Full-Depth Reclamation of Asphaltic Concrete Pavements

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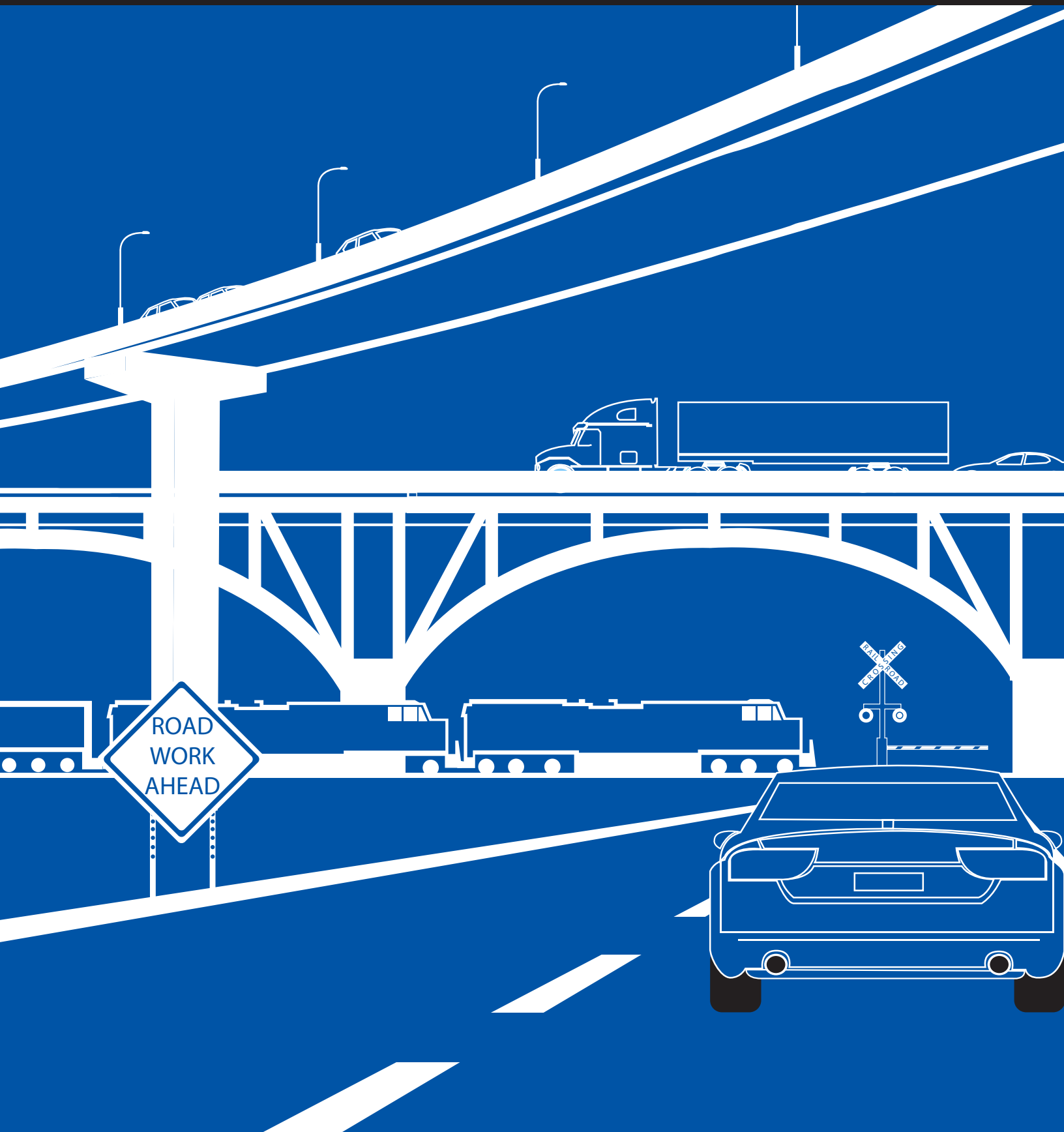

Kentucky Transportation Center
College of Engineering, University of Kentucky, Lexington, Kentucky

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Research Report
KTC-20-20/SPR18-558-1F

Full-Depth Reclamation of Asphaltic Concrete Pavements

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16. Abstract

The Kentucky Transportation Cabinet (KYTC) has used a full-depth reclamation (FDR) process over the past few years to rehabilitate asphalt pavements exhibiting widespread base failures. FDR transforms existing hot-mix asphalt (HMA) pavement and underlying granular materials into a stabilized base layer. The stabilized layer is then overlaid with a new pavement surface layer. Until now, deciding when and how to use the FDR process has not been well specified in Kentucky — the Cabinet has commonly used a Special Note for Cement Stabilized Roadbed as guidance and relied on the contractor for acceptable materials design. Previous research conducted by the Kentucky Transportation Center (KTC) and funded by KYTC proposed guidelines for FDR pavements and considered various binding compounds including, cement, asphalt emulsion, and foamed asphalt. Guidance also included a process for identifying potential projects for the FDR process and recommendations for examining material sampling, testing, mixture design, structural design parameters, and selection requirements for FDR treatment established through preconstruction planning activities. It also addressed quality control and quality assurance. This report builds on those guidelines by providing a special note for the use of the FDR in Kentucky.

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Implementation Statement

Use of full-depth reclamation to rebuild worn out asphaltic concrete pavements not only conserves energy and natural resources but is an ideal for rehabilitating lower volume routes that exhibit numerous base failures throughout the section.

Executive Summary

This report provides modified guidelines and specifications for using full-depth reclamation (FDR) on asphaltic concrete pavements in Kentucky. Material in this report builds on a previous research project (SPR 17-536). The guidance found in that report (Hunsucker et al., 2017) may be used to identify suitable projects for FDR and examine material sampling, testing, mixture design, structural design parameters, and selection requirements for FDR treatment established through preconstruction planning activities. A program focused on quality control/quality assurance testing and monitoring will permit verification of the designs.

1. Introduction and Background

In-place recycling and reclamation of asphalt pavements lets highway agencies optimize the value of in-place materials, minimize construction time and traffic flow disruptions, and reduce the number of construction vehicles moving into and out of construction areas. With in-place recycling and reclamation, existing deteriorated asphalt pavement is renewed using in-situ materials instead of virgin paving mixtures and materials. Recycling a pavement structure in place transforms a degraded pavement into a smooth and consistent structure that supports traffic requirements. Both material and monetary savings are realized through the use of in-place recycling and reclamation. Pavement geometrics and layer thickness can be maintained during construction because existing pavement materials are reused. Often, traffic flows are less impacted than when other rehabilitation techniques are used.

A common pavement rehabilitation technique is full-depth reclamation (FDR), where the full thickness of an asphalt pavement and a predetermined portion of the underlying materials (base, subbase, and/or subgrade) are pulverized or ground to a uniform particle size, blended with a stabilizing agent, and compacted to provide an upgraded, homogeneous material that results in a stabilized base course for the new pavement surface. Different compounds can be used to bind this material together, such as heated asphalt binders, asphalt emulsions, cement, fly ash, lime, and even water. Mechanical methods can also be used (e.g., adding granular material to modify the gradation to obtain better compaction and density). The Kentucky Transportation Cabinet (KYTC) has adopted FDR to treat asphalt pavements exhibiting widespread base failures. However, when and how to use the FDR process has not been well specified — the Cabinet has commonly used a Special Note for Cement Stabilized Roadbed as guidance and relied upon the contractor for an acceptable materials design.

A previous SPR study culminated in a report that organized and consolidated information about FDR and included implementable guidelines, criteria, and specifications (Hunsucker et al. 2017). The report proposed guidelines for FDR pavements and considered various binding compounds, including cement, asphalt emulsion, and foamed asphalt. Guidance for FDR of hot-mix asphalt (HMA) pavements was developed, including a process to identify projects on which its use would be appropriate, criteria for selecting stabilizing materials best suited to the project's materials, the optimum thickness of material to be recycled, the amount of stabilizer to be added, and the expected strength of the stabilized materials.

2. Methodology

This project sought to build on the guidelines and specifications outlined in Hunsucker et al. (2017) to generate a special note for FDR of asphaltic concrete pavement. The guidelines found in that report can be used to:

- Identify suitable projects for FDR;
- Examine material sampling, testing, mixture design, structural design parameters, and selection requirements for FDR treatment established through preconstruction planning activities;
- Perform quality control/quality assurance (QC/QA) testing and monitoring to permit design verification; and
- Modify guidance, if necessary, as a result of research findings.

To address the project objectives Kentucky Transportation Center (KTC) researchers investigated recent projects in Kentucky with the goal of documenting design information and determining the historical performance of as many as possible that employed any method of HMA reclamation or in-place recycling. This effort also included a number of site visits by KTC staff to visually inspect selected projects. Due to miscommunication with contractors, the Center's researchers could not be involved in construction. A Special Note for Construction FDR of HMA pavements using various means was modified. The special note in Appendix A will facilitate KYTC's efforts to implement the findings of Hunsucker et al. (2017).

3. Special Note for FDR of Asphaltic Concrete Pavement

Until now, KYTC has used its Special Note for Cement Stabilized Roadbed for FDR. The Special Note for FDR of asphaltic concrete pavement was modified during this study. It is contained in Appendix A.

4. Conclusions and Recommendations

FDR is a cost-effective method of rehabilitating old and worn asphalt pavements. KYTC and other agencies have constructed very successful projects over the years with minimal preconstruction and design activities.

Appendix A presents modified specifications for FDR of asphaltic concrete pavement. The Cabinet should implement the draft specifications on new rehabilitation projects where existing pavement exhibits severe base failures, cracking or raveling, and rutting or shoving, and which therefore needs rehabilitation. The guidelines presented in Hunsucker et al. (2017) can be used to identify suitable projects for FDR and examine material sampling, testing, mixture design, structural design parameters, and selection requirements for FDR treatment established through preconstruction planning activities. Additionally, QC/QA and monitoring should be continued to validate design performance. The findings of additional research may be further used to modify the Special Note and fully develop specifications for FDR design and construction.

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Appendix A: Special Note for Full Depth Reclamation with Cement

SPECIAL NOTE FOR FULL DEPTH RECLAMATION WITH CEMENT

1. GENERAL

1.1. Description. Full-depth reclamation (FDR) with cement (Type I or II) entails pulverizing and mixing existing asphalt pavement, base course material, and soil with Portland cement and water to produce a dense, hard, cement-treated base. It shall be proportioned, mixed, placed, compacted, and cured according to this specification. It must also conform to the lines and grades shown in the plans or established by the Engineer.

1.2. FDR shall incorporate the 12" of existing roadway material (asphalt, stone, and soil). The FDR must be constructed to full-pavement width in a monolithic manner to avoid the creation of longitudinal joints. To accommodate local traffic, manageable sections will need to be incorporated.

2. MATERIALS

2.1. Recycled Asphalt Pavement (RAP) and Base Material. These shall consist of the exiting asphalt pavement, existing base course material, and/or subgrade material. The base course and subgrade material shall not contain roots, topsoil, or any material that impedes its reaction with cement. The particle distribution of the processed material shall be such that 100% passes through a 3-in. sieve, at least 95% passes through a 2-in. sieve, at least 55% passes through a No. 4 sieve, and a maximum of 20% passes through a 200 sieve.

2.1.1. Mix Design. Contrary to Section 208 of the Standard Specifications, the contractor is responsible for providing the Department with analysis for determining optimum moisture content and maximum density of the existing roadbed prior to beginning FDR. Results of this analysis will be used as a benchmark during the mixing process.

2.1.2. Sampling. Remove samples of RAP, base material, and soil subgrade to the specified depth and perform appropriate testing to establish mix design. Submit the mix design to the Engineer for approval one week before the planned start of work. The Engineer approves the mix design only for monitoring quality control. Receipt of approval does not release the Contractor from their responsibilities.

2.1.3. Mix Design Development. Samples must be obtained inclusive of the depth to be recycled. Samples must be obtained at 1,000-foot intervals beginning at one end of the project, or when changes are observed or known (e.g., in soil type, pavement thickness, aggregate base thickness). Sampled materials must be properly processed and prepared to closely simulate field conditions (use auger cuttings taken from the surface to treatment depth). Samples shall be tested in accordance with AASHTO T134, blended with 6% dry weight cement. A geotechnical testing firm, pre-qualified by the Division of Professional Services shall test the samples and provide to the Engineer the following information as part of the mix design:

- Location of core samples.
- Thickness and description of existing pavement, aggregate, and soil layers to be reclaimed.
- Moisture-Density, AASHTO T134 results.

2.2. Cement. Type I or II cement shall comply with Section 801 of the current edition of KYTC's Standard Specifications for Road and Bridge Construction.

2.3. Water. Shall be free from substances that hamper the curing of cement-treated material.

3. EQUIPMENT

3.1. Description. FDR may be constructed with any machine or combination of machines that will produce a satisfactory product which meets requirements for pulverization depth, cement and water application, mixing, compacting, finishing, and curing as provided in this special note (Section 4).

3.2. Mixing Methods. Mixing shall be done in place using single-shaft or multiple- shaft mixers. Agricultural disks or motor graders are not acceptable mixing equipment.

3.3. Cement Proportioning. Cement shall be spread with a spreader truck designed to spread dry particulate, such as cement, to insure a uniform distribution. Spreaders or distributors shall be able to demonstrate a consistent and accurate application rate and dust control during the application. The mechanical cement spreader shall be capable of dispensing a measured quantity of cement (+/- 3 lbs. per square yard) in advance of the pulverizor just prior to each pass of the stabilizing operation. The pulverizor shall abut or slightly overlap (up to 3") the previous pass to ensure a continuous homogeneous mass of granular material and cement. The cement spreader does not have to abut or overlap the previous pass as long as the calculated quantity of cement is dispersed in front of the pulverizor.

3.4. Application of Water. Water may be applied through the mixer or by water trucks equipped with pressure-spray bars. If using a spray bar system, the road base shall be pre-wet to obtain optimum moisture content prior to dispensing the cement. Do not apply water directly to the roadway before or after cement placement without first pulverizing the roadbed.

3.5. Compaction. Compact the FDR base uniformly to a minimum of 95% of the maximum dry density in accordance with AASHTO T 134 based on a moving average of five consecutive tests. No individual test shall measure below 94%. Establish a compaction pattern that will achieve the required density without over compaction.

4. CONSTRUCTION REQUIREMENTS

4.1. General

4.1.1. Preparation. Methods, equipment, tools, and any machinery that will be used during construction shall be approved by the Engineer before the project starts. Prior to the reclaiming of the roadway, drop inlets or catch basins that might be affected must be sufficiently barricaded to prevent reclaimed subbase material, silt, or runoff from plugging the drainage system.

Adequate surface drainage must be provided for each stage of construction to prevent ponding on the reclaimed sub-base course prior to placing the bituminous concrete.

Reclamation shall be accomplished using a self-propelled, traveling rotary reclaimer (or an equivalent machine) capable of cutting through existing bituminous concrete pavement to depths of up to 16 inches in one pass. The machine shall be equipped with an adjustable grading blade, leaving its path generally smooth for initial compaction. Equipment such as road planers or cold milling machines designed to mill or shred the existing bituminous concrete — rather than crush or fracture it — shall not be used.

Existing bituminous pavement and underlying granular material and soil must be pulverized and mixed to form a homogenous mass of reclaimed sub-base material that will bond when compacted.

In areas where the proposed roadway's vertical or horizontal geometry differs from the existing roadway, the roadway shall be reclaimed in-place and the reclaimed material sub-base placed in windrows or stockpiled while filling or excavation done. When the proposed sub-grade elevation is achieved, the reclaimed sub-base material is placed back onto the roadway in lifts no greater than five (5) inches deep before compaction.

Reshaping using the reclaimed sub-base material should be minimized to ensure the roadway has a uniform thickness of reclaimed sub-base material throughout. When it is necessary to reshape the roadway, use additional sub-base or processed aggregate base (unless specified otherwise).

Reclaimed sub-base material shall be compacted before placing any additional granular material (aggregate base). After the reclaimed sub-base material is compacted, reshaped material or additional material placed on the roadway should not exceed five (5) inches in depth before it is compacted.

A motor grader shall be used for shaping, fine grading, and finishing the surface of the reclaimed material or any other granular materials that are placed to form the surface before paving.

Surface irregularities which develop during or after the work described in this section shall be corrected until achieving a firm and uniform surface that is approved by the Engineer.

4.1.2. Mixing and Placing. Do not commence FDR processing when the soil aggregate or sub-grade is frozen, or when the air temperature is below 40°F. Moisture in the base course material when cement is applied shall not exceed the quantity that will permit a uniform and through mixture of the pulverized asphalt, base material, and cement during mixing operations. It shall be within +/-2% of the optimum moisture content for the processed material at start of compaction.

Cement application, mixing, spreading, compacting, and finishing shall be continuous and completed within 2 hours of when mixing begins. Processed material that has not been compacted and finished shall not be left undisturbed for longer than 30 minutes.

4.1.3. Scarifying. Before cement is applied, initial pulverization or scarification may be required to the full depth of mixing. Scarification or pre-pulverization is a requirement under the following conditions:

- When processed material's moisture content is more than 3% above or below the optimum moisture content. When material is below the optimum moisture content, water shall be added. Pre-pulverized material shall be sealed and properly drained at the end of the day or if rain is expected.
- For slurry application of cement, initial scarification shall be done to provide a method of uniformly distributing the slurry over the processed material without excessive runoff or ponding.

4.2. Application of Cement. The specified quantity of cement shall be applied uniformly in a manner that minimizes dust and is satisfactory to the Engineer. If cement is applied as a slurry, the time from first contact of cement with water to application on the soil shall not exceed 60 minutes. No more than 30 minutes shall pass between the time when cement is placed on the soil to the start of mixing.

4.3. Mixing. Mixing shall begin as soon as possible after the cement has been spread and must continue until a uniform mixture is produced. The mixed material shall meet the following gradation conditions:

4.3.1. The final mixture (bituminous surface, granular base, and sub-grade soil) shall be pulverized so that 100% of it passes through a 3-in. sieve, at least 95% passes through a 2-in. sieve, and at least 55% passes through a No. 4 sieve. Additional material can be added to the top or from the sub-grade to improve the mixture gradation as long as this material was included in the mixture design.

4.3.2. The final pulverization test shall be made when mixing operations conclude. Mixing shall continue until the product is uniform in color, meets gradation requirements, and has the required moisture content throughout. The entire operation of cement spreading, water application, and mixing shall result in a uniform pulverized asphalt, soil, cement, and water mixture for the full design depth and width.

4.4. Compaction. Processed material shall be uniformly compacted to a minimum of 95% of the maximum standard dry density. Field density and testing frequency of compacted material can be determined according to KYTC Standard Specifications (Section 208). Optimum moisture and maximum density shall be determined before construction starts.

At the start of compaction, the moisture content shall be within +/-2% of the specified optimum moisture. All compaction operations shall be completed within 6 hours of the start of mixing.

4.5. Finishing. As compaction nears completion, the surface of the FDR material shall be shaped to the specified lines, grades, and cross sections. If necessary, or as required by the Engineer, the surface shall be lightly scarified or broom-dragged to remove imprints left by equipment or to

prevent compaction planes. Compaction shall continue until uniform and adequate density has been achieved.

During the finishing process the surface shall be kept moist using water spray devices that will not erode the surface. Compaction and finishing shall be done to produce a dense surface free of compaction planes, cracks, ridges, or loose material. All finishing operations shall be completed within 4 hours of the start of mixing.

4.6. Curing. Finished portions of the FDR base which are traversed by equipment used to construct an adjoining section shall be protected to prevent that equipment from marring or damaging completed work.

After the final finishing is complete, the surface shall be cured according to Section 208.03.06 of KYTC's Standard Specifications.

4.7. Traffic. Completed portions of FDR base can be opened immediately to low-speed local traffic and construction equipment if 1) curing seal is used, 2) the curing material is not impaired, and 3) the FDR base is stable enough to withstand marring or permanent deformation. The section can be opened up to all traffic after the FDR base has received a curing compound or subsequent surface and has attained the stability needed to withstand marring or permanent deformation. If continuous moist curing is employed in lieu of a curing compound or subsequent surfacing within 7 days, the FDR base can be opened to all traffic after the 7-day moist curing period if the FDR base has hardened sufficiently to prevent marring or permanent deformation.

4.8. Surfacing. In most cases, let the FDR cure for a minimum of two days (48 hours after completing finishing operations) to determine if isolated soft spots exist before applying a surface course . If the Engineer deems the situation warrants faster construction, surfacing can be placed any time after finishing as long as the soil-cement is stable enough to support the required construction equipment without marring or permanently distorting the surface.

4.9. Maintenance. The contractor shall maintain cement-treated material in good condition until all work is completed and accepted. Maintenance shall include immediate repairs of any defects. If it is necessary to replace processed material, replacement shall be for the full depth, with vertical cuts, using either cement-treated material or concrete. No skin patches are permitted. Such maintenance shall be done by the contractor at their own expense.

5. INSPECTION AND TESTING

5.1. Description. The contractor shall undertake the inspections and tests deemed necessary to ensure work conforms with requirements laid out in the contract documents. These inspections and tests may include, but are not be limited to:

Operations including mixing speed, yield monitoring, monitoring treatment depth, procedures for avoiding recycling and curing in inclement weather, methods to ensure that segregation is minimized, procedures for mix design modification, grading and compacting operations, and cement application procedure.

Only materials, machines, and methods meeting the requirements specified in the contract documents shall be used unless otherwise approved by the Engineer.

6. MEASUREMENT AND PAYMENT

6.1. Measurement.

6.1.1. Full-Depth Reclamation. When calculating payment, the Department will measure the quantity of completed and accepted FDR (in square yards). No payments will be made for corrective or reconstructed work or for water (which is considered incidental to this work item).

6.1.2. Asphalt Curing Seal. The Department measures curing seal for payment according to Section 208 of the current KYTC Standard Specifications.

6.2. Payment. The Department will remit payment for completed and accepted quantities under the following:

Code	Pay Item	Pay Unit
24936EC	Full Depth Reclamation with Cement	Square Yard
02542	Cement	Ton
02702	Sand for Blotter	Ton
00358	Asphalt Curing Seal	Ton*

Non-tracking Tack Coat may be used if approved by Department.