**FULL DEPTH RECLAMATION**

Presented to:

**LOCAL ROADS PROGRAM 2012**

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**What is Full Depth Reclamation (FDR)?**

Full Depth Reclamation is a pavement rehabilitation technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly ground, pulverized and blended to provide an upgraded, homogeneous material which can be used as is, or modified to make a designed (SBC) Stabilized Base Course.

*The sub-grade and any preceding course shall be suitable to support the construction equipment without settlement or displacement. Soft or yielding sub-grade shall be corrected before construction begins.*

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**STABILIZER DESIGN**

**FDR Candidates**

**Flexible Pavement Structures**

1. Parking Lots
2. Low Volume, Secondary Roads
3. City Streets and Medium Volume Roadways
4. Interstate Highways
5. Private and Regional Airports

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**Benefits**

1. Erases deep pavement crack patterns, thereby reducing the potential of returning reflective cracking.
2. FDR can be utilized to depths exceeding 12” (6” to 9” typical), eliminating potholes, utility cuts, and other irregularities.
3. Pulverized laminated layers become a homogenous, well graded (2” minus), workable material.

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**Benefits**

4. Cross section and profile of the road can be easily corrected by proper grading and compaction of the 2” minus material, assisting in:
   a. Proper drainage control, with ditch to ditch utilization.
   b. Increased ride quality due to swells, bumps, sags, and depressions.
   c. Excessive shoulder drop off safety problems.
   d. Repairing surface integrity due raveling, potholes, and bleeding.
5. An increase in the structural capacity of the new material can be achieved, after an evaluation and a modification done, by one, or a combination of the following methods:
   a. mechanical - with aggregate structure
   b. chemical - with chemical additives
   c. bituminous – with asphalt additives

Benefits

The FDR Process

Core Equipment
1.) Road Reclaimer
2.) Motor Grader
3.) Compactors
   A.) Vibratory Pad-foot
   B.) Pneumatic
   C.) Vibratory/Static Smooth Drum
4.) Water Truck

Construction Sequence

- Varies based upon scope of project and stabilizers being used
  1.) Single Pass Reclamation
  2.) Multiple Pass Reclamation

Single Pass or Multiple Pass Used Depending on:
- Severity of Distress
- Type and Quantity of Additive needed (if any)
- Thickness and variations of pavements to be recycled

Single Pass Reclamation

1.) Pulverize the existing pavement and underlying layers while simultaneously adding and mixing various stabilizing additives, if any
2.) Fine grade and compact the SBC
3.) Fog seal or prime the SBC, as required
4.) Apply the specified surface treatment
**SINGLE PASS RECLAMATION**
- Padfoot Compaction
- Grading and Shaping
- Vibratory Compaction

**Additional Aggregate Grind with Oil Injection**

**Padfoot Compaction Grading and Shaping Vibratory Compaction**

**Multiple Pass Reclamation**

1. **1st Pass**
   - Working Direction

2. **2nd Pass**
   - Liquid Additive System
   - Mixing the Additive at a constant depth.

**The FDR Process**

4 Primary Stabilizing Disciplines
1. Pulverization
2. Mechanical Stabilization
3. Bituminous Stabilization
4. Chemical Stabilization

**Dry Pulverization**

- Accomplished with a single pass
- In-situ pavement layers and pre-determined amount of underlying materials are pulverized and mixed
- Moisture for achieving the required density is the only additional material added

**Typically Used When:**
- Base, sub-base and/or sub-grade deficiencies are not apparent.
- Anticipated quality of pulverized base course is sufficient enough to support the anticipated loads after surface course placement.
**Mechanical Stabilization**
Involves the incorporation of imported granular materials
- Crushed Virgin Aggregate
  - Coarse to Fine in Gradation
- Recycled Asphalt Pavement (RAP)
- Can be performed with a single pass or with multiple passes

**Bituminous Stabilization**
Involves the incorporation of bituminous stabilizing additives
- Emulsified Asphalt - can use Anionic or Cationic
  - Type and quantity of emulsion is dependent upon mix design.
  - Emulsion is typically 50-62% AC.
  - Chemicals and additives affect set and cure times.
- Foamed/Expanded Asphalt
  - Elevated temperature asphalt cement (~320°F) is injected with a small amount of cold water (~2% by mass of AC)
  - The resulting thermal reaction greatly increases the surface area/volume of the AC, thereby decreasing its' viscosity and allowing for improved coating of fine materials.

**Chemical Stabilization**
Involves the incorporation of 1 or more of the following chemical stabilizing additives
- Portland Cement (dry or slurry)
- Lime - hydrated or quicklime (dry or slurry)
- Calcium Chloride
- Other chemical products
Type and Typical Trial Percents of Stabilizer Characteristics of Reclaimed Pavement Materials

Hydrated Lime or Quicklime 2-6% by weight
- lime-pozzolan 6-8% by weight
Reclaimed asphalt pavement (RAP) having some amount of silty-clay soil from subgrade with a plasticity index greater than 10.

Portland Cement 3-6% by weight
- Materials consisting of 100% RAP or blends of RAP and underlying granular base of non-plastic or low plasticity soils.
  - There should be sufficient fines to produce an acceptable aggregate matrix for the cement treated base (CTB) produced (not less than 45% passing the 4.75 mm or No. 4 sieve preferred).

Emulsified Asphalt 1-3% by weight
- Materials consisting of 100% of RAP and underlying granular base of non-plastic or low plasticity soils.
  - The maximum percent passing the 75um (No. 200) sieve should be less than 25%, the plasticity index less than 6 or the sand equivalent 30 or greater, or the product of multiplying the P.I. and the percent passing the 75um being less than 72.

Calcium Chloride 1% by weight
- Materials consisting of a blend of RAP and non-plastic base soils with 8-12% minus 75 micron material. Small amounts of clay 3-5% also are beneficial.

ADDITIVE SELECTION

- An emulsion stabilized base is flexible, fatigue resistant and not prone to cracking. However, it takes time to cure and develop its full strength. When in-place moisture levels are high, adding emulsion can increase moisture contents above optimum resulting in an unstable layer if not properly controlled.
- Cement is easy to apply dry or as a slurry. Dry applications may cause unacceptable dust problems in built up areas, however. Cement improves resistance to moisture and develops good early strength but shrinkage and freeze-thaw cracking can be a problem unless cement content is kept low (usually less than 6% usually).
- Calcium Chloride is a hygroscopic chemical meaning it absorbs moisture. This moisture facilitates compaction and then imparts strength. Calcium Chloride is the least expensive of the stabilizers and has been shown to reduce frost heaving. It works best in well graded non plastic soils containing about 10% minus 75 micron size (-200 mesh) material.
- Lime (Ca(OH)2), quicklime (CaO), and lime-pozzolan are effective economical stabilizers for problem fine graded soils with PI’s greater than 10 and the minus 75 micron fractions exceeding 25 percent (8). As with cement, lime/quicklime application as a slurry makes handling and dust control much simpler. This process is also susceptible to shrinkage and freeze-thaw cracking.

Mix Design Guidelines

- TARGET GRADATION:
  - SIEVE SIZE  PASSING
  - 3" - 100
  - 2" - 98-100
  - ¼ - 30-65
  - #40 - 5-40
  - #200 - 0-10*
- EMULSION
  - The suggested range of additional emulsion used, shall be between 1.5 – 5% depending upon the total liquid content needed for proper compaction established by a Proctor Design.
  - This is typically .5 gal./ sy. in. in most areas when existing road moisture is 2.5 – 3%.

Project Summary

- Choose the right candidate.
- Opt for the proper discipline and additive.
- Design and test.

A project no other form of maintenance will correct.
- Give yourself plenty of room to adjust for variables.
- This will be the foundation of your new road.

Summary

Full Depth Reclamation is a process that gives a viable option to total road material replacement.

Some of its advantages are:
-Conserves Energy
-Conserves Materials
-Crown and cross-slope is easily restored.
-Loss of curb reveal can be reduced or eliminated.
-Reflective Cracking Eliminated
-Long Term Cost Effective
-Environmentally Desirable - disposal of old pavement materials is greatly reduced. There is less air pollution due to no heating and/or material hauling.
-Future Maintenance Costs Are Reduced.
QUESTIONS ???

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<th>Testing Procedures Applicable</th>
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B. Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, ASTM D 698 or D 1557
C. Unconfined Compressive Strength of Compacted Lime Mixtures, ASTM D 5101, Procedure B |
| Cement | A. Moisture-Density Relations of Soil-Cement Mixtures, ASTM D 558, Method B
B. Compressive Strength of Molded Soil-Cement Mixtures, ASTM D 1633
C. Wetting and Drying Compacted Soil-Cement Mixtures, ASTM D 559, Test Method B |
B. Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures, ASTM E 2013
C. Effect of Moisture on Asphalt Concrete Paving Mixtures, ASTM E 2123
Indirect Tension Test for Resilient Modulus of Bituminous Mixtures, ASTM D 4123 |
| Calcium Chloride | A. Liquid Limit, Plastic Limit and Plasticity Index of Soils, ASTM D 4318
B. Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, ASTM D 698 or D 1557 |

Asphalt Mixtures

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Testing Methods

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Full Depth Reclamation is a process that gives a viable option to total road material replacement.

Some of its advantages are:

- **Conserves Energy** - It is completed in-place and on-grade so trucking and other material handling issues are eliminated or greatly reduced. Also, no heating fuel is needed since it is a cold process.
- **Conserves Materials** - Existing pavement materials (stone and asphalt) are re-used, thus conserving limited resources.
- **Crown and cross-slope** is easily restored.
- **Loss of curb reveal can be reduced or eliminated.**
- **Reflective Cracking Eliminated** - Existing cracked pavement is completely pulverized.
- **Long Term Cost Effective** - The cause of pavement failure, weak bases, is addressed.
- **Environmentally Desirable** - Disposal of old pavement materials is greatly reduced. There is less air pollution due to no heating and/or material hauling.
- **Future Maintenance Costs Are Reduced.**