

SECTION 344—FULL DEPTH RECLAMATION

344.1 DESCRIPTION—This work consists of in-place pulverizing and mixing a combination of existing roadway material layers, stabilizing additives, and imported aggregate or RAP material, as required, to specified depths and grading, and compacting the mixed materials to form a new pavement base layer upon which an asphalt overlay or a surface treatment is applied. This work is defined as full-depth reclamation (FDR), and often includes the incorporation of additional materials based on an approved FDR mix design.

344.2 MATERIAL—

(a) Reclaimed Material from Existing Roadway. Pulverize and mix existing roadway material layers, which may include bound pavement layers, aggregate subbase material, and subgrade material such that 95% of the material passes the 2-inch sieve.

(b) Aggregate.

1. General. Provide fine or coarse aggregate from approved aggregate producers listed in Bulletin 14 or provide reclaimed aggregate material (RAM) meeting the specified size (e.g., No. 57) as required by the approved mix design.

2. Fine Aggregate. Section 703.1, Type A or B.

3. Coarse Aggregate. Section 703.2, Type A, B, or C.

(c) Reclaimed Asphalt Pavement (RAP) Material from Other Roadways or Projects. Provide RAP material with 95% passing the 2-inch sieve. Process the RAP so that the final mixture conforms to Section 409.2(e).

(d) Stabilizing Additives. Provide one or more of the stabilizing additive materials listed below as included in the approved mix design. Potential additives are not limited to the materials listed below. Those listed below include references to sections with additional information.

1. Asphalt Material.

1.a Emulsified Asphalt. Section 702, Class CMS-2, SS-1h, CSS-1h, or CSS-1hPM.

2. Chemical.

2.a Portland Cement. Section 701

2.a.1 Portland Cement Slurry, Section 701 Portland Cement Slurry must be produced at a concrete plant listed in Bulletin 42, and supplied in Ready Mix Concrete Trucks approved by the DME/DMM. Other slurries must be provided in distributor and tanker trucks equipped with a recirculating pump and/or agitation system to prevent settling of the materials before application.

2.a.1.a Admixtures—Section 711.3

2.b Hydrated Lime. Section 723

2.c Fly Ash. Section 724.2

2.d Pozzolan.

2.d.1 Lime Pozzolan. Section 725

2.d.2 Pozzolan. Section 724

3. Calcium Chloride. Section 721

4. Magnesium Chloride. Use only as permissible on a project approval basis.

(e) **Water.** Section 720.2

(f) **FDR Mix Design.** Select one or more stabilizing additives based on the composition of the existing roadway materials according to Publication 242 Pavement Policy Manual. A formal design protocol should be followed to optimize the performance of the pavement section. After selecting the appropriate stabilizing additive(s), develop a mix design following the appropriate mix design procedures for the stabilizing additive(s) as follows:

Table A
Mix Design Procedure for Primary Stabilizing Additive Type

Primary Stabilizing Additive	Mix Design Procedure
Asphalt	Pub. 27 (Bulletin 27)
Chemical (Portland Cement, Fly ash, Hydrated Lime, Pozzolan** & Portland Cement Slurry)	ACI 211, Pub. 242 Appendix J
Calcium Chloride	PTM No. 106 *

*When used as the primary stabilizing material, calcium chloride should be applied as a minimum 35% solution at a rate between 0.10 to 0.15 gallons per square yard for each inch of depth reclaimed.

**Calcium oxide is used to activate the cementitious performance of pozzolan.

(g) **Asphalt Material.** Section 702, Emulsified Asphalt, Class AE-P, E-1 Prime, or EDP.

344.3 CONSTRUCTION—Comply with applicable environmental standards. Appropriate equipment and techniques should be used to adequately protect adjacent properties from fugitive dust or other material components of the FDR process. Dry additive will not be applied when the wind conditions, in the opinion of the site Inspector, are such that blowing additives become objectionable to traffic or adjacent property owners. Manual and/or gravity (tail gate) spreading of the additives is unacceptable.

Stabilization may be accomplished using asphalt material, Portland cement or other chemical stabilization materials, or calcium chloride consistent with recommendations of the FDR Best Practices found in Publication 242, and approved in the project mix design.

(a) **Equipment.** Provide the necessary equipment to pulverize reclaimed material to a maximum particle size of 2 inches in the greatest dimension, blend, shape, and compact the FDR materials.

1. Reclaimer. Provide a self-propelled, traveling rotary reclaimer or equivalent machine capable of cutting through existing roadway to depths of up to 16 inches, or as required by the design, with one pass. The equipment must also be capable of pulverizing “in-place” the existing pavement, subbase, and subgrade materials, at a minimum width of 8 feet, and mixing any added materials to the specified depth. The cutting drum must have the ability to operate at various speeds (rpm), independent of the machine’s forward speed, to control oversized material and gradation.

Use a machine equipped with a computerized integral liquid proportioning system capable of regulating and monitoring the water application rate relative to depth of cut, width of cut, and speed. Connect the water pump on the machine to the water supply tanker or distributor by a hose, and mechanically or electronically interlock the flow of water with the forward ground speed of the machine. Mount the spray bar to allow the water to be injected directly into the cutting drum/mixing chamber. Provide equipment capable of mixing water, dry or liquid stabilizing additives, emulsion, and the pulverized pavement into a homogenous mixture. Keep the cutting drum fully maintained and in good condition at all times throughout the project. Equipment such as road planers or cold-milling machines designed to mill or shred the existing roadway rather than crush or fracture them is not allowed.

1.a Use equipment capable of automatically metering liquids in the mixture and ensure thorough mixing of the reclaimed materials. Use equipment that is also able to record the volumes metered.

1.b Maintain equipment as specified in Section 108.05(c).

2. Placement Equipment. Use a motor grader or another method approved by the Representative.

3. Compaction Equipment. Provide suitable compaction equipment as follows: Use a pneumatic tire roller weighing 20 tons for breakdown and intermediate rolling for 8-inch depth or less and for final compaction of reclamation greater than 8-inch depth. Use a vibratory padfoot roller when the FDR depth is greater than 8 inches. Perform finish rolling using a single or tandem steel drum static roller of 12 to 14 tons.

(b) Weather Limitations. Do not place FDR materials when air temperature falls, or is anticipated to fall, below 40F within the subsequent required 7-day cure period. Do not perform reclamation in rain, or if rain is anticipated within 2 hours of completion of the work. Cement slurry with accelerating admixtures can be used in periods of cooler temperatures with the written approval of the DME/DMM. Do not place cement slurry mixtures with accelerating admixtures when the air temperature is anticipated to fall below 35F within the first 24 hours following placement.

(c) Quality Control. Provide a QC Plan for the FDR work a minimum of 2 weeks before the start of work. Identify the equipment, personnel, and processes to be used during the work. Ensure that all equipment is operational and functional before deployment to the job site. All equipment must be properly calibrated before application. This calibration should be verified through the test strip. Operators of water and additive applicators must keep proper records of the amount of material applied and the times of application.

(d) Test Strip. Before starting full production work, construct a 300-foot test strip demonstrating the FDR process including final compaction and shaping. Verify application rates for all materials incorporated into the FRD process including stabilization materials and water. Identify and correct any aspects of the work not conforming to the contract requirements before proceeding with full production work. If aspects of the work are not found to be adequately controlled to produce the desired mixed and refinished reclaimed roadway, construct additional test strips until the necessary control is established. After completing the test strip and demonstrating that the minimum density can be achieved, determine n=1 density of the FDR according to PTM No. 402 for each 3,000 square yard lot.

(e) Reclamation.

1. Pulverization. Before the application of any stabilizing additives, pulverize the roadway to the size and depth specified. Adding Calcium Chloride during pulverization is acceptable.

2. Mixing. Combine the FDR material, aggregates (if necessary), RAP (if necessary), stabilizing additive(s), and water according to the mix design and at the mix design recommended moisture content. Maintain adequate liquids in the mixture to ensure thorough mixing of the reclaimed material, aggregates, RAP, and stabilizing additives. If conditions change, make field adjustments to obtain a satisfactory FDR material.

If slurries are used, use Ready Mix Concrete Trucks or equip the distributor and tanker trucks with a re-circulating pump and/or agitation system to prevent settling of the materials before application.

If using slurry delivered in Ready Mix Concrete Trucks, verify "cement" application rate by calculating the weight of cement contained in the mixer truck and the area covered by the slurry after discharge by the Ready Mix Truck. The cement slurry producer shall supply a written record of the amount of cement, water, and admixture with each load of cement slurry. Evenly and uniformly distribute the cement slurry, over the area of the prepared subgrade, calculated to provide the required application rate. Accelerating or retarding admixtures maybe added to the cement slurry with the written approval of the DME/DMM.

3. Compaction. Compact the FDR material to a minimum density of at least 95% of the laboratory compacted maximum density at optimum moisture content. Demonstrate that the minimum specified density can be achieved during paving of the compaction control strip. After completing the compaction control strip, as specified in Section 344.3(e)3.a and demonstrating that the minimum density can be achieved, determine n=1 density according to PTM No. 402 for each 3,000-square yard lot.

Commence rolling at the low side of the course. Leave 3 to 6 inches from any unsupported edge(s) unrolled initially to prevent distortion. Compact the entire reclaimed area using the number of uniform passes of compaction equipment determined from the control strip, ensuring that uniform density is achieved throughout.

Complete compaction of chemically stabilized reclaimed material within 4 hours of the water/additive mixing operation.

3.a Compaction Control Strip. Determine the in-place density requirements by the construction of at least one 300-foot long control strip during initial reclamation. The compaction control strip may be contained within the project startup test strip. Take nuclear density reading tests according to PTM No. 402 after each pass of the compaction equipment. Continue compaction with each piece of equipment until no appreciable increase in density is obtained by additional passes. Upon completion of compaction, make a minimum of ten tests at random locations according to PTM No. 1 to determine the average in-place density of the compaction control strip. Provide density results to the Representative for verification to the minimum density requirements specified in Section 344.3(e)3.

If the density of the compaction control strip is less than the minimum density of at least 95% of the laboratory compacted maximum density at optimum moisture content, but the base course is uniform in texture, stable, and otherwise acceptable, provide additional compaction. If additional compaction does not achieve the minimum density, construct another compaction control strip to verify that the minimum density is achievable with the FDR process and mix design in use. Take a minimum of ten tests at random locations according to PTM No. 1 to determine the average in place density of the new compaction control strip. The minimum density for the new control strip is 98% of the control strip density.

3.b Moisture Content. Verify the original moisture content of the road material to be reclaimed before starting work. Make any appropriate adjustment between the moisture content determined at the time of mix design sampling and current moisture content by adjusting the design recommended water application rate.

The moisture content for compaction must achieve the optimum moisture content as determined from the project mix design, but cannot exceed optimum by more than 3%.

4. Finishing. Shape the FDR material surface not to exceed 3/4-inch irregularity of the lines, grades and/or cross-slope of the proposed roadway. Avoid excessively working the chemically stabilized FDR material, which may detrimentally affect the ultimate strength of the stabilized layer.

5. Cure. Cure the FDR material until the 7-day strength requirement is met. Do not allow heavy traffic on the reclaimed material during the 7-day cure period. Appropriate traffic signs must be posted to prevent heavy traffic on the constructed base until completion of base curing and application of the overlay.

For chemical stabilization, maintain the reclaimed layer in a damp condition by the daily application of water to the surface, or the application of an emulsified asphalt prime material at a rate between 0.05 to 0.1 gallons per square yard, followed by a fog seal at the rate of 0.25 gallons per square yard.

The rate of curing depends on many factors. In favorable weather conditions (no rain, sunshine, low humidity, high temperature), curing can take place at a considerably faster rate. Sufficient curing and strength gain could take from 2 or 3 days to at least 2 weeks depending on the type and amount of materials used and the climatic conditions. Verify by coring or test pit that curing has occurred throughout the full depth of the FDR before the application of an overlay or wearing course.

FDR should be proof rolled with a vehicle similar to the heaviest vehicle expected in traffic, or base opening on a strength measurement of the FDR, prior to opening to traffic. Same day return to car traffic at posted safe speeds is possible. In general, the constructed base could be opened to light traffic (vehicles under 5 tons) 2 hours after completion of the base construction, with proof rolling. Roadway should be at 50% of the design optimum moisture content or 3% total moisture content, whichever is reached first, prior to overlay. No damage should be apparent at slow speed, less than 10 miles per hour. Immediately correct any such damage to the satisfaction of the Representative. Otherwise verify strength by testing.

6. Surface Tolerance. Test the completed stabilized base for smoothness and accuracy of grade, both transversely and longitudinally. Satisfactorily correct any 3,000-square yard lot where the average surface irregularity exceeds 1/2 inch under a 10-foot template or straightedge, based on a minimum of at least three measurements within the lot.

Provide a minimum final surface cross slope of 1/4-inch per foot, or as otherwise required by the project design.

(f) Maintenance and Protection of Traffic (MPT). Relocate traffic using approved traffic control devices and procedures consistent with Section 901. Provide MPT until the road can be opened to traffic as specified in Section 344.3(h).

(g) Acceptance. Acceptance will be based on each 3,000-square yard lot complying with requirements for surface tolerance as specified in Section 344.3(e)6, for density as specified in Section 344.3(e)3, and strength as follows.

Any lot failing to meet the acceptance criteria will be identified for rework. With the approval of the Representative, additional cores may be taken to determine the extent of the failing area. Once a failed area has been identified, develop and obtain approval of a new mix design. Failed areas must be reclaimed again with the additional stabilizing material, as necessary, to achieve the required acceptance criteria. Fill any core holes remaining outside the reworked area with an approved repair material listed in Bulletin 15.

Take a minimum of three samples for strength testing for each lot size of 7,040 square yards. Follow PTM 1 for selecting sample locations. Cores should be 6 inches in diameter at a diameter to length ratio of 1:1.5. If possible, a core length of at least 60% of the design reclamation depth should be tested. Also, at least one full-depth sample per project mile should be extracted. If taking this sample is not possible with the 7-day core samples, take additional cores for strength testing after a 28-day cure time. Adjust the calculation of compressive strength as affected by the aspect ratio of the cylindrical specimen according to PTM No. 606 or ASTM C 42.

1. Asphalt Stabilized FDR. Achieve a minimum indirect tensile strength of 50 pounds per square inch when tested according to Bulletin 27.

2. Chemical Stabilized FDR. Achieve an unconfined compressive strength of 300 pounds per square inch to 500 pounds per square inch in 7 days when tested according to ACI 211 for the roads to be surfaced with less than a 3-inch overlay or asphalt surface treatment. Achieve an unconfined compressive strength value of 200 pounds per square inch to 500 pounds per square inch in 7 days for roads to be surfaced with an asphalt overlay of 3 inches or greater. Material tested to strengths greater than 900 pounds per square inch may result in shrinkage cracking, and rework will be required.

(h) Opening to Traffic. Do not open the road to unlimited traffic until the specified 7-day strength has been achieved. Limited local light vehicular traffic may be allowed once the reclaimed material has obtained a stable condition. Repair any damage resulting from local traffic. Do not allow trucks to use the road until the above referenced 7-day strength has been achieved.

344.4 MEASUREMENT AND PAYMENT—Square Yard

For the stabilization method selected with the approved mix design.