Full-Depth Reclamation with Cement

28th Annual Regional Local Roads Conference

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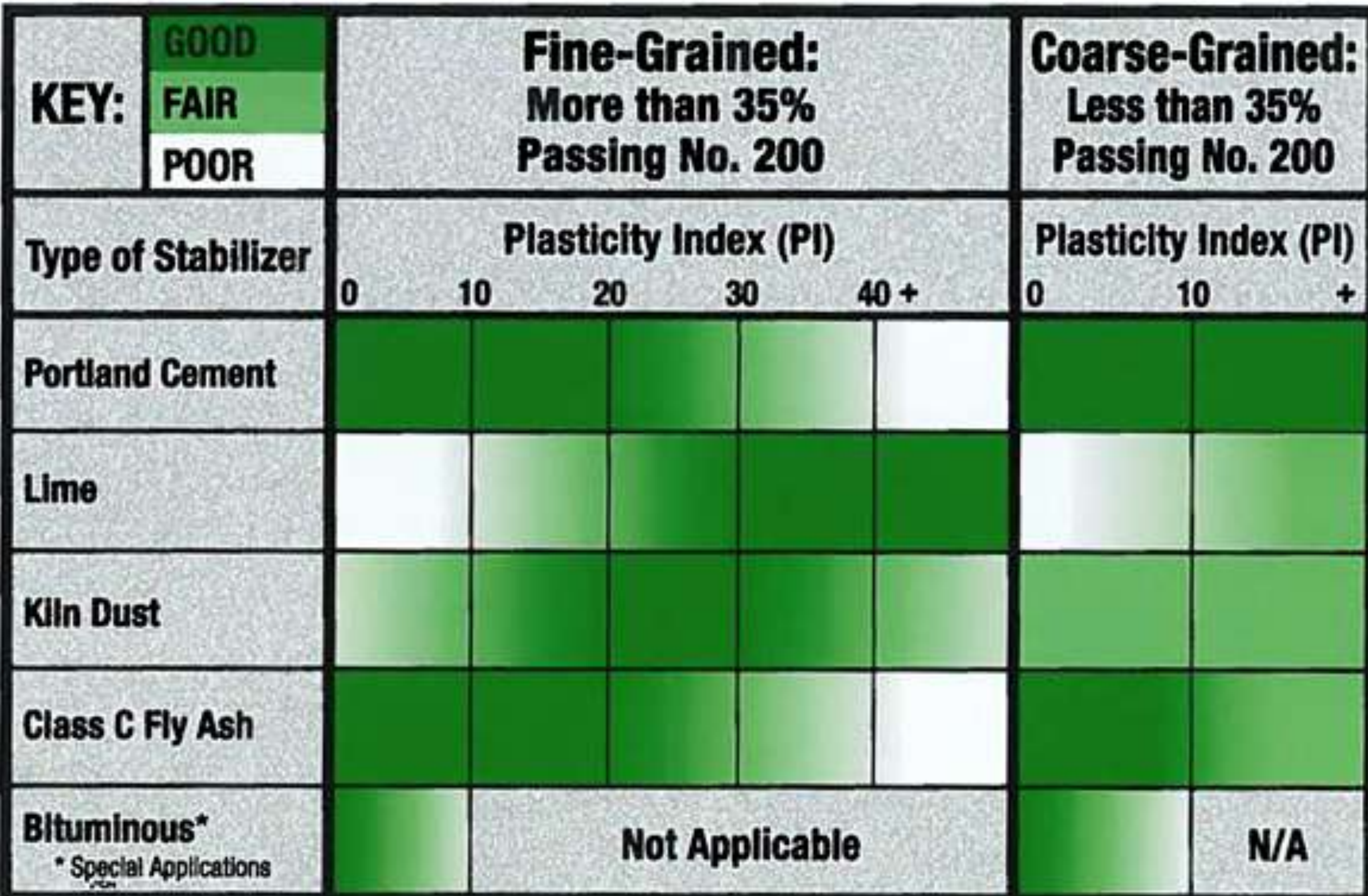
- Design
- Construction
- Field Testing
- Performance

Types of Reclamation Methods

- Mechanical Stabilization
- Bituminous Stabilization
  - emulsified asphalt
  - expanded (foamed) asphalt
- Chemical Stabilization
  - portland cement
  - slag cement
  - fly ash
  - kiln dust
  - lime
  - other


KEY:
GOOD
FAIR
POOR
Fine-Grained: More than 35% Passing No. 200
Coarse-Grained: Less than 35% Passing No. 200
Type of Stabilizer
Plasticity Index (PI)
0 10 20 30 40 +
Plasticity Index (PI)
0 10 +
Portland Cement
Lime
Kiln Dust
Class C Fly Ash
Bituminous*
* Special Applications
Not Applicable
N/A

Applications

What are you Trying to Achieve?

- Upgrading a low volume road
- Improving a weak subgrade
- Improving pavement strength without getting into the subgrade
- Rehabilitation of a severely distressed pavement

How do you know if you have a base problem and not just a surface deficiency?

Geotechnical/Pavement Investigation

- Construction Plans
- Pavement Evaluation
  - Visually indentify pavement distress
- Falling Weight Deflectometer
  - Pavement strength and identifies weak layer or weak areas
- Ground Penetrating Radar
  - Complete picture of pavement structure
- Soil borings/cores – so you know what the materials are and their condition

Rehabilitation Strategies

Attribute	Rehabilitation Strategy		
	Reclamation with Cement	Structural Overlay	Removal and Replacement
New pavement structure	√	√	√
Fast construction	√	√	X
Minimal traffic disruption	√	X	X
Minimal material in/out	√	X	X
Conserves resources	√	X	X
Maintains existing elevation	√	X	√
Low cost	√	X	X

Benefits of FDR with Cement

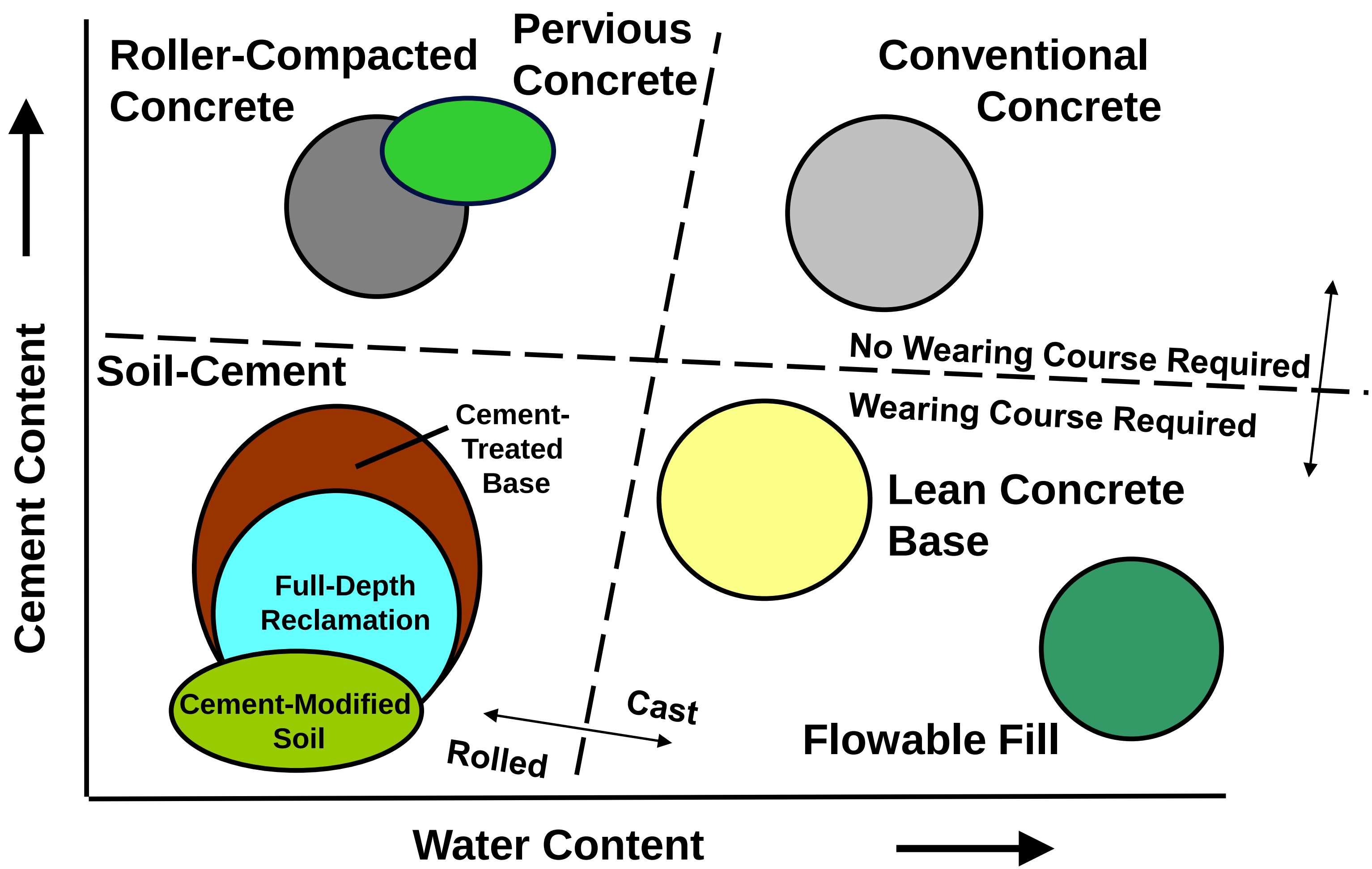
- Increased rigidity spreads loads
- Eliminates rutting below surface
- Reduced moisture susceptibility
- Reduced fatigue cracking in asphalt surfacing
- Allows for thinner pavement section

Pavement Thickness Design Procedures

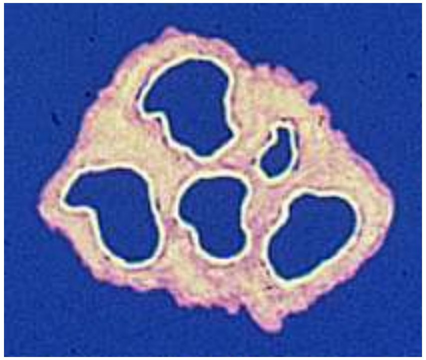
- 1993 AASHTO Pavement Design Guide
  - Subgrade – Modulus (CBR)
  - Subbase - Layer coefficients
    - 0.18 to 0.25
    - Not flexible so 0.25 is really the maximum
- New AASHTO Design Guide
  - Mechanistic-Empirical Design
  - Evaluates effects of pavement materials, traffic loading conditions, environmental factors, design features, and construction practices

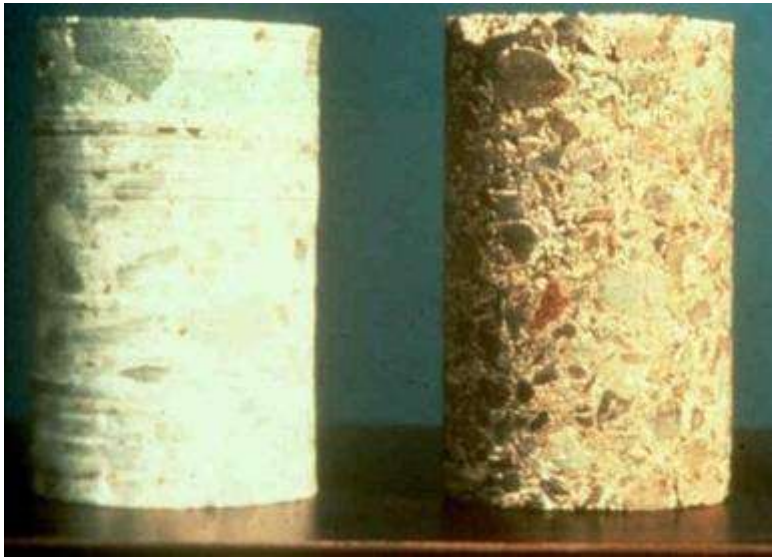
Laboratory Design

Cement-Based Pavement Materials

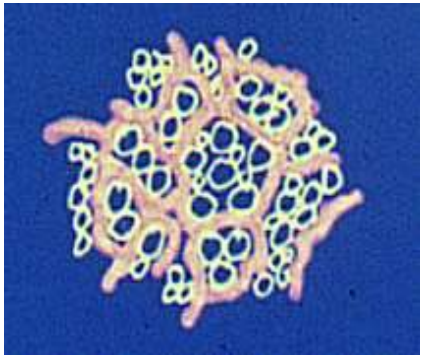


Concrete





Soil-Cement



Cementitious Gel or Paste

- coats all particles
- fills voids

Hydration Products

- all particles not coated
- voids not filled
- linkages bind soil agglomerations together

Pavement Materials Tests

- Sieve Analysis (ASTM C136)
- Atterberg Limits (ASTM D4318)
- Moisture-Density (ASTM D558)
- Durability Tests
  - Wet-Dry (ASTM D559)
  - Freeze-Thaw (ASTM D560)
- Soluble Sulfates (ASTM C1580)
- Compressive Strength (ASTM D1633)

Laboratory Mix Design

- Obtain representative samples of roadway material
- Determine construction conditions mix design will represent
  - Will there be a range of moisture contents?
  - Is there time to farm and dry the soil?
  - Will there be a range of soil types?
- Usually about 200 - 400 pounds of material is required
- Run sieve analysis (ASTM C136)
- Plastic soils - Atterberg Limits

Laboratory Mix Design

- Determine the max. dry density and opt. moisture content at various cement percentages (ASTM D558)
- May require additional samples at different moisture contents
- Typical designs vary between 2 and 8 percent cement by weight of dry material
- Prepare samples
- Cure samples

Imaging /Branding Update
Strategic Plan Update

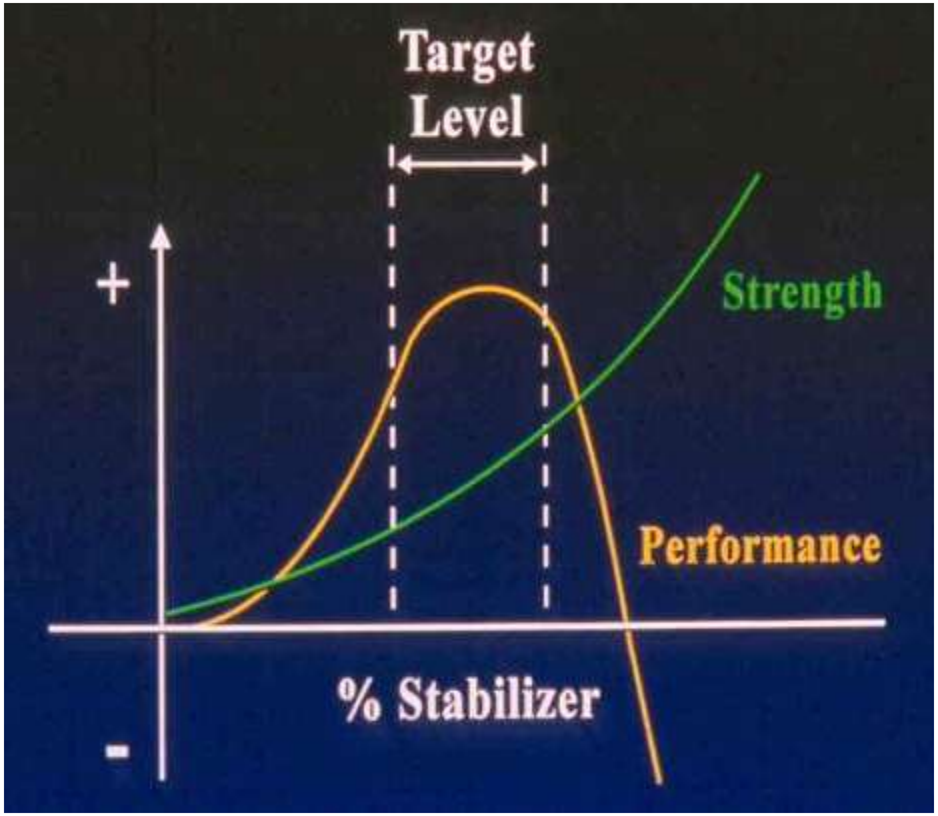
Strength Determination

- Unconfined Compressive Strength Testing
  - ASTM D1633
  - Used by most governing agencies
  - Simple and quick procedure
  - 7-day strengths ranging from 300 to 400 psi are generally recommended
  - Proven strength (support) under extremely heavy traffic conditions
  - Proven performance (durability) in wet-dry and freeze-thaw environments

Strength Determination

- California Bearing Ratio
  - ASTM D 1883: Bearing Ratio of Laboratory Compacted Soils
    - Fits into AASHTO Design Procedure
    - FAA Design Procedure
  - Typical value 30-80
    - Similar to crushed gravel
  - Takes 7-10 days
  - Expensive ($500-$600 per test)
  - Relates to field DCP testing (QC)

Please keep in mind that strength and performance are NOT the same thing!

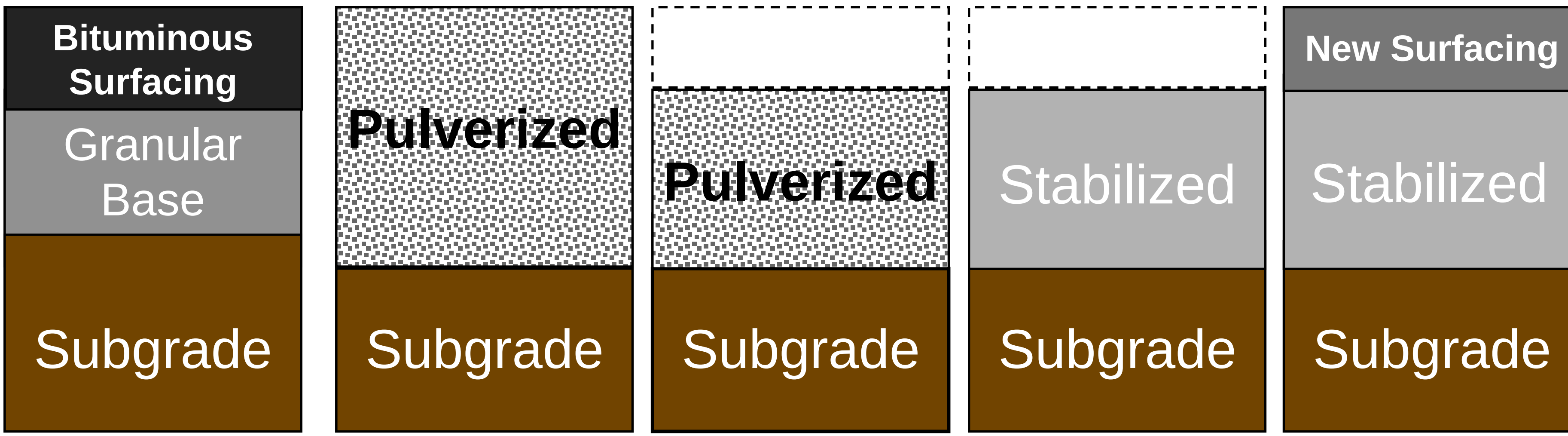


The purpose of the mix design procedure is to select the correct amount of stabilizer that most closely balances both strength AND performance for the roadway materials!

Construction

FDR Construction Process

Pulverize, Shape, Add Cement, Mix In Place, Compact, and Surface



Existing road

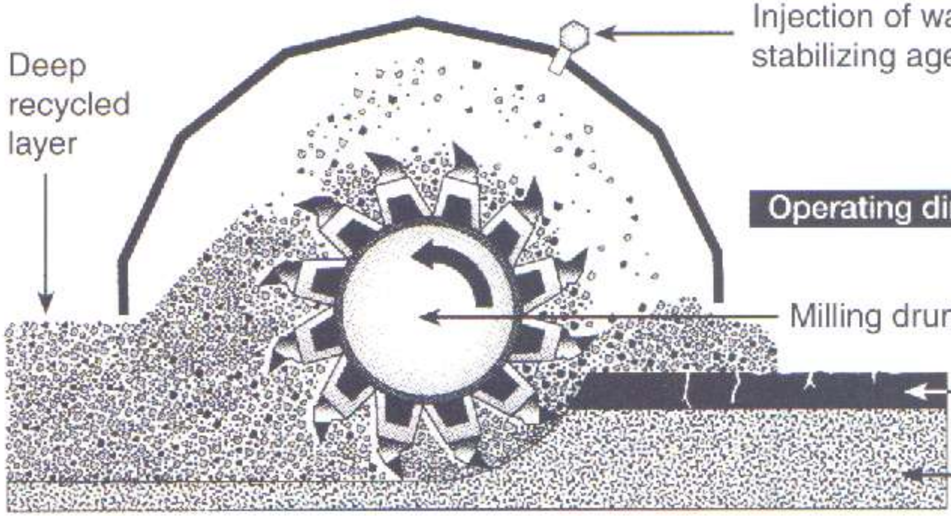
Pulverization to desired depth

Removal of excess material (if necessary) and shaping

Addition of cement, mixing, reshaping, and compaction

Final surface applicati

Inside a Reclaimer



Pulverization

- Pulverize mat to appropriate gradation
- Usually, only one pass is required

Cement Spreading

Cement is spread on top of the pulverized material in a measured amount in either a dry or slurry form

Dust Control is Very Important

- Vane feeder or similar device is key to success
  - Reduces fugitive dust
    - Dirty vehicles
    - Dirty homes
  - Reduces waste
    - Cement doesn't wind up anywhere but on and in the roadway

Cement Spreading

Sometimes the moisture content requires a little extra effort

Blending of Materials and Moisture Addition

Cement is blended into pulverized, reclaimed material and, with the addition of water, is brought to optimum moisture

Compaction and Grading

Material is compacted to 96 to 98 percent minimum standard Proctor density and then graded to appropriate Plan lines, grades, and cross-sections

Curing

Bituminous Compounds (cutbacks or emulsions)

Water
(kept continuously moist)

Field Testing

Testing Requirements

Gradation/Uniformity

A common gradation requirement is for 100 percent to pass a 3-inch sieve, a minimum of 95 percent to pass a 2-inch sieve, and a minimum of 55 percent to pass a No. 4 sieve (ASTM C136).

Density

A common density requirement is to be between 96 and 98 percent of the established laboratory standard Proctor density (ASTM D558).

Moisture

A common moisture requirement is to be within 2 percent of the laboratory established optimum moisture content (ASTM D558).

Testing Requirements

DCP

Typically looking for CBR correlation of 20 at 24 hours and 30 at 72 hours

Used to make field adjustments/confirm laboratory mix design proportions

Traffic and Surfacing

- Completed Cement Stabilized Base/Subgrade can be open immediately to low-speed light traffic and to construction equipment
- Subsequent pavement layers can be placed at any time
  - Typically recommend 24 -48 hours after final compaction

PROJECT EXAMPLES

Fowler II – Wind Farm Access Roads – 50 miles


3
3
5


WARNING
TEREX

Prairie Rose – Wind Farm Haul Roads – 30 miles

CAT
RM-500


RYAN
344 OAD

Bakken Oil Pads


WR 2500 S

ND Highway 1806 – 20 miles

Chipseal Surface

Cement Can’t Solve Everything – Engineering is still needed

Concluding Comments

- Use of in-place materials
- Very sustainable process
- Fast operation
- Constructed under traffic
- Structurally better than granular base
- Can apply local traffic almost immediately
- 30 to 60 percent less expensive than removal and replacement