How to Select the Appropriate Pavement Rehabilitation Option

David Rettner, PE
American Engineering Testing, Inc.

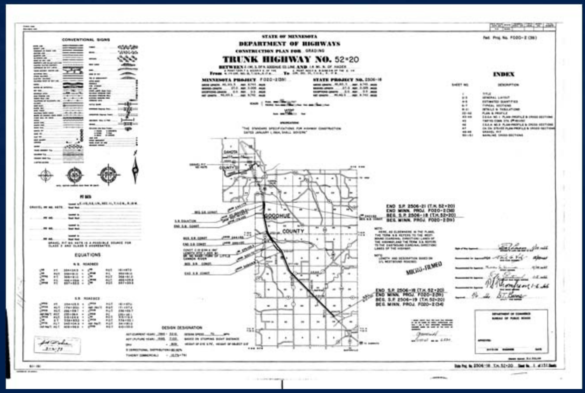
Pavement Rehabilitation Selection
Understanding the Problem

Pavement Assessment

- Pavement assessment is the first step in making good decisions.
- The condition of the existing pavement is assessed through:
  - Pavement History
  - Pavement Condition/Distress Survey
  - Pavement Strength Evaluation
  - Surface, Base and Subgrade Analysis
  - Surface and Subsurface Drainage Review
  - Others?

Pavement Assessment
Pavement History

- Historic or existing information for the pavement should be gathered and assessed, including:
  - Original design information
  - As-built/constructed data
  - Quality Control/Quality Assurance construction data
  - Pavement Management System (PMS) data
  - Maintenance activity records



Pavement Assessment
Pavement Condition/Distress Survey

- What is a pavement condition survey?
  - A detailed visual inspection which rates all of the surface irregularities, flaws and imperfections found in a given area
  - A link to key insights into the causes of deterioration
  - Project level versus network level

Pavement Assessment
Pavement Condition/Distress Survey

Bituminous Pavement Distresses

Pavement Assessment

Pavement Condition/Distress Survey

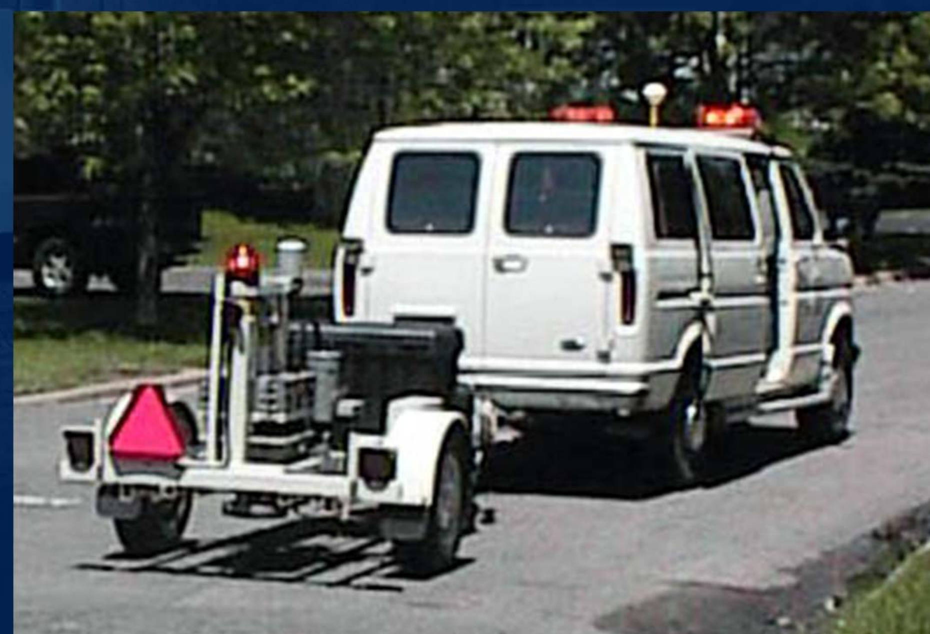
Concrete Pavement Distresses

Pavement Assessment
Pavement Strength Evaluation

- Evaluation of the structural capacity of an existing pavement can be determined by destructive or non-destructive methods
  - Non-destructive testing methods include Falling Weight Deflectometer (FWD), Ground Penetrating Radar (GPR) and Dynamic Cone Penetrometer (DCP)
  - Proof-rolling – granular surfaces only
  - Destructive testing methods include soil borings, probe holes, test pits and coring

Pavement Assessment
Pavement Strength Evaluation

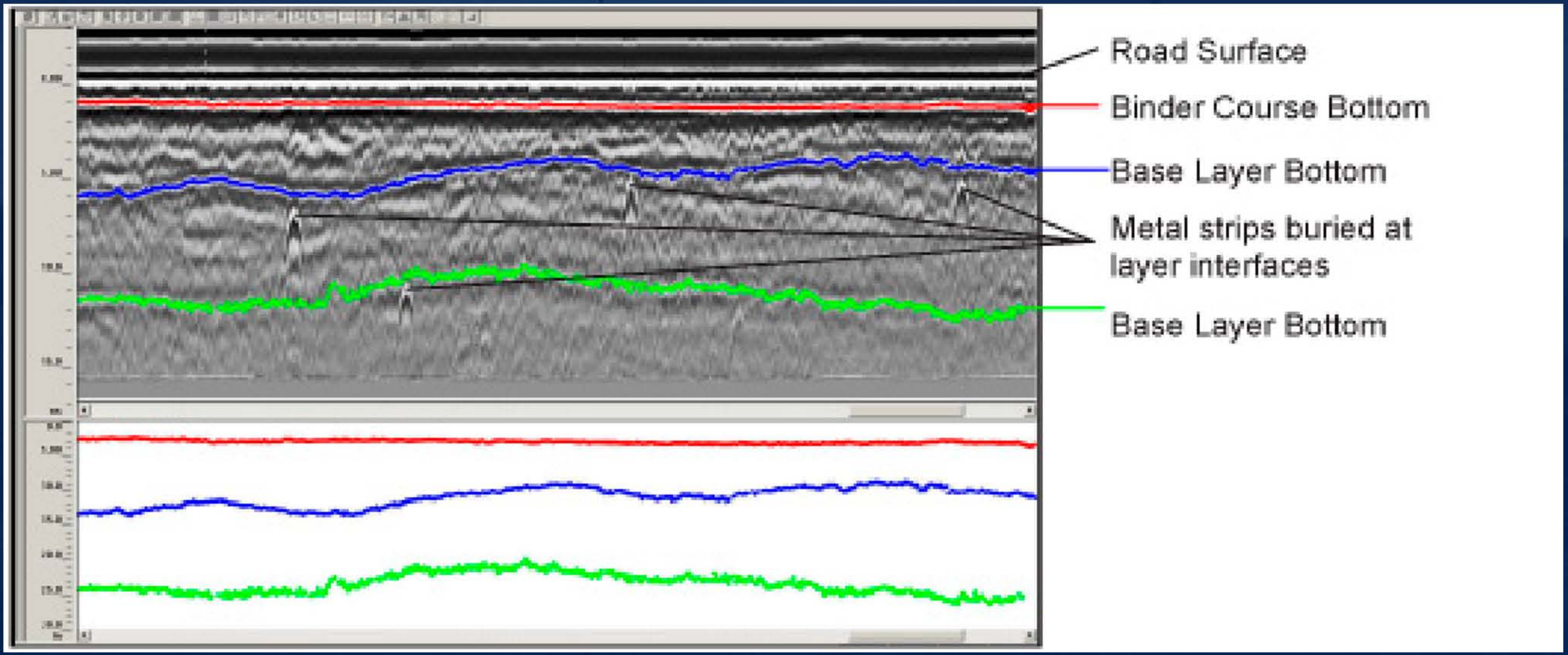
- FWD Testing
  - Data used to calculate pavement strength, capacity and remaining life



Pavement Assessment
Pavement Strength Evaluation

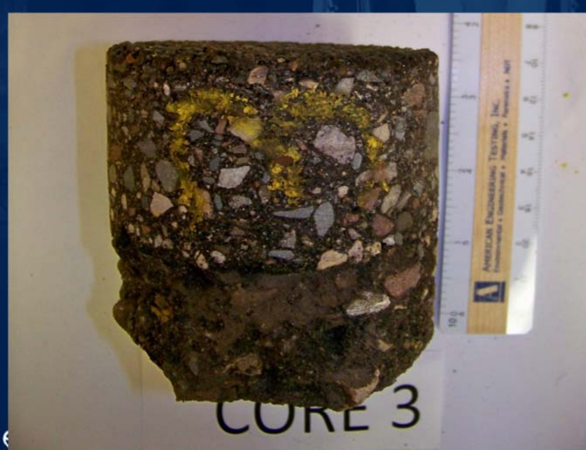
- Ground Penetrating Radar (GPR) Data
  - Provides a “picture” of pavement structure
  - Used for FWD Analysis

Pavement Assessment
Pavement Strength Evaluation




Pavement Assessment
Pavement Strength Evaluation

- Coring Data
  - Pavement layers (surface, base and sub-base) are measured, classified and photographed
  - Asphalt cores are measured and analyzed for stripping/segregation
  - Data used to calibrate GPR data

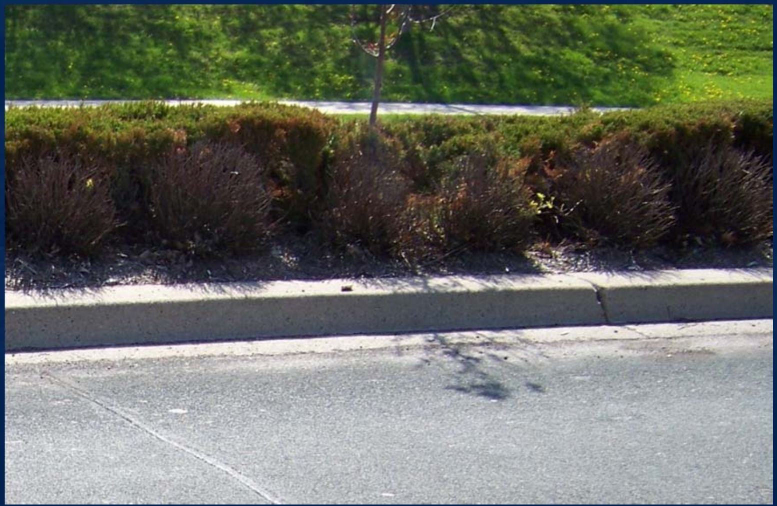


Pavement Assessment
Surface, Base and Subgrade Analysis

- Coring
  - Determination of pavement thickness, layering, condition of each layer, bonding between layers, presence of materials related to distress and strength
- Soil Borings/GPR
  - Thickness, type or classification, moisture content, contamination, strength determination

Pavement Assessment
Surface and Subsurface Drainage Review

- Visual inspection for presence of:
  - – Curb and gutter
  - – Ditches
  - – Subsurface drainage installed
    - Is it working?
- Soil borings:
  - – Base material type
  - – Subgrade material type



Pavement and Materials Assessment Approximate Costs

- Coring - $1,000 to $1,500 (per project < 2 miles)
- Soil / pavement borings ~$1,000 (per mile)
- FWD w/ analysis - $1,000 to $3,000 (per project < 2 miles)
- Sampling & subgrade testing - $1,500 (per project < 2 miles)
- DCP - equipment costs $1,500 (per project < 2 miles)

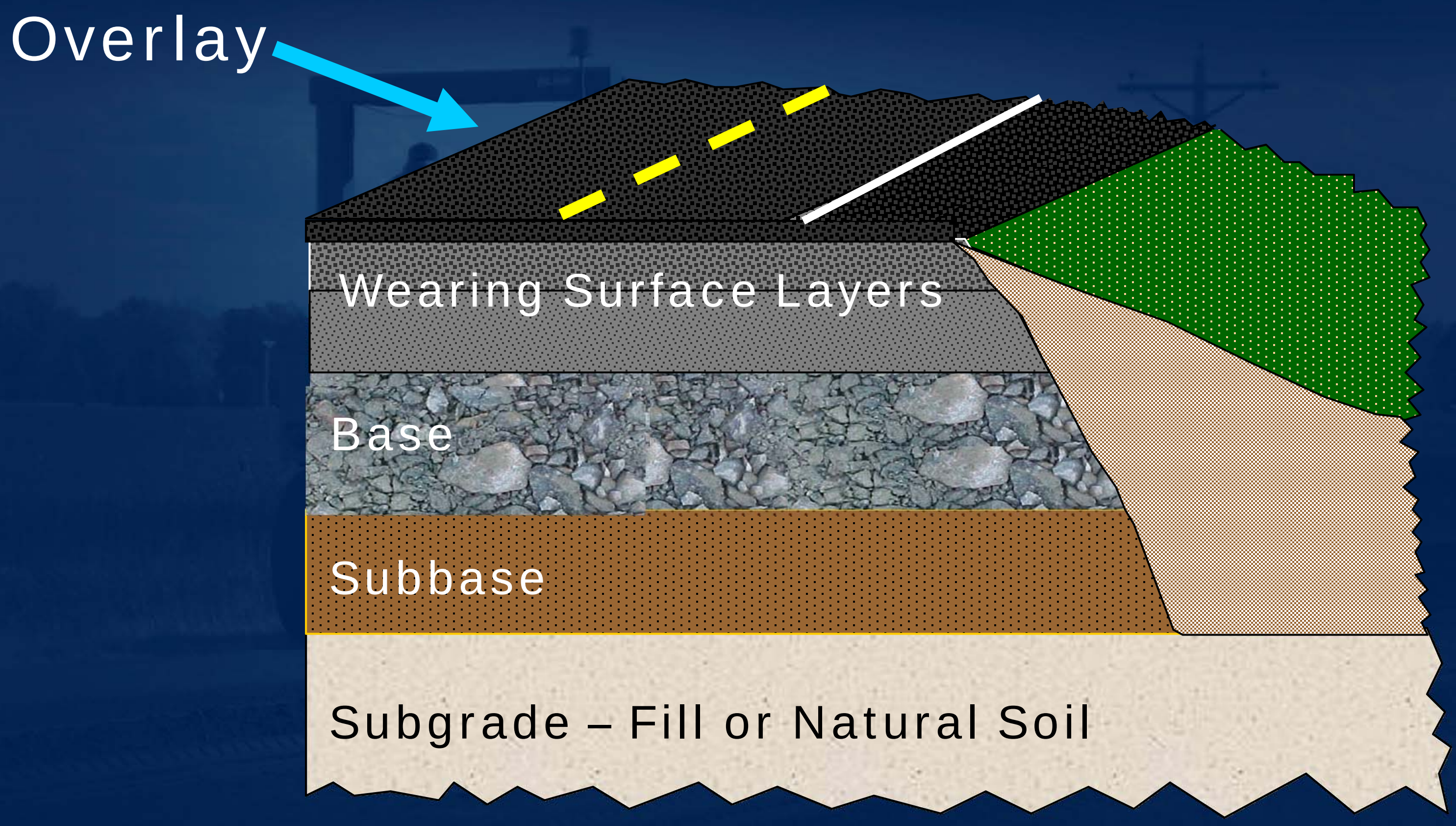
Costs will vary depending on many factors, especially mobilization and traffic control

Pavement Rehabilitation Selection
Choosing Rehabilitation Techniques

Bituminous Pavement Rehabilitation Techniques

- Overlays
  - Bituminous
  - Concrete
  - Mill and Overlay
  - Mill and Inlay
- Recycling Options
  - Cold In-place Recycling
  - Full-Depth Reclamation
    - Pulverization
    - Stabilization – including subgrade stabilization

Overlays


Overlay
Wearing Surface Layers
Base
Subbase
Subgrade – Fill or Natural Soil

Overlays

What is an Overlay?

- Placement of a new course of pavement on the remaining pavement structure
  - Bituminous or Concrete
  - Mill and Overlay/Inlay

Bituminous over Bituminous Overlays
What is a BOB Overlay?

- A new bituminous surface is paved over an existing bituminous pavement.
- Can be a non-structural or structural overlay:
  - Non-structural overlay
    - Generally used as a short-term fix
  - Structural overlay
    - Thicker mat that will increase pavement strength

Bituminous over Bituminous Overlays
Fundamentals of BOB Overlays

- Direct Placement or Milling
  - Direct placement when all the following are true:
    - Additional structure is necessary
    - No issues with existing pavement materials
    - No vertical limitations
  - Mill when one or more of the following is true:
    - Adequate structure in existing pavement
    - Problems with existing pavement materials
    - Vertical limitations exist

Bituminous over Bituminous Overlays Applications for Non-structural BOB Overlays

- Good Candidates include pavements with:
  - Good subgrade, base and cross-section
  - Adequate strength
  - Where a short term fix is acceptable
- Poor Candidates include pavements with:
  - Poor subgrade and/or base support
  - Significant surface distresses

Bituminous over Bituminous Overlays
Applications for Structural BOB Overlays

- Good Candidates include pavements with:
  - Good subgrade and base, but inadequate thickness
  - Marginal structure, but cannot be closed to traffic
- Poor Candidates include pavements with:
  - Poor subgrade and/or base support that cannot be overcome with a thick overlay
  - Frost issues

Concrete over Bituminous Overlays
What is a COB Overlay?

- A new concrete surface is paved over an existing bituminous pavement
- Typically used as an unbonded overlay (≥4”)
- Can be bonded or unbonded
  - For unbonded overlays, degree of bond is not considered in design

Concrete over Bituminous Overlays
Fundamentals of COB Overlays

1. Pavement Evaluation
2. Resurfacing Design
   - Resurfacing Thickness
     - Typically 6 – 11 inches on high volume roads
     - Minimum of 4 inches on low volume roads
   - Mixture Design
   - Joint Design
   - Drainage Design
   - Edge support considerations

Unbonded resurfacing thickness	Maximum transverse joint spacing
< 5 in. (12.7 cm)	6 x 6 ft (1.8 x 1.8 m) panels
5–7 in. (12.7–17.8 cm)	Spacing in feet = 2 times thickness in inches
> 7 in. (17.8 cm)	15 ft (4.6 m)

Concrete over Bituminous Overlays
Considerations for COB Overlays

- Original roadway width
- Vertical clearance
- Number of culverts and bridges
- Drainage
- Materials
- Schedule
- Traffic

Concrete over Bituminous Overlays

Applications for COB Overlays

- Good Candidates include pavements with:
  - Adequate subgrade support, but inadequate pavement structure
- Poor Candidates include pavements with:
  - Vertical geometry restrictions
  - Significant frost issues
  - Cannot be closed to traffic

Mill and Overlay

- Generally used with vertical restrictions or to correct severe surface defects
- Mill and overlay may increase the overall pavement height slightly
  - i.e. Mill 3”, Overlay 4”

Mill and Inlay

- Also used with vertical restrictions or to correct severe surface defects
- Maintains the same overall pavement height
  - i.e. Mill 3”, Overlay 3”
- Keep existing shoulders and/or curb

Recycling
FHWA - 2002 Recycled Materials Policy

- Recycled materials should get first consideration in materials selection
  - Recycling $\Rightarrow$ engineering, economic & environmental benefits
  - Review engineering & environmental suitability
  - Assess economic benefits
  - Remove restrictions prohibiting use of recycled materials without technical basis

U.S. Department of Transportation
Federal Highway Administration

Recycling
Why Recycle?

- Improve serviceability of aged, deteriorated pavements
- Reduce raw material costs
- Level deformations & re-establish crowns
- Retain overhead clearances

Recycling
Why Recycle (Cont)?

- Minimize lane closure time, user delays
- Public acceptance of recycling
- Recycled pavement can be recycled itself

Recycling
When to Recycle?

- Pavement at end of its serviceable life
  - Fatigue (alligator) cracking
- Oxidized
- Raveling of thermal cracks - potholes
- Low clearances under bridges

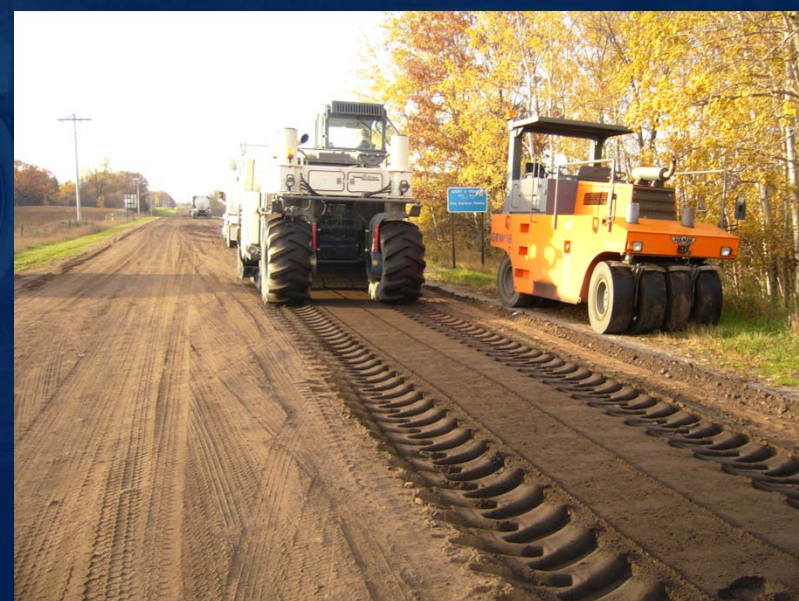
Recycling Options
Bituminous

- Mill, haul and recycle at HMA plant
- Cold In-place Recycle (CIR)
  - Conventional
  - Engineered
- Hot In-place Recycle (HIR)
- Full Depth Reclamation (FDR)
  - Pulverization
  - Stabilization

In-place Recycling
Bituminous Recycling Options

Cold In-Place Recycling

Full Depth Reclamation

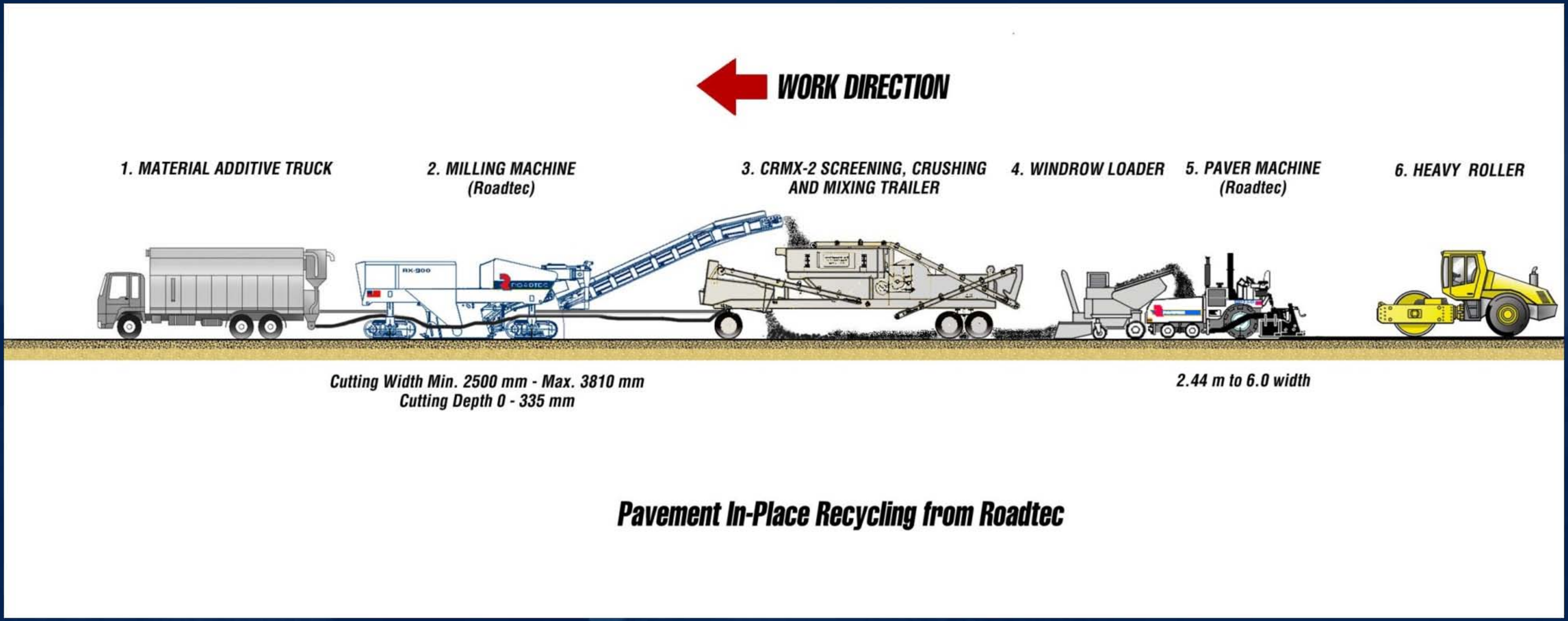


Cold In-place Recycling (CIR)

Cold In-place Recycling (CIR)
What is Cold In-place Recycling?

- CIR is the on-site rehabilitation of asphalt pavements without the application of heat during recycling.
- CIR interrupts the existing crack pattern and produces a crack-free layer for the new wearing course.

Cold In-place Recycling (CIR)
The Train Machine Concept



Used when the Engineer's design requires milled material needs to be screened, be of a uniform size and fully mixed in a pugmill

Cold In-place Recycling (CIR)

Fundamentals of CIR

- Analyze existing structure & conditions
  - Understand causes for distress
- Correct any drainage or base problems
- Two options:
  - Conventional
  - Engineered design process

Cold In-place Recycling (CIR)

Fundamentals of CIR

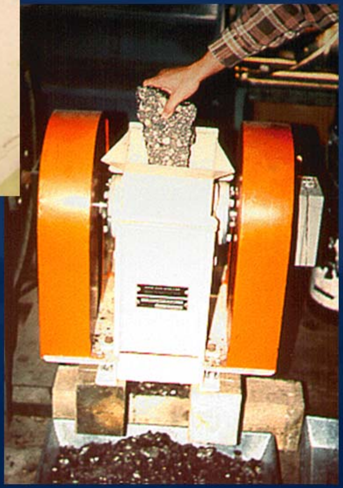
Comparison of Conventional and Engineered CIR

- Conventional
  - No mix design
    - 2% Emulsion
  - QC requirements
    - Two gradations per day
    - 100% passing 1-1/2”
    - 90-100% passing 1”
    - Control strip
- Engineered
  - Defined sampling protocol
  - Engineered design
  - Performance-related specs
  - Early strength & long term durability

Cold In-place Recycling (CIR)

Fundamentals of CIR

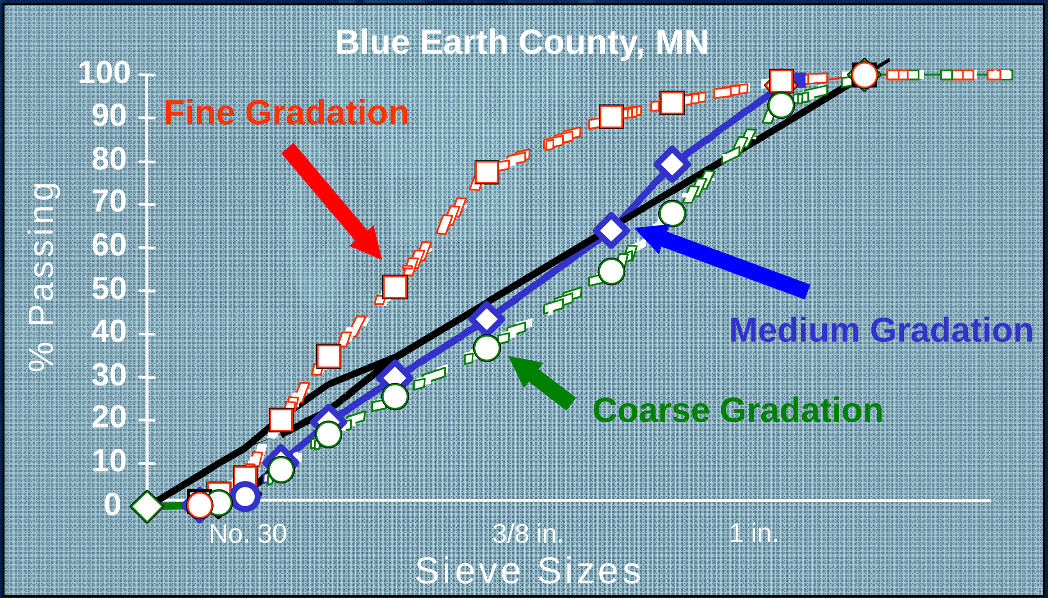
- Mix design
  - Reclaimed Asphalt Pavement (RAP) crushed to defined gradations
  - Emulsion formulated
  - Superpave Gyratory Compactor (SGC) mixes at field moisture content
- Performance-related tests



Cold In-place Recycling (CIR)
Mix Design

RAP/Base Analysis

- Foamed Asphalt, Engineered Emulsion and Fly Ash
  - Field cores crushed to 3 gradation bands
  - A design made for at least 2 gradations



Cold In-place Recycling (CIR)
Environmental Benefits of CIR

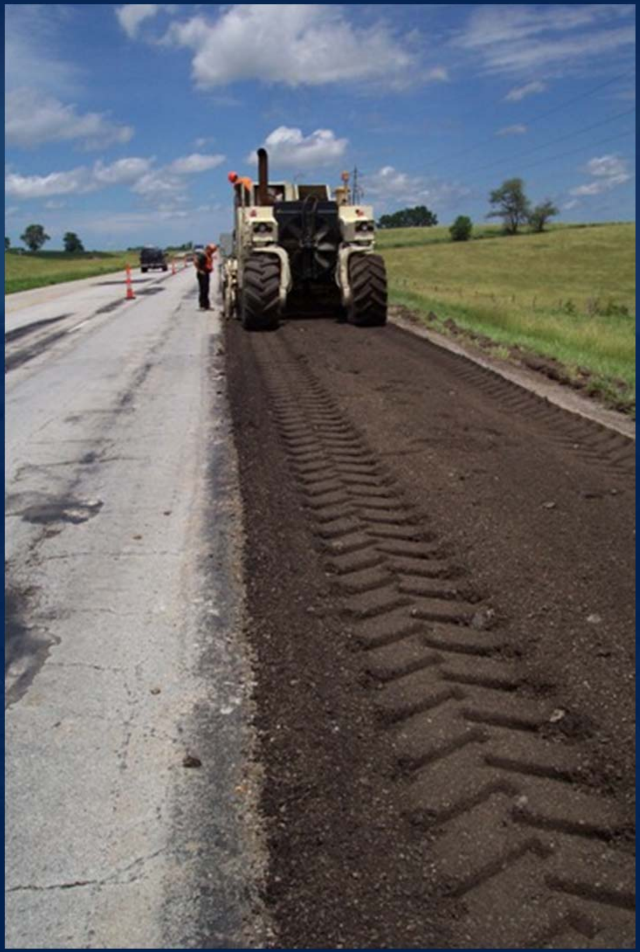
- No heat is used during the process thereby reducing the use of fossil fuels and also reducing air pollution.
- Since the existing aggregate and asphalt cement is reused, the need for virgin aggregate and asphalt cement are reduced or eliminated.
- 40% to 50% energy savings can be achieved using this process versus conventional approaches

Cold In-place Recycling (CIR)

Applications for CIR

- Good candidates include pavement with:
  - At least 4” of hot mix
  - Adequate base and subgrade
  - Severe pavement distresses
- Poor candidates include pavements with:
  - Inadequate base or subgrade support
  - Inadequate drainage
  - Paving fabrics or inter-layers

Full Depth Reclamation (FDR)



Full Depth Reclamation (FDR)

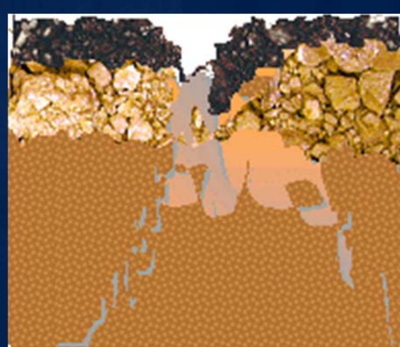
What is FDR?

- The full thickness of the asphalt pavement and a predetermined portion of the base, subbase and/or subgrade is uniformly pulverized and blended to provide a homogeneous material.
- If new material is not a sufficient base for a new surface course, the reclaimed materials are stabilized by mechanical, chemical or bituminous means.

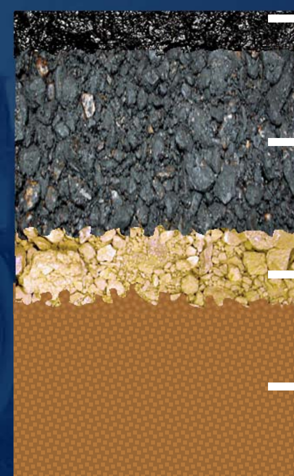
Full Depth Reclamation (FDR)

What is FDR?

Bituminous pavement needing repair

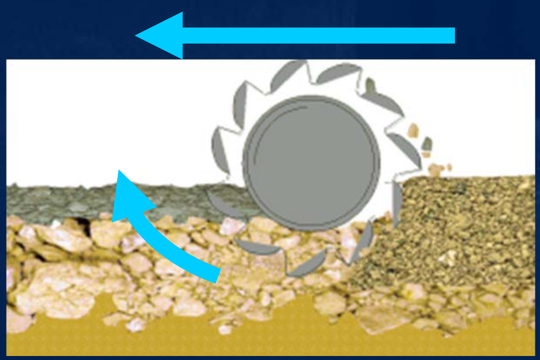


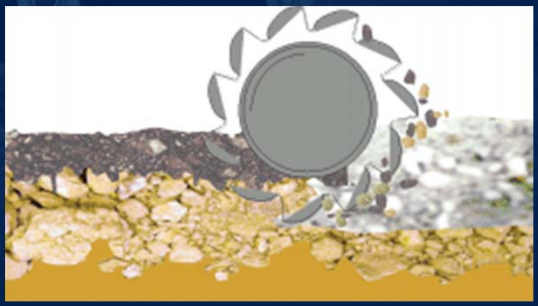
FDR Example

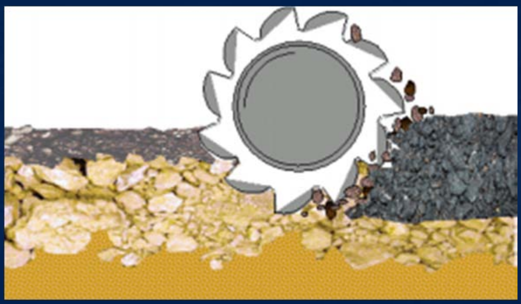


Full Depth Reclamation (FDR)
Types of FDR

- **Mechanical stabilization** - FDR without addition of binder (Pulverization)
- **Chemical stabilization** - FDR with chemical additive (Calcium or Magnesium Chloride, Lime, Fly Ash, Kiln Dust, Portland Cement, etc.)
- **Bituminous stabilization** - FDR with asphalt emulsion, emulsified recycling agent, or foamed/expanded asphalt additive

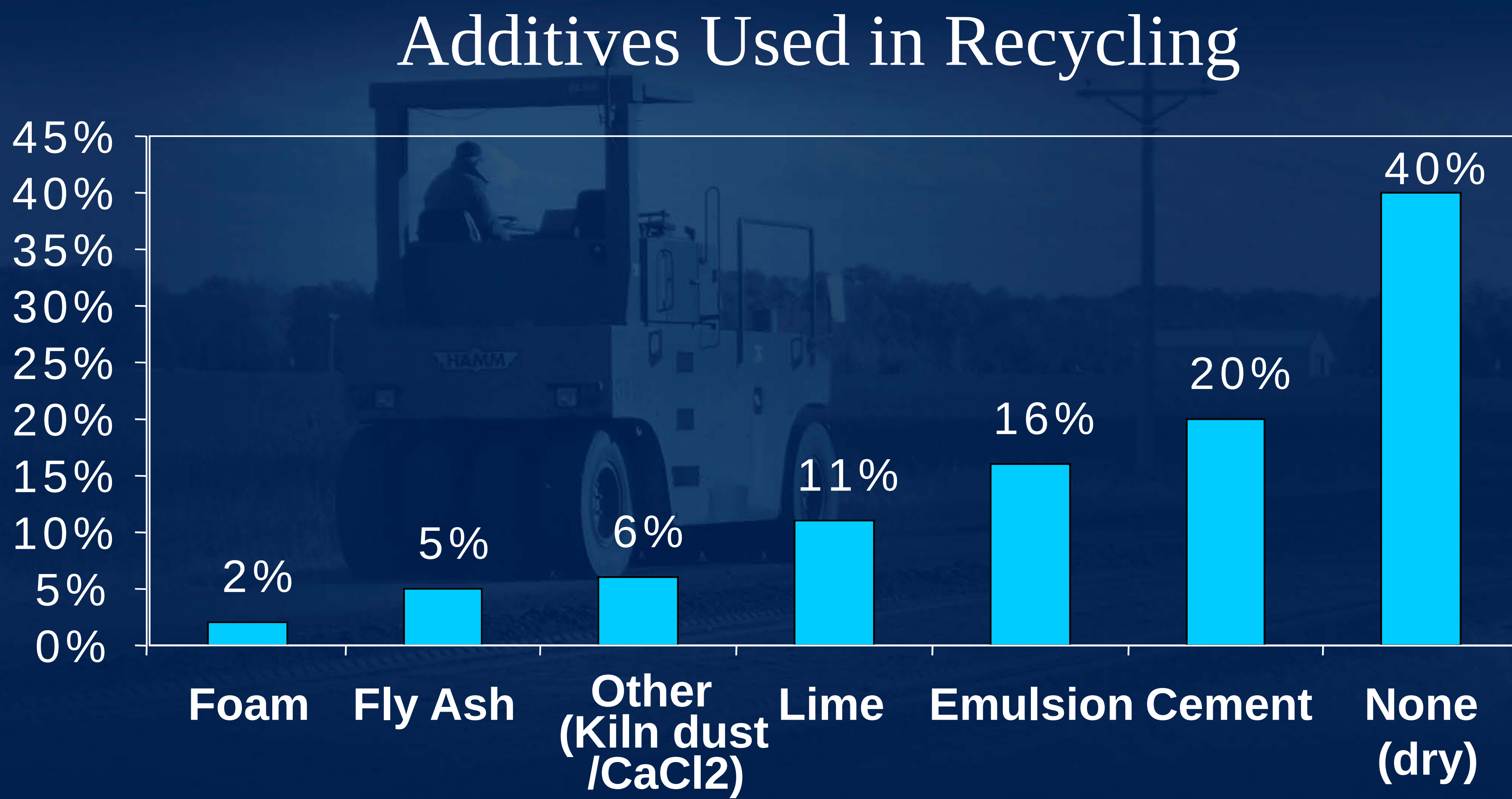






Full Depth Reclamation (FDR)

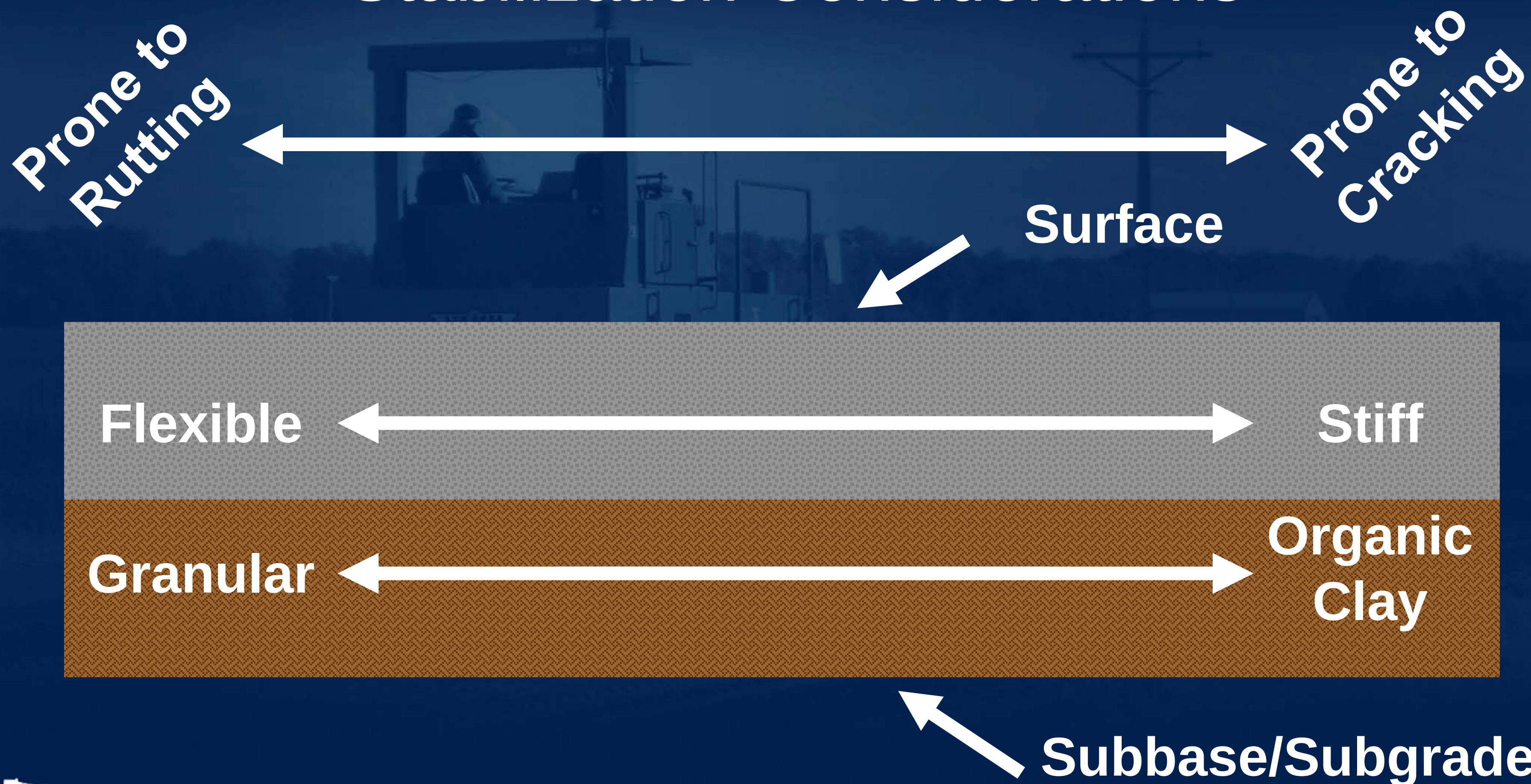
Types of FDR



Full Depth Reclamation (FDR)

Keys to Success

Stabilization Considerations



Full Depth Reclamation (FDR)

Keys to Success

Stabilization Considerations

Cutbacks or Road Mix

Proprietary Products

Emulsion

Foam Asphalt or Lime

Fly Ash or Cement

Prone to Rutting ⟷ **Prone to Cracking**

Flexible ⟷ **Stiff**

Granular ⟷ **Organic Clay**

Full Depth Reclamation (FDR)
Keys to Success

Stabilization Considerations

- Fly Ash or Cement Stabilization
  - Mill to 3”- material
  - Can incorporate some plastic subgrade soils
  - Cement addition rate of 2-4% by weight, fly ash addition rate of 6-10% by weight
    - Short working time due to hydration
  - Specific design for each project
  - Higher stiffness, lower flexibility

Full Depth Reclamation (FDR)
Applications for FDR

- Good Candidates include pavements with:
  - Need for upgrading, widening or rehabilitation
  - Bituminous surface on compacted base that:
    - Has sufficient depth to accommodate reclamation process (at least 2" greater than reclamation depth)
      - Exception: Compatible native materials meeting P200 & SE requirements
    - Generally has up to 20% fines (P200)

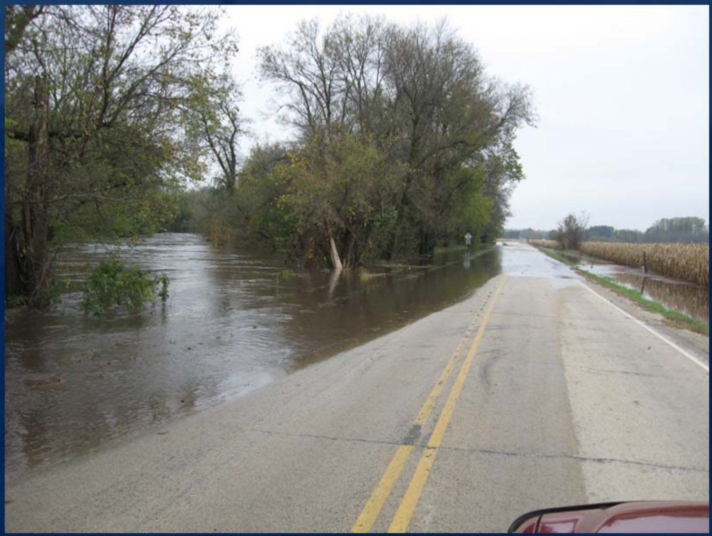
Full Depth Reclamation (FDR)
Applications for FDR

- Good Candidates (Continued):
  - – High severity distresses
    - Ruts
    - Base problems
    - Cracks
    - Edge failures
    - Potholes
  - – Good drainage or drainage to be corrected

Full Depth Reclamation (FDR)

Applications for FDR

- Poor Candidates include pavements with:
  - Clay-like native soils
    - Exception- can be stabilized with fly ash or lime/cement
  - Doesn’t meet P200 criteria & can’t or won’t accept added rock
  - Drainage problems
    - Including ditch & regional flooding problems



Full Depth Reclamation (FDR)
Summary

- Builds structure down into pavement
  - Site assessment, sampling & mix design key to success
  - Performance-related design tests & specs improve reliability & performance
    - Early Strength
    - Cured Strength
    - Cracking Resistance
    - Moisture Resistance
    - QA / QC

CIR and FDR Differences

CIR and FDR Considerations:

- What is the depth of my existing pavement?
  - CIR is best for pavements at least 5” thick
  - FDR is for any depth
- Is the pavement thickness consistent or variable?
  - FDR is better for variable thickness pavements

CIR and FDR Differences

CIR and FDR Considerations (Continued):

- What is the condition and strength of the pavement base and subbase?
  - CIR requires base support for the heavy train equipment
  - FDR will break up cracking patterns in the base
- What is the required ease of construction?
  - CIR is all done at once
  - FDR has greater difficulty in getting material placed