Recommended
Quality Control Sampling and Testing Guidelines
For
Full Depth Reclamation Using Cementitious Stabilizing Agents
FDR302

9/12/2017

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NOTICE

It is not intended or recommended that these guidelines be used verbatim within a specification. Owner Agencies should use them to help establish their particular project specification. Owner Agencies should understand that all geographical areas and pavement rehabilitation/preservation projects are unique and the availability of materials and equipment may vary as well. ARRA assumes no liability for utilization of these guidelines by any Individual or Entity. Contact ARRA for answers to questions and for a list of ARRA member Contractors and Suppliers.

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1. General

Quality Control (QC) sampling, testing and inspection shall be conducted by the Contractor to ensure optimum performance of the full depth reclamation (FDR) material. QC shall be conducted in accordance with the procedures outlined in Table 1 and below. Additional sampling and testing shall be conducted if significant changes in reclaimed material characteristics are observed, such as a change in the percentages of Reclaimed Asphalt Pavement (RAP) and underlying materials, a much coarser or finer gradation, or when considerable variability is occurring in field test results.

The Contractor's testing personnel and laboratory shall be certified in the applicable test methods and/or approved by the Owner Agency prior to beginning FDR. All testing performed by the Contractor shall be provided to the Owner Agency, when requested, within two business days of obtaining results.

If test results conducted during the placement of the FDR do not meet requirements presented in Table 1 the Owner Agency shall be immediately notified. The roadway shall then be inspected and monitored prior to the application of the surface course and any resultant deficiencies shall be rectified in accordance with the requirements of the plans and specifications.

User Note: These QC guidelines identify suggested material sampling and testing methods that are related to FDR process control to maximize final product performance. To adjust for varying field conditions during FDR pavement production, changes in rolling patterns, moisture content, stabilizing agent content and additive content may be necessary to obtain optimum performance. When taking material samples the time between sampling and testing may affect the results obtained. The Contractor should consult with the Material Supplier to ensure proper timelines are followed so as to ensure accurate test results.

2. Stabilizing Agent and Additive Spreader/Distributor

Spreaders or distributors used to apply dry powder stabilizing agents and/or additives shall be non-pressurized mechanical vane-feed, cyclone or screw type capable of providing a consistent, accurate and uniform distribution of material, while minimizing dust during construction. Corrective aggregate may be placed by a mechanical spreader, a conventional paver, or by tailgating with end dump trucks and spread to a uniform thickness with a motor grader.

3. Cementitious Stabilizing Agent Compliance

The cementitious stabilizing agent shall be established by a mix design prior to the start of full depth reclamation in accordance with guidelines presented in *ARRA FDR202 - Recommended Mix Design Guidelines for Full Depth Reclamation (FDR) Using Cementitious Stabilizing Agents*. If actual test results conducted during FDR do not meet the requirements of Section 3 of Table 1, the Owner Agency shall be immediately notified. The roadway shall then be inspected and monitored prior to the application of any surface course. Resultant deficiencies shall be rectified in accordance with the requirements of the plans and specifications.

User Note: Cementitious stabilizing agents used for the FDR process should be selected to obtain optimum performance and mix workability. They should be established by a mix design prior to the start of the process. The stabilizing agent selected for a particular project will depend on environmental conditions and material availability, and should follow guidelines presented in *ARRA FDR202*.

3.1 Cement

When required by the mix design, cement (portland or blended hydraulic), in either dry or slurry form, shall comply with the QC procedures outlined in Section 3.1 of Table 1. Slurry made from cement shall contain a minimum of 30% dry solids content. A COA shall be provided by the Material Supplier with each delivery of cement or a sample from the delivery tanker may be tested for verification in lieu of the COA.

3.2 Class C Fly Ash

When required by the mix design, self-cementing class C fly ash shall comply with the QC procedures outlined in Section 3.2 of Table 1. A COA shall be provided by the Material Supplier with each delivery of class C fly ash or a sample from the delivery tanker may be tested for verification in lieu of the COA.

3.3 Cementitious Stabilizing Agent Application Rate

At the start of production the optimum cementitious stabilizing agent rates established by the mix design shall be followed and, when necessary, modified to within the tolerances established in the mix design to adjust for changing field conditions. Cementitious stabilizing agents shall be transported to the site in bulk tankers.

When dry cement is spread using a spreader, it shall be applied to the road after initial pulveriation and the application rate verified according to Section 3.3.1 of Table 1. Dry cement shall be spread to the full width of the reclaiming drum to ensure uniform cement distribution throughout the mix. When spreading cement to the full width of the drum a standard “canvas patch” test, or similar procedure, shall be used to check the application rate as prescribed in Section 3.3.1 of Table 1. A canvas of known area shall be placed on the existing pavement prior to application of cement. After the cement is spread on the existing pavement, the canvas shall be weighed to verify the application rate.

When cement is applied by means of slurry injection, the consumption of cement (and water) shall be obtained from the computer that controls the slurry mixing unit. A volumetric distribution shall also be performed using the weight of dry cement used in the slurry mixer per load as prescribed in Section 3.3.2 of Table 1.

If field conditions or performance indicate the need for an adjustment to the application rate, adjustments shall be made. If the actual applied rate does not fall within the mix design tolerance, the performance of the roadway shall be monitored prior to application of the surface course. Resultant deficiencies shall be rectified in accordance with the requirements of the plans and specifications.

4. Stabilizing Additive Compliance

Stabilizing additives shall be lime, lime slurry, corrective aggregate or a combination thereof. The need for a stabilizing additive shall be established by a mix design prior to the start of reclaiming in accordance with guidelines presented in *ARRA FDR202*.

User Note: Stabilizing additives are used when the gradation can be improved, as is the case for corrective aggregate, or for a reduction in plasticity, as is the case for lime. The stabilizing agent selected for a particular project will depend on environmental conditions and material availability, and should follow the guidelines presented in *ARRA FDR202*. It is important that stabilizing additives be added at the rate specified in the mix design to ensure that optimal performance of the FDR material is achieved.

4.1 Lime

When required by the mix design, lime shall comply with the QC procedures outlined in Section 4.1.1 of Table 1. Lime shall be applied by means of slurry injection or dry. Lime slurry shall contain a minimum of 30% dry solids content. The consumption of lime (and water) shall be obtained from the computer that controls the slurry mixing unit. A volumetric distribution shall also be performed using the weight of dry lime used in the slurry mixer per load, as prescribed in Section 4.1.2 of Table 1.

When dry lime is spread using a spreader, it shall be applied to the road prior to reclaiming and the application rate verified according to Section 4.1.3 of Table 1. Dry lime shall be spread to the full width of the reclaiming drum to ensure uniform lime distribution throughout the mix. When spreading lime to the full width of the drum a standard "canvas patch" test, or similar procedure, shall be used to check the application rate as prescribed in Section 4.1.3 of Table 1. A canvas of known area shall be placed on the existing pavement prior to application of lime. After the lime is spread on the existing pavement, the canvas shall be weighed to verify the application rate.

4.2 Corrective Aggregate Compliance

When required by the mix design, corrective aggregate shall meet the gradation dictated by the mix design and the physical properties presented in Table 2 of *FDR102* and shall comply with the QC procedures outlined in Section 4.2.1 and Section 4.2.2 of Table 1. A COA from an Owner Agency certified Aggregate Supplier may be used in lieu of QC testing.

Corrective aggregate addition rate shall be determined by volumetric distribution utilizing weigh tickets from the haul trucks and the applied area, and shall comply with QC procedures outlined in Section 4.2.3 of Table 1.

User Note: Corrective aggregates may be incorporated into the mix to obtain the desired mix characteristics or desired gradation. The gradation of the material will depend on the desired effect but are typically unwashed screenings, chips, continuously graded aggregate or RAP. There should be a quantifiable improvement in measured mix properties to justify the added expense of corrective aggregates.

5. Reclaimed Pavement Material

Reclaimed pavement material shall consist of reclaimed asphalt pavement (RAP) and underlying materials. RAP shall consist of asphalt coated material. Underlying materials can consist of aggregate base, subbase or subgrade materials. The reclaimed pavement materials shall be sampled and tested in accordance with Section 5.1 of Table 1 for maximum particle size, and with Section 5.2 for air dried or wet field gradation. Samples may be obtained prior to or after the addition of stabilizing agent.

User Note: Maximum particle size is important to ensure that the texture and consistency in the final FDR mat is optimized. It is not possible to reduce the maximum size of the FDR material to less than the maximum size of the in-situ materials. A wet sieve analysis in the field provides an indication of the consistency of the FDR material and can be used for comparison with the mix design gradation to adjust the cementitious stabilizing agent rate.

6. Water

Moisture content shall be controlled to ensure adequate chemical reaction of the stabilizing agent and any additives, and to ensure optimum compaction of the FDR mixture. Moisture content monitoring shall comply with the QC procedures outlined in Section 6.0 of Table 1.

7. Construction

User Note: Performance testing (unconfined compressive strength, indirect tensile strength) of field produced and either field or laboratory compacted samples as a QC testing requirement for FDR materials is not recommended. Variations in environmental conditions (ambient temperatures, curing rates, moisture levels, solar influence, wind, etc.) produce inconsistent test results which make it difficult to establish and control testing results.

Immediate coring of FDR materials is not recommended for obtaining performance test samples as a significant amount of time, weeks to months, can be required for the material to fully cure and develop sufficient strength to withstand coring forces.

ARRA is investigating ways to implement performance testing; however, additional research is required to determine reliable field performance testing methods and procedures. At this time, if field testing is mandated by the Owner Agency, specimens must be compacted within the same timeframe and ambient conditions as field compaction, and should be used for information purposes only. Onsite compacted specimens are the only way to simulate actual construction conditions.

7.1 Pulverization

Before the stabilization process begins, the area to be stabilized shall be pre-pulverized, graded, and/or shaped to the lines and grades as shown on the plans and specifications. Pulverization depth measurements of reclaiming shall be obtained at available longitudinal joints according to Section 7.1 of Table 1.

7.2 Cementitious Application and Mixing

Removal and disposal of excess material, if required, shall be performed on the pulverized asphalt, base and subgrade material prior to cementitious treatment. Following pulverization and any trimming, if necessary, the cementitious material shall be spread on or applied to the pulverized material in accordance with the requirements of the mix design and the requirements of section 3.3.1 or 3.3.2 of Table 1.

Apply no more cementitious stabilizing agent to an area than can be adequately mixed within the time constraints of section 7.2.1 of Table 1. Apply cementitious stabilizing agent only when the anticipated weather meets the requirements of section 7.2.2 of Table 1.

If using dry stabilizing agent, water application shall only be added through the mixer/reclaimer's integrated fluid injection system during mixing. Mixing shall continue until the entire mixture, RAP, base and/or subgrade material is pulverized and gradation requirements are met.

Mixing depth measurements of reclaiming shall be obtained at available longitudinal joints according to Section 7.2.3 of Table 1.

7.3 Control Strip

A control strip shall be constructed to determine the optimum rolling pattern required to achieve the specified percent compaction. The control strip shall be established in accordance with the procedures outlined in *ARRA FDR102* and the QC procedures outlined in Section 7.3 of Table 1.

7.4 Compaction

Apply no more cementitious stabilizing agent to an area, and the Contractor shall sequence operations, such that the time constraints of section 7.4.1 of Table 1 are met. At the start of compaction the

moisture content shall meet the requirements of Section 6.0 of Table 1. The mixed material shall be uniformly compacted in one layer. Testing for compaction shall be in accordance with Section 7.4.2 of Table 1.

7.5 Mat Width and Cross-Slope

FDR mat cross-slope shall be measured across the mat width before and after compaction to ensure that the desired cross-slope is achieved, according to Section 7.5.1 of Table 1.

User Note: Depth and cross-slope requirements for a roadway will vary depending on condition of the existing roadway and operations prescribed in the plans and specifications. For roadways that exhibit a loss of profile outside of a 0.5% tolerance from the desired FDR profile, the plans and specifications should stipulate either a constant milling depth, placement depth, or desired cross-slope i.e. the existing cross-slope is 3.0% and the maximum specified is 2.5%. In this scenario a premilling line item should be included where the profile of the existing roadway prohibits obtaining both a depth and cross-slope. In the event that the existing roadway profile is consistent with the desired FDR profile, both a thickness and cross-slope may be specified.

Mat width shall comply with the QC procedures outlined in Section 7.5.2 of Table 1.

User Note: Measurement of FDR mat width is important where the desired mat width is wider than the existing asphalt pavement.

8. Surface Tolerance and Smoothness

Surface tolerance shall be measured as a pavement deviation within a 10 foot (3 m) straight edge utilizing a wedge ruler that can slide between the pavement/straight edge interface to accurately measure the gap. Surface tolerance shall comply with QC procedures outlined in Section 8.0 of Table 1.

User Note: Surface tolerance is important to ensure that end user comfort is maximized and expected long-term performance of the FDR pavement is realized. Use of the International Roughness Index (IRI), Mean Roughness Index (MRI), Profile Index (PI), or Ride Number (RN) for FDR pavements has grown as a measurement of smoothness due to acceptance of these methods for both asphalt and concrete pavements. ARRA believes that these techniques can be used successfully for FDR pavements; however, substantial evidence does not currently exist to determine specification guidelines for the results obtained. ARRA plans to compile results to establish suggested guidelines in the future.

Table 1. Quality Control Requirements by Contractor

Section	Type of Testing	Method	Frequency	Sample Location & Size	Target	Means of Rectification
3.1	Cement (portland or blended hydraulic)	Supplier generated COA[1]	Before use of every delivery load	N/A	According to *ARRA FDR102* and mix design	Do not use and remove material on site
3.2	Self-Cementing Class C Fly Ash	Supplier generated COA[1]	Before use of every delivery load	N/A	According to *ARRA FDR102* and mix design	Do not use and remove material on site
3.3.1	Cement Dry Spread Rate	Volumetric distribution	Every half mile (0.8 km)	From pavement. One 3X3 foot canvas patch test	± 5% of mix design application rate	Adjust application rate and complete non-conformance report if outside tolerance
3.3.2	Cement Slurry Application Rate	Volumetric distribution % solids by drying or hydrometer	Once for every delivery load	Application rate: one delivery load over area applied % solids from batch tank, 1 qt (1 L)	± 5% of mix design application rate	Adjust application rate and complete non-conformance report if outside tolerance
4.1.1	Lime	Supplier generated COA[1]	Before use of every delivery load	N/A	According to *ARRA FDR102* and mix design	Do not use and remove material on site
4.1.2	Lime Slurry Application Rate	Volumetric distribution % solids by drying or hydrometer	Once for every delivery load	Application rate: one delivery load over area applied % solids from batch tank, 1 qt (1 L)	According to *ARRA FDR102* and mix design	Adjust application rate and complete non-conformance report if outside tolerance
4.13	Lime Dry Spread Rate	Volumetric distribution	Every half mile (0.8 km)	From pavement. One 3X3 foot canvas patch test	± 5% of mix design application rate	Adjust application rate and complete non-conformance report if outside tolerance

Section	Type of Testing	Method	Frequency	Sample Location & Size	Target	Means of Rectification
4.2.1	Corrective Aggregate Gradation	Supplier generated COA[1] or laboratory analysis (AASHTO T 11 and T 27 or ASTM C117 and C136)	Before the start of placement and once every 1,000 tons (metric tons) thereafter	From stockpile, in accordance with AASHTO T 2 or ASTM D75 requirements	According to mix design tolerance in *ARRA FDR202*	Alternate source
4.2.2	Corrective Aggregate Physical Properties	Supplier generated COA[1] or laboratory analysis (AASHTO T 96, T 176 and T 85 or ASTM C131, D2419 and C127)	Once before placement	From stockpile, in accordance with AASHTO T 2 or ASTM D75 requirements	According to Table 2 of *ARRA FDR102* and mix design	Alternate source
4.2.3	Corrective Aggregate Addition Rate	Volumetric distribution	Every 1/2 mile (0.8 km)	Application rate: one delivery load over area applied	± 10% of mix design application rate	Adjust aggregate placement
5.1	FDR Maximum Particle Size	AASHTO T 27 ASTM C136 Air dried or wet gradation	Start of day and every 1/2 mile (0.8 km) thereafter	Sample in accordance with AASHTO T 168 or ASTM D979 from mat, minimum weight of 5 lbs. (2.5 kg)	100% passing specified maximum size	Reduce speed of reclaimer and/or adjust mixing chamber door openings
5.2	FDR Gradation	Air dried or wet gradation	Twice/day for first two days and once/day thereafter or if visual change in gradations occurs	Sample in accordance with AASHTO T 168 or ASTM D979 from mat, minimum weight of 22 lbs. (10 kg)	According to mix design tolerance in *ARRA FDR202*	Reduce speed of reclaimer and/or adjust mixing chamber door openings
6.0	Moisture Content of Reclaimed Mixture	AASHTO T 329 AASHTO T 265, ASTM D2216 or ASTM D4643	In control strip and as required	Sample in accordance with AASHTO T 168 or ASTM D979 after all additives have been added to mixture, minimum weight of 20 lbs. (9 kg)	Adjust to achieve desired fluids content for proper mixing and compaction, -1 to +2% of optimum moisture content determined in accordance with ASTM D588	Adjust water
7.1	Depth of Pulverization[2]	Depth probe measurement	Every 500 ft. (150 m)	Across mat width	Minimum plan or specified depth	Adjust pulverization depth

Section	Type of Testing	Method	Frequency	Sample Location & Size	Target	Means of Rectification
7.2.1	Stabilization Application and Mixing Time Constraints	Timepiece	Each construction section	N/A	The first contact of cementitious stabilizing agent with water prior to application on the reclaimed material shall not exceed 60 minutes. The time from cementitious stabilizing agent placement to start of mixing shall not exceed 30 minutes.	Reduce stabilization area or add more equipment to meet time constraints
7.2.2	Ambient Temperature	Any Owner Agency approved method	At the start of each day and every two hours thereafter	N/A	> 35 °F (2 °C) and no freezing temperatures within 7 days of completion of FDR	Suspend reclaiming until temperature requirements can be met
7.2.3	Depth of Stabilized Material	Depth probe measurement	Every 1,000 ft (300 m), recording every 10th measurement	Vertical measurement adjacent to longitudinal joints	Minimum plan and specified depth	Adjust mixing depth
7.3	Control Strip	Nuclear gauge per AASHTO T 355 (ASTM D2950) or Owner Agency approved method[2]	During the first day and if significant changes in reclaimed mix properties occur	One spreader or distributor load	Rolling pattern necessary to meet specified percent compaction	N/A

Section	Type of Testing	Method	Frequency	Sample Location & Size	Target	Means of Rectification
7.4.1	Compaction Time Constraints	Timepiece	Each construction section	N/A	Compaction shall begin no more than 20 minutes after mixing or immediately upon achieving gradation and moisture requirements. All compaction operations shall be completed within 2 hours from start of mixing operations. No section shall be left undisturbed for more than 30 minutes during compaction operations.	Reduce stabilization area or add more equipment to meet time constraints
7.4.2	Reclaimed Material Compacted Density	Nuclear gauge AASHTO T 310 (ASTM D6938) or Sand Cone AASHTO T 191 (ASTM D1556)[2]	Initial control strip and every 1,000 ft. (300 m) as required	Random sampling as per ASTM D3665	≥ 98% of ASTM D588, based on a moving average of five consecutive tests, with no test below 96%	Establish new rolling pattern
7.5.1	Cross-slope[2]	10 ft.(3 m) Straight edge	Every 1000 ft. (300 m)	Across mat width after grading and finish rolling	± 0.1% of desired cross fall	Regrade as necessary
7.5.2	Mat Width	Tape measurement	Ongoing, recording every 1,000 ft. (300 m)	Across mat width	± 2 inches (50 mm)	Adjust reclaimer passes/overlaps
8.0	Surface Tolerance	10 ft. (3 m) Straight edge	Ongoing, recording every 1,000 ft. (300 m)	At joints and ongoing	< 1/2 in. (12 mm) longitudinal and < 3/8 in. (10 mm) transverse	Trimming, milling or abrasive grinding

Notes for Table 1

1. A Certificate of Analysis (COA) provided by the Material Supplier that includes test results that verify that the product supplied meets the minimum specified quality standards.

2. Both pulverization depth and cross-slope requirements for a roadway may not be achievable as described in Sections 7.1 and 7.5.1. FDR material will not compact to the pulverized thicknesses as the RAP will fluff after pulverization and cementitious stabilizing agent application, depending

on material, methods and environmental factors. Because of this material expansion, the elevation of the final FDR pavement may increase compared to the existing pavement. Depending on the road geometry this additional material may be removed and placed in areas where minor cross fall corrections are required. Premilling may also be performed if the final FDR elevation is to match the existing pavement elevation.

3. It has not been determined at this time if electromagnetic gauges are suitable for use on full depth reclamation mixtures; therefore, they are not recommended for use.