Full-Depth Reclamation with Cement Using A Ready Mixed Concrete Truck

Opening Comments

- Anti-Trust Statement
- Recording this webinar
- IRMCA website www.irmca.org


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Today's Presenters

- Don A. Clem, PE (Colorado) Vice President Local Paving National Ready Mixed Concrete Association
- Jonathan Pease CEO/Founder Rock Solid Stabilization and Reclamation

National Ready Mixed Concrete Association

- National Trade Association – Established in 1930
- HQ in Alexandria, VA
- 1,400+ Member Companies
- NRMCA Represents ~75% of North American Ready Mixed Production
- Mission - Serve Industry and Partners Through:
  - Compliance and Operations
  - Engineering
  - Government Affairs
  - *Local Paving: Pave Ahead™ Initiative (PaveAhead.com)*
  - *Structures and Sustainability: Build With Strength™ Initiative*

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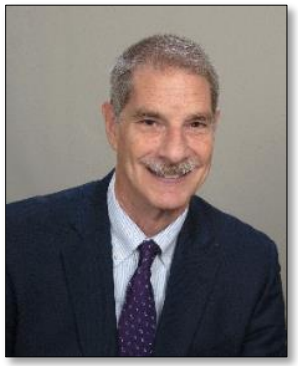
Your Instructors Today…

- Don A. Clem, P.E.
  - NRMCA Local Paving, Vice President, Northwest Rocky Mountains
  - 41 Years in Practice
  - Pavement Design, Concrete Overlays, Forensics



- Jonathan Pease
  - CEO/ Founder, Rock Solid Stabilization and Reclamation
  - Over 30 years experience in infrastructure construction
  - Current President, Asphalt Recycling & Reclamation Association

ROCK SOLID STABILIZATION & RECLAMATION, INC.

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NRMCA Local Paving Division:
Technical and Promotion Personnel - Regional Assignments

www.PaveAhead.com

'Meet The Experts' Page

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Don Clem, P.E.
Vice President
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Phil Kresge
Sr. Vice President
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Senior Director
Southeast

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About the Course

Professional Development Hour (PDH) certificate

- 1.0 PDH certificate to each attendee
- **Learning Objectives:**

- Understand the definition of Soil-Cement / Full-Depth Reclamation (FDR)
- Learn the advantages of Soil-Cement / FDR for rehabilitation of a pavement
- Understand the process to determine appropriate cement content target
- Learn about the Soil-Cement / FDR construction process
- Learn about the use of cement slurry delivered in ready mixed concrete trucks

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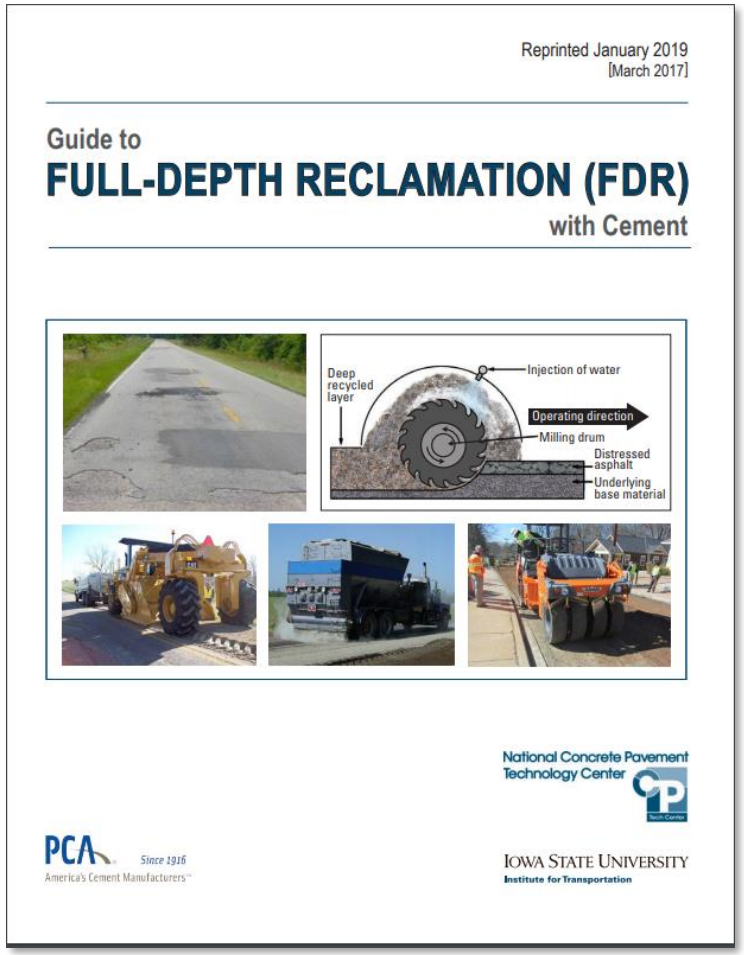
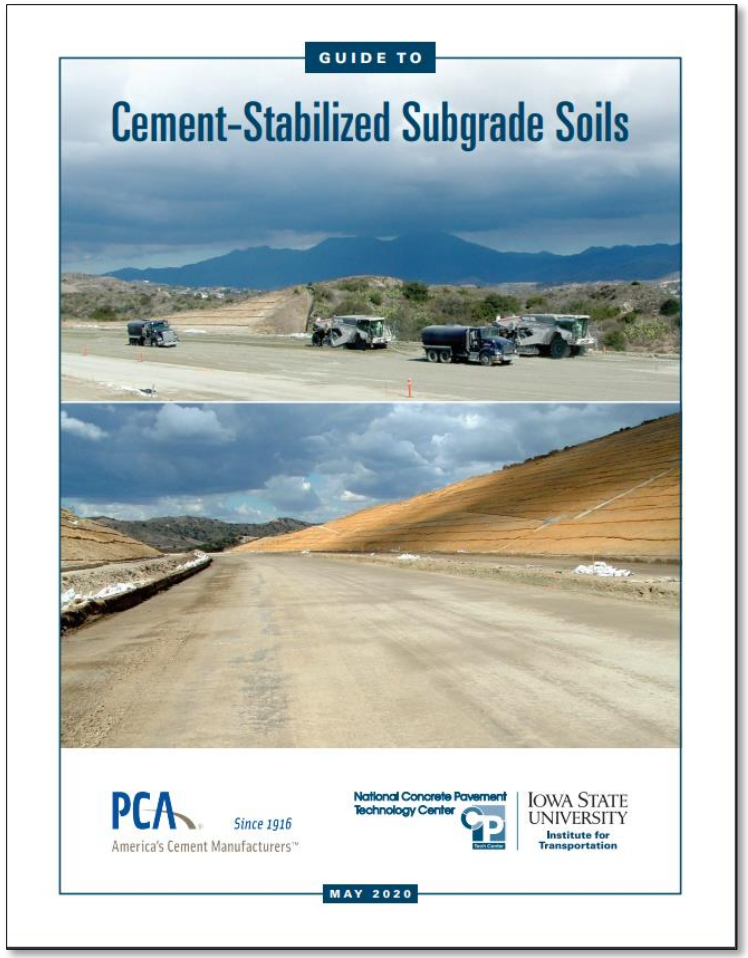
References





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References

Cement Slurry Delivery System Using a Ready Mixed Concrete Truck for Full-Depth Reclamation Presents New Growth Opportunities

By Don A. Clem, P.E., Vice President Local Paving, NRMCA, Wayne S. Adaska, P.E., Director, Pavements and Geotechnical Markets, PCA and Greg E. Halsted, P.E., Manager, Pavements and Geotechnical Markets, PCA

Introduction

Across the country, thousands of miles of federal, state, county, and city roads are rapidly deteriorating and in need of immediate rehabilitation. Most of these roadways were constructed utilizing an asphalt wearing surface with untreated granular base materials and were often under-designed for today's heavier traffic loads.

Figure 1. Spreading cement slurry from a ready mixed concrete truck (Photos courtesy Scott Hall, Sagamore Ready Mix, left; Dr. Spencer Guthrie, BYU, right)

Salvaging these existing failed flexible pavements is a good practice, both environmentally and economically, because they still contain good granular material that, when blended with portland cement can be reused and recycled into a strong, durable new base. A process commonly referred to as full-depth reclamation (FDR) is a technique in which the old asphalt pavement and a portion of the underlying base, subbase, and/or subgrade materials are pulverized and blended together with portland cement to create an enhanced roadway base material. The steps for FDR consist of the pulverization of the existing materials, removal of any materials for grade control, the incorporation of any additional materials, mixing, initial shaping of the new base mixture, compaction, final shaping, curing, and the application of a new surface or wearing course, which may be concrete, asphalt, or a chip seal application, depending on the anticipated traffic and desired roadway life (Figure 2).

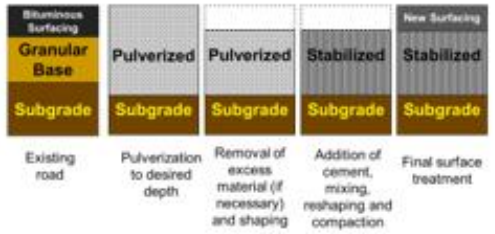

Figure 2. Steps involved in the construction of full-depth reclamation with cement

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Soil-Cement / Full-Depth Reclamation with Cement Using a Ready Mixed Concrete Truck - **Agenda**

- Understand the definition of Soil-Cement / Full-Depth Reclamation (FDR)
- Advantages of the Soil-Cement / FDR process
- How to determine the appropriate cement content target
- Soil-Cement / FDR construction process
- Cement slurry delivered in a ready mixed concrete truck

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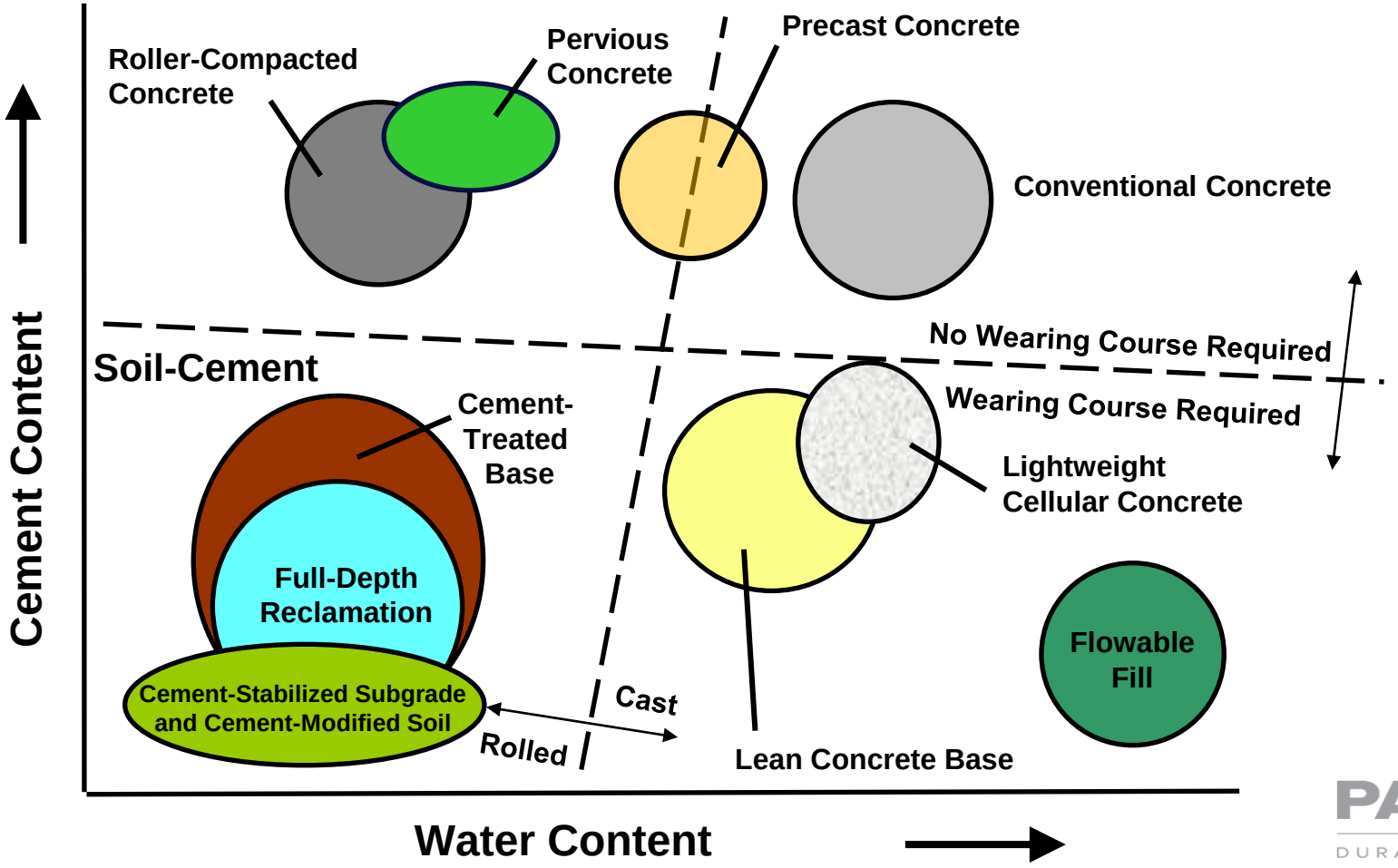
Cement-Based Paving/Geotech Materials



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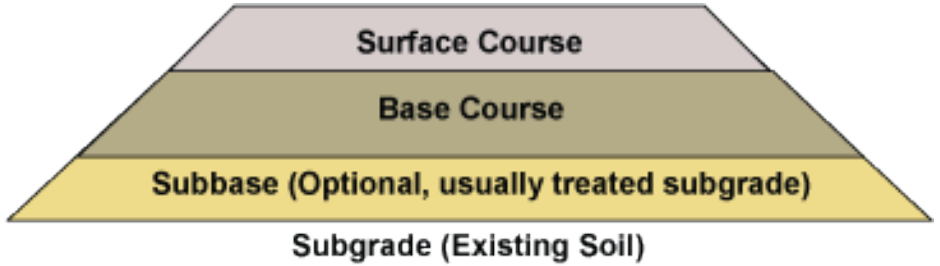
Important Definitions

Modification

- Material is treated with a relatively small proportion of portland cement in order to amend its undesirable properties, so they are suitable for use in subgrade or foundation construction



Stabilization

- Material is treated with a predetermined amount of portland cement to provide strong, durable bases and subgrades

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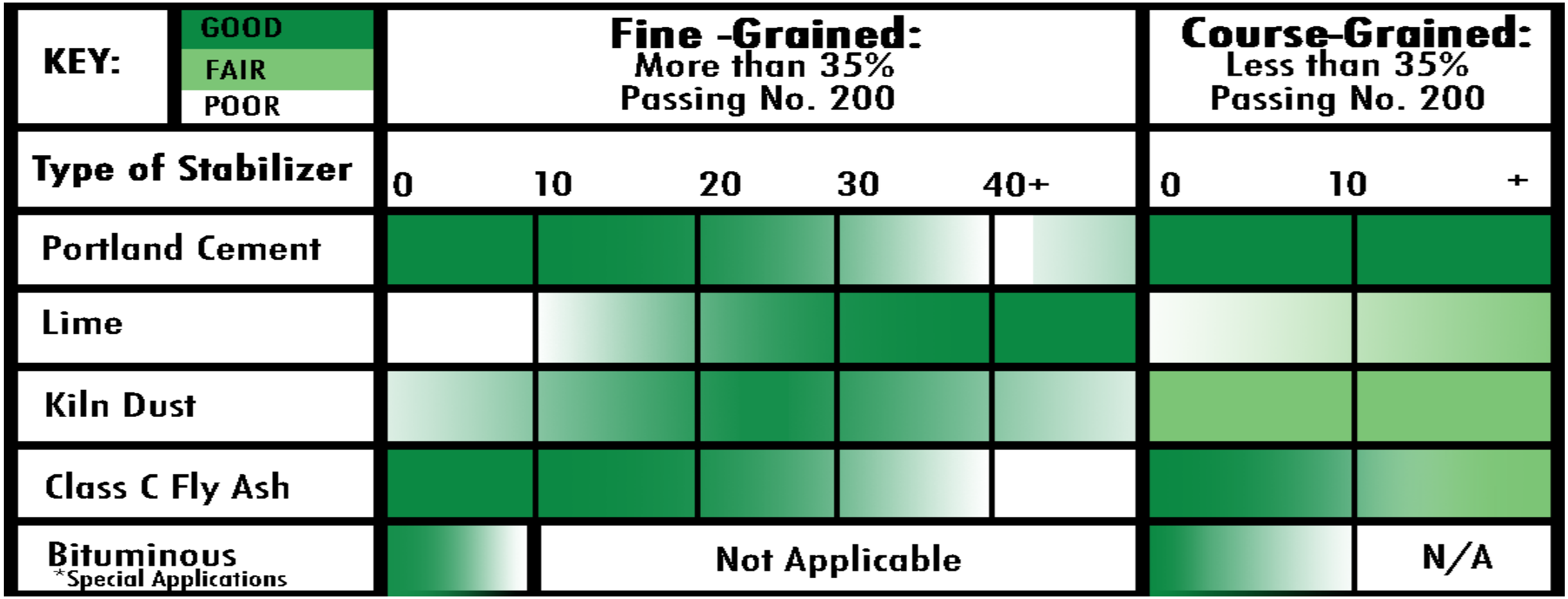
Typical Additives for Soil Stabilization or Modification



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Soil-Cement - Definition

- Soil-cement refers to a compacted engineered mixture of soil, cement, and water designed and constructed for various pavement and geotechnical applications and characteristics.
- The term soil-cement can be considered an umbrella term covering four types of cement-based products:
  - Cement-Modified Soil (CMS)
  - Cement-Stabilized Subgrade (CSS) Soil
  - Cement-Treated Base (CTB)
  - Full-Depth Reclamation (FDR) with Cement

FDR - Definition

- Method of flexible pavement reconstruction that utilizes the existing asphalt, base, and/or subgrade material to produce a new stabilized base course for a chip seal, asphalt, or concrete wearing surface.

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Types of FDR Methods

- Mechanical Stabilization
- Bituminous Stabilization
  - Emulisified asphalt
  - Expanded (foamed) asphalt
- Chemical
  - Portland cement Dry or Slurry
  - Slag cement
  - Fly ash
  - Other polymers or Enzymes
- * All the above could use “ADD ROCK” if needed

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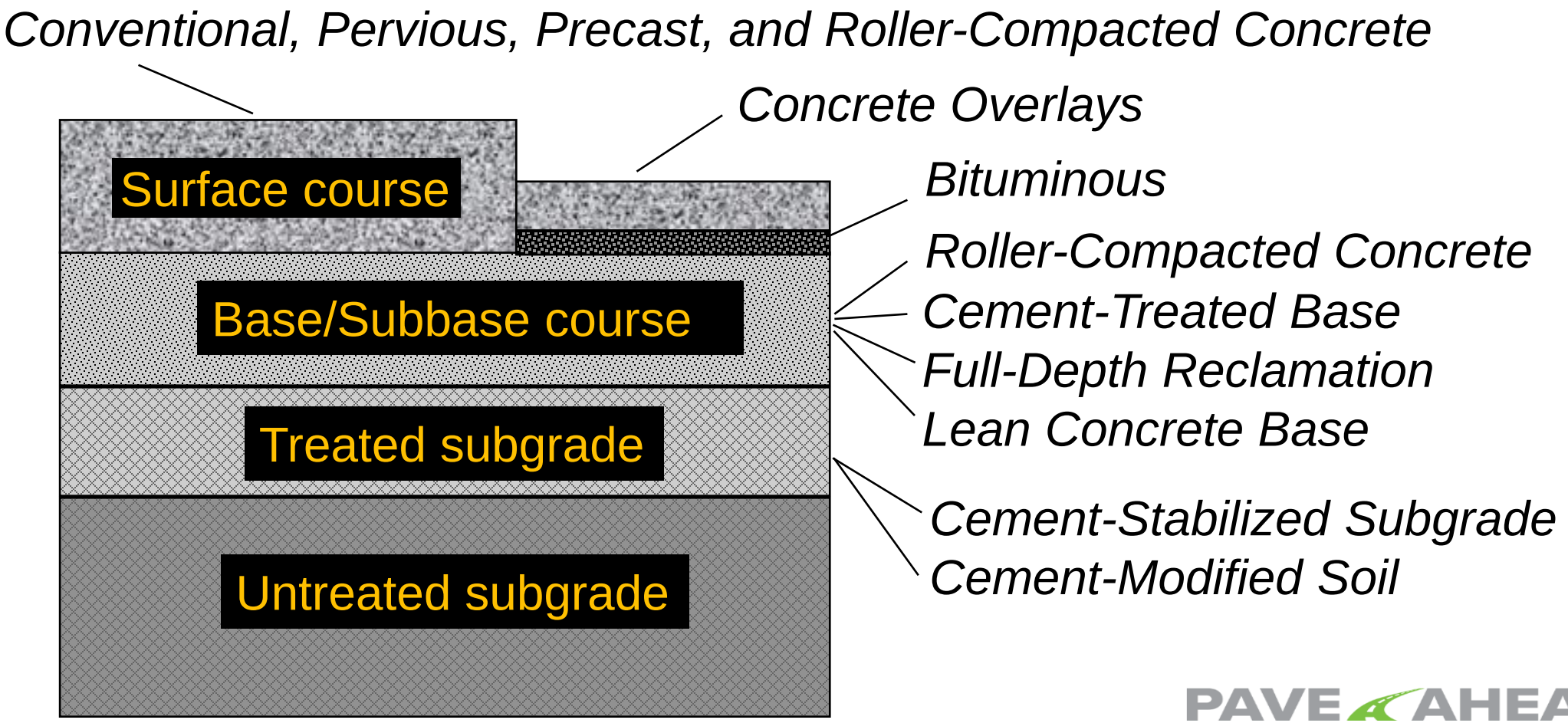
Cement-Based Paving/Geotech Materials



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The Soil-Cement Family

- Cement-Modified Soil (CMS)
- Cement-Stabilized Subgrade (CSS) Soil
- Cement-Treated Base (CTB)
- Full-Depth Reclamation (FDR) with Cement

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Soil-Cement/ Full Depth Reclamation with Cement Using a Ready Mixed Concrete Truck - Agenda

- Understand the definition of Soil-Cement / Full-Depth Reclamation (FDR)
- **Advantages of the Soil-Cement / FDR process**
- How to determine the appropriate cement content target
- Soil-Cement / FDR construction process
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Advantages of the Soil-Cement/ FDR process

- Use of in-place materials
- Little or no material hauled off and dumped
- Maintains or improves existing grade
- Conserve virgin material
- Saves cost by using in-place “investment”
- Saves energy by reducing mining and hauls
- Very sustainable process

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Benefits

	FDR	Overlay	Remove & Replace
New pavement			
Fast construction			
Minimal traffic disruption			
Minimal material transportation			
Conserves resources			
Maintains existing elevation			
Lower cost			

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A Sustainable Approach

Green Savings

FDR leaves a significantly smaller carbon footprint compared to traditional reconstruction methods. By using cold processes, reusing existing materials, working on-site, and reducing trucking, we decrease greenhouse gas emissions and conserve energy.

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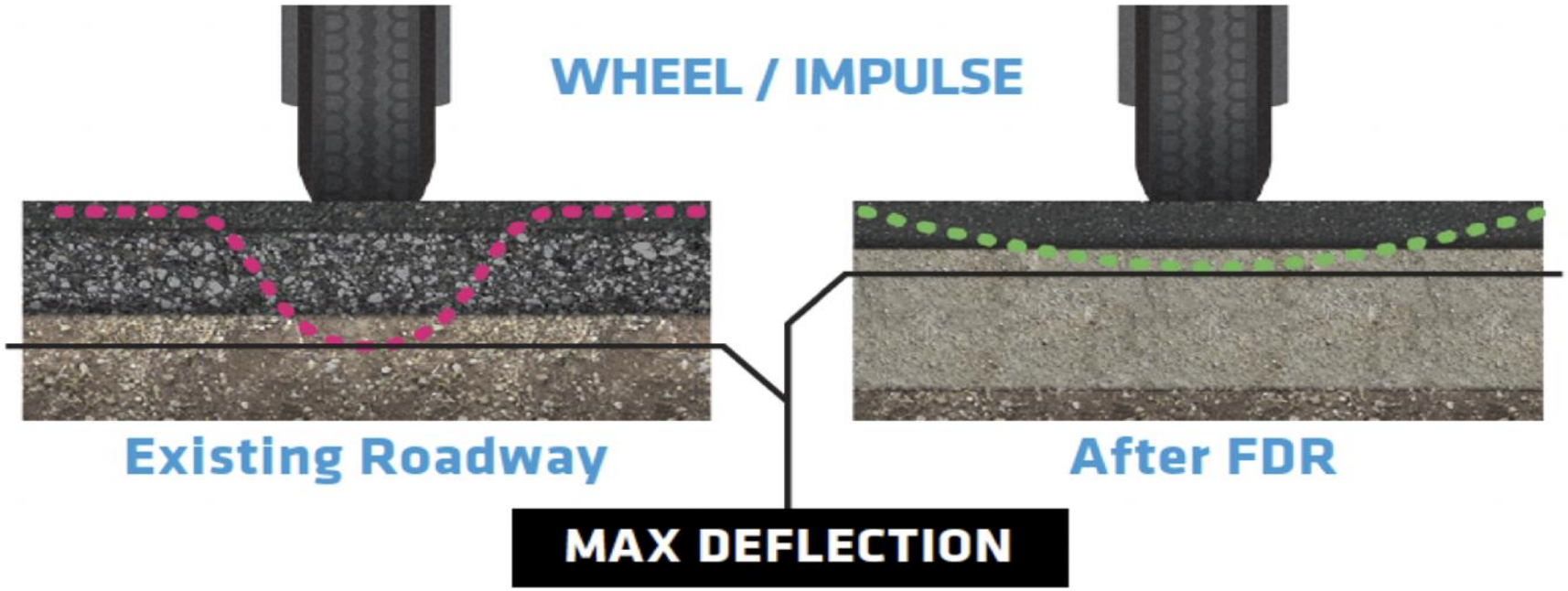
Wheel Load Deflection – Before/ After FDR

REINFORCED STRENGTH



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Advantages of Using Portland Cement as a Stabilizer

- Increases rigidity which spreads loads
- Eliminates rutting below the surface
- Reduces moisture susceptibility
- Reduces fatigue cracking in the asphalt surface
- Allows for thinner pavement section

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Advantages of Cement Slurry Application Method

- Reduces dusting associated with dry spreading methods
- Equipment varies in different regions of US from using ready mixed concrete truck chute to tanker trucks with mixing and metering delivery systems
- Laboratory research has demonstrated that the slurry process unconfined compressive strength (UCS) meets or exceeds that of dry spreading (SN3108)

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Slurry Stabilization and Reaction Chemistry of Cement-Treated Soils - PCA R&D SN3108 (2009)

- Authors Stephen Sebesta and John P. Harris, Texas Transportation Institute
- Treatment of soil (low PI) by slurry produced strength results equal to or better than dry powder application
- Slurry age had no impact on soil strength up to 2.0 hours
- Increasing delay time (time between mixing cement into soil and compaction) negatively impacted UCS for both dry and slurry
- Percent solids in slurry should be selected based on delivery equipment, economy, and project factors (in-situ moisture, etc.), as the percent solids did not appreciably impact UCS
- For high PI soils, 50 percent solids produced the best strength results

Illinois Department of Transportation

- After over 3 years of work, recently adopted the following spec: Special Provision For Full-Depth Reclamation (FDR) with Cement or Cement Slurry
- Consensus specification developed under the direction of IDOT engineer of concrete and soils James Krstulovich, PE and IRMCA assistant executive director Theron Tobolski
- Includes provisions for both dry cement and cement slurry FDR applications

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PULVERIZED MATERIAL GRADATION			
Grad No.	Sieve Size and Minimum Percent Passing		
	3 in. (75 mm)	2 in. (50 mm)	No 4 (4.75 mm)
PM 4	100	95	55

- Gradation of pulverized materials
- The distributor shall be a mechanical type and shall be approved by the Engineer. The distributors or truck mixers used to apply the cement and/or chemical admixtures for FDR shall be able to demonstrate a consistent and accurate application rate while minimizing dust during construction according to Article 107.36.
- The road reclaimer shall be self-propelled and capable of fully pulverizing the existing pavement, incorporating the water, and mixing the materials to produce a homogeneous material. The minimum power of the road reclaimer shall be 540 hp (403 kW). The road reclaimer shall be capable of reclaiming not less than 8 ft (2.4 m) wide and up to 12 in. (305 mm) deep in each pass. The road reclaimer shall be capable of injecting water directly into the mixing chamber via an electronic control system that records the amount of water injected. The cutting drum shall be fitted with cutting teeth capable of trimming earth, aggregate, and bituminous surface treatments or hot mix asphalt mixtures, and be accurately adjusted vertically and held in place. The machine shall weigh at least 12.5 tons (11.3 metric tons) and shall not develop a center deflection of more than 1/8 in (0.125 mm).

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- Following initial pulverization and shaping, the quantity of dry cement or cement slurry specified in the mix design shall be spread uniformly on the finished surface. The cement spread shall be calculated to provide the required application rate in a manner that minimizes dust or slurry runoff and is satisfactory to the Engineer. The application of the cement shall be limited to that amount which can be mixed and compacted with the pulverized material within 4 hours.
- When cement slurry is used, the surface of the pulverized material shall be lightly scarified or disked prior to slurry application, and berms shall be formed to prevent excessive runoff, unless the Contractor has demonstrated to the satisfaction of the Engineer that the slurry has been proportioned such that it will not run off.
- Cement slurry shall be produced in a ready mixed concrete plant or other type of mixing device approved by the Engineer and delivered in truck mixers or other approved slurry transport equipment. Cement slurry shall be proportioned such that it contains a minimum 60 percent dry solids content by weight. The cement slurry producer shall supply a record of the amount of cement, water, and chemical admixtures with each truck delivery. The time from first contact of cement with water to application on the prepared surface of the initially pulverized material shall not exceed 60 minutes unless an approved retarding admixture is used, in which case the Engineer may allow a maximum of 90 minutes.

Soil-Cement / Full-Depth Reclamation with Cement Using a Ready Mixed Concrete Truck - Agenda

- Understand the definition of Soil-Cement / Full-Depth Reclamation (FDR)
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FDR Mix Design Process

- We will focus on determining the proper cement content for an FDR mix design for the sake of time but know that determining cement content for a soil-cement project is very similar.

FDR Mix Design Process

- Conduct field evaluation to determine the materials that make up existing pavement structure
- Obtain representative sample with a core rig or jackhammer for the asphalt
- Obtain representative sample with an auger or post-hole digger for the base
- The materials are then taken to a geotechnical laboratory where an FDR mix design will be conducted

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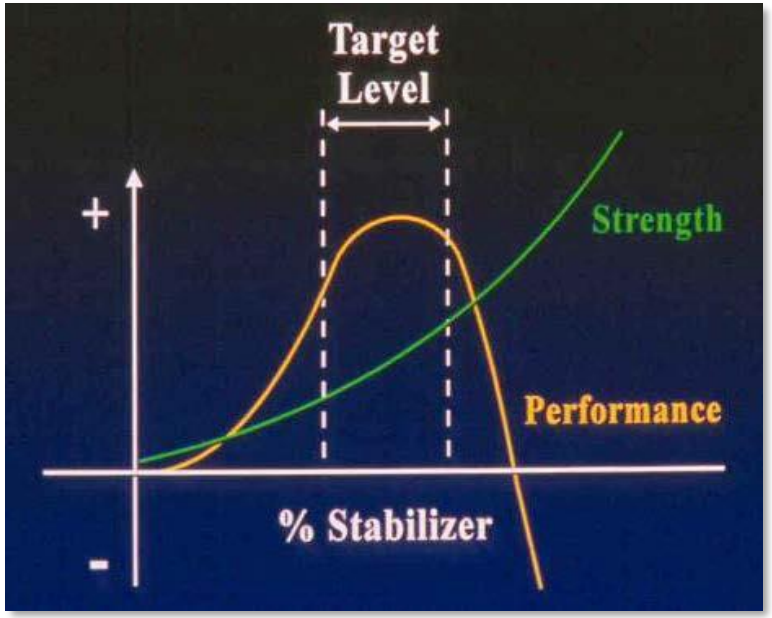
FDR Mix Design Process (continued)

- The laboratory FDR mix design will include:
  - Sieve analysis
  - Compaction requirements
  - Maximum dry density
  - Optimum moisture content

- Finally, analyzing the above, the lab will determine the target cement content which will provide the specified unconfined compressive strength for the project



FDR Mix Design Process (continued)

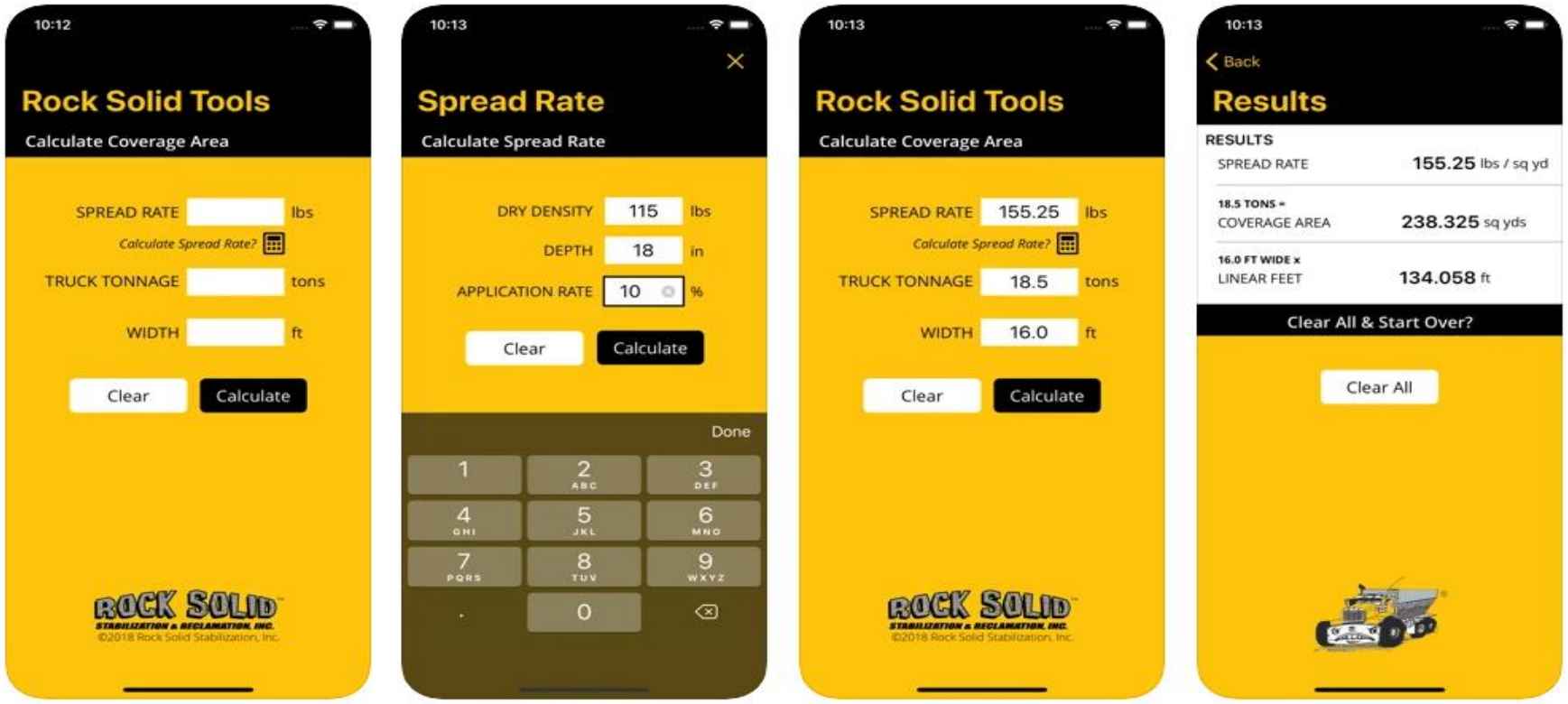
- Using the target cement content provided by the lab, project personnel will use the following charts to determine cement spread rates in the field:

Percent cement by dry weight of material	Density = 115 lb/ft^3					Density = 125 lb/ft^3				
	Cement spread requirements in pounds per square yard for compacted thicknesses					Cement spread requirements in pounds per square yard for compacted thicknesses				
	8 in.	9 in.	10 in.	11 in.	12 in.	8 in.	9 in.	10 in.	11 in.	12 in.
3.0	20.7	23.3	25.9	28.5	31.1	22.5	25.3	28.1	30.9	33.8
3.5	24.2	27.2	30.2	33.2	36.2	26.3	29.5	32.8	36.1	39.4
4.0	27.6	31.1	34.5	38.0	41.4	30.0	33.8	37.5	41.3	45.0
4.5	31.1	34.9	38.8	42.7	46.6	33.8	38.0	42.2	46.4	50.6
5.0	34.5	38.8	43.1	47.4	51.8	37.5	42.2	46.9	51.6	56.3
5.5	38.0	42.7	47.4	52.2	56.9	41.3	46.4	51.6	56.7	61.9
6.0	41.4	46.6	51.8	56.9	62.1	45.0	50.6	56.3	61.9	67.5
6.5	44.9	50.5	56.1	61.7	67.3	48.8	54.8	60.9	67.0	73.1
7.0	48.3	54.3	60.4	66.4	72.5	52.5	59.1	65.6	72.2	78.8
7.5	51.8	58.2	64.7	71.2	77.6	56.3	63.3	70.3	77.3	84.4
8.0	55.2	62.1	69.0	75.9	82.8	60.0	67.5	75.0	82.5	90.0
8.5	58.7	66.0	73.3	80.6	88.0	63.8	71.7	79.7	87.7	95.6
9.0	62.1	69.9	77.6	85.4	93.2	67.5	75.9	84.4	92.8	101.3
9.5	65.6	73.7	81.9	90.1	98.3	71.3	80.2	89.1	98.0	106.9
10.0	69.0	77.6	86.3	94.9	103.5	75.0	84.4	93.8	103.1	112.5

There’s an APP for that!!

- Google “Rock Solid Stabilization & Reclamation”

iPhone Screenshots



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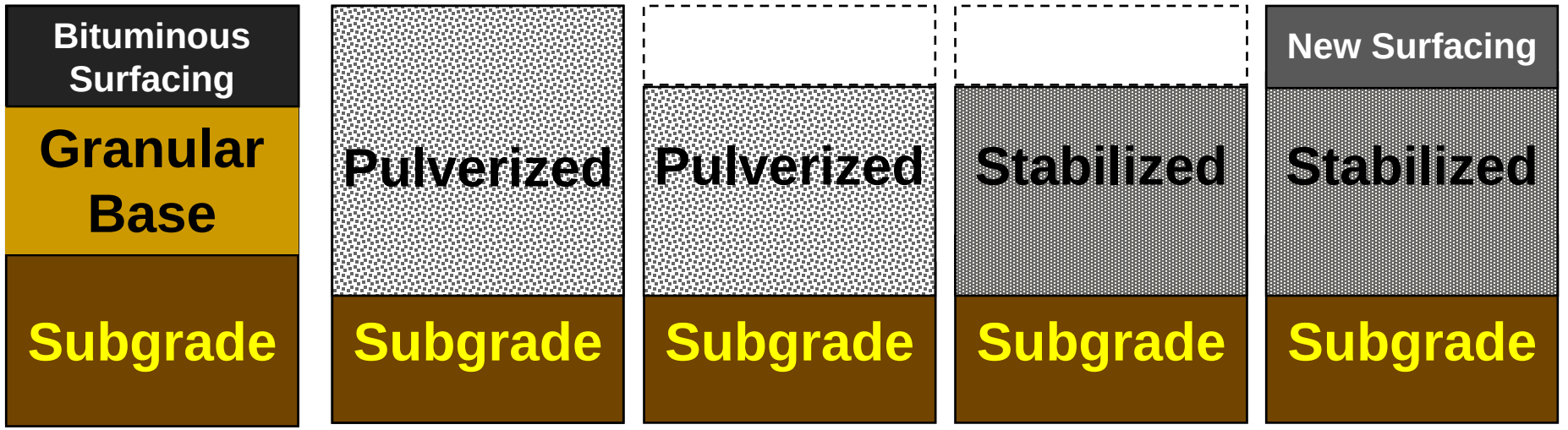

Existing road

Pulverization to desired depth

Removal of excess material (if necessary) and shaping

Addition of cement, mixing, reshaping and compaction

Final surface treatment

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FDR Construction Process – Initial Pulverization

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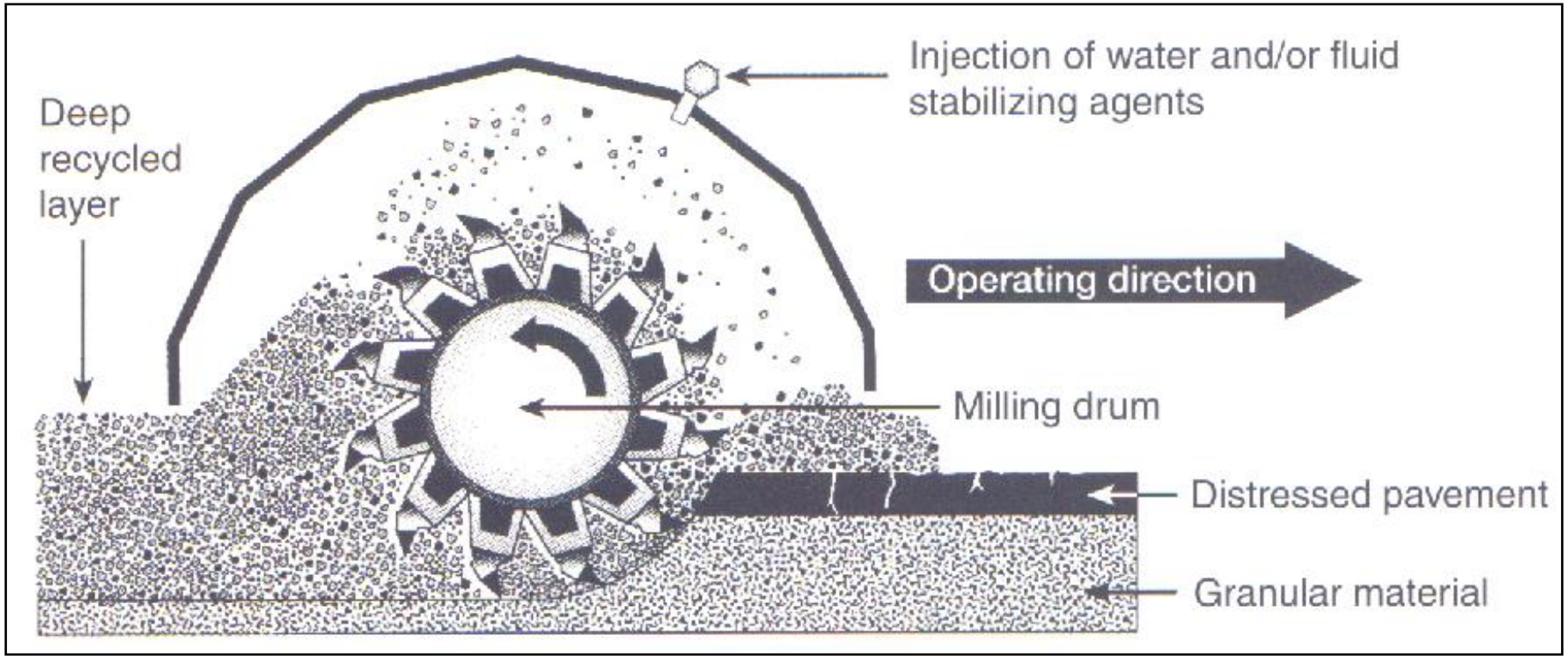
FDR Construction Process – Pulverization Schematic



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FDR Construction Process - Reshaping

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FDR Construction Process – Cement Slurry Application

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FDR Construction Process - Dry Cement Application

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FDR Construction Process – Material Blending

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FDR Construction Process – Material Blending

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FDR Construction Process – Material Blending

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FDR Construction Process - Compaction

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FDR Construction Process - Grading

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FDR Construction Process – Finish Rolling

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FDR Construction Process - Curing

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FDR Construction Process – Micro-Cracking

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FDR Construction Process - Surfacing

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Cement Slurry Mix Design

- Generally, slurry contains cement, water, and sometimes chemical admixtures, such as a hydration stabilizer (extends setting time)
- Water reducers are sometimes used to reduce agglomeration
- Slurry typically contains about 70 percent solids by weight, which equates to a W/C ratio of 0.43
- Slurry can contain 2 to 3 percent entrapped air
- Trial batches should be run to determine W/C ratio, respective batch weights, and admixture dosage rates to produce a slurry with fluid consistency that does not segregate, and easily flows down the chute

Estimated Batch Weights for Slurry at Various W/C Ratios

	W/C Ratio = 0.43			W/C Ratio = 0.46			W/C Ratio = 0.50		
Material	Weight (lb)	Specific Gravity	Volume (cu ft)	Weight (lb)	Specific Gravity	Volume (cu ft)	Weight (lb)	Specific Gravity	Volume (cu ft)
Cement	2200	3.15	11.2	2130	3.15	10.8	2020	3.15	10.3
Water	946 (113 gal)	1.00	15.2	980 (117 gal)	1.00	15.7	1010 (121 gal)	1.00	16.2
Air (2%)			0.6			0.5			0.5
Total	3146		27.00	3110		27.00	3030		27.00

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Slurry Mix Design – General Rules

- Application rate of FDR is based on the weight of the cement in the slurry
- The water in the slurry just facilities discharge and placement of the slurry
- Sand / pea gravel may be added to facilitate mixing and placing
- So, for a given set of materials, a producer should be able to develop one slurry mix design that will work for most applications
- The target weight per unit area is achieved by adjusting the treatment area in the field

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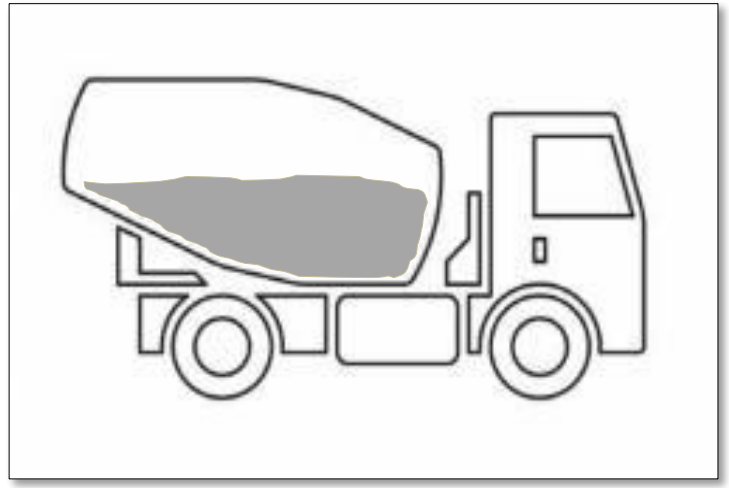
Charging the Truck Mixer

- Initially, only about 80 percent of the anticipated mixing water is added
- With mixer running, the cement is slowly added (reduces cement balls)
- Then, the balance of the water is added
- Mixed until a creamy consistency is observed
- Charge only to 60 to 80 percent of mixer capacity to ensure adequate mixing and minimize spillage during transport



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Cement Slurry Spreading

- Knowing the soil density, target cement content, and depth of treatment, the spread rate is determined
- Example:
  - MDD of 125 lb/ft^3
  - 5.0 percent cement
  - 9-inch treatment depth
- The cement spread rate is 42.2 lb/y^2 (4.7 lb/ft^2)

Percent cement by dry weight of material	Density = 115 lb/ft^3					Density = 125 lb/ft^3				
	Cement spread requirements in pounds per square yard for compacted thicknesses					Cement spread requirements in pounds per square yard for compacted thicknesses				
	8 in.	9 in.	10 in.	11 in.	12 in.	8 in.	9 in.	10 in.	11 in.	12 in.
3.0	20.7	23.3	25.9	28.5	31.1	22.5	25.3	28.1	30.9	33.8
3.5	24.2	27.2	30.2	33.2	36.2	26.3	29.5	32.8	36.1	39.4
4.0	27.6	31.1	34.5	38.0	41.4	30.0	33.8	37.5	41.3	45.0
4.5	31.1	34.9	38.8	42.7	46.6	33.8	38.0	42.2	46.4	50.6
5.0	34.5	38.8	43.1	47.4	51.8	37.5	42.2	46.9	51.6	56.3
5.5	38.0	42.7	47.4	52.2	56.9	41.3	46.4	51.6	56.7	61.9
6.0	41.4	46.6	51.8	56.9	62.1	45.0	50.6	56.3	61.9	67.5
6.5	44.9	50.5	56.1	61.7	67.3	48.8	54.8	60.9	67.0	73.1
7.0	48.3	54.3	60.4	66.4	72.5	52.5	59.1	65.6	72.2	78.8
7.5	51.8	58.2	64.7	71.2	77.6	56.3	63.3	70.3	77.3	84.4
8.0	55.2	62.1	69.0	75.9	82.8	60.0	67.5	75.0	82.5	90.0
8.5	58.7	66.0	73.3	80.6	88.0	63.8	71.7	79.7	87.7	95.6
9.0	62.1	69.9	77.6	85.4	93.2	67.5	75.9	84.4	92.8	101.3
9.5	65.6	73.7	81.9	90.1	98.3	71.3	80.2	89.1	98.0	106.9
10.0	69.0	77.6	86.3	94.9	103.5	75.0	84.4	93.8	103.1	112.5

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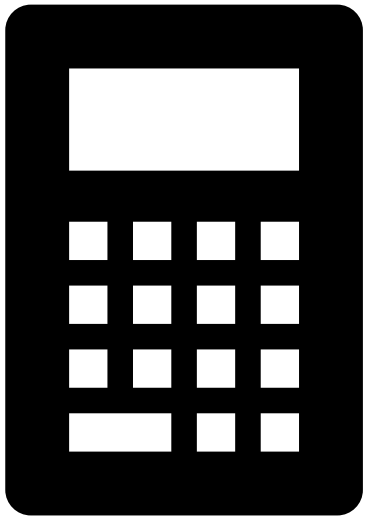
Cement Slurry Spreading

- It makes no difference whether the cement is applied in dry or slurry form - the weight spread rate is the same
- Coverage area is just the weight of cement in the mixer truck (from the batch ticket) divided by the spread rate
- Example:
  - 1 y^3 of cement weighs 2,200 lb (at W/C ratio of 0.43)
  - The truck is filled with 8 y^3 of slurry
  - The coverage area equals 3,745 ft^2
    - *((2,200 lb/y^3 x 8 y^3) ÷ (4.7 lb/ft^2))*
- Assuming an 8-foot treatment width:
  - The entire load needs to be emptied in 468 linear feet
    - *(3,745 ft^2 ÷ 8 ft)*



Cement Slurry Equipment

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Cement Slurry Equipment

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Cement Slurry Equipment

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Cement Slurry Equipment

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Cement Slurry Spreading – Slurry Spreader

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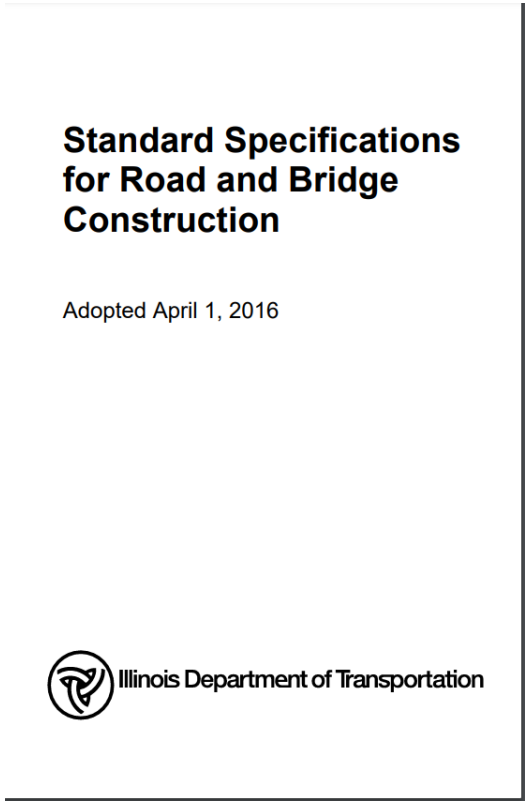
States with Soil-Cement / FDR Specifications Allowing Cement Slurry

- **Partial** list:
  - Illinois
  - Indiana
  - Pennsylvania
  - And more to follow …



Sample FDR Slurry Projects

- Salt Lake City and several other cities in northern Utah – over 10 years of slurry used for urban street reconstruction
- City of Eugene, Oregon – 4 street projects
- Tipton County, Indiana – 19 miles
- INDOT I-69 project – 2 miles (switched to slurry)
- INDOT I-65 and I-70
- Kennedy Connector – Cincinnati, OH (switched to slurry)
- Texas – TXI developed slurry truck in mid 2000
- SuperSlurry (Martin Marietta product) common in TX, LA, and licensed in KS
- Infrastructure Research, LLC is commercializing a small slurry spreader that attaches to a ready mixed concrete truck chute

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Sample FDR Slurry Projects

Malta, Montana (FHWA)

I-69 rebuild north of Indianapolis

Kennedy Connector, Ohio

Slurry spreader attached to RMC truck

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https://paveahead.com/resources

Cement Stabilized Pavement Layers

Learn more:

- Cement-Stabilized Subgrade (CSS) Soils
- Cement-Treated Base (CTB)
- Full-Depth Reclamation (FDR) With Cement Slurry
- Article: Full-Depth Reclamation With Cement Slurry
- Video: Full-Depth Reclamation With Cement Slurry

Design and construction:

- Guide to Cement-Stabilized Subgrade Soils
- Guide to Full-Depth Reclamation (FDR) with Cement

Case study:

- Website: Cement Stabilized Subgrade Soils Case Studies from the Portland Cement Association
- Website: Full Depth Reclamation Case Studies from the Portland Cement Association

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- https://cptechcenter.org/
- https://www.cement.org/
- https://cshub.mit.edu/
- https://www.ascconline.org/
- http://www.acpa.org/

Closing Comments

- Next Webinar is on July 14th 12:00 PM CST Titled:

Concrete Pavement Myths

Speakers

- Luke McHugh PE, Senior Director, Local Paving National Ready Mixed Concrete Association

- Registration Opens on Monday June 21st 2021

- IRMCA also offers Free Engineering Assistance

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