

# Concrete Overlay Design and Construction of Bonded and Unbonded Concrete Overlays



**TERRA Innovation Series**  
**Albertville, MN**  
**July 30, 2008**



# *Why Concrete Overlays?*

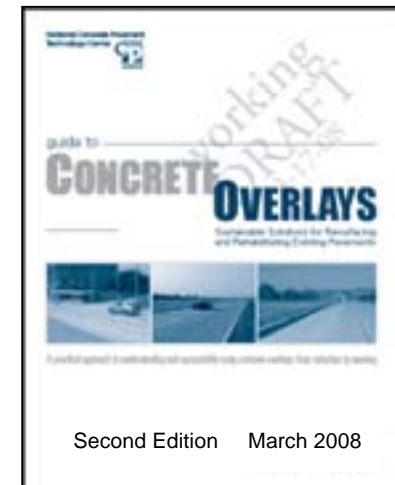
- Does not require extensive repairs of existing pavement
- Long performance
- High load-carrying capacity
- Well demonstrated/documentated maintenance and rehabilitation method
- Effective life-cycle costs



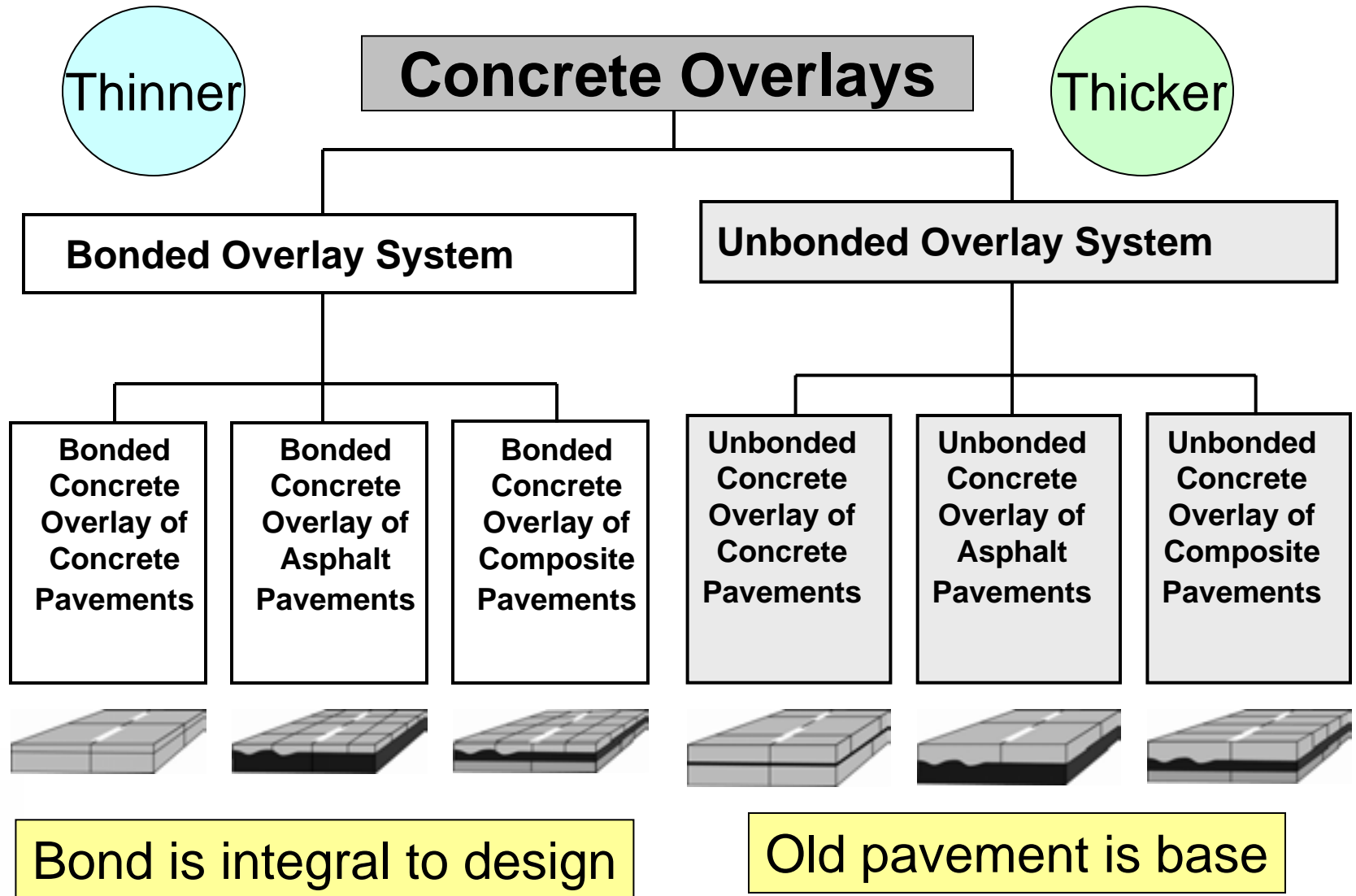
# Concrete Overlay Guide

A 75-page “Guide to Concrete Overlay Solutions”

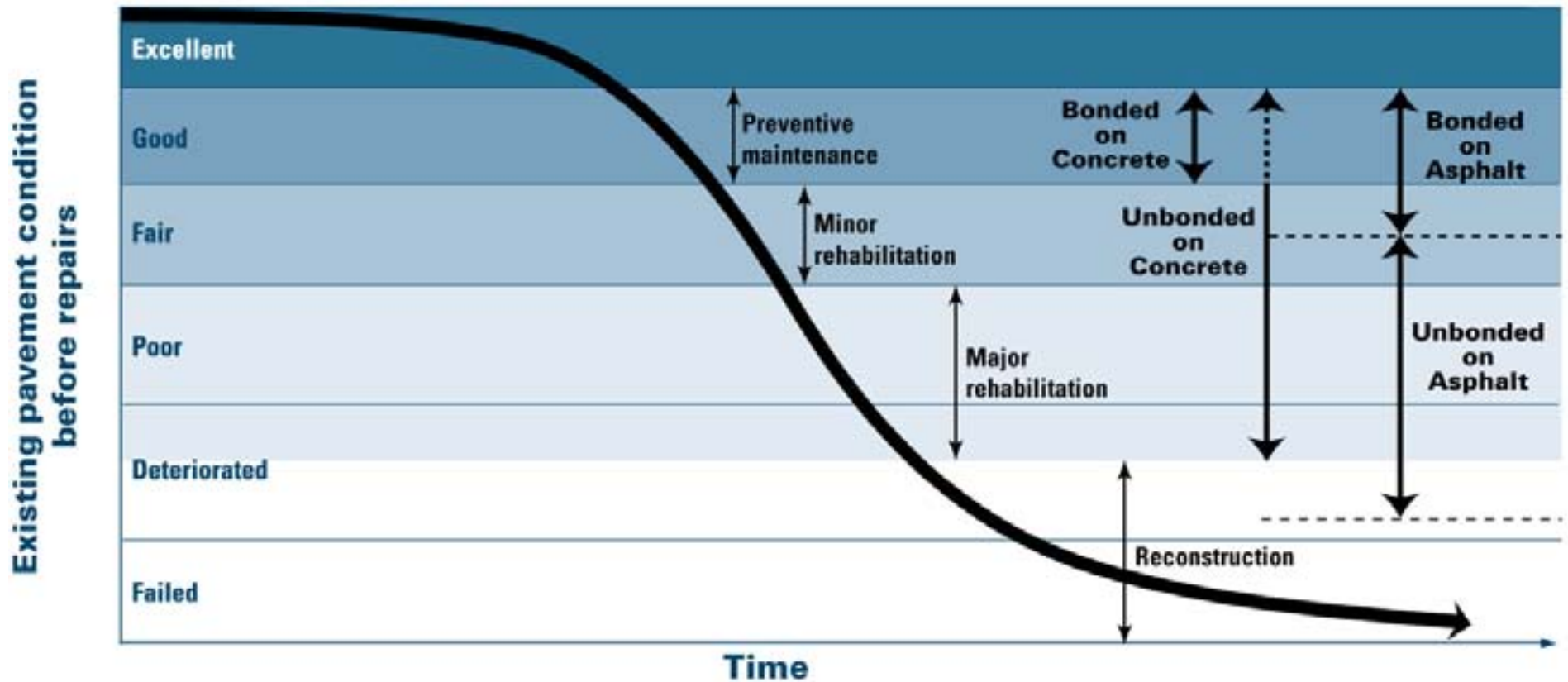
- For Field Application Program
- Overview of Overlay Families
- Overlay types and uses
- Six Overlay Summaries
- Evaluations & Selections
- Design Section
- Miscellaneous Design Details
- Overlay Materials Section
- Work Zones under Traffic
- Key Points for Overlay Construction
- Accelerated Construction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



# System of Concrete Overlays

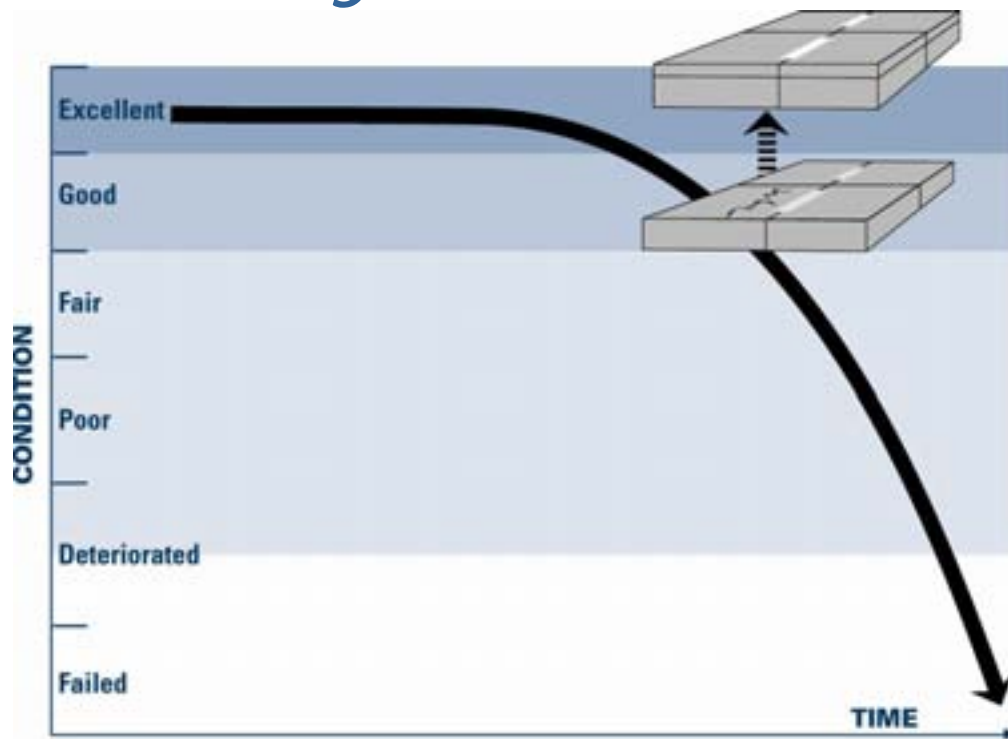


# Overlay Solutions for Rehabilitation and Maintenance



# Uses and Advantages- Bonded Overlay of Concrete

2"–5" thickness



- 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.

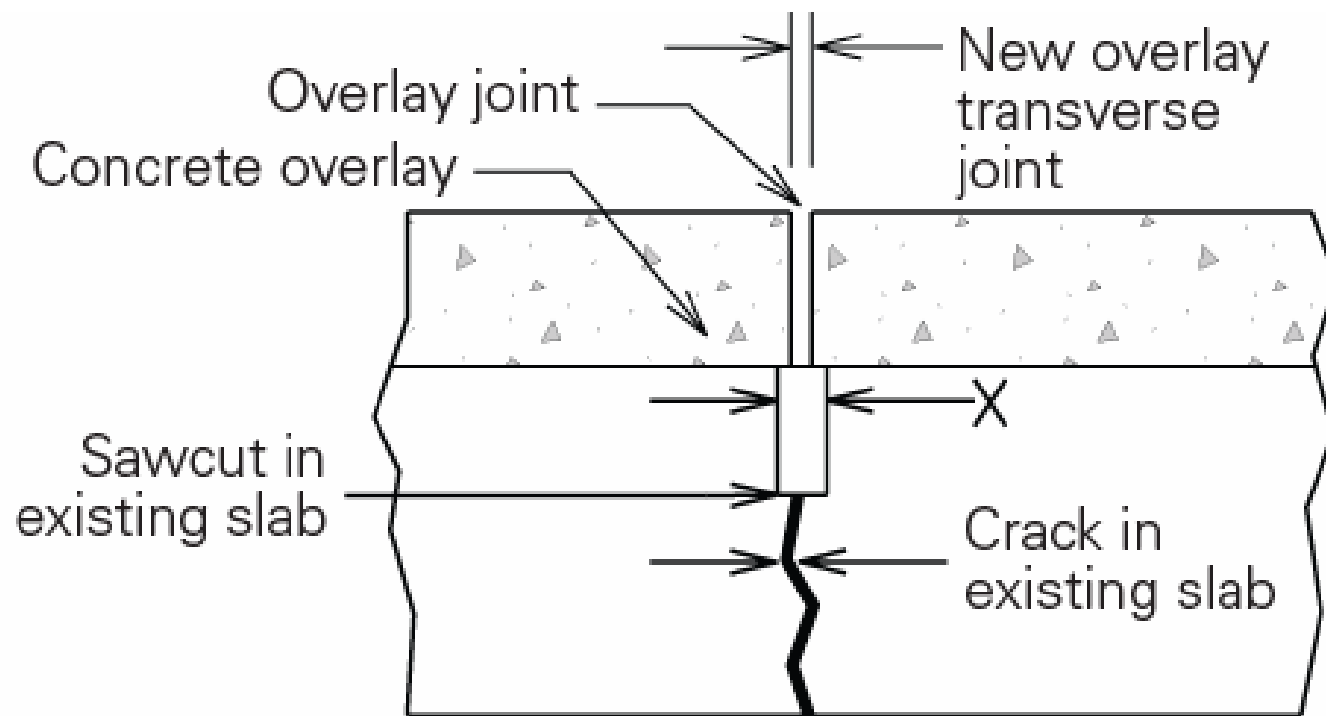


# *Surface Preparation for Bonded Overlay*

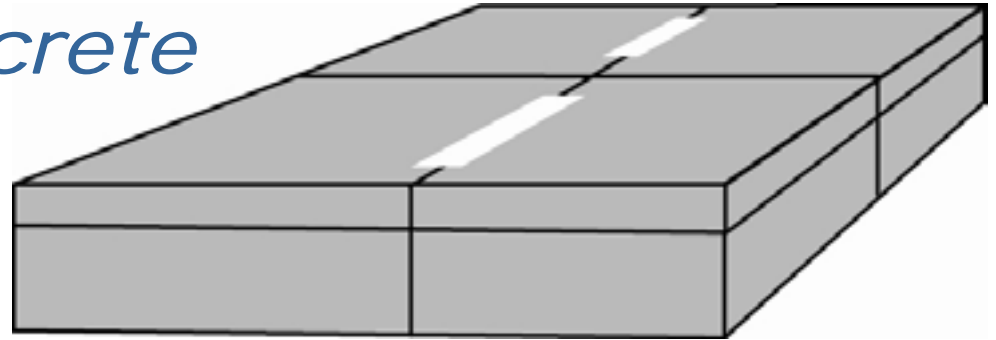
## *Bonding is Critical*

- Shotblasting
- Milling





# *Important Elements-Bonded Resurfacing of Concrete*



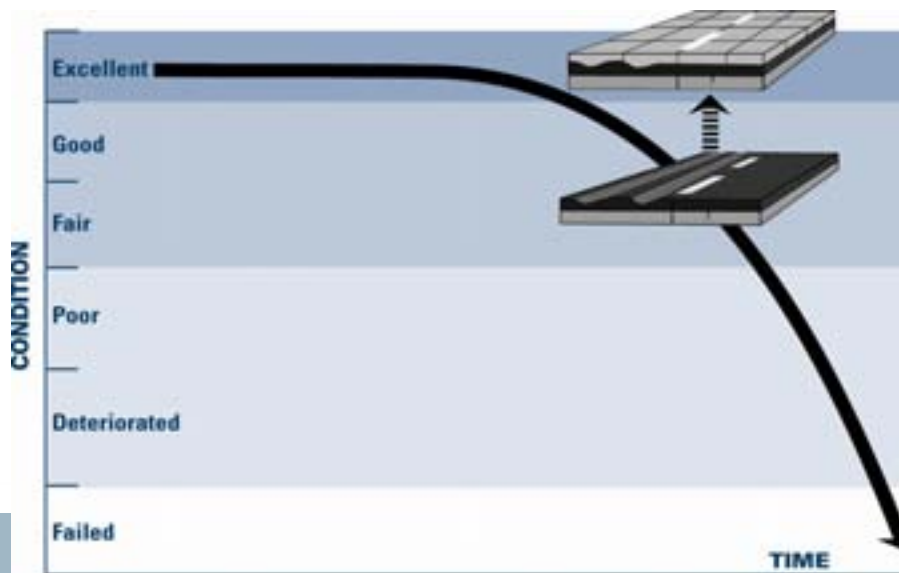
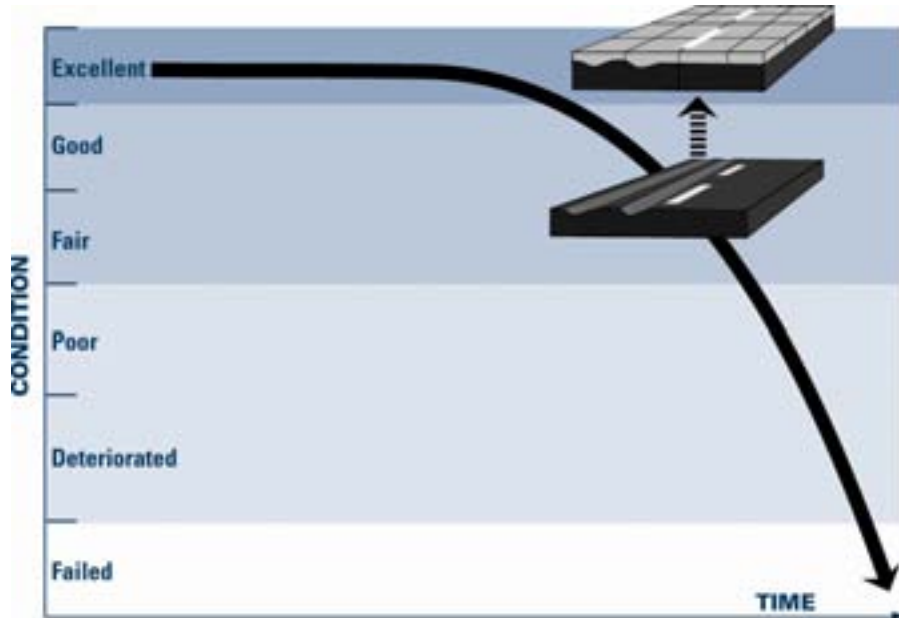
- Clean Surface/Bond is important for good performance as a monolithic pavement.
  - Concrete aggregate used should have thermal properties similar to that of existing pavement to minimize shear stress in bond.
  - Existing joints must be in fair condition or be repaired
  - Timing of joint sawing is 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.
-

# *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.



# Uses and Advantages- Bonded Overlay of Asphalt or Composite Pavements



2"–5" thickness

- Use when existing pavement is in fair or better structural condition with surface distress.
- Use to eliminate any surface defects; increase structural capacity; and improve surface friction, noise, and ride.

# *Milling: Bonded Overlay of Asphalt or Composite Pavements*

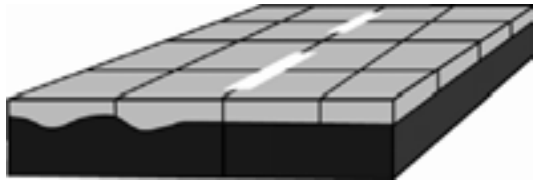
The three main objectives of milling:

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)

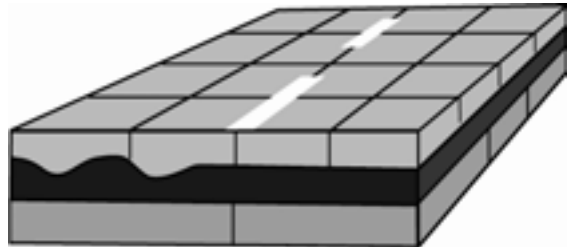


# *Important Elements of Bonded Concrete over Asphalt/Composite*

## **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.



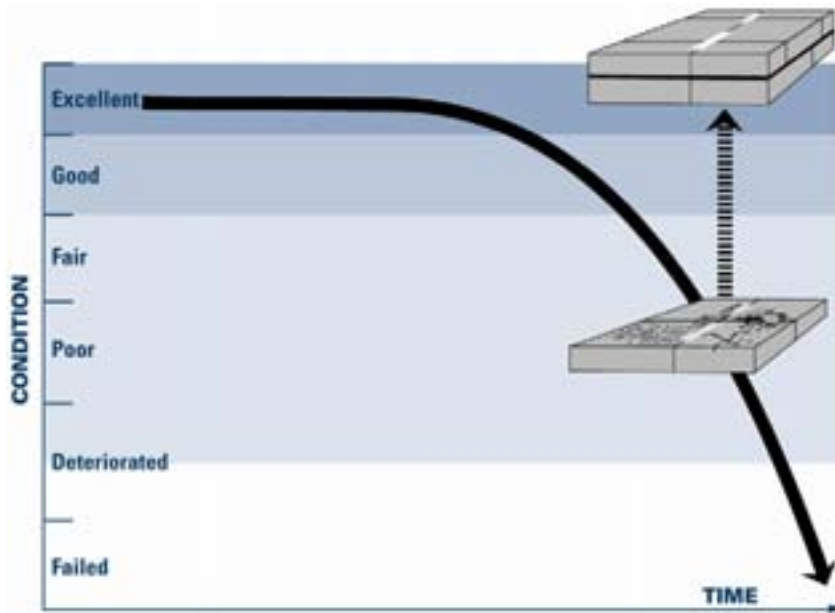
## **Bonded Concrete Resurfacing of Composite Pavements**

- Same as Asphalt Pavements.
- Look at HMA profile and condition for underlining PCC distress.



# Uses and Advantages - Unbonded Overlay of Concrete Pavements

**4" - 11" thickness**



- 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.

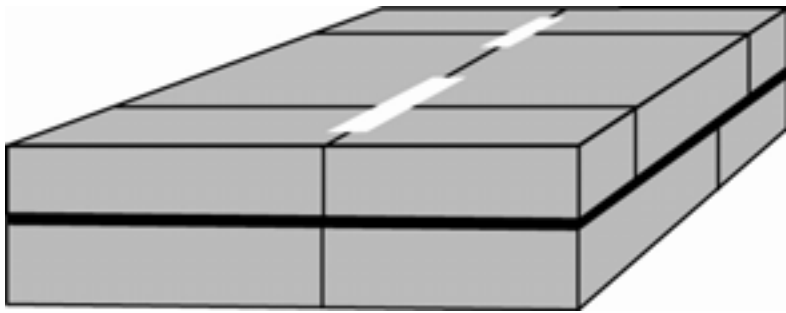
- Also results in improved surface friction, noise, and ride.



# *Asphalt Separation Layer*

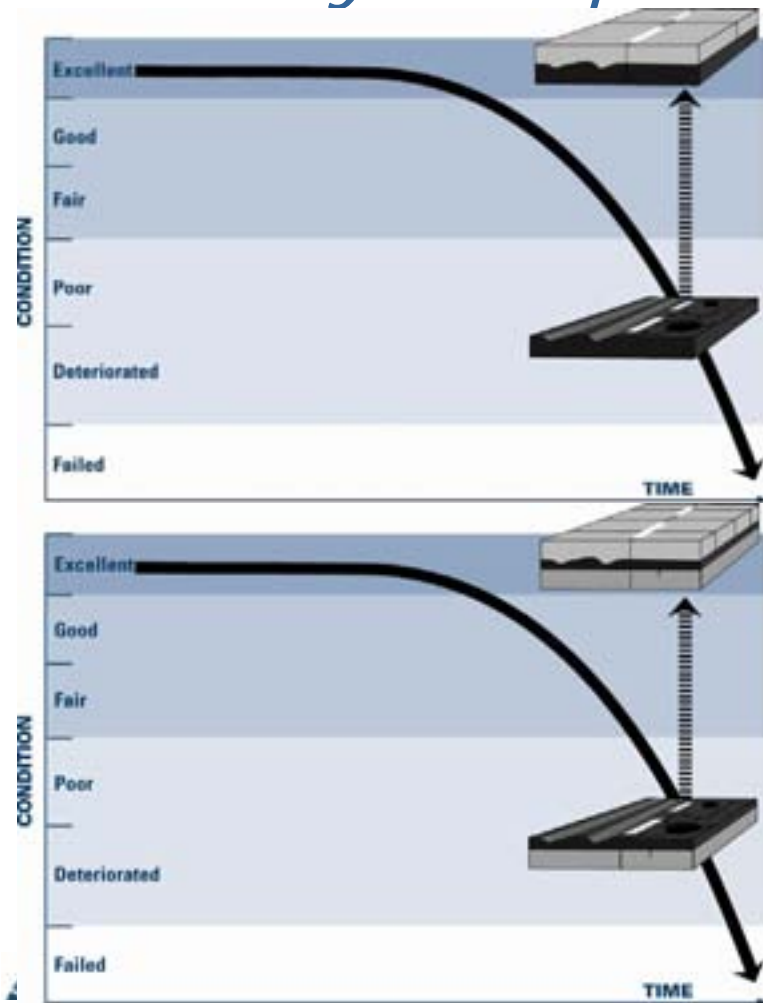


# *Important Elements - Unbonded Concrete Overlay of Concrete Pavements*



- 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 may be important to reduce pore pressure.
- Shorter joint spacing helps minimize curling and warping stresses.
- No need to match joints with those of the underlying concrete pavement.

# *Uses and Advantages - Unbonded Concrete Overlay of Asphalt or Composite Pavements*

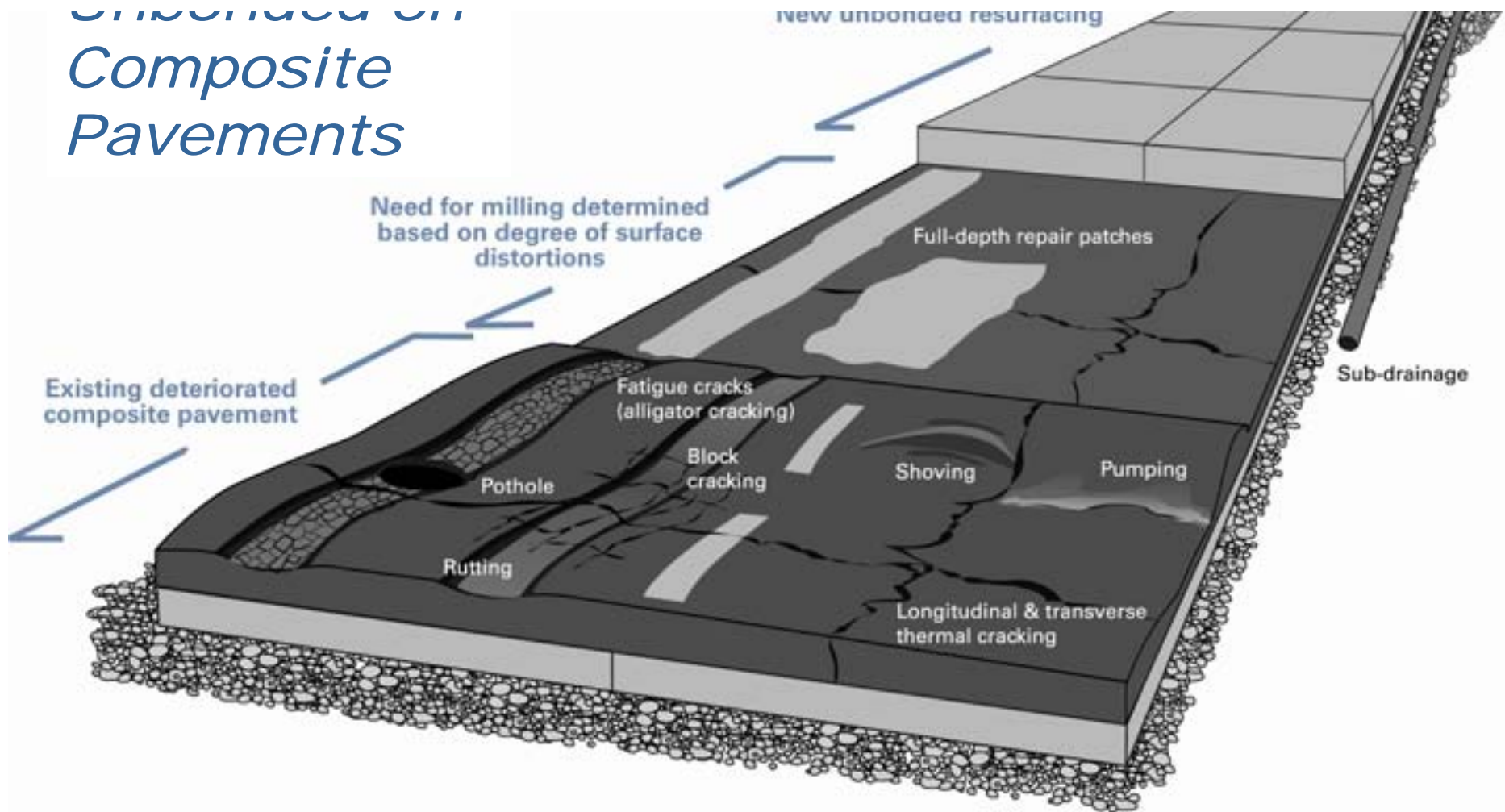


**4" - 11" thickness**

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

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

# Construction of Composite Pavements



- Tented panels with significant movement can be repaired to relieve the pressure and provide uniform support before construction of an overlay.
- Faulted panels that do not exhibit continuing movement have proven to provide adequate support for concrete overlays.
- Edge drains have also been successfully used to reduce the progression of faulting.

## *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.
- Partial bonding between the overlay and the asphalt layer of the existing composite pavement is acceptable and may even improve load-carrying capacity.
- 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.

# *Evaluations of Existing Pavements for Overlays*

- Evaluation establishes if existing pavement is a good candidate for an overlay.
  - ✓ The condition of the existing concrete pavement can be initially assessed through:
    - Visual examination of existing distresses.
    - Cores for concrete material condition
  - ✓ Can it provide an uniform and stable support system for the overlay?
    - Surface deflects can be overcome.
    - Does the condition of the pavement fit the type of overlay proposed?
    - Is the existing slab or joints moving?



# *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



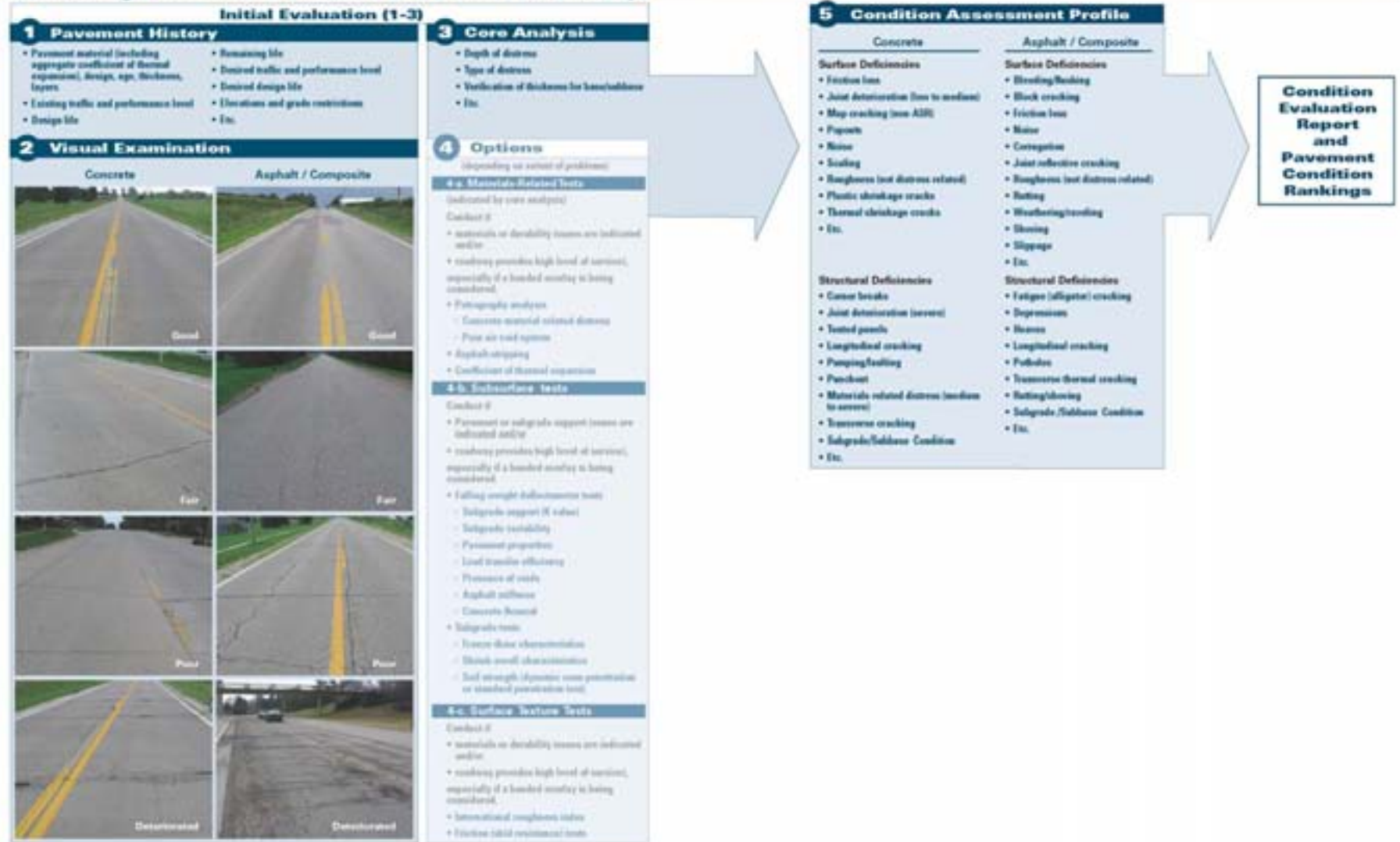
# *Pavement Evaluation*

On high-volume roads, falling weight defectometer (FWD) testing can provide subgrade k-values and variability, concrete modulus, load transfer efficiency, and presence of voids.



# Pavement Evaluation

## Evaluating Pavement Condition for Concrete Overlays



## Evaluating Pavement Condition for Concrete Overlays

**Initial Evaluation (1-3)**

**1 Pavement History**

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

**2 View**

**3 Core Analysis**

- Depth of distress
- Type of distress
- Evaluation of distresses for base condition
- Etc.

**5 Condition Assessment Profile**

Concrete	Asphalt / Composite
<b>Surface Deficiencies</b>	<b>Surface Deficiencies</b>
• Cracking (non-reflective)	• Cracking/Spalling
• Joint deterioration (non-reflective)	• Block seating
• Rutting/Tracking (non-ASB)	• Frost heave

**Condition Evaluation report and current condition ratings**

**1 Pavement History**

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



The screenshot shows a software interface with a grid of six pavement images on the left and a data table on the right. The data table includes columns for 'Location', 'Date', 'Description', and 'Status'. The 'Description' column contains text such as 'Cracking (non-reflective)', 'Joint deterioration (non-reflective)', 'Rutting/Tracking (non-ASB)', 'Cracking (reflective)', 'Joint deterioration (reflective)', 'Rutting/Tracking (ASB)', 'Cracking (ASB)', 'Joint deterioration (ASB)', 'Rutting/Tracking (ASB)', 'Cracking (ASB)', 'Joint deterioration (ASB)', and 'Rutting/Tracking (ASB)'. The 'Status' column contains values like 'Good', 'Fair', 'Poor', and 'Very Poor'.

# Evaluating Pavement Condition for

## Initial Evaluation (15-)

- ### 1 Pavement History
- Pavement material (including aggregate) and condition of existing pavement, design age, thickness, type
  - Existing traffic and performance level
  - Design life
  - Remaining life
  - Desired traffic and performance level
  - Desired design life
  - Structure and grade constraints
  - Site

### 2 Visual Examination



## 2 Visual Examination



# Evaluating Pavement Condition for Concrete Overlays



## 3 Core Analysis

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

# Evaluating Pavement Condition for Concrete

**Initial Evaluation (1-3)**

### 1 Pavement History

- Pavement material (including aggregate) coefficient of thermal expansion, design age, thickness, etc.
- Existing traffic and performance level
- Sweptable
- Designing life
- Desired traffic and performance level
- Desired design life
- Structure and grade constraints
- Slope

### 2 Visual Examination

Concrete	Asphalt / Concrete

### 3 Core Analysis

- Depth of distress
- Type of distress
- Evaluation of distress
- Etc.

### 4 Optimal

## 4 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 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

### Condition Assessment Profile

Concrete	Asphalt / Concrete
• Deflectometer	• Surface Deflectometer
• Core	• Stripping/Sealing
• Petrography (see below)	• Shrink-swell testing
• Coefficient of thermal expansion	• Freeze-thaw
• Etc.	• Seal
• Petrography	• Sealing
• Concrete material related distress	• Joint/seam testing
• Poor air void system	• Roughness (see below)
• Asphalt stripping	• Sealing
• Coefficient of thermal expansion	• Weathering/sealing
• Etc.	• Sealing
• Etc.	• Etc.
• Deflectometer	• Subgrade Deflectometer
• Core	• Freeze/thaw testing
• Petrography (see below)	• Expansion
• Coefficient of thermal expansion	• Shrink
• Etc.	• Longitudinal cracking
• Petrography	• Transverse cracking
• Concrete material related distress	• Sealing/sealing
• Poor air void system	• Subgrade (fallow) condition
• Asphalt stripping	• Etc.
• Coefficient of thermal expansion	
• Etc.	

Condition Evaluation Report and Pavement Condition Rankings



## 5 Condition Assessment Profile

### Concrete

#### Surface Deficiencies

- Friction loss
- Joint deterioration (low to medium)
- Map cracking (non-ASR)
- Popouts
- Noise
- Scaling
- Roughness (not distress related)
- Plastic shrinkage cracks
- Thermal shrinkage cracks
- Etc.

#### Structural Deficiencies

- Corner breaks
- Joint deterioration (severe)
- Tented panels
- Longitudinal cracking
- Pumping/faulting
- Punchout
- Materials-related distress (medium to severe)
- Transverse cracking
- Subgrade/Subbase Condition
- Etc.

### Asphalt / Composite

#### Surface Deficiencies

- Bleeding/flushing
- Block cracking
- Friction loss
- Noise
- Corrugation
- Joint reflective cracking
- Roughness (not distress related)
- Rutting
- Weathering/raveling
- Shoving
- Slippage
- Etc.

#### Structural Deficiencies

- Fatigue (alligator) cracking
- Depressions
- Heaves
- Longitudinal cracking
- Potholes
- Transverse thermal cracking
- Rutting/shoving
- Subgrade/Subbase Condition
- Etc.

**Condition  
Evaluation  
Report  
and  
Pavement  
Condition  
Rankings**

# Overlay Decision Flow Chart

## Pavement Condition Rankings (Based on existing pavement conditions)

### Concrete Pavement Condition

**Good (Concrete)**  
Structurally and materially sound but in need of increased structural capacity, improved ride ability or skid resistance, or removal of surface defects

### Asphalt/Composite Pavements Condition

**Good (Asphalt/Composite)**  
Structurally and materially sound but in need of increased structural capacity, improved ride ability or skid resistance, or removal of surface defects

**Fair (Concrete)**  
Structurally and materially sound but in need of surface repairs or enhancement

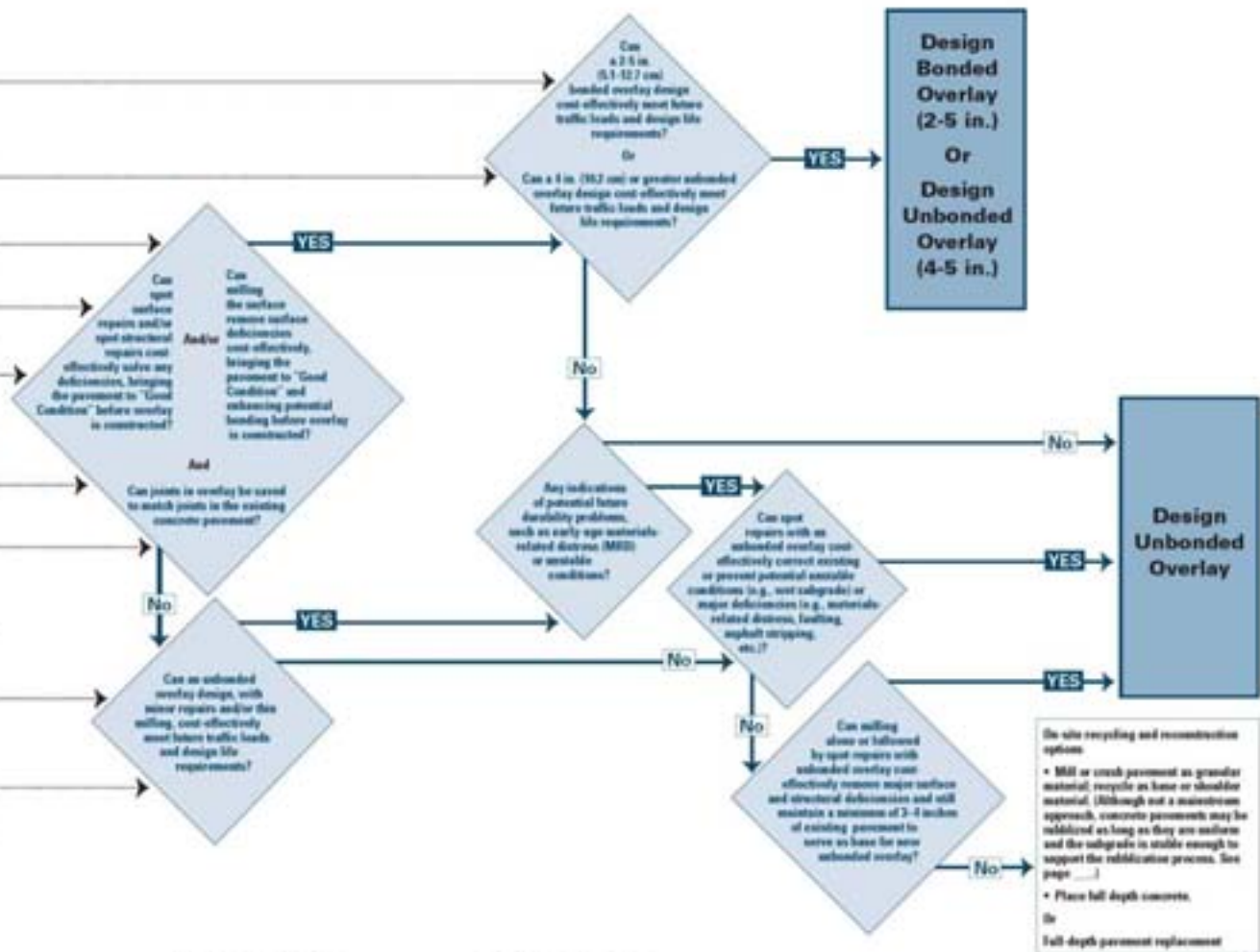
**Fair (Asphalt/Composite)**  
Structurally and materially sound but has surface distresses such as rutting, shoving, slippage, or thermal cracking

**Poor (Concrete)**  
Has measurable surface distresses and exhibits some structural, material, and/or other durability related deterioration

**Poor (Asphalt/Composite)**  
Has measurable surface distresses such as severe rutting, shoving, slippage, blow and cracking, and exhibits some structural deterioration

**Deteriorated (Concrete)**  
Exhibits significant deterioration, including structural, material, and/or other durability related distresses

**Deteriorated (Asphalt/Composite)**  
Exhibits significant surface deterioration and some structural distresses



**On-site recycling and reconstruction options**

- Mill or crush pavement as granular material, recycle as base or shoulder material. (Although not a maintenance approach, concrete pavements may be rehabilitated as long as they are uniform and the subgrade is stable enough to support the rehabilitation process. See page ...)
- Place full depth concrete.
- Or
- Full depth pavement replacement

# Overlay Decision Flow Chart

## Pavement Condition Rankings (based on existing pavement conditions)

### Overlay Decision Flow Chart

#### Pavement Condition

Based on existing pavement conditions

#### Concrete Pavement Conditions



#### Concrete Pavement Condition

**Good (Concrete)**  
Structurally and materially sound but in need of increased structural capacity, improved ride-ability or skid resistance, or removal of surface defects.

#### Asphalt/Composite Pavements Condition

**Good (Asphalt/Composite)**  
Structurally and materially sound but in need of increased structural capacity, improved ride-ability or skid resistance, or removal of surface defects.

**Fair (Concrete)**  
Structurally and materially sound but in need of surface repairs or enhancement.

**Fair (Asphalt/Composite)**  
Structurally and materially sound but has surface distress such as rutting, shoving, slippage, or thermal cracking.

**Poor (Concrete)**  
Has measurable surface distresses and exhibits some structural, material, and/or other durability-related deterioration.

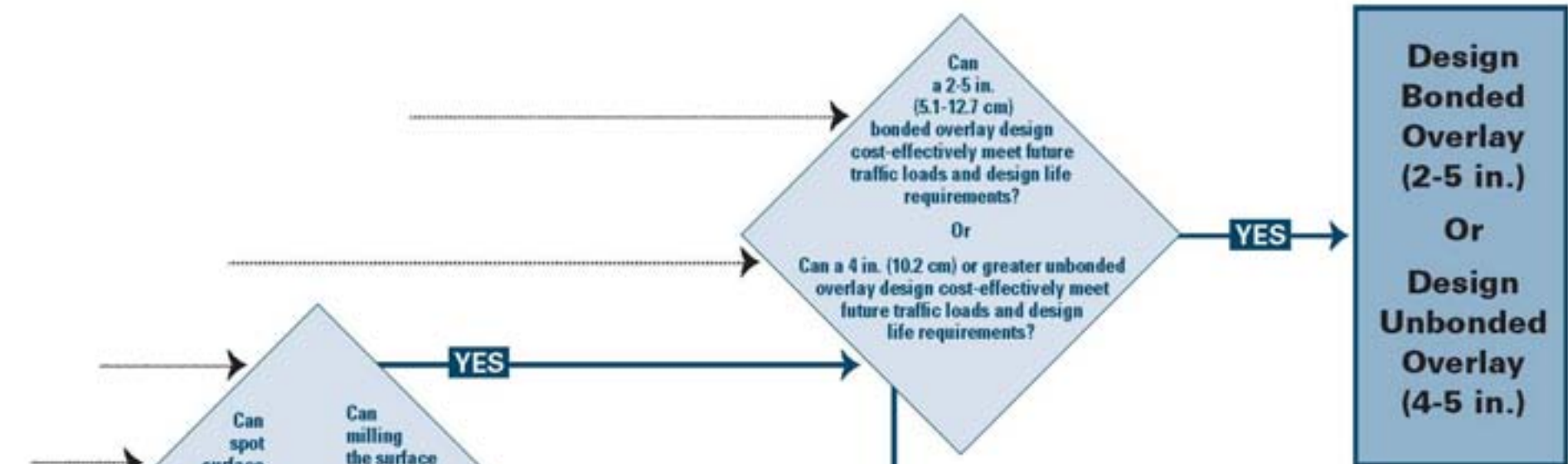
**Poor (Asphalt/Composite)**  
Has measurable surface distresses such as severe rutting, shoving, slippage, thermal cracking, and exhibits some structural deterioration.

**Deteriorated (Concrete)**  
Exhibits significant deterioration, including structural, material, and/or other durability-related distresses.

**Deteriorated (Asphalt/Composite)**  
Exhibits significant surface deterioration and some structural distresses.



Guide to Concrete Overlay



# Overlay Decision Flow Chart

## Pavement Condition Rankings

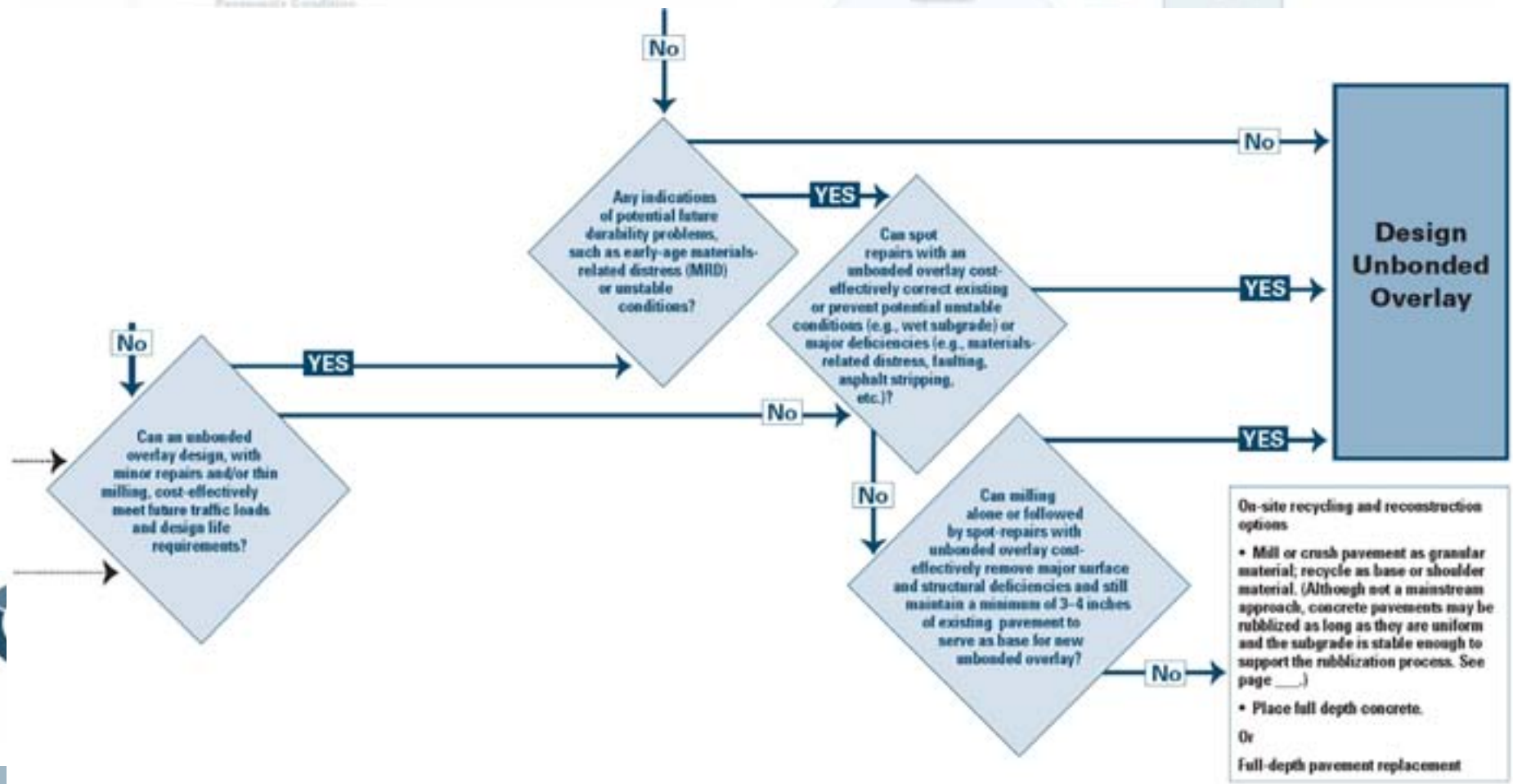
(Based on existing pavement conditions)

### Concrete Pavement Conditions

#### Good Condition

Structurally and aesthetically sound with no need of increased structural capacity, repaired into utility or other functions, or removal of surface distress

### Asphalt/Composite Pavement Conditions



**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

# *Milling of Bonded Concrete Overlay Surface*



## *Milling of Bonded Concrete Overlay Surface*



**THANK YOU!**

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