pennsylvania
DEPARTMENT OF TRANSPORTATION
LOCAL TECHNICAL ASSISTANCE PROGRAM

Full Depth Reclamation

"a roadway rehabilitation technique"

Roads Scholar I Course

Revised April 4, 2018

Pennsylvania Local Technical Assistance Program (LTAP)

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The Pennsylvania Local Technical Assistance Program (LTAP) shares transportation knowledge, improves road maintenance and safety skills, and puts research and new technology into practice at the local level through:

Training: Workshops are scheduled throughout the state and can be requested as a road show.

Technical Assistance: LTAP technical experts are available by phone, by email, and in person to help townships troubleshoot specific issues on their roadways.

Newsletter: LTAP distributes a quarterly newsletter, *Moving Forward*, which features the latest news and new practices and technologies.

Technical Information Sheets: Tech sheets provide useful, technical information on such topics as effective stop sign placement, how to use the MUTCD, paving roads, and other safety and maintenance issues related to local roads.

Website: LTAP's website, www.ltap.state.pa.us, is a valuable tool that provides up-to-date information on workshops, news items, LTAP Advisory Committee members, tech sheets, newsletters, and other resources.

All LTAP services are offered at NO Cost to Municipalities!!!

Roads Scholar Program - Professional Certification Program

- Must complete 10 (I) and 8 (II) approved workshops within a three-year period
- Pass (70%) an in-class 12 question quiz taken at the end of each workshop
- Successful completion of an approved CPR training is equal to 1 workshop credit.

You MUST include your name/contact information on the green answer sheet for credit.

PROGRAM OBJECTIVES/OUTLINE

Course Objectives

The participant will be able to:

- identify typical roadway distress that can be addressed by Full Depth Reclamation
- describe recommended construction activities
- list the factors used in selecting the stabilization process

Presentation Outline

- Pre Quiz
- Process description & Candidate selection
- Benefits of Full Depth Reclamation
- Roadway Sampling & Laboratory Testing
- Project Steps
- Construction Process
- Post Quiz / Road Scholar Questions

WHAT IS FULL DEPTH RECLAMATION?

Full Depth Reclamation as defined by ARRA:

"A pavement rehabilitation technique in which the full flexible pavement section and a pre-determined portion of the underlying materials are uniformly crushed, pulverized or blended, resulting in a stabilized base course."

What is Full Depth Reclamation?

- A process which pulverizes the existing pavement materials and mixes a specified depth of underlying materials to create a new sub base.
- Typical depth of 6 to 8 inches.
- Recycling method:
  - the asphalt pavement section
  - a predetermined amount of underlying materials
  - treated to produce a stabilized base course.

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Types of Full Depth Reclamation

- Reclamation Pulverization (no external material)
- Mechanical Stabilization (aggregates, RAP)
- Calcium Chloride Stabilization
- Chemical Stabilization (cement, hydrated lime, fly ash, lime pozzolan)
- Bituminous Stabilization (emulsion, foaming)
- Combination of preceding methods

Selection of FDR depends on: underlying soils, existing pavement condition & material, traffic load, and target bearing capacity

In general, the type of FDR construction is selected based on the existing pavement condition and materials, availability of materials, traffic demand, and cost. In its simplest form, FDR consists of in-situ pulverization of existing pavement and underlying layers, uniform blending of pulverized material, grading, and compaction. The only additive in this case will be water to assist with blending and compaction. Water is the only additive common to all FDR techniques. Most often, additional materials are needed to improve the quality and capacity of the stabilized base through FDR. These materials include emulsion or foamed asphalt for bituminous stabilization of the base, cement, or other cementing agents considered as chemical stabilizers, or simply aggregates to ensure proper material gradation to ensure durability and load carrying capacity. It is not uncommon to see a combination of these procedures applied if the conditions require that.

When is FDR Appropriate?

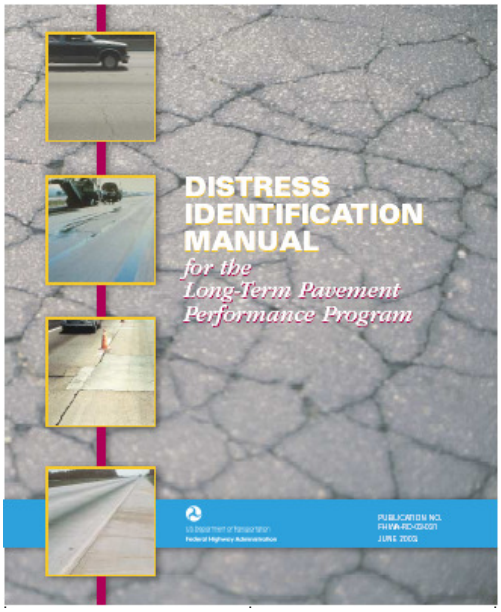
- The pavement is seriously damaged and cannot be rehabilitated with simple resurfacing.
- The existing pavement distress indicates that the problem likely exists in the base or subgrade.
- The existing pavement distress requires full-depth patching over more than 15-25% of the surface area.
- The pavement structure is inadequate for the current or future traffic.

Where is FDR Appropriate?

- Flexible pavements or unpaved roads
- Renewal of deteriorated roads by incorporating existing materials
- Severely raveled or fatigue cracked roads
- Roads with high spots (heaves) or depressions if due to underlying layers

Why is FDR Appropriate?

- Another tool to be considered when conducting your roadway condition survey
- Considered a rehabilitation technique
- Creates a new stabilized subbase



Candidate Roads for FDR

<u>Commonly Used for:</u>

- Dirt & Gravel Roads
- Low to Medium Volume Paved Roads
- Borough/City Streets

<u>Also used for:</u>

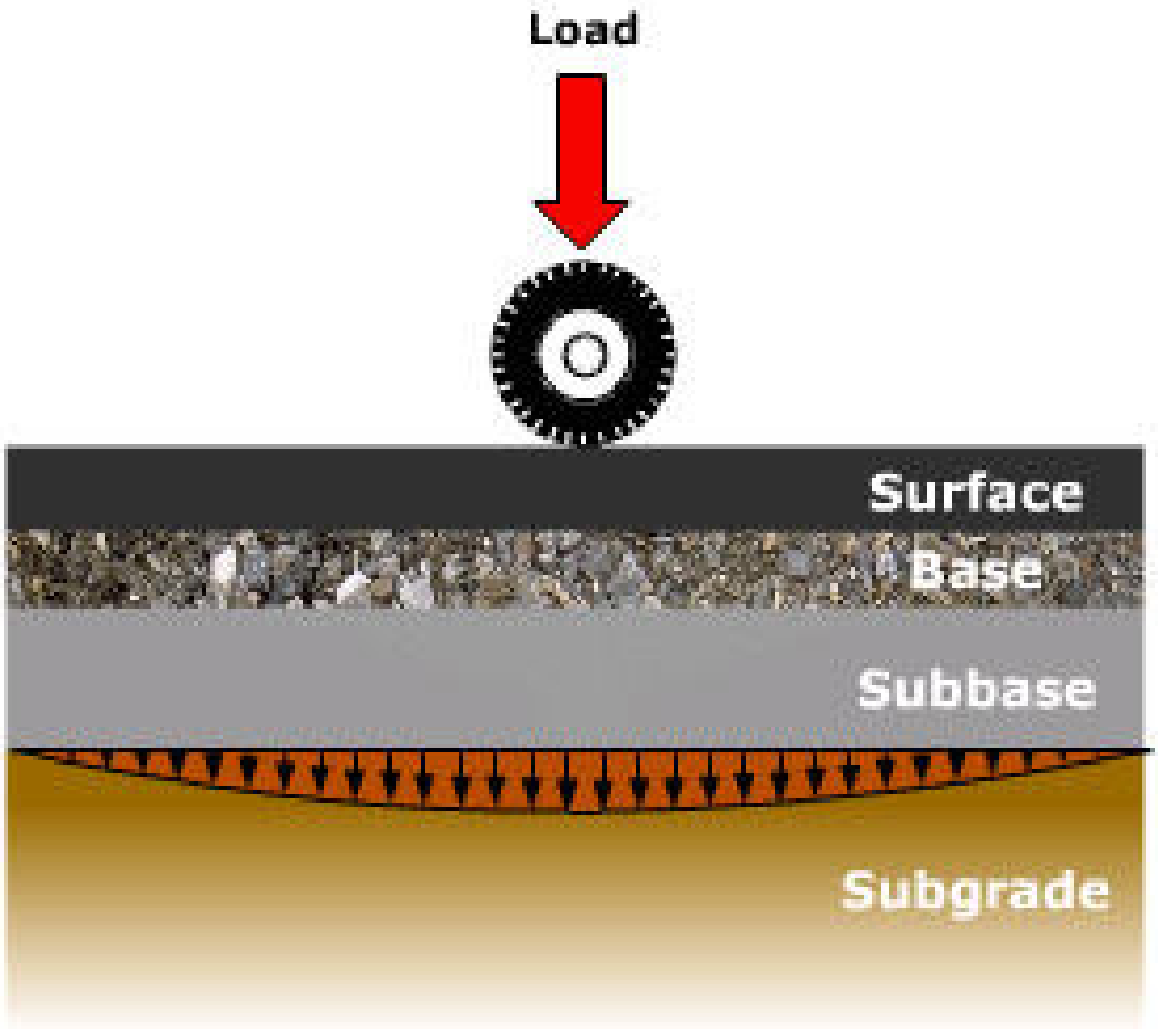
- High Volume Paved Roads
- Commercial/Industrial Roads
- State Highways
- Interstates






Features & Benefits of FDR

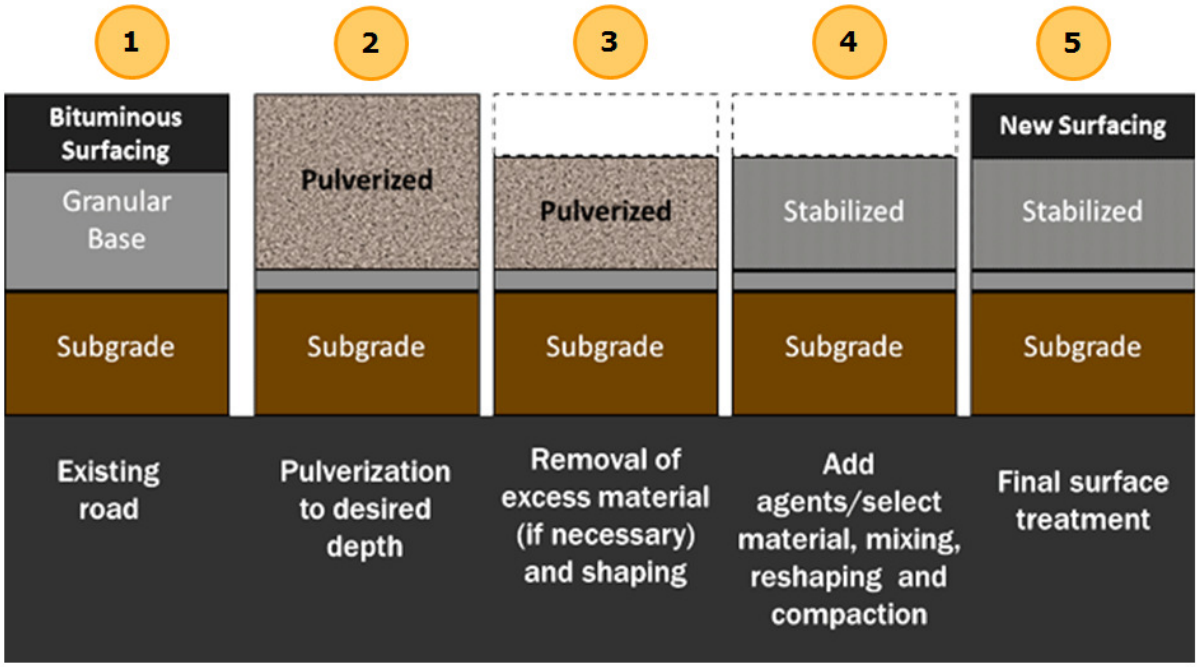
- Pulverizes all asphalt failures (100%).
- Incorporates underlying material in mix.
- May utilize subgrade soils.
- Additive equipment delivers the product directly onto reclaimed area.
- Single lane closures can be achieved.
- Reclaimed materials add years of longevity to your new roadway.
- Creates a uniform load carrying capacity, level surface & cross slope on which to place a new surface.



Process Overview

The next series of slides will provide an overview of the FDR process.

1) Existing Roadway
2) Pulverization of the existing material, depending on the design, it may incorporate the subgrade soil. Grade and compact. Depending on the stabilization type, this may be the final step.
3) Material removal. Material removal should be carefully considered as it may remove a significant portion of the stabilized material, in some cases removal of material prior to stabilization is preferred.
4) Add stabilizing agent. Remix. Grade. Compact.
5) Install wearing surface. FDR is **NOT** a suitable wearing surface. Placement of bituminous material or driving surface aggregate completes the project.

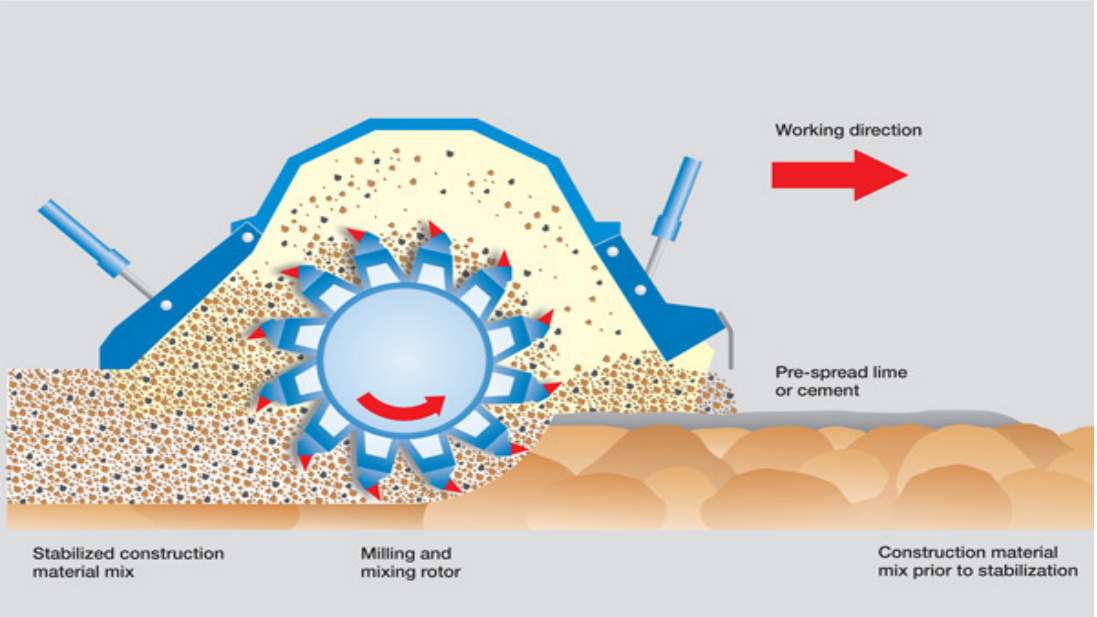


The process typically utilizes several pieces of equipment,

- a reclaimer,
- tanker (water, bituminous material, spreader(s),
- motor grader,
- breakdown roller, and padfoot roller.

Typical reclaimer shown here.

The cutting head is similar to a very large rototiller with carbide teeth that is typically between 8 and 14 feet wide and can cut to a depth of about 18 inches. Typical working depths are generally 6 to 10 inches. Experience has shown that the rotation of the cutting head is always in the 'up' direction as shown in the cartoon on this slide.



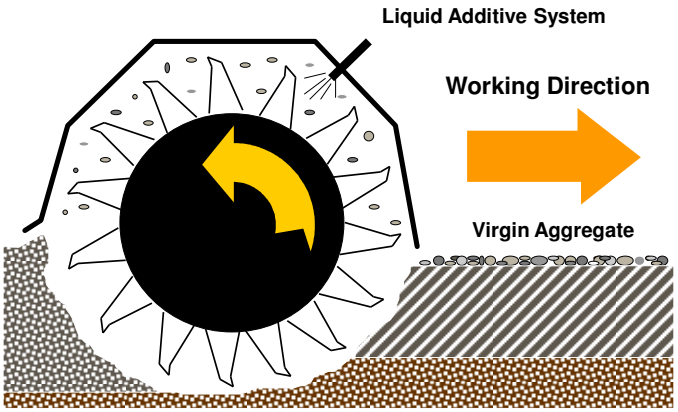
The cutting head is similar to a very large rototiller with carbide teeth that is typically between 8 and 14 feet wide and can cut to a depth of up to 18 inches. Typical working depths are generally 6 to 10 inches. Experience has shown that the rotation of the cutting head is always in the 'up' direction as shown in the cartoon on this slide.

<u>Single Pass Reclamation:</u>

- Pulverization only - no stabilizing additives.
- Calcium Chloride may be injected during this stage.
- No major geometric corrections needed.
- Thin (< 6 in.) asphalt pavement.

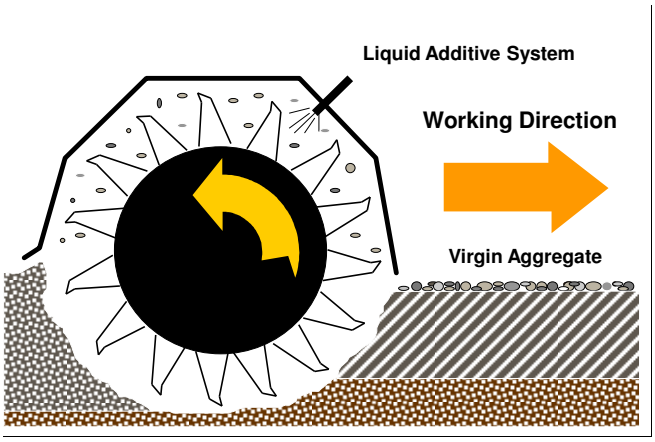
Experience has shown that the rotation of the cutting head is always in the 'up' direction as shown in the cartoon on this slide.

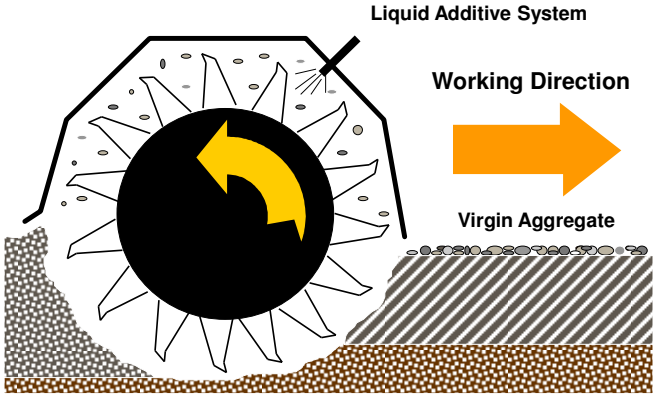
Calcium chloride aids in compaction but does not bond material together.



Multiple Pass Reclamation:

- Stabilizer added
- Major grade or profile corrections needed
- Thick asphalt pavement
- Pavement to be widened





Pulverization consists of grinding the existing roadway into a consistent size (<2 in.) material.

Process Overview

Stabilization consists of the addition of the selected agent onto the pulverized surface.

… and blending it into the road base with the appropriate amount of moisture. The stabilization process includes the incorporation or blending of the material into the roadbed

Shaping consists of judicious grading of the base to integrate the surface profile that is desired in the final product. Grading and compaction are critical steps in this process. The final shape of the road must be graded into the base. Grading and compaction must be completed within the initial 2 hours after the water is applied. What is happening in the processed base materials is a chemical reaction. All shaping must be completed before the cementatious materials begin to set. Working beyond this time will disrupt the hydration process and result in failure of the layer.

Compaction of the pulverized and shaped layer will contribute significantly to the strength that the layer will develop. The compaction method must be applicable to the depth of the pulverization. Deep pulverization will require different techniques to adequately compact to the 95% of standard Proctor required (AASHTO T99).

Compaction technique should be matched to the depth of the reclamation. To achieve the maximum benefits from this process, the base needs to be at maximum density.

Compaction Equipment. Vibratory pad-foot roller 52,000-pounds centrifugal force or Pneumatic Tire Roller 25 ton for breakdown compaction.

The finish compaction should be done with a single or tandem steel drum static roller 12-14 ton.

Although the surface at this stage of the project can be driven on by passenger vehicles, it is not intended as the final driving surface. A quick inspection of the surface reveals insufficient aggregate in the surface to act as an abrasion resistant surface. FDR also does not have the long-term ability to withstand long-term direct contact with vehicular traffic without a final driving surface.

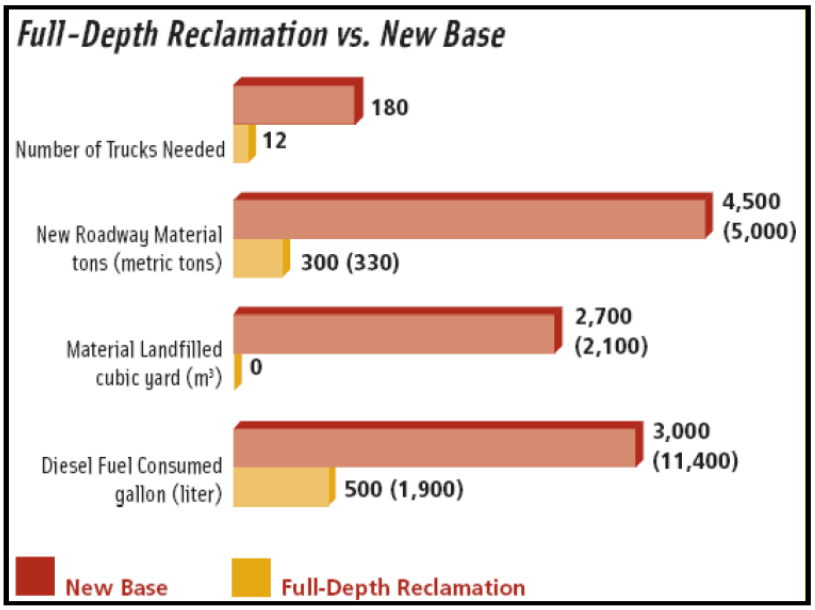
Benefits of FDR

Environmental Benefit

- Renewable use of existing resources
- Sustainable road construction
- Green highway technology

Economic Benefits

- Reduced cost because of renewable use of existing resources
- Reduced construction time and minimal traffic disruption



Roadway Rehabilitation Cost Comparison

	FDR Low Range $3.50/SY	FDR High Range $7.00/SY	10% Base Repair $33.00/SY	15% Base Repair $33.00/SY	20% Base Repair $33.00/SY	30% Base Repair $33.00/SY
Base Repair (5" depth) cost per mile	$0	$0	$38,720	$58,080	$77,440	$116,160
FDR cost per mile	$45,173	$90,347	$0	$0	$0	$0
Total Cost per Mile	$45,173	$90,347	$38,720	$58,080	$77,440	$116,160

FDR Cost	Reconstruction Cost
FDR Base - $10.00 SY	Base Replacement - $32.67 SY
4.5″ Overlay - $17.90 SY	4.5″ Overlay - $17.90
Total Cost per SY - $27.90	Total Cost per SY - $50.57
Total Project Cost - $327,360	Total Project Cost - $593,316

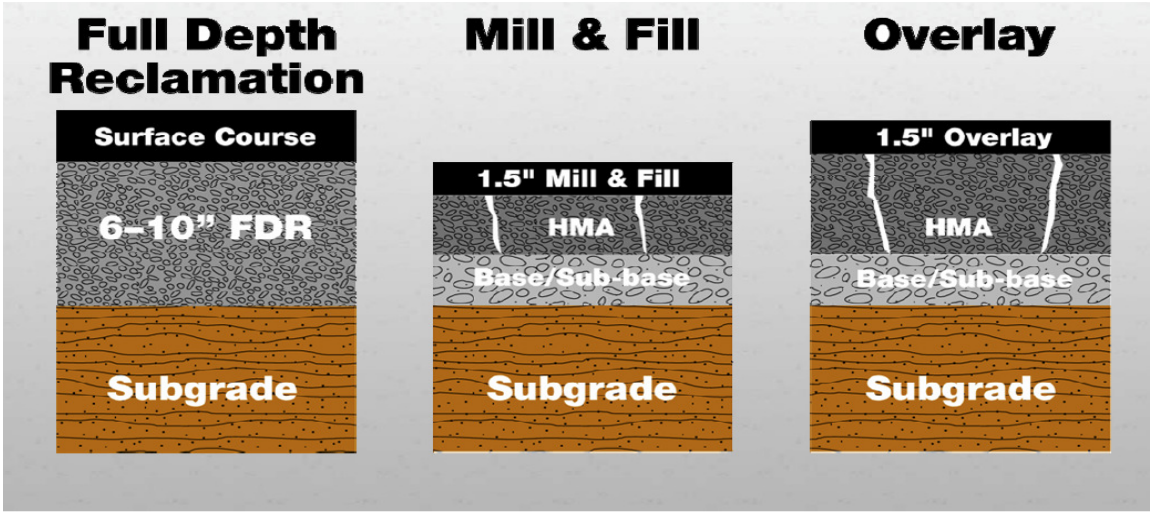
Except for the FDR cost, which was based on the Butler County work, the other unit prices used were average unit prices from ECMS.

In this case a very strong pavement section was constructed, and the alternative cost of reconstructing a similar pavement structure approaches a factor of two. For projects with less pavement structure, this ratio may vary.

Technological Benefit

- Simple construction
- Ability to address base problems
- Working with materials at ambient temperature
- Create a uniform platform for surface layers

FDR can be utilized to depths exceeding 12 inches (6 in. to 8 in. is typical).



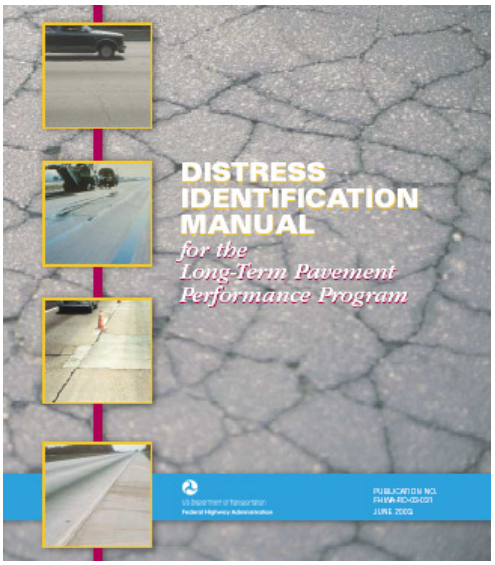
Completely erases deep pavement cracking, which eliminates the potential of reflective cracking.

Project Steps

- Project Planning
- Site Assessment and Distress Survey
- Sampling and Laboratory Testing
  - Decide who will perform this and how
- Design Considerations
- Mix Design
- Construction
  - In-House versus Contractor Work
  - Who does what
  - Equipment availability

Project Planning

- Include your Municipal Services and/or Representative in the process
- Understand the steps necessary to prepare for a successful project
- Who is going to perform the site assessment?
- Determine how the material samples will be obtained and who will compete the design for the FDR Mix and Pavement Structure to meet current and future traffic needs
- Selection of Appropriate FDR Technique
- How will you perform Quality Control?
- Preparation of bidding documents - Procurement of Needed Construction Equipment, Labor, and Materials.
- Does your project require Prevailing Wage?
- Construction - will you use a contractor, in-house forces or a combination?
- Plan a preconstruction meeting and review coordination and contractual requirements and expectations



Site Assessment and Distress Survey

- Distress Condition
  - Type
  - Extent
  - Severity
- Drainage Related Issues
- Structural Evaluation - subgrade
- The goal is to determine the primary cause of the pavement distress in order to evaluate feasible options or pavement rehabilitation
- For example:
  - Overlay will not work when base failure is caused by poor soils
  - FDR is not necessary for aged/oxidized asphalt on stable subgrade

Site Assessment and Distress Survey Con.

It is important to identify the types and severity of distress:

- Asphalt rutting vs. base rutting
- Cracking – fatigue, edge, thermal or base failure
- Base failure (percent of the road)
- Asphalt Oxidation/degradation
- Drainage and water-related problems

Identify

- Distress
- Fatigue cracking and rutting
- Assess drainage, including drainage features
- Protect drainage and other buried features
- Consider depth of limits of pulverization
- Protect utilities
- Intersection tie-ins
- Both overhead and lateral restrictions

Sampling and Laboratory Testing

- Collection of field samples is very important.
- Guidelines in Publication 447
- A minimum of 3 sample locations per road
- Additional locations selected upon pavement condition and variability
- Sample locations selected following Pennsylvania Test Method (PTM#1)

ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_19/PTM_TOC.pdf

Samples of soil, aggregate subgrade, and pavement are necessary. Since moisture is an important element of the FDR process, the existing subgrade moisture content is important in determining how much moisture must be added to achieve density.

- Evaluate the existing pavement and soil subgrade and obtain samples
- Determine thickness of asphalt and aggregate subbase
- Type of soils and their stability and moisture

Obtain enough samples for analysis since it is hard to go back and get more.

Project Assessment

Project assessment is very important to the development of a potential FDR project. All the elements of a project reflected on the slide can play an important part in the decision to use FDR, and in the full development of a FDR project.

Identify buried obstructions

- Geo-grid, rock, field stone, concrete, etc.
- Utilities

Sampling and Laboratory Testing

- Backhoe, saw cut or jack hammer are acceptable
  - Core boring alone usually does not allow enough sample to be obtained
  - If core boring, take sufficient samples
- Sampling Procedure – Cores

To be effective the samples collected must be representative of the existing road structure. Samples should be taken at intervals of 500' using PTM 1 to select locations. For projects exceeding 1 mile, the sample frequency can be reduced, particularly if the road is uniform throughout the length. There should be a minimum of 3 samples per project. Note that samples taken from highly distressed areas may not be representative of the entire road.

  - Core through all layers expected to be reclaimed
  - Total sample depth of 1.5 times reclaimed layer
  - Use minimum 4" auger sampling for subgrade

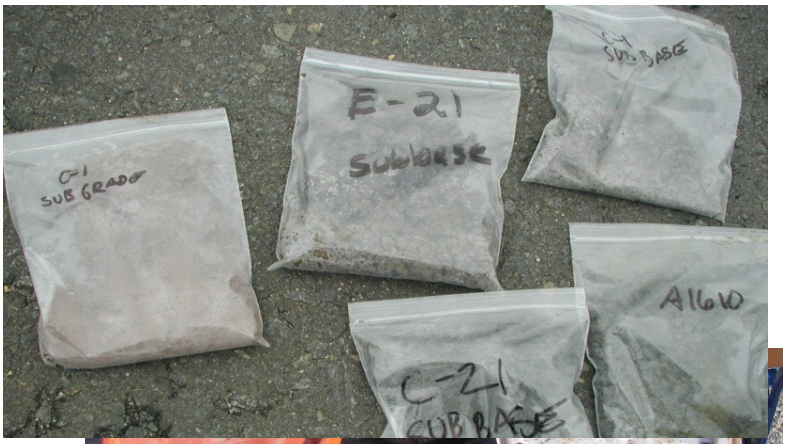
Sampling Procedures - Test Pits

- Select representative cross section locations – left/center/right
- Minimum test pit should be 3 ft. x 5 ft.
- Depth of 1.5 times the anticipated depth of pulverization
- Log all material removed, take photos
- Collect sufficient material for testing
- Minimum 100 lbs./location

Test pits are vital to a FDR project. They provide access to the subgrade, and are the source of sufficient material quantity to perform laboratory testing. Test pits representative of the roadway cross section should be made to obtain samples for mix design work. If differences in the existing road structure are identified, test pit material samples should be collected at locations representative of each different area.

Sampling Procedures - Test Pits

Ideally, have a soil engineer's representative on site.



Obtain separate samples of soil, aggregate subbase and asphalt

- Subgrade samples must be sealed in plastic bags or buckets to preserve the moisture content.
- The necessary identification marking is also important.
- Typically, five gallon buckets with lids are used to insure enough soil is obtained.
- Obtain more than enough material – it is hard to go back and excavate more
- Obtain a bulk sample without rock fragments- they are discarded from lab testing

Laboratory Testing

- A qualified lab or technical representative to be approved by the Municipality
- Once testing is complete, the qualified entity will determine which stabilization method(s) to be used
- Further testing and designs are developed to determine quantities of the additive per specification of the stabilization method
- Soil classification
- For chemical stabilization, the application rate depends upon:
  - Soil type (gravel, sand, silt or clay)
  - Moisture (in-situ and seasonal fluctuations)
  - Weather and construction season
  - Long-term traffic and service life
  - Desired strength
- Need to determine the strength of the soil that underlies the proposed pavement
- Assists in determining if performance and strength can be improved with mechanical stabilization

Design Considerations

- Review the existing pavement condition
- Match stabilization method with existing materials and soils
- Consider the anticipated road use
- Consider thickness of existing material available for reclamation
- Investigate any significant problematic areas (base/subbase failures)
- Review drainage issues
- Design Life
- Design Traffic
  - ADT
  - Heavy vehicles
- Road Geometry
- Drainage Needs
  - Surface
  - Sub-surface

Design considerations for FDR are the same as for other roadway pavement designs. A suitable design life can be selected for the class of road. The number and size of heavy vehicles is the most important factor in pavement structural design. The design should also address appropriate geometric design features such as horizontal curves, super elevation, and pavement cross slope.

As with all pavement repair or rehabilitation, drainage needs must be addressed. This includes not only the accommodation of surface runoff, but also the effective removal of subsurface water from the pavement layers. Water, and particularly subsurface water, is responsible for a large proportion of all pavement damage. In addition to weakening subgrade soils, it also causes damage to pavement materials in several possible ways.

The structure layer coefficient is determined by the FDR process used. Appropriate values for the various types of FDR including mechanical, chemical, and bituminous stabilization are provided in Table 9.3 of Publication 242, Pavement Policy Manual.

- Pavement Design Process – Pub. 242
- Determine structural requirements necessary for traffic/subgrade support
  - Determine FDR structural contribution, based on the FDRs thickness and strength.
  - Determine total structure required, the remainder of structure will be made up of asphalt or driving surface aggregate.
- The pavement design should be completed by a qualified engineer

Mix Design

Steps in Mix Design

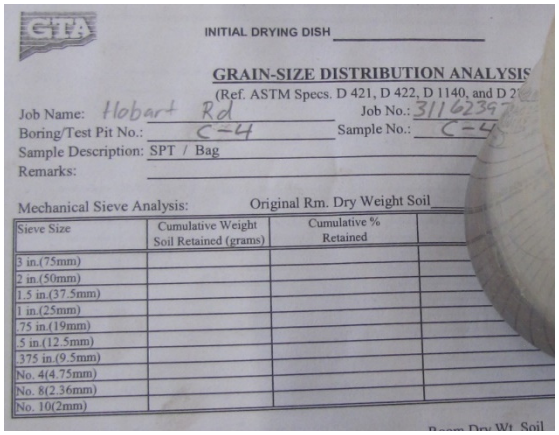
- Procure in place materials
- Characterize materials
- Select appropriate stabilizers
- Develop mix design

Materials for Mix Design

- Materials to the depth of pulverization
- Underlying material including subgrade

Characterize Materials for Mix Design

- Asphalt content and gradation of surface material
- Base/subbase gradation
- Subgrade plasticity
- Subgrade gradation
- Sand equivalent for combined materials



INITIAL DRYING DISH _____

GRAIN-SIZE DISTRIBUTION ANALYSIS

(Ref. ASTM Specs. D 421, D 422, D 1140, and D 2

Job Name: Hobart Rd Job No.: 3116239

Boring/Test Pit No.: C-4 Sample No.: C-4

Sample Description: SPT / Bag

Remarks:

Mechanical Sieve Analysis: Original Rm. Dry Weight Soil

Sieve Size	Cumulative Weight Soil Retained (grams)	Cumulative % Retained	
3 in.(75mm)			
2 in.(50mm)			
1.5 in.(37.5mm)			
1 in.(25mm)			
.75 in.(19mm)			
.5 in.(12.5mm)			
.375 in.(9.5mm)			
No. 4(4.75mm)			
No. 8(2.36mm)			
No. 10(2mm)			

Materials for each layer of the pavement must be tested for gradation. If there is more than one asphalt layer, they could be combined and the asphalt content and gradation be determined for the combined material. Asphalt content determination will be needed only if emulsion or foaming stabilization will be applied.

Selection of Stabilizer

- The choice of the stabilizing agent must be made to match the properties of the soil
- Gradation
- Clay content (plasticity)
- Soil Characteristics
- Pairing of the soil to the stabilizing agent emphasizes the need for a detailed characteristic of the base material for the mix design

Pa. Soil Map

County conservation districts can help provide soil composition information. Soils vary significantly throughout Pennsylvania.

Soil Particle Types

- Boulders – large particles of rock >12 in.
- Cobbles – medium sized particles of rock between 3 in. and 12 in.
- Gravels – smaller fragments of rocks, generally between 0.2 in. to 3.0 in.
- Sands – small rock particles < 0.2 in. Can be classified and course or fine.
- Silts – very fine soil particles; < 0.003 in.
- Clays – very fine soil particles; < 0.003 in.; plastic (stick together)

Size Classification

Type	Sieve #	Limits (inches)	Limits (mm)
Gravel	3″ to #4	3.0 to 0.2	76.200 to 4.750
Sand	#4 to #200	0.2 to 0.003	4.750 to 0.0075
Silt & Clay	< #200	< 0.003	< 0.0075

This chart helps explain the differences in soil types that may be encountered. ASTM Sieve Designations/ Particle Size analysis (REV Dec 2016).

Mix Design – Soil Classification

Determine particle size distribution by gradation tests

Sand and Gravel

- Course-grained
- Formed by mechanical weathering of parent rock
- Non-cohesive (do not stick together)
- Drain quickly
- Do not shrink or swell with change in moisture content
- Stable under wheel loads when confined

Silt

- Extremely small particles
- Formed by mechanical weathering of parent rock
- Non-cohesive (do not stick together)
- Do not drain quickly
- Tend to shrink or swell with change in moisture content
- Very susceptible to capillary action & frost action
- Can be unstable under wheel loads

Clay

- Extremely small particles
- Formed from chemical weathering of parent rock
- Cohesive (particles stick together)
- Considerable strength when dry, great loss of strength when wet
- Can absorb significant water and shrink and swell with change in moisture content
- Drain very slowly, susceptible to capillary action & frost action

Mix Design – Soil Classification

Determine soil consistency by plasticity tests

- "Plastic Soils" Roll into a 1/8" thread without breaking
- Lowest % of moisture which allows it to remain plastic is the "plastic limit" (PL)
- Plasticity Index (PI) is a measure of the plasticity of a soil. Soils with a high PI tend to be clay, those with a low PI send to be silt.

Mix Design – Stabilizing Agents

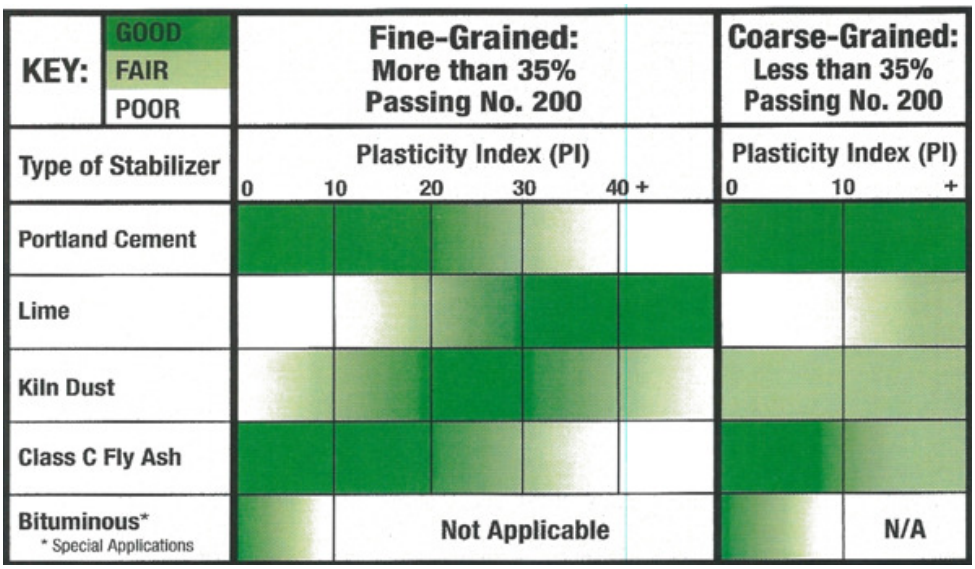
Now that you have determined your soil properties, how do you decide on the stabilizing technique?

- Pulverization
- Mechanical stabilization (aggregates, RAP)
- Calcium Chloride
- Chemical stabilization (cement, fly ash, etc.)
- Bituminous stabilization (emulsion, foaming)
- A combination of preceding methods

This is a simplified guide to assist in the selection of the stabilizing agent once the characteristics of the roadway base are known. This highlights the importance and need for sampling the roadway before the project. The old "rule-of-thumb" 10% Portland cement at 8 inches isn't always the best mixture design. One size does not fit all.

ARRA guide to selection of chemical stabilizing agents

Note: Portland Cement treats a wider range of soil types but is not appropriate for all soils such as high plasticity clays.



Mix Design – Mechanical Stabilization, Pub. 447

- Mechanical stabilization is useful for unpaved or gravel roads
- Roads with little pavement structure
- Addition of virgin aggregate or RAP

Similarly, RAP could be added to the mix to mechanically stabilize the mix before any chemical or bituminous stabilization is applied. It must be noted that sometimes the addition of RAP is needed because of difficulties in pulverizing to the needed depth, for example, when extremely large aggregate form the base and pulverization through this base is not possible.

Mix Design – Chemical Stabilization

Chemical Additives

The most common chemical stabilizers are cement and lime even though fly ash and calcium chloride have also been used in FDR projects.

- Cement – limestone and other additives heated in a kiln (2700 degrees Fahrenheit) and crushed
- Hydrated Lime/Quick Lime – Calcium Oxide (CaO) produced by heating of limestone in a kiln (1800 degrees Fahrenheit)
- Fly Ash – Byproduct from coal-fired power plants
- Lime Pozzolan – a silica/aluminum material (volcanic ash) which has little to no cementing ability but when in "finely divided" form mixed with moisture and calcium hydroxide produces a material which has cementing properties

What do the chemicals do? The can dry soils.

- Chemicals absorb water
- The chemical reaction gives off heat – driving off additional moisture

What do the chemicals do? They can modify soil properties.

- Reduce plasticity
- Reduce soil swell

Chemicals create a permanent cementation resulting in:

- Higher compression strength and load carrying ability
- Very low deformation/ compression even when wet
- Significant resistance to freeze and thaw cycles

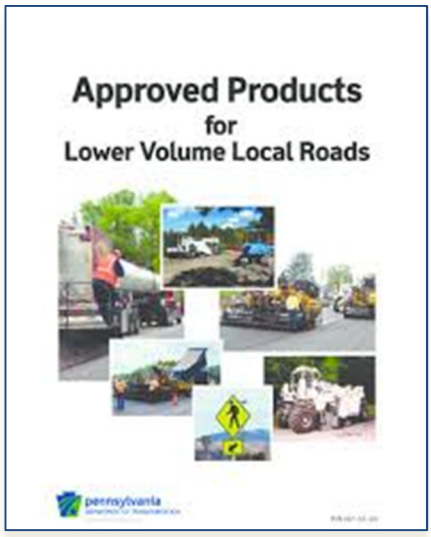
Construction

Which construction methods did you choose?

- Pulverization
- Mechanical Stabilization
- Calcium Chloride Stabilization
- Chemical Stabilization
- Bituminous Stabilization

Each has a separate specification in:

- Publication 447 - Approved Products for Lower Volume Local Roads and
- Publication 408 – Construction Specification



Construction – Pulverization

The objective of this process is to produce a subbase that in conjunction with the driving surface that is capable of supporting the design traffic load.

Publication 447 Specification MS 0370-0005

Description: "This work consists of the in-place pulverization and uniform blending of existing roadway surface materials and predetermined thickness of underlying material creating a homogenous mixture of reclaimed base material. It also consists of shaping, finishing, fine grading, and compaction of the reclaimed base material."

- In-place pulverization and uniform blending
- Shaping, finishing, fine grading and compaction
- Specific equipment needed
  - Reclaimer – no planers or cold milling machines
  - Pad-Foot or 25-ton breakdown roller
  - 12 – 14-ton finish roller
- Weather limitations- Do not place from November 1 to March 31 or when the air or surface temperature is 40°F and lower.

Construction – Mechanical Stabilization

Publication 447 Specification MS 0370-0020

Description: "This work consists of incorporation of imported granular material during the pulverization or mixing pass."

Addition of one or more of the following:

- RAP
- Aggregate: #8, #10, #57, #67
- Gradation & quantity as required by mix
- In-place pulverization and uniform blending
- Shaping, finishing, fine grading and compaction
- Specific equipment needed
  - Reclaimer – no planers or cold milling machines
  - Pad-Foot or 25-ton breakdown roller
  - 12 – 14-ton finish roller
- Weather limitations- Do not place from November 1 to March 31 or when the air or surface temperature is 40°F and lower.

Aggregate and RAP added

RAP Gradation Requirements	
Sieve Size	Percent Passing
2 inch	100
1.75 inch	95-100
#200	0-20

Appendix B-3 Publication 27 design procedure requirements

Construction – Calcium Chloride Stabilization

Publication 447 Specification MS 0370-0030

Description: This work consists of pulverization and mixing of a combination of virgin aggregate (if specified), RAP, RAM, and calcium chloride.

- Addition of Calcium Chloride:
  - 35% Solution @0.10 – 0.15 gallons/s.y. per inch of depth
- Mix Design
  - Core samples
  - Submission to PennDOT & Municipality
- In-place pulverization and uniform blending
- Shaping, finishing, fine grading and compaction
- Specific equipment needed
  - Reclaimer – no planers or cold milling machines
  - Pad-Foot or 25-ton breakdown roller
  - 12 – 14-ton finish roller
- Weather limitations- Do not place from November 1 to March 31 or when the air or surface temperature is 40°F and lower.
- Calcium Chloride can be injected during the pulverization pass or
- Incorporated into the blending pass after pre-pulverization and shaping
- Curing
  - Allow the stabilized base to cure for 5 days after final compaction
  - Protect surface from drying

Construction – Chemical Stabilization

Publication 447 Specification MS 0370-0035

Description: This work consists of pulverization and mixing of a combination of virgin aggregate (if specified), RAP, RAM, and Subgrade material. Once pulverized, add the Chemical stabilization additive per mix design, mix together to create chemically stabilize base course. Addition of one or more of the following:

- Cement – Pub 408 Sec 701 (3% - 8%)
- *Hydrated Lime - Pub 408 Sec 723 (2% - 6%)
- *Fly Ash – Pub 408 Sec 724.2(a) (6% - 14%)
- Lime Pozzolan – Pub 408 Sec 725 (6%- 8%)

*Hydrated Lime or Fly Ash will not be used as singular additive but will be a combination of the two.

Additive Application

- Dry requires yield test & is subject to wind conditions
- Wet requires re-circulation or agitation to prevent settling

Curing

- Apply bituminous prime coat* or approved alternative
- *Apply cover aggregate if maintaining traffic
- In-place pulverization and uniform blending
- Shaping, finishing, fine grading and compaction
- Specific equipment needed
  - Reclaimer – no planers or cold milling machines
  - Pad-Foot or 25-ton breakdown roller
  - 12 – 14-ton finish roller
- Weather limitations- Do not place from November 1 to March 31 or when the air or surface temperature is 40°F and falling.
- Apply stabilizing material.
- Apply the proper amount of water.
- Mix these with the existing roadbed materials.

Note: aggregate can be added if appropriate.

Construction – Mechanical Stabilization Cont.

One issue associated with the use of anhydrous cement powder and other fine cementatious materials is, as you can see, DUST. The threat of dust is linked to weather conditions with light winds. Modern distribution trucks are equipped with vacuum pickup that minimizes this problem. The use of slurries in place of dry powders is starting to gain acceptance because of the dust issue, but this practice has its own limitations. For most cementatious materials the setting reaction begins once water is admixed with the powder which will result in the necessity to integrate the slurry into the pulverized roadway faster. This would necessitate placing the slurries over shorter distances than are currently practiced with powders.

Construction – Bituminous Stabilization

Publication 447 Specification MS 037-0040

Description: This work consists of the incorporation of bituminous stabilization material during the pulverization or mixing process of a FDR project.

Addition of Bituminous Material
- Emulsified Asphalt
- Polymer modified can used as necessary

May also require the addition of aggregate
- AASHTO #8, 57, or 67

- In-place pulverization and uniform blending
- Shaping, finishing, fine grading and compaction
- Specific equipment needed
- Reclaimer – no planers or cold milling machines
  - Pad-Foot or 25-ton breakdown roller
  - 12 – 14-ton finish roller
- Mixing- MUST verify liquid injection quantity is accurate
- Curing- If raveling is present apply a bituminous prime coat
- Weather limitations- Do not place from September 1 to April 30 in Districts 1-0, 2-0, 3-0, 4-0, 9-0, and 10-0; and from October 1 to April 1 in all other districts. No freezing temperatures may occur for 24 hours before or when the temperature is 45°F and lower.

Construction – Grading and Shaping

The motorized road grader is the typical means for final shaping of the road to line, grade, and cross slope.

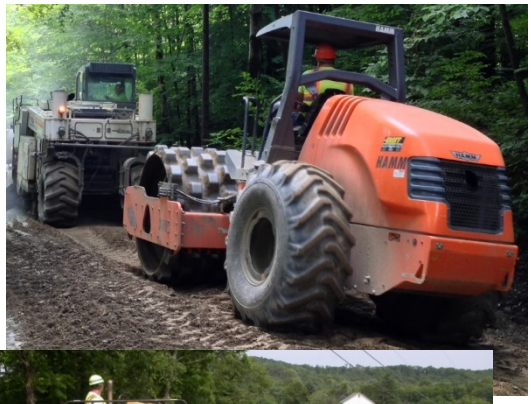
Shaping consists of grading to integrate into the base the surface profile that is desired for the final product. The shaping operation is not intended to use the grader to blend the materials, the reclaimer has already done that. It is only intended to create the final shape of the road.

A light grading of the surface may be necessary following pad-foot roller compaction to remove the pad marks. Final shaping establishes the crown, superelevation, and grade of the final reclaimed road. It is important to control the width of the reclaimed material to prevent spreading, which results in the final reclaimed layer being less than the design thickness. This can be detrimental to the life of the finished roadway.

Construction – Compaction Equipment

Compaction methods should be matched to the depth of the reclamation to achieve the maximum benefit of FDR the base needs to be at maximum density.

Multiple passes of rolling equipment are necessary to accomplish compaction of the reclaimed layer. It is important to verify the proper moisture content for compaction exists at the time of rolling. It is also important to be sure the drying effects of wind and sun do not change the moisture content significantly before compaction is completed.



The pad-foot roller is shown working itself out of the mat. In the background, the motor grader is smoothing out the surface in preparation for further compaction.

When the reclaimed layer is more than 8 inches deep, the use of a pad-foot roller is necessary to assure the bottom portion of the lift is properly compacted.

Finish rolling is accomplished using a smooth drum roller. The smooth sealed surface of the reclaimed layer will receive the new surface course to be applied.

Construction – In-Place Density Testing

Regardless of the type of reclamation used, the nuclear density gage is an important tool for controlling the work in the field. The nuclear gage can provide the in-place density of the reclaimed mat, and reports the density achieved by the compaction process. In general, density can be increased by additional passes of the rollers. The required minimum density is 95 percent of the dry density from the mix design. The optimum moisture for compaction is determined from the proctor test during the mix design process. These two pieces of information are critical to the control of FDR work in the field.

Construction – Compacted Surface

The final compacted surface is shown in this slide. It is relatively smooth, and evidences the particle size created by the reclaimer. However, it is not durable to trafficking.

Project Management & Quality Control

- Pre-construction meeting
- Preliminary equipment checks
- Measure chemical application rate and mix depth
- Monitor moisture levels in soil and adjust water application rate
  - * Too dry – chemical needs water to react
  - * Too wet – additional chemical needed to dry soils
- Verify adequate pulverization and mixing
- Perform field density testing for compaction
- Ensure curing coats are applied

The stability of the surface should be confirmed prior to applying surface material. Typically, a five (5) day cure time is necessary to allow the stabilizing agent to develop the necessary chemical bonds prior to allowing heavy/commercial traffic back on the roadway. Heavy vehicles should not drive on the FDR prior to placing of the wearing surface.

Full Depth Reclamation – Summary

Project Planning

- Work with PennDOT District Municipal Services staff throughout process
- View roadway project
- Perform a roadway condition survey to identify current distress
- Consider an LTAP Tech Assist
- Check roadway for hidden utilities

Material Testing and Sampling

- Determine who will take / test samples
- Take samples that represent the full depth of the intended pavement
- Have laboratory analyze material and give recommendations for additive material
- Determine if a stabilizer is needed and what kind of stabilizer would benefit the roadway structure

Publication 447 Additive Selection Guide

- Asphalt emulsions are easy to apply and dust free
- An emulsion stabilized base course is flexible and not prone to cracking
- When in place moistures are high adding emulsion can increase moisture above optimum resulting in an unstable layer
- Cement is easy to apply dry or as a slurry
- Cement improves resistance to moisture and develops good early strength
- Shrinking cracking can result from high cement applications (>6%)
- Calcium Chloride is hygroscopic (absorbs moisture)
- The moisture facilitates compaction then imparts strength
- Calcium chloride has been shown to reduce frost heave
- Lime/Fly Ash increases the amount of silicates in silicate deficient silty materials which allows for proper strength gain to take place

Note: When considering stabilizers, various combinations can be used together for various reasons

Full Depth Reclamation – Summary

- Conserves energy, significantly reducing or eliminating trucking and other material handling issues.
- Eliminates heating fuel, since it is a cold process.
- Conserves materials by recycling 100% of the existing pavement materials (stone and asphalt) and subgrade soils, conserving limited resources.
- Crown and cross-slope easily restored.
- Minor grade changes can be made.
- Loss of curb reveal can be reduce or even eliminated
- Reflective cracks are eliminated
- Long-term cost-effective solution that addresses 100% of the cause of pavement failure, weak bases.
- Environmentally desirable by recycling all materials in-place, saving time, money and resources.
- Future maintenance costs are reduced.

FOR MORE ASSISTANCE...

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