/01
Tuesday, June 12, 2001
Actually Opened Saturday