

# Special Specification 3017

## Full-Depth Recycling and Treatment Using Foamed Asphalt (Road-Mixed)



### 1. DESCRIPTION

Provide for full-depth recycling (FDR) of the existing surface and the underlying base material using foamed asphalt and an in-place mixing process to create a homogenous mixture.

### 2. MATERIALS

Furnish uncontaminated materials of uniform quality in accordance with the plans and specifications. Notify the Engineer of the proposed material sources and when there are necessary changes to the material sources. The Engineer will verify the specification requirements are met before the sources are approved for use. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

- 2.1. **Asphalt.** Furnish the type and grade of performance-graded (PG) binder or asphalt cement (AC) in accordance with Item 300, "Asphalts, Oils, and Emulsions" as shown on the plans.
- 2.2. **Additional Material.** When shown on the plans, furnish additional material meeting the requirements of Item 247, "Flexible Base" or Item 302, "Aggregates for Surface Treatments" for the type and grade required.
- 2.3. **Additive.** When shown on the plans, provide the amount and type of additive required.
- 2.3.1. **Lime.** When shown on the plans, furnish lime in accordance with DMS-6350, "Lime and Lime Slurry," and DMS-6330, "Pre-Qualification of Lime Sources." Use hydrated lime or commercial lime slurry as required.
- 2.3.2. **Cement.** When shown on the plans, furnish hydraulic cement in accordance with DMS-4600, "Hydraulic Cement," and the Department's Hydraulic Cement Quality Monitoring Program (HCQMP). Sources not on the HCQMP will require testing and approval before use.
- 2.3.3. **Fly Ash.** When shown on the plans, furnish fly ash in accordance with DMS-4615, "Fly Ash for Soil Treatment." Use Class CS or FS as shown on the plans.
- 2.4. **Mix Design.** The Engineer will provide an approved mixture design meeting the requirements listed in Tables 1 and 2 before the start of any work pertinent to this item.

The mixture design will report the optimum moisture content, maximum dry density, percent additive, percent of additional material when applicable, percent of existing material, and the optimum foamed asphalt content.

**Table 1**  
**Laboratory Mixture Design Properties**

Mixture Property	Test Method	Minimum Requirement
Indirect Tensile Strength (IDT), <sup>1</sup> psi	Tex 226-F	45
Moisture Conditioned IDT, <sup>1,2</sup> psi	Tex 226-F	30
Moisture Conditioned Unconfined Compressive Strength, <sup>3</sup> psi	Tex 117-E, Part II	120

1. Average of 3 test specimens. Compact test specimens in accordance with Tex-206-F within 0.3% of the optimum moisture content and 1.0 pcf of the maximum dry density. Oven dry test specimens after compaction in an oven at  $104 \pm 5^\circ\text{F}$  for a minimum of 72 hr.
2. Moisture condition the test specimens by submerging them in water for  $24 \pm 1$  hr. after oven drying.
3. Average of 2 test specimens. Oven dry test specimens after compaction in an oven at  $104 \pm 5^\circ\text{F}$  for a minimum of 72 hr. Moisture condition the test specimens by submerging them in water for  $24 \pm 1$  hr. after oven drying.

**Table 2**  
**Foamed Asphalt Properties**

Material Property	Minimum Requirement
Asphalt Binder Expansion ratio <sup>1</sup>	8 times
Asphalt Binder Half-Life, seconds <sup>1</sup>	6

1. The recycler shall have a test nozzle attached to one side of the spray bar from which a quantity of foamed asphalt is injected into a straight sided container during recycling. The half-life is a measure of time for the foamed asphalt to reach half the height of the maximum expansion noted in the container. The container is set aside for a minimum of 1 hr. or until the foamed asphalt has subsided completely and the unexpanded volume of the quantity of asphalt injected into the container is noted. The expansion ratio is the ratio of the maximum expansion volume to the unexpanded volume.

- 2.5. **Water.** Furnish water free of industrial waste and other objectionable material.

---

### 3. EQUIPMENT

Provide machinery, tools, and equipment necessary for proper execution of the work.

- 3.1. **Storage Facility.** Store cement, quicklime and dry hydrated lime in closed, weatherproof containers.
- 3.2. **Slurry Equipment.** Use slurry tanks equipped with agitation devices to slurry cement, hydrated lime, or quicklime at the project or at another location approved by the Engineer. The Engineer may approve other slurring methods. Provide a pump for agitating the slurry when the distributor truck is not equipped with an agitator. Equip the distributor truck with a sampling device in accordance with Tex-600-J, Part I.
- 3.3. **Dry Distribution Equipment.** Provide equipment to spread the cement or lime or fly ash evenly across the area to be treated. Provide equipment with a rotary vane feeder to spread the cement or lime, when shown on the plans.
- 3.4. **Rollers.** Provide rollers in accordance with Item 210, "Rolling."
- 3.5. **Proof Rollers.** Provide proof rollers in accordance with Item 216, "Proof Rolling," when required.
- 3.6. **Reclaimer.** Furnish a reclaimer with the following equipment and capabilities for treatment with foamed asphalt.
  - 3.6.1. Self-propelled mixer capable of fully mixing the existing road to the depth shown on the plans with foam asphalt, water, and when applicable additives and additional material to produce a homogeneous mixture.
  - 3.6.2. Minimum power capability of 600 hp.

- 3.6.3. Increase the effective volume of the mixing chamber in relation to depth of cut.
- 3.6.4. Two microprocessor controlled systems, complete with two independent pumping systems and spray bars, to regulate the application of foamed asphalt cement, separate from water that is used to increase the moisture content of the mixed material. Both systems shall perform in relation to the forward speed of the reclaimer and the mass of the material being processed.
- 3.6.5. Two spray bars, one for foamed asphalt and one for compaction moisture, each fitted with self-cleaning nozzles at a maximum spacing of one nozzle for each 6 in. width of the mixing chamber. Monitor the flow rate to each nozzle to verify that all nozzles are producing foamed asphalt at the same rate.
- 3.6.6. The foamed asphalt shall be produced at the spray bar in individual expansion chambers into which hot asphalt cement, water, and air are injected under pressure through individual and small orifices that promote atomization. The rate of addition of water into the hot asphalt cement shall be kept at a constant percentage by mass of asphalt cement by the same microprocessor.
- 3.6.7. A system within the operator cabin to verify the foamed asphalt is being evenly distributed across the full width of the spray bar at the rate specified. The system shall be demonstrated to the Engineer to verify even spraying.
- 3.6.8. An electrical heating system capable of maintaining the temperature of asphalt cement flow components above 300°F.
- 3.6.9. A single asphalt cement feed pipe installed between the recycler and the supply tanker. Do not use circulating systems that incorporate a return pipe to the supply tanker.
- 3.6.10. An inspection or test nozzle shall be fitted at one end of the spray bar that produces a representative sample of foamed asphalt cement.

---

#### 4. STAFFING REQUIREMENTS

Provide an onsite technician to supervise the FDR process and any other related process control of the product for the control strip and a minimum of 3 days of production. This technician must have a minimum experience of 2 yr. supervising projects using FDR with foamed asphalt.

---

#### 5. CONTROL STRIP

Construct a control strip at a location approved by the Engineer using the equipment specified for the FDR treatment. Process material in the control strip for a lane width, 300 ft. in length, and to the depth shown on the plans. Meet the quality control requirements in Section 7 and provide those results and all other pertinent information to the Engineer upon completion of the control strip.

Proof roll the control strip in accordance with Item 216 at the direction of the Engineer. Do not proceed to full construction without the approval of the Engineer.

---

#### 6. CONSTRUCTION

Construct each layer uniformly, free of loose or segregated areas, and with the required density and moisture content. Provide a smooth surface that conforms to the typical sections, lines, and grades shown on the plans, or as directed.

- 6.1. **Preshaping.** Where required to pre-shape the pavement, pulverize existing bituminous surface and all existing pavement layers to the required depth less one inch. Incorporate water and additional flexible base or other approved materials during this operation, if needed. Shape roadway material in accordance with applicable bid items to conform to typical sections shown on the plans and as directed before the addition of

the foamed asphalt. Compact the material to support equipment and / or traffic, and to provide depth control during mixing.

- 6.2. **Mixing.** Before mixing, aerate if too wet and add water if too dry to achieve the required moisture content. Add foamed asphalt at the percentage determined in Section 2.4, "Mix Design." Monitor the required depth of mixing regularly. Apply foamed asphalt only on an area where mixing and compaction can be completed the same working day.

Complete the entire operation of mixing the existing road and incorporating additional flexible base, water, and foamed asphalt in one pass. Ensure that each adjacent pass of the mixer overlaps the previous pass by a minimum of 6 in. Use multiple passes if the quality control requirements specified in Section 7 are not met.

After mixing, the Engineer will sample the mixture at roadway moisture and test in accordance with Tex-101-E, Part III, to determine compliance with the gradation requirements in Table 3.

**Table 3**  
**Gradation Requirements**

Sieve Size	Percent Passing
1-3/4 in.	100
3/4 in.	85

- 6.3. **Application of Additive.** When required, uniformly apply additive in advance of the mixer. Minimize dust and scattering of additives by wind. Do not apply additives when, in the opinion of the Engineer, wind conditions cause blowing additive to become dangerous to traffic or objectionable to adjacent property owners.

- 6.3.1. **Lime.** Uniformly apply lime using dry or slurry placement as shown on the plans, or as directed by the Engineer. Add lime at the percentage determined in the mix design. Apply lime only to the area to be reclaimed during the same working day.

Start lime application only when the air temperature is at least 35°F and rising or is at least 40 °F. Take the temperature in the shade and away from artificial heat. Suspend application when the Engineer determines that weather conditions are unsuitable.

- 6.3.1.1. **Dry Placement.** When necessary, sprinkle in accordance with Item 204, "Sprinkling." Distribute the required quantity of hydrated lime with approved equipment. Only hydrated lime may be distributed by bag. Do not use a motor grader to spread hydrated lime.

- 6.3.1.2. **Slurry Placement.** Provide slurry free of objectionable materials, at or above the approved minimum dry solids content, and with a uniform consistency that will allow ease of handling and uniform application. Inject slurry directly into mixing chamber via independent metered spray system

Deliver commercial lime slurry to the jobsite or prepare lime slurry at the jobsite or other approved location by using hydrated lime as specified.

Distribute slurry uniformly by making successive passes over a measured section of roadway until the specified lime content is reached.

- 6.3.2. **Cement.** Uniformly apply cement using dry or slurry placement as shown on the plans, or as directed by the Engineer. Add cement at the percentage determined in the mix design. Apply cement only to the area to be reclaimed during the same working day. Apply cement only on an area where mixing, compacting, and finishing can be completed during the same working day.

Start cement application only when the air temperature is at least 35°F and rising or is at least 40°F. The temperature will be taken in the shade and away from artificial heat. Suspend application when the Engineer determines that weather conditions are unsuitable.

- 6.3.2.1. **Dry Placement.** Distribute the required quantity of dry cement with approved equipment. Minimize dust and scattering of cement by wind. Do not apply cement when wind conditions, in the opinion of the Engineer, cause blowing cement to become dangerous to traffic or objectionable to adjacent property owners.
- 6.3.2.2. **Slurry Placement.** Mix the required quantity of cement with water, as approved. Provide slurry free of objectionable materials and with a uniform consistency that can be easily applied. Agitate the slurry continuously. Apply slurry within 2 hr. of adding water and when the roadway is at a moisture content drier than optimum. Distribute slurry uniformly by making successive passes over a measured section of the roadway until the specified cement content is reached.
- 6.3.3. **Fly Ash.** Uniformly apply fly ash using dry placement unless otherwise shown on the plans. Add fly ash at the percentage determined in the mix design. Apply fly ash only on an area where mixing, compacting, and finishing can be completed during the same working day.
- 6.4. **Weather Restrictions.** Suspend foaming application when the surface temperature is below 50°F. Suspend foaming application when the weather forecast predicts freezing temperatures within 7 days after incorporation of the foamed asphalt. Suspend foamed asphalt application when the Engineer determines weather conditions are unsuitable.
- 6.5. **Compaction.** Compact the mixture using density control, unless otherwise shown on the plans.

Begin rolling longitudinally at the sides and proceed toward the center, overlapping on successive trips by at least one-half the width of the roller unit. On super-elevated curves, begin rolling at the low side and progress toward the high side. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph, as directed.

Perform initial compaction using a heavy "sheep's foot" tamping roller applying high amplitude and low frequency. Maintain the heavy tamping roller within 150 ft. of the mixer at all times. Continue rolling until the heavy pad-foot roller "walks out" of the material. Walking out for the heavy tamping roller is defined as light being evident between all of the pads at the material-heavy tamping roller drum interface.

After the completion of heavy tamping rolling, remove remaining tamping marks. Cut slightly below the depth of the tamping marks and ensure material being cut is kept moist at all times. Achieve desired slope and shape to the lines and grades as shown in the plans. Perform final surface shaping on the same day as the foamed asphalt is incorporated. Clip, skin, or tight-blade the surface to remove and waste accumulated fines. Do not use fines to fill surface irregularities. The finished surface shall not vary by more than 3/8 inch when tested with a 10 ft. straight edge applied in the longitudinal or transverse direction. Variations shall be corrected by the contractor at no cost to the Department.

Use a vibratory roller and pneumatic roller to compact the bladed material. Do not finish-roll in vibratory mode. If necessary, use a light spray of water to aid in final compaction density and appearance.

Rework material that fails to meet or loses the required moisture, density, stability, or finish within 24 hr. of completion of compaction. Add additional foamed asphalt and additives at the percentage directed by the Engineer.

Reworking includes loosening, adding material or removing unacceptable material if necessary; mixing as directed; compacting; and finishing. Continue work until specification requirements are met. Perform the work at no additional expense to the Department.

When an area fails to meet or loses required moisture, density, stability, or finish more than 24 hr. after completion of compaction and before the next course is placed or the project is accepted, remove the

unacceptable material and replace with new material that meets the mix design requirements. Compact and finish until specification requirements are met. Perform the work at no additional expense to the Department.

Suspend field operations when significant changes of materials being treated occur. Provide the Engineer with recommendations to modify operations based on the changes of materials. This may include changes in additives, or percentages of foamed asphalt. Alternatively remove and replace all unstable and unsatisfactory material with flexible base in accordance with Item 247 or as directed by the Engineer. Provide the engineer with a foamed asphalt treatment proposal for all areas requiring full depth repair.

6.5.1. **Ordinary Compaction.** Roll with approved compaction equipment, as directed by the Engineer. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.

6.5.2. **Density Control.** The Engineer will determine roadway density of completed sections in accordance with Tex-115-E for each day of production or a minimum of 1 per lift. The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

The full depth of the layer shall be compacted to an average of 97% and the bottom half of the layer shall not be less than 95% of the maximum density determined in accordance with Tex-113-E, unless otherwise shown on the plans.

6.6. **Curing.** Cure the finished section for a minimum of 1 hr. after compaction and apply a fog or a fog/sand seal before opening to traffic. The Engineer may allow traffic on the finished section during curing if proof rolling indicates adequate stability. Proof roll the roadbed in accordance with Item 216, "Proof Rolling," when shown on the plans or directed.

If deformation occurs, do not allow traffic to return to the finished section until the mixed material is firm enough to accommodate traffic without deformation. Apply primes and seals or additional courses within 14 calendar days of final compaction.

When no specific detour is required, provide one-way traffic control until proof rolling permits the return of normal traffic to the compacted material.

---

## 7. QUALITY CONTROL

The Contractor is responsible for quality control (QC) of the treatment process and the completed base. Use the testing frequencies listed in Table 4, unless otherwise directed by the Engineer.

7.1. **Depth of Pulverization.** Measured on roadway on a daily basis.

7.2. **Gradation** Measure in accordance with Tex-101-E, Part III.

7.3. **Foamed Asphalt Content.** Apply the amount of foamed asphalt determined from the mix design. Verify the percentage of asphalt added to the pulverized material using asphalt meter readings, the quantity of material reclaimed (depth, width, and length); and estimated in-place density in accordance with Tex-115-E. Change of the asphalt content, type, or supplier must be approved by the Engineer before the start of production.

7.4. **Foamed Asphalt Treatment Water content.** Apply the water content determined from the mix design to produce the foamed asphalt. Measure the water content added using a water monitoring device from the reclaimer. When necessary, adjust the water content and notify the Engineer within 1 hour after material is reclaimed and treated.

7.5. **Expansion Ratio and Half-Life.** Measure the expansion ratio and half-life of the foamed asphalt before the start of daily production. Meet the requirements listed in Table 2.

- 7.6. **Moisture Content.** Measure the moisture content in accordance with Tex-103-E before adding the foamed asphalt. Verify the moisture content when precipitation occurs after testing and before the foamed asphalt is added.

**Table 4**  
**Testing Frequency**

Test	Frequency
Depth of Pulverization	1 per day of production
Gradation	1 per day of production
Foamed Asphalt Content	1 per day of production
Foamed Asphalt Treatment Water Content	1 per day of production
Expansion Ratio & Half-Life	1 per day of production
Moisture Content	1 per day of production

---

## 8. MEASUREMENT

- 8.1. **Asphalt.** Unless otherwise shown on the plans, asphalt material will be measured by one of the following methods:

- 8.1.1. **Volume.** Asphalt material, including all components, will be measured at the applied temperature by strapping the tank before and after road application. The distributor calibrated strap stick will be used for measuring the asphalt level in the distributor asphalt tank. The certified tank chart will be used to determine the beginning gallons and the final gallons in the distributor tank. The quantity to be measured for payment will be the difference between the beginning gallons and the final gallons.

- 8.1.2. **Weight.** Asphalt material will be measured in tons using certified scales meeting the requirements of Item 520, "Weighing and Measuring Equipment," unless otherwise approved. The transporting truck must have a seal attached to the draining device and other openings. Random checking on public scales at the Contractor's expense may be required to verify weight accuracy.

Upon work completion or temporary suspension, any remaining asphalt material will be weighed by a certified public weigher, or measured by volume in a calibrated distributor or tank and the quantity converted to tons at the measured temperature. The quantity to be measured will be the number of tons received minus the number of tons remaining after all directed work is complete and minus the amount used for other items.

- 8.2. **Additive.**

- 8.2.1. **Lime.** When lime is furnished in trucks, the weight of lime will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."

When lime is furnished in bags, each bag must indicate the manufacturer's certified weight. Bags varying more than 5% from that weight may be rejected. The average weight of bags in any shipment, as determined by weighing 10 bags taken at random, must be at least the manufacturer's certified weight.

- 8.2.1.1. **Hydrated Lime.**

- 8.2.1.1.1. **Dry.** Lime will be measured by the ton (dry weight).

- 8.2.1.1.2. **Slurry.** Lime will be measured by the ton (dry weight) of the hydrated lime used to prepare the lime slurry at the jobsite.

- 8.2.1.1.3. **Commercial Lime Slurry.** Lime slurry will be measured by the ton (dry weight) as calculated from the minimum percent dry solids content of the slurry, multiplied by the weight of the slurry in tons delivered.
- 8.2.2. **Cement.** Cement will be measured by the ton (dry weight). When cement is furnished in trucks, the weight of cement will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."
- When cement is furnished in bags, indicate the manufacturer's certified weight. Bags varying more than 5% from that weight may be rejected. The average weight of bags in a shipment, as determined by weighing 10 bags taken at random, must be at least the manufacturer's certified weight.
- Cement slurry will be measured by the ton (dry weight) of the cement used to prepare the slurry at the jobsite or from the minimum percent dry solids content of the slurry, multiplied by the weight of the slurry in tons delivered.
- 8.3. **Fly Ash.** Fly ash will be measured by the ton (dry weight). When fly ash is furnished in trucks, the weight of fly ash will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."
- When fly ash is furnished in bags, each bag must indicate the manufacturer's certified weight. Bags varying more than 5% from that weight may be rejected. The average weight of bags in any shipment, as determined by weighing 10 bags taken at random, must be at least the manufacturer's certified weight.
- 8.4. **Foamed Asphalt Treatment.** Foamed Asphalt treatment will be measured by the square yard of surface area. The dimensions for determining the surface area is established by the widths shown on the plans and lengths measured at placement.

---

## 9. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid in accordance with Section 8.1., "Asphalt", Section 8.2.1., "Lime", Section 8.2.2., "Cement", Section 8.3., "Fly Ash", and Section 8.4. "Foamed Asphalt Treatment".

Furnishing and delivering new base will be paid for in accordance with Item 247, unless otherwise shown on the plans.

Mixing, spreading, blading, shaping, compacting, and finishing new or existing base material will be paid for under Section 8.3., "Foamed Asphalt Treatment." Removal and disposal of existing asphalt concrete pavement will be paid for in accordance with pertinent Items or Article 4.2., "Changes in the Work."

Additives and foamed asphalt used for reworking a section will not be paid for directly but will be subsidiary to this Item.

Sprinkling and rolling, except proof rolling, will not be paid for directly but will be subsidiary to this Item unless otherwise shown on the plans. When proof rolling is shown on the plans or directed by the Engineer, it will be paid for in accordance with Item 216, "Proof Rolling."

Where subgrade is constructed under this Contract, correction of soft spots in the subgrade or existing base will be at the Contractor's expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade or existing base will be in accordance with pertinent Items or Article 4.2., "Changes in the Work."

- 9.1. **Asphalt.** Asphalt will be paid for at the unit price bid for "Asphalt." This price is full compensation for materials, delivery, equipment, labor, tools, and incidentals.
- 9.2. **Lime.** Lime will be paid for at the unit price bid for "Lime" of one of the following types: Hydrated (Dry), Hydrated (Slurry), or Commercial Lime Slurry. This price is full compensation for furnishing lime.
- 9.3. **Cement.** Cement will be paid for at the unit price bid for "Cement." This price is full compensation for furnishing cement.
- 9.4. **Foamed Asphalt Treatment.** Foamed Asphalt treatment will be paid for at the unit price bid for "Full Depth Recycling and Treatment using Foamed Asphalt (Road Mixed) for the depth specified. No payment will be made for thickness or width exceeding that shown on the plans.

This price is full compensation for shaping existing material, loosening, mixing, pulverizing, spreading, applying additives and Foamed Asphalt, compacting, finishing, curing, curing materials, blading, shaping and maintaining shape, replacing mixture, disposing of loosened materials, processing, hauling, preparing secondary subgrade, water, equipment, labor, tools, and incidentals.