Guide to Concrete Overlays for Resurfacing & Rehabilitating Existing Pavements

August 7, 2008 – Iowa DOT Seminar

Dale S. Harrington P.E. – Representing CP Tech Center
Concrete Overlay Guide

A 80-page “Guide to Concrete Overlay Solutions”

- For Field Application Program
- Overview of Overlay Families
- Overlay types and uses
- Six Overlay Summaries
- Evaluations & Selections
- Design Section
- Miscellaneous Design Details
- Overlay Materials Section
- Work Zones under Traffic
- Key Points for Overlay Construction
- Accelerated Construction
- Project & Specifications Considerations
- 10,000 to be printed
Overlay Committee (17 Members)

- Andy Bennett, Michigan Department of Transportation
- Jim Cable, P.E., Iowa State University
- Dan DeGraaf, Michigan Concrete Paving Association
- Jim Duit, Duit Construction Co., Inc., Oklahoma
- Todd Hanson, Iowa Department of Transportation
- Randell Riley, Illinois Chapter ACPA
- Matt Ross, Missouri/Kansas Chapter ACPA
- Jim Shea, New York State Chapter ACPA
- Gordon Smith, Iowa Concrete Paving Association
- Sam Tyson, Federal Highway Administration
- Leif Wathne, American Concrete Pavement Association
- Jim Grove, CP Tech Center
- Matt Zeller, Concrete Paving Association of Minnesota
- Jeff Uhlmeyer, Washington State DOT
- Kevin Maillard, OHM Advisors
- Robert Rodden, American Concrete Paving Association
- Shannon Sweitzer, North Carolina Turnpike Authority
Why Concrete Overlays?

• Does not require extensive repairs of existing pavement

• Long performance

• High load-carrying capacity

• Well demonstrated/documented maintenance and rehabilitation method

• Effective life-cycle costs
Why are we not using Concrete Resurfacing Technology more?

Perception:
• Pavement design theories for bonded and unbonded overlays (resurfacing) are difficult to understand
• There is lack of confidence in overlays because of lack of understanding on how they work
• They are not perceived to be fast track construction like HMA
• Many DOT designers think you must close a roadway to vehicle traffic (particularly two lane roadways)
• They are considered expensive to remove and replace
System of Concrete Overlays

Thinner

Concrete Overlays

Thicker

Bonded Overlay System

Unbonded Overlay System

Bonded Concrete Overlay of Concrete Pavements

Bonded Concrete Overlay of Asphalt Pavements

Bonded Concrete Overlay of Composite Pavements

Unbonded Concrete Overlay of Concrete Pavements

Unbonded Concrete Overlay of Asphalt Pavements

Unbonded Concrete Overlay of Composite Pavements

Bond is integral to design

Old pavement is base
Overlay Solutions for Rehabilitation and Maintenance

<table>
<thead>
<tr>
<th>Existing pavement condition before repairs</th>
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<tbody>
<tr>
<td>Excellent</td>
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<tr>
<td>Good</td>
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<tr>
<td>Fair</td>
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<tr>
<td>Poor</td>
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<tr>
<td>Deteriorated</td>
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<tr>
<td>Failed</td>
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<tr>
<th>Time</th>
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</table>

- Preventive maintenance
- Bonded on Concrete
- Unbonded on Concrete
- Bonded on Asphalt
- Unbonded on Asphalt
- Reconstruction
- Major rehabilitation
- Minor rehabilitation
### Pavement Evaluation

#### Evaluating Pavement Condition for Concrete Overlays

<table>
<thead>
<tr>
<th>Initial Evaluation (1-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pavement History</strong></td>
</tr>
<tr>
<td>- Pavement material (including aggregate coefficient of thermal expansion), design, age, thickness, layers</td>
</tr>
<tr>
<td>- Remaining life</td>
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<tr>
<td>- Desired traffic and performance level</td>
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<tr>
<td>- Desired design life</td>
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<tr>
<td>- Elevations and grade restrictions</td>
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<tr>
<td>- Etc.</td>
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<tr>
<td><strong>Core Analysis</strong></td>
</tr>
<tr>
<td>- Depth of distress</td>
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<tr>
<td>- Type of distress</td>
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<tr>
<td>- Verification of thickness for base/subbase</td>
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<tr>
<td>- Etc.</td>
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<tr>
<td><strong>Visual Examination</strong></td>
</tr>
<tr>
<td>Concrete</td>
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<tr>
<td>Asphalt / Composite</td>
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</tbody>
</table>

#### Options (depending on extent of problems)

4-a. Materials-Related Tests (indicated by core analysis)

- Conduct if materials or durability issues are indicated and/or
- roadway provides high level of service, especially if a bonded overlay is being considered.
- Petrography analysis
- Concrete material related distress
- Poor air void system
- Asphalt stripping
- Coefficient of thermal expansion

4-b. Subsurface tests

- Conduct if pavement or subgrade support issues are indicated and/or
- roadway provides high level of service, especially if a bonded overlay is being considered.
- Falling weight deflectometer tests
  - Subgrade support (K value)
  - Subgrade variability
  - Pavement properties
  - Load transfer efficiency
  - Presence of voids
  - Asphalt stiffness
  - Concrete flexural
- Subgrade tests
  - Freeze-thaw characterisation
  - Shrink-swell characteristics
  - Soil strength (dynamic cone penetration or standard penetration test)

4-c. Surface Texture tests

- Conduct if materials or durability issues are indicated and/or
- roadway provides high level of service, especially if a bonded overlay is being considered.
- International roughness index
- Friction (skid resistance) tests

#### Condition Assessment Profile

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Asphalt / Composite</th>
</tr>
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<tbody>
<tr>
<td>Surface Deficiencies</td>
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<tr>
<td>Friction loss</td>
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<tr>
<td>Joint deterioration (low to medium)</td>
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<tr>
<td>Map cracking (non-ASR)</td>
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<tr>
<td>Popouts</td>
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<tr>
<td>Noise</td>
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<td>Scaling</td>
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<tr>
<td>Roughness (not distress related)</td>
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<tr>
<td>Plastic shrinkage cracks</td>
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<tr>
<td>Structural Deficiencies</td>
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<tr>
<td>Crack breaks</td>
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<tr>
<td>Joint deterioration (severe)</td>
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<td>Topped panels</td>
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<td>Longitudinal cracking</td>
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<td>Pumpaning/feathering</td>
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<td>Materials-related distress (medium to severe)</td>
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<tr>
<th>Condition Evaluation Report and Pavement Condition Rankings</th>
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<tr>
<td>Fatigue (silting) cracking</td>
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Evaluating Pavement Condition for Concrete Overlays

1 Pavement History

- Pavement material (including aggregate coefficient of thermal expansion), design, age, thickness, layers
- Existing traffic and performance level
- Design life

2 Visual Inspection

3 Core Analysis

- Remaining life
- Desired traffic and performance level
- Desired design life
- Elevations and grade restrictions
- Etc.

4 Lab-Related Texture Tests:
- Conduct if materials or durability issues are indicated and/or
- roadway provides high level of services, especially if a bonded overlay is being considered.
- International roughness index
- Friction-related resistance tests

5 Condition Assessment Profile

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2 Visual Examination

Concrete

Asphalt / Composite

- Remaining life
- Desired traffic and performance level
- Design life
- Elevation and grade restrictions
- Etc.

Condition Profile
- Deficiencies
  - Spalling
  - Cracking
  - Discoloration
  - Joint
  - Settlement
  - Pavement thickness

General Deficiencies:
- (alligator) cracking
- Transverse cracking
- Longitudinal cracking
- Shear cracking
- Network thermal cracking
- Oxidation
- Subgrade condition

Condition Evaluation Report and Pavement Condition Rankings

Tech Center
3 Core Analysis

- Depth of distress
- Type of distress
- Verification of thickness for base/subbase
- Etc.

4 Subsurface tests

- Conduct if materials or durability issues are indicated and/or:
  - roadway provides high level of services, especially if a treated overlay is being considered.
- International roughness index
- Friction-related resistance tests

5 Condition Assessment Profile

Concrete
- Surface deficiencies
- Fracture loss
- Joint deterioration (low to medium)
- Map cracking (non-ASR)
- Popouts

Asphalt / Composite
- Surface deficiencies
- Blending/Balking
- Block cracking
- Fracture loss
- Noise

Condition Evaluation Report and Pavement Condition Rankings

Tech Center
### 4 Options

(4 depending on extent of problems)

#### 4-a. Materials-Related Tests

**Conduct if**
- materials or durability issues are indicated and/or
- roadway provides high level of service, especially if a bonded overlay is being considered.

- Petrography analysis
  - Concrete material related distress
  - Poor air void system
  - Asphalt stripping
  - Coefficient of thermal expansion

#### 4-b. Subsurface Tests

**Conduct if**
- Pavement or subgrade support issues are indicated and/or
- roadway provides high level of service, especially if a bonded overlay is being considered.

- Falling weight deflectometer tests
  - Subgrade support (K value)
  - Subgrade variability
  - Pavement properties
  - Load transfer efficiency
  - Presence of voids
  - Asphalt stiffness
  - Concrete flexural

- Subgrade tests
  - Freeze-thaw characteristics
  - Shrink-swell characteristics
  - Soil strength (dynamic cone penetration or standard penetration test)

#### 4-c. Surface Texture Tests

**Conduct if**
- materials or durability issues are indicated and/or
- roadway provides high level of service, especially if a bonded overlay is being considered.

- International roughness index
- Friction (skid resistance) tests

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#### Condition Assessment Profile

- Concrete
  - General Deficiencies
  - Joint deterioration
  - Deterioration (low to medium)
  - Deterioration (high)
  - Concrete cracking (non-ASR)
  - Concrete cracking (ASR)
  - Slab shrinkage cracks
  - Slab shrinkage cracks
  - Slab surface distress (not distress related)
  - Slab surface distress (distress related)

- Asphalt / Composite
  - General Deficiencies
  - Raveling
  - Block cracking
  - Fracture loss
  - Noise
  - Corrosion
  - Joint reflective cracking
  - Roughness (not distress related)
  - Rutting
  - Weathering/remaining
  - Shoving
  - Sippage
  - Etc.

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#### Condition Evaluation Report and Pavement Condition Rankings
## 5 Condition Assessment Profile

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</table>
Can a 2-5 in. (5.1-12.7 cm) bonded overlay design cost-effectively meet future traffic loads and design life requirements?  
Or  
Can a 4 in. (10.2 cm) or greater unbonded overlay design cost-effectively meet future traffic loads and design life requirements?  

- Can spot surface repairs and/or spot structural repairs cost-effectively solve any deficiencies, bringing the pavement to "Good Condition" before overlay is constructed?  
- Can milling the surface remove surface deficiencies cost-effectively, bringing the pavement to "Good Condition" and enhancing potential bonding before overlay is constructed?  
- Can joints in overlay be saved to match joints in the existing concrete pavement?  

- And some structural distresses  
- And/
Overlay Decision Flow Chart

Pavement Condition Rankings
(based on existing pavement conditions)

Concrete Pavement Condition

No

Any indications of potential future durability problems, such as early-age materials-related distress (MRD) or unstable conditions?

YES

Can spot repairs with an unbonded overlay cost-effectively correct existing or prevent potential unstable conditions (e.g., wet subgrade) or major deficiencies (e.g., materials-related distress, faulting, asphalt stripping, etc.)?

YES

Design Unbonded Overlay

No

Can an unbonded overlay design, with minor repairs and/or thin milling, cost-effectively meet future traffic loads and design life requirements?

YES

Can milling alone or followed by spot repairs with unbonded overlay cost-effectively remove major surface and structural deficiencies and still maintain a minimum of 3-4 inches of existing pavement to serve as base for new unbonded overlay?

No

On-site recycling and reconstruction options
- Mill or crush pavement as granular material; recycle as base or shoulder material. (Although not a mainstream approach, concrete pavements may be rubblized as long as they are uniform and the subgrade is stable enough to support the rubblization process. See page ____.)
- Place full depth concrete.
- Or
- Full-depth pavement replacement
Important Elements-Bonded Resurfacing of Concrete

• Clean Surface/Bond is important for good performance as a monolithic pavement.
• Concrete aggregate used should have thermal properties similar to that of existing pavement to minimize shear stress in bond.
• Existing joints must be in fair condition or be repaired.
• Timing of joint sawing is important.
• Matching joints with underlying pavement allows structure to move monolithically.
• Cut tranverse joints full depth +1/2” and longitudinal joints at T/2.
• Curing should be timely and adequate, especially near the edge, due to the surface-to-volume ratio and the risk of early-age cracks.
Surface Preparation for Bonded Overlay Bonding is Critical

- Shotblasting
- Milling
Cleaning the Surface to Prepare for Bonding

• Sweeping surface followed by compressed air cleaning in front of the paver.

• Air blasting or water blasting is only necessary to remove material that cannot be removed any other way.

• Water or moisture should not be on the surface prior to paving or de-bonding can occur.
Important Elements of Bonded Concrete over Asphalt/Composite

Bonded Concrete Resurfacing of Asphalt Pavements

- *previously called ultra-thin whitetopping, UTW*

  - Small square panels reduce curling, warping, & shear stresses.
  - Mill if necessary to correct crown, remove surface distresses, improve bonding. Insure to leave 3” min. HMA after milling.
  - HMA surface temperature below 120 F before paving.

Bonded Concrete Resurfacing of Composite Pavements

  - Same as Asphalt Pavements.
  - Look at HMA profile and condition for underlining PCC distress.
Milling: Bonded Overlay of Asphalt or Composite Pavements

The three main objectives of milling:

1. to remove significant surface distortions that contain soft asphalt material;

2. to reduce high spots to help ensure minimum resurfacing depth and reduce the quantity of concrete needed to fill low spots;

3. to roughen a portion of the surface to enhance bond development between the new concrete overlay and the existing asphalt. (don’t leave a thin lift)
Important Elements - Unbonded Concrete Overlay of Concrete Pavements

- Full-depth repairs are required only where structural integrity is lost at isolated spots.
- Asphalt separator layer is important to isolate unbonded overlay from underlying pavement and minimize reflective cracking.
- With heavy truck traffic, adequate drainage design
- Shorter joint spacing helps minimize curling and warping stresses.
- No need to match joints with those of the underlying concrete pavement.
Asphalt Separation Layer
Important Elements - Unbonded Concrete Resurfacing of Asphalt or Composite Pavements

• Full-depth repairs are required only where structural integrity is lost at isolated spots.

• Mill surface distortions of 2 in. or more.

• Existing pavement profile indicates isolated areas of vertical distortion in the underlying concrete that could signal movement from drainage or material-related distresses, repairs may be necessary.

• Timing of the joint sawing is important, particularly for thinner resurfacing.

• Concrete patches in the existing pavement should be separated from the overlay with a thin layer of fabric or other bond breaker; or joints should be sawed in the overlay around the concrete patch perimeter.
Important Elements - Unbonded Concrete Resurfacing of Asphalt or Composite Pavements

• Surface temperature of the asphalt layer of the existing composite pavement should be maintained below 120°F when placing overlay.

• Partial bonding between the overlay and the asphalt layer of the existing composite pavement is acceptable and may even improve load-carrying capacity.
Milling of Bonded Concrete Overlay Surface
Milling of Bonded Concrete Overlay Surface
Concrete Overlays

Payment

Furnished-
Cubic Yard

Placement-
Square Yard

NOTE: Divided payment is the most equitable and economic.
Work Zone Traffic Management

Maintenance and rehabilitation projects that involve bonded and unbonded concrete overlays require:

• Balancing safety and road use demands with cost involves evaluating the requirements and priorities of the project.
Minimize Costs

• Where possible costs can be minimized by:
  - Reducing the frequency that work zones are established
  - Reducing the length of time work zones are in place
  - Reducing the volume of traffic through the work zone (where possible)
  - Decide either close road with detours & crossover
  - Construct under traffic
Concrete Overlay Staging

• Concrete overlays can be successfully and cost-effectively constructed without closing the roadway to traffic

• A common misperception is that concrete overlay construction on two-lane roadways requires road closures

• Concrete overlays may be constructed on four-lane divided roadways without crossovers and head-to-head traffic
Michigan Strategy - All types of Overlays

Unbonded over Asphalt

- Construction of one lane at a time
- Similar to asphalt resurfacing
Michigan Factors

- Less lateral space available during this operation
  - Float operator, inspector, and paver crew need to fit within the new edge of slab and the white edge line
- Batch Truck Movements in and out of traffic
- Ride quality…..harder to obtain high numbers
- Much more time for traffic to get thru project (while paving)
- Edge drop factors
  - Vehicle Traffic is confined to outer edge
  - Potential Soft Shoulder exists at edge
  - Motorists may not be aware of shoulder situation
  - Height of overlay adds to steepness of the pre-existing side slope
Colorado

- Concrete overlay on asphalt 2-lane state highways
- Using pilot car during construction
- 24-hours a day
Colorado Strategy

- Heavily traveled truck routes with heavily rutted asphalt that has potentially driving issues

- One lane construction under traffic

- 70 miles of concrete overlay over asphalt
Concrete Bonded Overlay
US 69 in McAlester, Texas
Clearance Challenges

The primary challenges to maintaining reduced clearances are:

• Equipment Clearances:
  - Physical tracks and frame of the slip-form paving machine
  - Traditional paving controls such as use of a string line

• Adequate working area for workers

• Traffic controls for traffic in adjacent lanes

• Traffic Users (vehicles, bicycles, pedestrians, etc.)
Minimum Equipment Clearance

• The minimum clearance needed for a standard concrete paver operation is 4 ft. (1.22 m) per machine side:
  - This allows 3 ft. (0.91 m) for the paver track/worker
  - 1 ft. (0.30 m) or paver control string line
Reducing Equipment Clearance

• With adequate planning, required equipment clearances can be significantly reduced in concrete overlay projects and near-zero or zero clearances can be achieved to meet project needs.

• Some paving machine manufacturers have developed special paving machines specifically designed to execute minimum clearance projects.
Reducing Equipment Clearance

• Contractors around the country have made various modifications to standard pavers to achieve near-zero to zero (less than 1 ft) clearances.
Special Paving Considerations

- Stringline location – String was on both sides.
- This also could be done with one string and then cross slope the paver.
- Sawing – because of a thin section sawing had to be carefully watched,
- Thin section might crack early and 353% more joints to saw than normal paving.
Minimum Clearance Four Track Paver
Reducing Equipment Clearances

• When zero or near-zero clearance is required other paving control options may be used to reduce the clearance distance

• The average profiler, a movable string line, or a ski can be used in tight areas

• These methods rely on the smoothness of an existing lane for their smoothness or lack thereof
Two-Lane Highway Under Traffic

• Typically traffic control zones are kept to 0.25 mile (0.4 km) in length without the use of a pilot car

• In rural areas it is more feasible to pave longer sections, so a pilot car and flaggers are often used

• Other traffic control measures including flaggers and traffic control signals may be warranted according to jurisdictional requirements
### Standard Road Plan: Lane Closure with Flaggers and Pilot Car

**Speed Limit**

<table>
<thead>
<tr>
<th>Speed Limit</th>
<th>ADT</th>
<th>A</th>
<th>C</th>
<th>E</th>
<th>F</th>
<th>H max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 or less</td>
<td>up to 2,500</td>
<td>250'</td>
<td>40'</td>
<td>100'-200'</td>
<td>500'</td>
<td>2.5 mi.</td>
</tr>
<tr>
<td>2,500 - 5,000</td>
<td>250'</td>
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<td>more than 5,000</td>
<td>300'</td>
<td>60'</td>
<td>100'-200'</td>
<td>1000'</td>
<td>1.5 mi.</td>
</tr>
<tr>
<td>40 - 45</td>
<td>up to 2,500</td>
<td>300'</td>
<td>60'</td>
<td>100'-200'</td>
<td>700'</td>
<td>2.5 mi.</td>
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<td>80'</td>
<td>200'-300'</td>
<td>2000'</td>
<td>1.5 mi.</td>
</tr>
</tbody>
</table>

A pilot car will be required when the length of the work area exceeds one-quarter mile on primary highway projects.

1. Sign optional for ADT less than 5,000.
2. In rural areas during non-peak hours, the contractor may extend the lane closure up to 1.0 mile beyond the maximum shown in the table. Once the traffic control devices have been placed to extend the lane closure, the movement of the devices shall progress downstream until the H distance is once again within the limit shown in the table.

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**Contact Name:**
Traffic Control
Flaggers
Pilot Car
TC-282

DESIGN LIFT THICKNESSES 2" OR LESS

DESIGN LIFT THICKNESSES GREATER THAN 2" (WITH FILLET)

DESIGN LIFT THICKNESSES GREATER THAN 2" (WITHOUT FILLET)
Overlay of Two-Lane Roadway with Paved Shoulders (Conventional Paver)
Overlay of Two-Lane Roadway with Paved Shoulders (Conventional Paver)
Tiebars stapled to asphalt if overlay is < 5 in. (12.7 cm)
If ≥ 6 in. (15.2 cm) then place tiebar in the center of the overlay

Keep joint out of wheel line where possible

Sawcut joint only if joint is in the wheel path

Extend tiebar only if wheel loads are to be on concrete widening

3–6 ft (0.9–1.8 m) concrete widening unit

Pervious widen with asphalt or concrete

Bonded or Unbonded Overlay of Asphalt or Composite.
(Previously widen with asphalt or concrete. To be widen with new overlay)
Edge Drop Off Fillets

Bonded overlay 2–4 in. (5.1–10.2 cm) thick

Unbonded overlay greater than 4 in. (10.2 cm)
Colorado Overlay “6x6”
US-287

Colorado 6x6-6"  
Asphalt - 4" - Milled  
Concrete - 6" Thick - Joint Spacing 6' X 6'  
Tie Steel at Lane Lines Only – No Dowels  
Joints 1/8" Not Sealed  
Traffic < 5 Million ESAL’s of Trucks  
Cars Unlimited  
Maintenance - Leave Single Cracked Panels
Overlay of Two-Lane Pavement Widening to Three Lanes with Paved Shoulders (Conventional Paver)
Overlay of Two-Lane Pavement Widening to Three Lanes with Paved Shoulders (Conventional Paver)
Overlay of Four-Lane Roadway with Paved Shoulders (Conventional Paver)
Overlay of Four-Lane Roadway with Paved Shoulders (Conventional Paver)
THANK YOU!

Dale S. Harrington
Representing the National Concrete Pavement Technology Center
dharrington@snyder-associates.com
515-964-2020