Session 11: Concrete Overlays
Learning Outcomes

• Define Concrete Resurfacing
• Define Bonded & Unbonded Overlays
• List Benefits of Overlays
• Describe Evaluation Considerations
• Describe Primary Design Considerations
• Describe Materials & Construction Activities
Benefits of Concrete Overlays

- Concrete overlays consistently provide cost-effective solutions.
- Concrete overlays can be constructed quickly and conveniently.
- Concrete overlays are easy to maintain.
- Concrete overlays can serve, in and of themselves, as complete preventive maintenance, preservation, or rehabilitation solutions.
- It is an integral component of a comprehensive asset management approach.
- Cost effectively extends pavement life and improves both functional and structural characteristics.
- Concrete overlays are an effective means to enhance pavement sustainability by improving
  - surface reflectance (albedo),
  - increasing structural longevity,
  - enhancing surface profile stability, and maintaining ride quality.
Questions

• How often do you use Concrete Overlays
• What functions do they serve?
• What materials have you used for partial-depth repairs? What is your typical material?
• What kind of problems have you had?
• How long do you estimate that your partial-depth repairs last?
Number of Concrete Overlays from 1900 through 1969 and from 1970 through 2010

- 1,152 concrete overlays in the U.S., dating from to 1901 through 2012
- Concrete overlays have been successfully constructed in 45 different states
Percentage of Bonded and Unbonded Concrete Overlays by Existing Pavement Type

- Bonded on Asphalt: 42%
- Bonded on Composite: 8%
- Bonded on Concrete: 13%
- Unbonded on Asphalt: 3%
Concrete Overlays

Intersections

Rural secondary roads

Urban freeway/interstate

Urban arterial

Rural primary/interstate
Types of Concrete Overlays

**Bonded Overlay Option**
(Preventative Maintenance/Minor Rehabilitation)
In general, bonded resurfacing is used to eliminate surface distress when the existing pavement is in good structural condition.
Bonding is essential, so thorough surface preparation is necessary before resurfacing.

**Unbonded Overlay Option**
(Minor/Major Rehabilitation)
In general, unbonded resurfacing is highly reliable, with longer design life than rehabilitation with asphalt.
Minimal pre-resurfacing repairs are necessary for unbonded resurfacing.
## Bonded vs. Unbonded Overlay Considerations

<table>
<thead>
<tr>
<th>Concrete Overlay</th>
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<td><strong>Bonded</strong></td>
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<tr>
<td><strong>Purpose</strong></td>
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<td><strong>Condition of Existing Pavement</strong></td>
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| **Resulting Improvements to the Pavement** | • Long-term wearing surface added  
• Surface defects eliminated  
• Surface characteristics like smoothness, friction, and/or noise improved  
• Load-carrying capacity added  
• Pavement life extended | • Load-carrying capacity restored and increased  
• Pavement life extended  
• Surface defects eliminated  
• Surface characteristics like smoothness, friction, and/or noise improved |
BONDED OVERLAY OF ASPHALT OR COMPOSITE PAVEMENTS

Existing pavement condition
Fair or better structural condition with surface distress
- HMA pavements with some structural integrity
  - Limited structural (fatigue) cracking
  - No stripping/raveling in HMA layers
  - HMA thickness after milling - 3 in minimum
- Rutting in HMA layers ok
- Non-load associated cracking ok

2”–5” thickness
Bonded Overlay of Concrete

- Use when existing pavement is in good structural condition with some surface distress.
- Use to eliminate any surface defects; increase structural capacity; and improve surface friction, noise, and rideability.
- Typically used directly over concrete without additional repairs except for spot-repairing of severely deteriorated areas.

2”–5” thickness
Unbonded Overlay of Concrete Pavements

- Use when existing pavement is in poor condition, including with material-related distress such as D-cracking and ASR, when underlying pavement and subbase are stable and uniform except for isolated areas that can be repaired.

- Use to restore structural capacity of the existing pavement and increase pavement life equivalent to full-depth pavement.

- Also results in improved surface friction, noise, and ride.
Uses and Advantages - Unbonded Concrete Overlay of Asphalt or Composite Pavements

- Use when existing pavement is deteriorated condition.
  - severe rutting,
  - potholes,
  - alligator cracking,
  - shoving, and pumping
  - exhibits past D-cracking and ASR,

- Used when underlying pavements and subbase are stable and uniform except for isolated areas that can be repaired.

- Use to restore structural capacity of the existing pavement

- Use to increase pavement life equivalent to full-depth pavement.
Asset Management Through Concrete Resurfacing

Preservation = Preventative Maintenance + Minor Rehabilitation
Preventive Maintenance

- Preventive maintenance is a major component of pavement preservation.
- It consists of extending the service life of structurally sound pavements by applying cost-effective treatments to the surface or near the surface.
- Bonded concrete overlays of approximately 51 to 102 mm (2 to 4 in) thickness provide preventive maintenance strategies.
Minor Rehabilitation

- Minor rehabilitation is used when structural capacity needs to be restored to a pavement but major rehabilitation is not required.

- Bonded and unbonded concrete overlays of 4 in. provide excellent minor rehabilitation solutions.
Purpose and Project Selection

- Concrete resurfacings require uniform support conditions if satisfactory performance is to be realized.
- Nearly all the documented cases of premature overlay failure can be traced to some violation “picking the wrong project” to resurface.
- For this reason, the evaluation of the existing pavement is paramount to determine if uniform support and movement control exists, or if it can be cost-effectively achieved.
- To have a successful overlay, regardless if it is bonded or unbonded, the good and poor characteristics of the existing pavement must be understood along with the level of expected success for dollars expended.
Evaluations of Existing Pavements for Overlays

- Evaluation is also used to determine:
  - Required repairs where needed
  - Establish the concrete overlay design thickness
  - When combined with an overlay can the existing pavement help carry anticipated traffic as:
    - an integrated part of the pavement (bonded)
    - or serve as a base or subbase
What are We Putting Overlays On?

- Age of Different Asphalt Layers
- Estimate Remaining Life
- Performance Grades of Lifts (records)
- Pavement Management Records
- Type and Amount of Traffic Now and in the Future
- Elevations and Grade Restrictions
Coring

- Layer confirmation
- Layer thicknesses
  - Variability
  - Minimum requirements for thin overlays
- Subsurface conditions
  - Stripping
  - Delaminations
- Samples for laboratory testing
  - Material properties
Overlay Selection – Existing Conc.

**Fair Condition**
Structurally sound but has minor surface distresses such as random cracking, periodic partial-depth joint spalling and shadowing. Check for undulating profile grade to determine if sub drainage issues exist or other foundation issues such as secondary consolidation of an open graded base exists.

**Poor Condition**
Has measurable surface distresses beyond those described as fair condition. These include: full-depth joint deterioration, working cracks, spot structural failures, faulting and/or material related distresses (MRD).

**Deteriorated Condition**
Exhibits Poor Conditions as well as significant surface deterioration and structural distresses. If severe or potentially severe joint deterioration from freeze-thaw damage or MRD is present and it exists 3’ to 4’ beyond joint at nearly every joint, then overlays are not normally a good candidate unless the service life is reduced.
Overlay Selection – Existing Conc.

Milling/Minor Spot Repairs
Can milling and minor spot repairs cost effectively remove deficiencies and bring the pavement to a “Good Condition” and meet other constraints (i.e. vertical clearance, shoulders, safety rails, foreslopes, etc.) to allow for a bonded overlay?

YES

NO

Milling & Patching
Can milling and/ or structural repairs (patching) cost effectively solve deficiencies and bring the existing pavement to a condition that will provide uniform support as a subbase and meet other constraints (i.e. vertical clearance, shoulders, safety rails, foreslopes, etc.) and bring the existing pavement to a condition that will provide a uniform subbase for an unbonded overlay?

YES

Bonded Overlay Over Existing Pavement

- Joint Spacing (See Section __)
- Match existing underlying joints with saw-cut full depth of overlay plus 1/2"

Install subdrains if needed (See Section __)

Note: Concrete overlay thickness to be appropriately designed considering estimated traffic, desired design life and budget.

Unbonded Overlay Over Existing Pavement

- Joint Spacing (See Section __)
- Place separator layer (Geotextile or 1” min. asphalt)

Install subdrains if needed (See Section __)

Install full-depth flowable mortar patches. No sawing.
Overlay Selection – Existing Asph.

**Fair Condition**
Structurally sound but has minor surface distresses such as potholes, block cracking, random thermal cracking. Check for undulating profile grade to determine if sub-drainage issues exist. Check cores to ensure no measurable stripping or delamination in the asphalt.

**Poor Condition**
Has measurable distresses beyond those described as Fair conditions such as alligator cracking, rutting, shoving, slippage, stripping, raveling and freeze-thaw damage.

Note: Asphalt is a good reflector of underlining distresses such as a poor subbase conditions.

**Deteriorated Condition**
Exhibits Poor Conditions as well as significant deterioration, raveling, thermal expansion, stripping and structural distresses.
Overlay Selection – Existing Asph.

Milling/Minor Spot Repairs
Can milling & minor spot repairs cost effectively solve deficiencies and bring the pavement to a “Good Condition” and meet other constraints (i.e. vertical clearance, shoulders, safety rails, foreslopes, etc.) to allow for bonded overlay?

NO

Milling & Patching
Can spot structural repairs and/or milling cost effectively solve deficiencies to meet vertical and structural requirements and bring the existing pavement to a condition that provide a uniform subbase for an unbonded overlay?

YES

Bonded Overlay
Over Existing Pavement

3'' Min. Asphalt

Joint Spacing
(See Section __)

Install subdrains if needed
(See Section __)

Note: Concrete overlay thickness to be appropriately designed considering: estimated traffic, desired design life and budget.

Unbonded Overlay
Over Existing Pavement

3'' Min. Asphalt

Joint Spacing
(See Section __)

Install subdrains if needed
(See Section __)
Interrelated Overlay Design Factors

- Desired service life, load-carrying capacity
- Design (thickness, etc.)
- Analysis
- Costs
- Existing pavement condition, preoverlay repairs
Design Tools for Unbonded Overlays

- StreetPave Software:
  - Concrete Thickness Design
  - Asphalt Thickness Design
    (Asphalt Institute)
  - Life Cycle Cost Analysis
- Updated IS184 Publication
BONDED CONCRETE OVERLAY OF ASPHALT OR COMPOSITE PAVEMENT
PURPOSE OF ASPHALT MILLING FOR CONCRETE BONDED OVERLAY

• Remove distortions 2” or more
• Reduce high spots to insure minimum overlay depth
• Match adjacent lanes
• Enhance bond
• Meet vertical elevation requirements
• Restore profile
CAUTIONS ABOUT MILLING

- Milling should be minimized to retain structural support of pavement
- Preferable to mill to depth that will minimize the potential for delamination between lifts
- Grade corrections should be made in the thickness of the concrete overlay

Excessive milling of existing asphalt beyond asphalt lifts (tack line)
Stripping

The loss of bond between aggregates and asphalt binder that typically begins at the bottom of the HMA layer and results in structural support.

**Summary of Possible Causes:**

- Water in the HMA causing asphalt binder stripping along the aggregate face.
  - Bottom-up stripping is difficult to recognize because it manifests itself on the pavement surface as other forms of distress including rutting, shoving/corrugations, raveling, or cracking.
- Asphalt overlays over existing open-graded surface course can result in stripping.
Fiber-Reinforced Concrete

- However, fiber reinforcement should be considered in any of the following situations:
  - The project has specific vertical restrictions
  - The asphalt lift is very thin (and thus may not readily bond with the concrete)
  - The base thickness and/or condition is inadequate
  - The design thickness makes conventional reinforcement difficult to use
Effects of Joint Spacing:
Bonded Concrete Resurfacing of Asphalt Pavements

Short joint spacing allows the slabs to deflect instead of bend. This creates the need to balance thickness and joint spacing.

JOINTING AND MILLING
Longitudinal Joint Layout

2 ft x 2 ft

3 ft x 3 ft

4 ft x 4 ft

6 ft x 6 ft

Outer Shoulder

Traffic

12 ft
Surface Preparation

- Milling AC surface
  - Remove rutting
  - Restore profile
  - Enhance bond
- Minimum AC thickness remaining after milling: 3 to 5 in.
- Surface cleaning
Surface Cleaning

Power Sweeping

Air Blasting

Water Blasting
PCC Placement and Finishing

• Same as conventional PCC paving
  – Slipform
  – Fixed form
• Avoid surface contamination
PCC Joint Sawing

CRITICAL
• Effective curing
• Timely joint sawing
Bonded over Asphalt/Composite
Keys to Success

• Bonding is critical
• Small square panels reduce curling, warping, & shear stresses in bond (1.5 times thickness).
• Mill to remove surface distresses, or improve bonding.
• Be sure to leave 3” to 4” of HMA after milling.
• HMA surface temperature below 120 F before paving.
• Joints in the overlay should not be placed in wheel paths, if possible
• Application of curing compound is critical
Bonded Concrete Overlay of Concrete

2” – 5” Thick
Poor Bonding: Delamination of Concrete Overlay over Concrete
PRE-OVERLAY REPAIRS

Full Depth Patches
Maintaining Bond

Replaced Asphalt Patch with Concrete Patch
Bonded Overlay of Concrete – Full Depth Cut & Width of Cut
Coefficient of Thermal Expansion (CTE)

- Overlay CTE should be similar to underlying pavement.
- If not near the same, the overlay CTE should be lower than existing pavement.
- Key similar coarse aggregate type.
IA 3, west of Hampton, IA
Bonded Overlay on Concrete: Keys to Success

- Concrete aggregate used in overlay should have thermal properties similar to that of existing pavement.
- Matching joints with underlying pavement allows structure to move monolithically.
- Existing joints must be in fair condition or be repaired.
- Timing of joint sawing is important.
- Cut transverse joints full depth +1/2” and longitudinal joints at T/2.
- Width of transverse joint of overlay to be equal to or greater than underlying crack width of the existing pavement.
- Curing should be timely and adequate.
Concrete Unbonded Overlay of HMA or Composites - Trouble Shooting
Unbonded Overlays of Existing Asphalt or Composite Pavement

- Slabs ≥ typically 5 in thick or greater
- Placed directly on AC pavement (little pre-overlay repair)
- Designed as a new concrete pavement over AC base
Joint Load Transfer

• Dowels normally cannot be accommodated for thickness 6 in. or less & typically not used for thickness less than 8 in.

• For thicker pavements (heavier truck traffic), use dowels at transverse joints

• Existing concrete pavement provides good support and results in lower deflections under truck traffic
Overload of Concrete Pile in Front of Paver

Remove Unnecessary Baskets
Urban Street Unbonded Overlays

4” Milling

Michigan Project

5” Unbonded Concrete Overlay
Semi- Uniform Platform

Remaining HMA severely damaged from trucks hauling away millings

Removed 6-in. of existing 9-in HMA Pavement
Unbonded Over Asphalt/Composite

Keys to Success

• Milling to eliminate surface distortions of 2 in. or more

• Complete repairs at isolated spots where structural integrity needs restoring

• Concrete patches in the existing pavement should be separated from the overlay

• Surface temperature of existing asphalt pavement should be maintained below 120°F (48.9°C) when placing overlay

• Partial bonding between the overlay and the existing asphalt pavement is acceptable and may even improve load-carrying capacity
Concrete Unbonded Overlay of Concrete
UNBONDED OVERLAYS CAN BE PLACED OVER POOR CONCRETE PAVEMENTS
Milling Existing Concrete

Milling the existing concrete on Little Mack Avenue
(Photo courtesy of Dan DeGraaf, Michigan Concrete Paving Association)
SPOT REPAIRS FOR UNBONDED OVERLAYS OF CONCRETE

Joint Patching
SEPARATION LAYER

• Required for good performance
  – Isolate overlay from existing distress
    ▪ Prevent reflective cracking
    ▪ Prevent bonding/mechanical interlocking
  – Provide level surface for overlay construction

• Recommended separation layer material:
  – 1-2 in HMA
  – Geotextile fabric
WHY AN ADEQUATE INTERLAYER?

- Overlay
- Old pavement
- Thicker interlayer (1"
- Smoother slip plane
- "Key"
What is it?

- Nonwoven
- Woven
Color of Fabric

Two Predominant Colors Used
Black and White

- Black - carbon molecules which absorb Ultra-Violet energy
- Requires damping to reduce heat below 110 F.
- Use in spring and fall

- White - pure polypropylene resin and reflects Ultra-Violet energy
- Does not require damping to reduce heat
- Use in summer months
• The geotextile should be placed by rolling it out onto the underlying surface, and pulling the material tight enough so that no wrinkles or folds occur, but not so tight that the fibers pull apart.

• The geotextile should be placed in advance of paving a reasonable distance (max. 1000’ +/-)
Placement of Geotextile

- Overlaps in adjacent rolls should measure 8” ± 2”, and no more than three layers of material should overlap at any location.
To secure the geotextile, pins or nails should be punched through 2- to 2.75-in galvanized washers or discs every 6 ft or less.
Unbonded Overlay of Concrete Pavements: Keys to Success

• Full-depth repairs - only where structural integrity is lost at isolated spots.
• Separator layer (normally 1” asphalt or geotextile fabric)
• Use to restore structural capacity of the existing pavement and increase pavement life equivalent to full-depth pavement.
• Faulting of 3/8 in. or less in the existing concrete pavement
• Shorter joint spacing helps minimize curling and warping stresses.
• To not match joints with those of the underlying concrete pavement.
Quantity Estimates

- Estimating plan quantity
  - Overlay cubic yard pay item is to adjust the theoretical volume by an appropriate factor that accounts for the non-uniformity of the existing surface

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<thead>
<tr>
<th>Concrete Overlay Thickness</th>
<th>½” Placement Tolerance as a % of Design Thickness</th>
<th>Additional % Adjustment for Gross Surface Irregularities in the Existing Surface</th>
<th>Total Adjustment Factor to be Applied to Theoretical Volume</th>
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</thead>
<tbody>
<tr>
<td>4”</td>
<td>12.5%</td>
<td>5%</td>
<td>17.5%</td>
</tr>
<tr>
<td>6”</td>
<td>8.3%</td>
<td>5%</td>
<td>13.3%</td>
</tr>
<tr>
<td>8”</td>
<td>6.3%</td>
<td>5%</td>
<td>11.3%</td>
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<tr>
<td>10”</td>
<td>5.0%</td>
<td>5%</td>
<td>10.0%</td>
</tr>
<tr>
<td>12”</td>
<td>4.2%</td>
<td>5%</td>
<td>9.2%</td>
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Overlay Costs

![Graph showing the relationship between Overlay Thickness (in.) and Concrete Overlay Cost ($/yd²). The equation for the polynomial trend line is y = 0.3599x² - 2.0216x + 16.807, with R² = 0.7705.](image)