State of Illinois
Department of Transportation
Bureau of Local Roads and Streets

SPECIAL PROVISION
For
FULL-DEPTH RECLAMATION (FDR) WITH CEMENT OR CEMENT SLURRY

Effective: May 1, 2021

All references to Divisions, Sections, and Articles in this Special Provision shall be construed to mean specific Divisions, Sections, and Articles in the Standard Specifications for Road and Bridge Construction adopted by the Department of Transportation.

Description. This work shall consist of constructing a base course by pulverizing in-place bituminous surface treatment or hot mix asphalt layers, portions of the aggregate base material, and/or subgrade to a specified depth and maximum size; spreading and mixing cement, water, and additives with the recycled material; and shaping, compacting, and curing the mixture.

Materials. Materials shall be according to the following Articles/Sections of the Standard Specifications.

Item	Article/Section	
(a)	Cement (Notes 1 and 2)	1001.01(a)
(b)	Concrete Admixtures (Note 2)	1021
(c)	Water	1002
(d)	Fine Aggregates (Note 3)	1003
(e)	Coarse Aggregates (Note 3)	1004
(f)	Soil for Soil-Cement Base Course (Note 4)	1009.03
(g)	Reclaimed Asphalt Pavement (Note 5)	1031
(h)	Pulverized Material (Note 6)	
(i)	Bituminous Materials (Note 7)	1032

Note 1. Bulk cement may be used for the road reclaimer method if the equipment for handling, weighing, and spreading the cement is approved by the Engineer.

Note 2. The type and allowable percentage will be described in the mix design.

Note 3. The mix design will specify gradation and quality of any additional aggregate. 100 percent of any additional aggregate shall pass a 1 1/2 in. (37.5 mm) sieve and shall contain a maximum of 15 percent retained on a 1 in. (25 mm) sieve. Additional fine aggregate shall meet Class B quality as a minimum. Additional coarse aggregate shall meet Class C quality as a minimum.

Note 4. This soil requirement only applies when subgrade material is included in the pulverized material.

Note 5. The RAP material shall not exceed the maximum size requirement of the pulverized material, and when blended with the pulverized material shall produce a product which meets the specifications of the mix design.

Note 6. Pulverized material shall consist of the mixture resulting from pulverizing in-place bituminous surface treatment or hot mix asphalt layers layers, aggregate base material, and/or subgrade to a specified depth. After pulverization, the gradation of the pulverized material shall meet the following requirements.

PULVERIZED MATERIAL GRADATION			
Grad No.	Sieve Size and Minimum Percent Passing		
	3 in. (75 mm)	2 in. (50 mm)	No 4 (4.75 mm)
PM 4	100	95	55

Note 7. The bituminous materials used for curing shall be emulsified asphalt RS-2, CRS-2, HFE 90, or HFE 150; rapid curing liquid asphalt RC-70; or medium curing liquid asphalt MC-70 or MC-250.

Equipment. Equipment shall be according to the following Articles of Division 1100 – Equipment.

(a) Heavy Pneumatic-Tired Rollers .....1101.01(b)
(b) Vibratory Roller (Note 1) .....1101.01(g)
(c) Motor Grader 1101.05
(d) Distributor (Note 2)
(e) Truck Mixer (Note 2) .....1103.01(b)
(f) Road Reclaimer (Note 3)
(g) Tamping Roller (Note 4) .....1101.01(d)
(h) Membrane Curing Equipment .....1101.09(a)
(i) Aggregate Spreaders (Note 5) 1102.04
(j) Water Truck (Note 6)

Note 1. The vibratory steel roller shall have a minimum gross weight of 10 tons (9 metric tons) and shall provide a total applied force not less than 325 lb/in. (57 N/mm).

Note 2. The distributor shall be a mechanical type and shall be approved by the Engineer. The distributors or truck mixers used to apply the cement and/or chemical admixtures for FDR shall be able to demonstrate a consistent and accurate application rate while minimizing dust during construction according to Article 107.36.

Note 3. The road reclaimer shall be self-propelled and capable of fully pulverizing the existing pavement, incorporating the water, and mixing the materials to produce a homogeneous material. The minimum power of the road reclaimer shall be 540 hp (403 kW). The road reclaimer shall be capable of reclaiming not less than 8 ft (2.4 m) wide and up to 12 in. (305 mm) deep in each pass. The road reclaimer shall be capable of injecting water directly into the mixing chamber via an electronic control system that records the amount of water injected. The cutting drum shall be fitted with cutting teeth capable of trimming earth, aggregate, and bituminous surface treatments or hot mix asphalt mixtures, and be accurately adjusted vertically and held in place. The machine shall weigh at least 12.5 tons (11.3 metric tons) and shall not develop a center deflection of more than 1/8 in (0.125 mm).

Note 4. The tamping roller shall be a self-propelled vibratory padfoot roller with a minimum drum width of 7 ft (2.1 m) and gross weight of not less than 10 tons (9 metric tons). A tamping roller shall be required for each road reclaimer.

Note 5. Imported granular material used for FDR shall be spread with an aggregate spreader or placed with a spreading and finishing machine according to Article 1102.03.

Note 6. Water trucks used shall be set up for a controlled and non-eroding spray.

CONSTRUCTION REQUIREMENTS

Proportioning. Proportioning shall be as follows.

(a) Samples. Samples of the cement, chemical admixtures, additional fine and coarse aggregate, reclaimed asphalt pavement, and material to be pulverized (all in-place bituminous surface treatment or hot mix asphalt layers layers, aggregate base material, and/or subgrade through the full design depth) shall be obtained and submitted to the Engineer at least 60 days prior to the construction of the full-depth reclamation with cement. Sample sizes shall be a minimum of 25 lb (11 kg) for the cement, 1 qt or 1 L for the chemical admixtures, and 200 lb (91 kg) for the material to be pulverized. Any additional aggregates or RAP material samples shall be at a minimum the anticipated mix design proportion percentage multiplied by 200 lb (91 kg).

(b) Mix Design. The actual proportions of cement, water, aggregates, RAP, chemical admixtures, and soil will be determined by the Engineer prior to construction using the submitted samples. The Engineer reserves the right to make such adjustments in proportions as are considered necessary during the progress of the work.

A mix design for each distinct change of in-place materials shall be developed prior to construction using all actual materials proposed for the project and submitted to the Department. The mix design shall follow items listed for soil-cement mixtures in the Department's "Geotechnical Manual". The final mix design will be approved by the Engineer.

FDR WITH CEMENT MIX DESIGN REQUIREMENTS	
Test Method	Requirement
Gradation for Pulverized Material, Illinois Test Procedure 27[1], AASHTO T 88	Report
Liquid Limit[2], AASHTO T 89	Report
Plasticity Index[2], AASHTO T 90	Report
Moisture-Density Relationship, Illinois Modified AASHTO T 134 (Method B)[1]	Report
Unconfined Compressive Strength, 7-Day, Illinois Modified AASHTO T 22[1], psi	500 min
Freeze-Thaw Durability *(choose one)* Vacuum Saturation Strength (ASTM C 593[3]), psi Mass Loss (AASHTO T 136), percent loss	 350 min 14 max
Additional Additive(s)[4] Concrete Admixtures Coarse Aggregate Fine Aggregate RAP	 Report Report Report Report
Cement[4], percentage by dry mass	Report

Notes: 1. Test information contained in the Manual of Test Procedures for Materials.

2. Only required if subgrade soil is being incorporated into the mixture.

3. Samples will be prepared according to Illinois Modified AASHTO T 134 (Method B), cured according to AASHTO T 136, vacuum saturated according to ASTM C 593, and test for unconfined compressive strength.

4. Report will include type/gradation and producer/supplier.

Weather Limitations. This work shall not be performed when the FDR to be processed is frozen, when the ambient air temperature is less than 40 °F (4 °C) or greater than 95 °F (35 °C), or if the weather is rainy. The weather forecast shall not call for temperatures less than 32 °F (0 °C) within 7 days after placement of any portion of the project.

Preparation of Subgrade. The area to be processed shall have all vegetation and other objectionable material removed. Widening and grade correction areas shall be shaped to the proper grade and cross section. Subgrade in cut or at grade sections shall be prepared according to Article 301.03 and 301.04; except the minimum immediate bearing value (IBV) of the soil shall be 3.0. The IBV will be determined according to Illinois Test Procedure 501 or 502.

Where soft and unstable subgrade material is encountered beneath the area to be pulverized, the Engineer will determine whether the ground and soil conditions warrant more extensive treatments according to the Department's "Subgrade Stability Manual". Soft and unstable material that will not compact when rolled or tamped, shall be removed and disposed of according to Article 202.03, and replaced with material approved by the Engineer according to Articles 205.04 and 205.05.

Initial Pulverization and Shaping. The existing pavement shall be initially pulverized by the road reclaimer and shaped by the motor grader to the required lines, grades, and cross section before the addition of dry cement or cement slurry. Water, fine and/or coarse aggregate, RAP material, or other additives required may be added during this operation. The pulverized and shaped material shall be compacted to support equipment and/or traffic without excessive rutting or shoving and to facilitate depth control during processing.

During the start of pulverization, the Contractor shall complete a strip for evaluation by the Engineer. To ensure the pavement is being pulverized to the specified gradation, the Contractor shall excavate a pulverized area of 10 sq ft (1 sq m), in two separate locations during the first day of pulverizing, as directed by the Engineer. Modifications to the pulverizing procedure must be made if the size and/or gradation requirements are not met. These excavations shall be repaired with by recompacting the pulverized material. If pulverization procedures or conditions change, additional excavations to inspect the pulverized pavement size and gradation shall be made, as directed by the Engineer.

Unsuitable or unstable material encountered during the pulverization and shaping process shall be removed and disposed of according to Article 202.03. Areas of approximately 10 sq ft (1 sq m) or less may be repaired by use of aggregate replacement material. Larger unstable areas require removal and replacement, as directed by the Engineer. Following subgrade repairs, aggregate replacement material shall be placed to the depth of the FDR specified thickness.

After initial pulverization is complete, the pulverized material shall undergo an initial shaping to the proper lines and grades with a motor grader.

Cement Application. Following initial pulverization and shaping, the quantity of dry cement or cement slurry specified in the mix design shall be spread uniformly on the finished surface. The cement spread shall be calculated to provide the required application rate in a manner that minimizes dust or slurry runoff and is satisfactory to the Engineer. The application of the cement shall be limited to that amount which can be mixed and compacted with the pulverized material within 4 hours.

When cement slurry is used, the surface of the pulverized material shall be lightly scarified

or disked prior to slurry application, and berms shall be formed to prevent excessive runoff, unless the Contractor has demonstrated to the satisfaction of the Engineer that the slurry has been proportioned such that it will not run off.

Dry cement shall not be applied when wind conditions are such that blowing cement becomes objectionable to adjacent property owners or creates a hazard to traffic on adjacent roadways, as determined by the Engineer.

Cement slurry shall be produced in a ready mixed concrete plant or other type of mixing device approved by the Engineer and delivered in truck mixers or other approved slurry transport equipment. Cement slurry shall be proportioned such that it contains a minimum 60 percent dry solids content by weight. The cement slurry producer shall supply a record of the amount of cement, water, and chemical admixtures with each truck delivery. The time from first contact of cement with water to application on the prepared surface of the initially pulverized material shall not exceed 60 minutes unless an approved retarding admixture is used, in which case the Engineer may allow a maximum of 90 minutes.

No equipment, except that used in applying cement and mixing, will be allowed to pass over the applied cement, and this equipment shall be operated in such a manner as to avoid displacement of cement.

The Engineer shall be notified any time the cement application rate is changed. The cement application rate shall be checked and recorded for each segment in which the rate is changed.

Mixing. Mixing shall begin as soon as possible after the cement has been applied, but shall not exceed 30 minutes from the time cement has been applied. Mixing shall continue until a uniform mixture of pulverized material, cement, admixtures, aggregate, and water is obtained that passes the gradation and moisture content specified. A final gradation test shall be made at the conclusion of mixing operations.

During mixing, water application shall only be done through the road reclaimer's integrated fluid injection system.

Dry cement or cement slurry which has been disturbed or displaced by rain, the Contractor's equipment or other traffic after application, shall be replaced.

After mixing is complete, the material shall be shaped to the proper lines and grades with a motor grader.

Compaction and Finishing. Compaction shall begin within 30 minutes of the most recent mixing pass and be completed no later than two hours after mixing begins. The mixture shall be compacted according to the following.

(a) Moisture Content. At the start of compaction, the moisture content shall be between 80 to 120 percent of the optimum moisture content determined according to Illinois Modified AASHTO T 134 (Method B) for the mix design.

(b) Density. The compacted, full-depth reclamation base course shall have a minimum dry density of 98 percent of the laboratory standard dry density based on a moving average of five consecutive tests with no test below 95 percent. The in-place dry density will be determined according to Illinois Modified AASHTO T 191, or Illinois Modified AASHTO T 310 (Direct Transmission Density/Backscatter Moisture). The laboratory standard dry density will be determined according to Illinois Modified AASHTO T 134 (Method B) for the mix design.

Any portion of the base course that has a density less than 95 percent of the standard laboratory density shall be corrected by continued compaction within specified time constraints, or removed and replaced.

(c) Rollers. Immediately after processing and final shaping, the FDR base course shall be compacted with equipment meeting the following requirements.

MINIMUM ROLLER REQUIREMENTS FOR FDR		
Initial Roller	Final Roller[1] (one or more of the following)	Density Requirement
Tamping roller	P, V_S	As specified in the Compaction section (b) above

Note(s): 1. Equipment definitions in Table 1 of Article 406.07.

(d) Rolling and Finishing. The initial roller shall be within 500 ft. (150 m) behind all road reclaimer units. The FDR base course shall be uniformly compacted by the tamping roller, applying high amplitude and low frequency. Initial rolling shall be performed until the initial roller walks out of the material and the specified density has been obtained. Walking out for the tamping roller is defined as light being clearly evident between all of the pads at the material-padfoot drum interface and the pads being no more than 3/16 in. (5 mm) deep. Care shall be exercised to ensure satisfactory density along the edges of the section and adjacent to construction joints.

Any unstable material encountered while compacting or under construction trafficking shall be treated as defined in the sections titled Preparation of Subgrade and Initial Pulverization and Shaping. If a large area of unstable material is identified during the compaction process, work on the affected area shall be halted and the Engineer notified.

When initial compaction of the FDR base course is nearing completion, the surface of the base course shall be shaped to the required lines, grades, and cross section with a motor grader. The FDR base course shall be cut no deeper than necessary to remove roller marks from the initial compaction and to achieve desired cross slope.

The bladed recycled material shall be compacted by final rollers until the required density is obtained. The number of passes and order of rollers may be altered to meet density requirements. Finish rolling shall not be done in vibratory mode. The moisture content of the surface material shall be maintained at or slightly above its specified optimum during all finishing operations and until the curing material is applied. Water may be lightly sprayed by a water truck to aid in improving final density and appearance. A second water truck is required if water is also being added at the road reclaimer.

Surface compaction and finishing shall be done in such a manner as to produce a smooth, dense, uniform, closely knit surface, relatively free from cracks, ridges, low spots, or loose material, conforming to the crown, grades, and lines shown on the plans.

Protection and Curing. After the FDR base course has been finished, it shall be protected against drying for a period of 7 days by applying a bituminous material or the surface shall receive continuous moist curing with a non-eroding water spray for a minimum of 7 days, unless a surface course is placed within 7 days, at which point moist curing may be discontinued.

Curing shall be applied as soon as possible after the completion of final rolling. Prior to applying the curing, the FDR base course surface shall be dense, free of all loose and extraneous materials, and contain sufficient moisture to prevent excessive penetration of the curing material. Bituminous material shall be uniformly applied at the rate of 0.20 gal/sq. yd. (0.90 L/sq. m) to the surface of the FDR base course by a pressure distributor to give complete coverage without excessive runoff. The exact rate of application and temperature will be specified by the Engineer. If needed, water shall be applied to fill surface voids immediately before the bituminous material cover is applied. The equipment used for wetting the finished FDR base course with water or to apply the bituminous protective cover shall be of such limited weight that its use will not cause marring or rutting of the base course. Should it be necessary for construction equipment or other traffic to use the bituminous covered surface before the bituminous material has cured sufficiently to prevent pickup, sufficient blotter fine aggregate shall be applied with aggregate spreaders to prevent pickup.

Finished portions of the FDR base course that are traveled on by equipment used in constructing an adjoining section shall be protected in such a manner as to prevent equipment from marring or damaging completed work.

Construction Joints. At the end of each day's construction, a straight transverse construction joint shall be formed by cutting back into the completed work to form a vertical face. Damage to completed work shall be avoided.

Opening to Traffic. The finished FDR base course may be opened immediately to local traffic and to the Contractor's construction equipment once the base has hardened sufficiently to withstand marring or permanent deformation by such traffic and received a bituminous or other approved sealing membrane. The base course may be opened to all traffic after the 7-day protection period, provided the base course is not damaged, marred, or distorted by such traffic, and provided that the protection and curing material specified in the Protection and Curing section above is not impaired.

Maintenance. The Contractor shall maintain the entire FDR base course in a manner satisfactory to the Engineer until the surface course has been constructed. Maintenance shall include immediate repairs of any defective or damaged portions of the base course. Repairs or replacements shall be made in such a manner as to ensure restoration of a uniform surface and durability of the portion repaired or replaced.

Tolerance in Thickness. The FDR base course shall be constructed to the thickness shown on the plans. Base thickness will be based on thickness measurements of cores taken, measured, and recorded according to Article 407.10(a)(2). Any portion of the FDR base course that is less than 90 percent of the specified thickness shall be removed and replaced with new material to the correct thickness.

Quality Control/ Quality Assurance (QC/QA).

(a) Quality Control by the Contractor. The Contractor shall perform or have performed the inspection and tests required to assure conformance to contract requirements. Quality Control includes the recognition of obvious defects and their immediate correction. This may require increased testing, communication of test results to the job site, modification of operations, suspension of the work, or other actions as appropriate.

The Engineer shall be immediately notified of any failing tests and proposed remedial action. Passing tests shall be reported to the Engineer no later than the start of the next work day.

(b) Quality Assurance by the Engineer. The Engineer will conduct independent assurance tests on split samples taken by the Contractor for quality control testing. In addition, the Engineer will witness the sampling and splitting of these samples and will immediately retain witnessed split samples for quality assurance testing.

(c) Test Methods and Frequency. Test methods and test frequencies shall be according to the following table.

QC/QA MINIMUM TESTING FREQUENCY[2]			
Test	Test Method	QC Frequency[1]	QA Frequency[1]
Depth of Pulverization		1 per 500 feet (150 m)	1 per 1000 feet (300 m)
Pulverized Material Gradation	AASHTO T168	1 per 0.5 day of production	1 per day of production
Cement Application Rate	Note 2	1 per 500 feet (150 m)	1 per 1000 feet (300 m)
One-Point Moisture-Density	Illinois Modified AASHTO T272	1 per 0.5 day of production	1 per day of production
Density	Illinois Modified AASHTO T191 or T310	1 per 500 feet (150 m)	1 per 1000 feet (300 m)

Note: 1. The Contractor shall perform all quality control tests within the first 500 ft (150 m) after startup or any change in the mix or depth of pulverization. The Engineer will also run split samples at these locations.

2. Cement application rates shall be verified by calculating the weight of cement contained in the cement tanker/truck mixer and the area covered after application. For slurry application rates, calculate the weight of cement as the weight of slurry minus weight of water.

Method of Measurement. The work will be measured for payment as follows.

(a) Contract Quantities. The requirements for the use of Contract Quantities shall conform to Article 202.07(a).

(b) Measured Quantities. The work will be measured for payment as follows.

(1) Cement incorporated in the full-depth reclamation mixture will be measured for payment in hundredweights (kilograms), but payment will not be made for cement in excess of 105 percent of the amount specified by the mix design or approved by the Engineer.

(2) Any additional aggregate, including RAP, used to meet the requirements of the mix design will be measured for payment in square yard (square meter).

(3) Full-depth reclamation will be measured for payment in place and the area computed in square yards (square meters) of the recycled pavement.

(4) Removal and disposal of unstable and/or unsuitable material will be measured for payment according to Article 202.07(b).

(5) Replacement of unstable and/or unsuitable material will be measured for payment according to Article 204.07(b).

(6) Cement treatment of unstable pulverized base course, when specified by the Engineer, will be measured for payment according to (1) and (3) above.

Basis of Payment. This work will be paid for at the contract unit prices as follows.

(a) The cement material will be paid for at the contract unit price per hundredweight (kilogram) for CEMENT.

(b) If any additional aggregate, including RAP, is required to meet the requirements of the mix design, the cost will be paid for at the contract unit price per square yard (square meter) for ADD ROCK. The cost incurred introducing the additional aggregate into the FDR base course will not be paid for separately, but shall be considered as included in the contract unit price for FULL-DEPTH RECLAMATION below. No additional compensation will be awarded to the Contractor because of reduced production rates associated with the addition of the additional aggregate.

(c) The full-depth reclamation will be paid for at the contract unit price per square yard (square meter) for FULL-DEPTH RECLAMATION, of the thickness specified.

(d) Removal and disposal of unstable and/or unsuitable material will be paid for according to Article 202.08.

(e) Replacement of unstable or unsuitable material will be paid for according to Article 204.08.

(f) Cement treatment of unstable pulverized base course, when specified by the Engineer, will be paid for at the contract unit prices for (a) and (c) above.