

VIRGINIA DEPARTMENT OF TRANSPORTATION
DRAFT SPECIAL PROVISION FOR
FULL-DEPTH RECLAMATION (FDR)

I. DESCRIPTION

Full-depth reclamation (FDR) is defined as those processes in which all of the asphalt pavement layers and some portion of the underlying unbound layers are pulverized, stabilized, and compacted in place. This is most commonly performed using hydraulic cement, lime, foamed asphalt or asphalt emulsion as the primary stabilizing additives and to a typical depth of 6 to 12 inches.

The Contractor shall furnish all labor, materials and equipment required for completing the work. The Contractor shall select the final mix design and construction methods to meet the performance requirements specified herein. The Contractor shall also be responsible for developing and implementing a Quality Control Plan to ensure that operational techniques and activities provide integral and finished material of acceptable quality. Contractor sampling and testing shall be performed to control the processes and ensure material compliance with the requirements of the Contract. The Contractor shall provide their Quality Control Plan and Job Mix Formula(s) to the Department for approval no less than thirty (30) calendar days prior to the start of FDR operations.

For each recycling project, a quality control plan is required, and shall include the following (minimum) information:

- Describe the Contractor's Quality Control organization, including the number of full-time equivalent employees or Sub-Contractors with specific Quality Control responsibilities, including an organizational chart showing lines of authority and reporting responsibilities.
- List by discipline the name, qualifications, duties, responsibilities and authorities for all persons proposed to be responsible for Construction Quality Control;
- Provide Quality Control sampling, testing and analysis plan with methods that include a description of how random locations for testing and sampling are determined;
- Identify the laboratory(s) to be used for each type of testing;
- Specify documentation for QC activities;
- Provide procedures to meet contract requirements for corrective action when QC criteria are not met.

The Contractor is required to have a technical representative on the site at all times during the mixing and placement operations. At a minimum, this person must:

- Have 2 years minimum experience with the FDR process,
- Have supervised a minimum of 5 successful FDR projects,
- Have experience in developing FDR mix designs,
- Have the experience to perform and supervise field process control testing, and
- Submit a list of references, with current telephone numbers, who are able to verify the experience required herein

The contractor may use consultants or manufacturers' representatives to satisfy the requirements of this section provided they meet the requirements above and are on-site at all times construction operations are being performed.

II. MATERIALS

- (a) **Stabilizing Agent(s)** – The amount of stabilizing agent(s) to be used shall be determined by a mixture design process. Hydraulic cement shall conform to the requirements of Section 214. Lime shall conform to the requirements of Section 240. Fly ash shall conform to the requirements of Section 241. All liquid asphalts used for stabilizing agents shall be on the VDOT approved list for emulsions and PG binders, Approved List 50 and 50.1. Liquid asphalts not currently on the approved list shall be submitted to VDOT for approval. Asphalt emulsions shall conform to the requirements of Section 210; liquid asphalts shall meet the requirements of Section 211.02 (a).

- (b) **Water** – Any water used for mixing shall meet the requirements of Section 216 of VDOT’s Road and Bridge Specifications.
- (c) **FDR** – The FDR material shall have 100% of all particles passing the 2.0inch (50mm) size and 55% of all particles passing the 3/8inch (9.5mm) size prior to the addition of any stabilizing agents.
- (d) **Other Additives** – If necessary, additional additives may be used to meet the requirements in Table 3. In the case where an additional additive is used, the type and dosage must be described in the JMF(s) submitted to the Department. For FDR using asphalt emulsion, hydrated lime shall be added according to the requirements in Section 211.02(i).
- (e) **Addition of Crushed Reclaimed Asphalt Pavement (RAP) Material** – RAP material may be added by the Contractor and shall meet the requirements of Section 211.02(j) and Table 1.

TABLE 1 – ADDITIONAL CRUSHED RAP

Tests	Method	Limit
Deleterious Materials: Clay Lumps and Friable Particles in Aggregate	AASHTO T 112	0.2% maximum
Maximum size, 100% Passing, Sieve Size	AASHTO T 27	2.0 inches (50 mm)

- (f) **Additional aggregate** – Based on the results of the mixture design or other requirements, the Contractor shall determine if additional aggregate is required. Any additional aggregate shall meet Section 203 and the requirements in Table 2, and it shall be graded to produce a product which meets the specification given in Table 3.

TABLE 2 – ADDITIONAL AGGREGATE

Tests	Method	Limit
Los Angeles Abrasion Value	AASHTO T 96	45% maximum loss
Sand Equivalent	AASHTO T 176	60% minimum
Maximum size, 100% Passing, Sieve Size	AASHTO T 27	2.0 inches (50 mm)
Water absorption	AASHTO T 85	3% maximum

- (g) **Handling and Storage** – Store cement to prevent moisture degradation and partial hydration. Do not use cement that has become hard, caked or lumpy. Store aggregates and RAP so that segregation and inclusion of foreign materials are prevented. Do not use the bottom six (6) inches of aggregate or RAP piles in contact with the ground.

III. Job Mix Formula

Mixture Designs – FDR mix design(s) in the form of a job-mix formula (JMF) shall be submitted to the Department for approval no less than 30 calendar days prior to the start of FDR operations, more than one JMF may be required. The gradation of each JMF shall have a minimum 100% passing the 2.0-inch (50 mm) sieve with a minimum 55% passing the 3/8-inch (9.5 mm) sieve.

The Contractor shall obtain sufficient samples of the material to be reclaimed directly from the project site for laboratory testing and mix design analysis. Samples shall be obtained from every 2500 linear feet, within each lane and to the proposed total recycling depth with a minimum of six (6) locations for each mix design. Additional locations may be selected based on pavement conditions and variability.

Mixture Designs Submittal – The design shall be performed by the contractor in accordance with these specifications and submitted to the Engineer for approval thirty (30) working days prior to the planned start of the work. The mix design submittal shall include, at a minimum, the information below:

- 1) Target field density,

- 2) Percent by weight of all stabilizing agent(s) to be added to the recycled mix,
- 3) Percent by weight of water (at room temperature) required,
- 4) Expansion ratio and half-life characteristics and temperature of asphalt binder at the time of injection into foaming chamber (for mixtures using foamed asphalt), minimum curing time/set time for the asphalt emulsion and temperature of asphalt emulsion at the time of incorporating into the mixture (for mixtures using asphalt emulsion), and
- 5) Target gradation (including any aggregate to be added).

Table 3 – Full-Depth Reclamation Mix Design Requirements

Test	Test Method	Criteria
Liquid Limit, Plastic Limit, and Plasticity Index of Soil	VTM-7	Report
Dry Preparation and Mechanical Analysis of Soils, Select Material, Subbase and Aggregate Bases	VTM-25	Report
Classification of Soils	AASHTO M 145	Report
Moisture-Density Relations of Soil-Cement Mixtures	AASHTO T 134	Report
Moisture Density Relations for Bituminous Stabilizing Agents	AASHTO T 180	Report
Compressive Strength of Soil-Cement Cylinders	ASTM D 1633	Min. 250 psi (Max. 450 psi) at seven (7) days
Determining the Strength of Soil-Lime Mixtures	VTM-11	Min. 150 psi
Dry Indirect Tensile Strength (ITS) for Foamed Asphalt Stabilizing Agent	AASHTO T 283 Section 11*	45 psi minimum
Marshall Stability Test for Asphalt Emulsion Stabilizing Agent	ASTM 5581 (6 inch specimens), AASHTO T 245 (4 inch specimens)**	2500 lbs minimum (6 inch (150mm) diameter specimen), or 1250 lbs (4 inch (100mm) diameter specimen)

* Three (3) specimens shall be produced using 75 blows per side (or 30 gyrations per AASHTO T 312) compacted at or below OMC and cured as follows: 4 inch (100 mm) diameter specimens, oven dry at 40°C for 72 hrs and cool to ambient for 24 hrs; 6 inch (150 mm) diameter specimens, air dried for 24 hours, then an additional 48 hours at 40°C in sealed plastic bag, cool to ambient temperature for 24 hrs.

** Three (3) specimens shall be produced at 75 blows per side (or 30 gyrations per AASHTO T 312) and cured at 60°C to constant mass, Hold specimens at 40°C for 2 hours in a forced draft oven immediately prior to testing.

If a change in source materials is made during construction, a new JMF(s) shall be established and approved prior to use on the project. The JMF(s) shall meet the above criteria at the approved stabilizing agent(s) content.

IV. EQUIPMENT

- (a) **Pulverizing** – The equipment used to reclaim existing pavements shall be capable of pulverizing existing pavement, as well as any additional materials, to meet the gradation provided in the approved mix design, for the widths provided in the Plans, to the depth specified in the approved pavement design.
- (b) **Stabilizing** – The equipment used to stabilize the pulverized materials shall be capable of incorporating the stabilizing agent(s) at the rate provided in the approved mix design, automatically metering dosage and mixing the full depth and width of pulverized material to a homogenous mixture.

- (c) **Grading** – The equipment used to grade the stabilized material shall be capable of working within the constraints of the excavation and of grading the full width of stabilized material in conformity with the lines and grades provided in the Plans.
- (d) **Compacting** – The equipment used to compact the stabilized material shall be capable of working within the constraints of the excavation and of compacting the stabilized material in conformity with the lines and grades provided in the Plans, as well as in conformity with the density requirements provided in the approved mix design.

V. CONSTRUCTION METHODS

- (a) **Grass and Other Vegetation** – all grass and other vegetation shall be removed from the edge of the existing pavement to prevent contamination of the pulverized bituminous material during the milling operation.
- (b) **FDR** – Recycling shall be performed to the depth provided in the approved mix design while simultaneously incorporating stabilizing agent(s), mineral filler, additional aggregate and water. Mixing shall continue until, and the speed of the recycling unit adjusted to ensure, a homogenous mixture of the above materials and pulverized materials is achieved.

The application rate of all stabilizing agents shall be continuously monitored using calibrated, automatic meters. The application rate shall be within 0.20 percentage points of the optimal stabilizing agent(s) content provided in the approved mix design. If the measured application rate falls outside the above tolerance, then the recycling operations shall be stopped and corrected before proceeding.

The water content of the stabilized material shall be monitored closely to ensure conformance with the approved mix design and to ensure proper compaction.

Longitudinal joints between adjacent stabilization passes shall be overlapped at least four (4) inches. Transverse joints created by the recycling process shall be sawcut, if necessary, to provide a vertical, clean face to ensure proper compaction.

- (c) **Grading and Compacting** – The grading and compacting shall be performed within the constraints of the excavation and the stabilized material shall be compacted in conformity with the lines and grades provided in the Plans. Compaction shall progress across the full width of the stabilized area until maximum density under this roller is achieved.

Once the entire working width (full lane width plus affected shoulder width) has been stabilized and only after primary compaction has been completed, the entire working width shall be graded to the required profile and cross-slope. Disturbance to the stabilized and primarily compacted material shall be kept to a minimum during this grading and shaping operation.

Any additional water required to achieve maximum density shall be applied by spraying the surface of the stabilized material with light applications. Care shall be taken not to over-apply additional water to any areas of stabilized material.

- (d) **Surfacing** – The surface of the compacted material shall be kept moist until covered with an asphalt-based layer in the case of cement stabilized materials. For bituminous stabilized materials, the FDR shall be allowed to cure until the moisture of the material is a maximum of 50% the optimum moisture content or until approval of the Engineer is received. Subsequent asphalt-based layers can be placed any time after finishing, as long as the FDR is sufficiently able to support the required construction equipment without marring or permanent distortion of the surface.

VI. ACCEPTANCE TESTING

- (a) **Field Compaction** – Density shall be determined with a nuclear gauge operating in direct transmission mode conforming to the requirements of VTM-10 to the full depth of the FDR layer. The Contractor shall have had the gauge calibrated within the previous 12 months by approved calibration service. In addition,

the Contractor shall maintain documentation of such calibration service for the 12-month period from the date of the calibration service.

The project will be divided into lots by the Engineer for the purpose of defining areas represented by each series of tests.

Lot – For the purposes of acceptance, each day’s production shall be considered a lot unless the paving length is less than 3,000 linear feet or greater than 7,500 linear feet. When paving is less than 3,000 feet, it shall be combined with the previous day’s production or added to the next day’s production to create a lot as described below.

For the purposes of acceptance, the size of a lot shall be 5,000 linear feet, with 1,000 foot sublots, the full width of the lane (including any affected shoulder width). When a partial lot occurs upon completion of the project, the lot shall be added to the previous lot if less than 3,000 linear feet or considered a separate lot if greater than 3,000 linear feet.

Each lot shall be tested for density by taking a nuclear density reading from two stratified-random test sites selected by the Engineer within each subplot. Test sites shall not be located within 18 inches of any longitudinal joint.

The average of the subplot density measurements will be compared to the maximum density from the approved mix design to determine the acceptability of the lot. Once the average density of the lot has been determined, the Contractor will not be permitted to provide additional compaction to raise the average. If two consecutive sublots produce density results less than 97.0 percent of the target density, the Contractor shall immediately notify the Engineer and institute corrective action. By the end of the day’s operations, the Contractor shall furnish the test data developed during the day’s production to the Engineer.

Payment will be made in accordance with the requirements of Table 4.

TABLE 4 - Payment Schedule for Lot Densities

% of Density from Approved Mix Design	% of Payment
97.0 or greater	100
96.0 to less than 97.0	95
95.0 to less than 96.0	90
Less than 95.0	75

- (b) **Depth Check** – Depth checks will be performed by the Contractor twice per lot after compaction and prior to the placement of the next pavement layer. The depth checks shall be performed twice per lot following VTM-38B.

Acceptance of FDR for depth will be based on the mean result of measurements of samples taken from each lot of material placed.

A lot will be considered acceptable for depth if the mean result of the tests is within the tolerance of the plan depth for the number of tests taken as shown in Table 5.

Table 5 – Process Tolerance for Depth Checks

Plan Depth, inches	Tolerance, inches			
	1 test	2 tests	3 tests	4 tests
>6 ≤ 8	0.9	0.65	0.5	0.4
>8 ≤ 12	1	0.9	0.7	0.5
>12	1.2	1	0.8	0.6

If an individual depth test exceeds the tolerance for one test, that portion of the lot represented by the test will be excluded from the lot. If an individual test result indicates that the depth of material represented by the test is more than the tolerance for one test, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the test. If an individual test result indicates that the depth of the material represented by the test is deficient by more than the tolerance for one test, correction of the base course represented by the test shall be made as specified hereinafter.

If the mean depth of a lot of material is excessive, the Contractor will not be paid for that material in excess of the tolerance throughout the length and width represented by the tests. The Department can require excessive material to be removed at the Contractor's expense.

If the mean depth of a lot of material is deficient by more than the allowable tolerance, correction will not normally be required and the Contractor will be paid for the quantity of material that has been placed in the lot.

- (c) **Gradation** – The contractor will check the unstabilized gradation twice per day.
- (d) **Stabilizing Agent Dosage Rate** – Contractor shall verify the dosage rate ten times per lot. The dosage rate shall be within 0.20 percentage points of the approved mix design. If the dosage rate is beyond this tolerance, then paving shall stop and the contractor shall take corrective measures.
- (e) **Construction Records** – The Contractor shall prepare separate test reports meeting the requirements of AASHTO R 18 or may use the current appropriate VDOT forms. Records documenting the dosage rate of stabilizing agent(s) and other test results from Table 3 shall be provided to the Engineer, unless specified otherwise.

VII. WEATHER LIMITATIONS

Recycling operations shall be completed when the atmospheric temperature and material to be processed (measured in the shade and away from artificial heat) is a minimum 40°F (4°C). The weather forecast shall not call for freezing temperature within 48 hours after placement of any portion of the project.

VIII. MEASUREMENT AND PAYMENT

FDR will be measured by the square yard of the completed sections for the depth specified in the plans and paid for at the Contract unit price per square yard of depth. This price shall be full compensation for removal and processing of the existing pavement; for preparing, hauling, and placing all materials; furnishing additives (including RAP and aggregates if required but not including stabilizing agents), for all freight involved; for all manipulations, including rolling and brooming, testing, stabilizing agent supplier services, and for all labor, tools, equipment and incidentals necessary to complete the work.

Stabilizing agents will be paid as follows:

Liquid Asphalt plus Emulsion will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the emulsion into the mixture. An emulsion content of 3.0% by weight of the reclaimed material shall be used for bidding purposes prior to the completed design. The actual

emulsion content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Liquid Asphalt (foamed) will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the foamed asphalt into the mixture. A foamed asphalt content of 2.5% by weight of the reclaimed material shall be used for bidding purposes prior to the completed mix design. The actual foamed asphalt content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Hydraulic Cement will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the hydraulic cement into the mixture. A cement content of 5.0% by weight of the reclaimed material shall be used for bidding purposes prior to the completed design. The actual cement content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Lime will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the lime into the mixture. A lime content of 5.0% by weight of the reclaimed material shall be used for bidding purposes prior to the completed design. The actual lime content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Other Cementitious Material will be paid for at the Contract unit price per ton. This price shall be full compensation for furnishing and incorporating the cementitious into the mixture. A cementitious content of 5.0% by weight of the reclaimed material shall be used for bidding purposes prior to the completed design. The actual cementitious content will be adjusted based on the quantity necessary to meet the design requirements in Table 3.

Payment shall be made under:

Pay Item	Pay Unit
Full-Depth Reclamation (Depth)	Square Yard
Liquid Asphalt (Emulsion)	Ton
Liquid Asphalt (Foamed)	Ton
Hydraulic Cement	Ton
Lime	Ton
Other Stabilizing Materials	Ton
Additional Aggregate	Ton
Additional Crushed RAP	Ton