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UPDATED TEST PROCEDURES

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DISCLAIMER

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This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Edith Arambula-Mercado, P.E. # 108462.

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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INTRODUCTION

Based on the findings of the study and feedback from stakeholders, the research team recommended the following updates to the test procedures for FDR mixture design with emulsified asphalt or foamed asphalt:

- Based on practical considerations in laboratory material quantities, specimen preparation, and testing, for **specimen size**, the procedures should only use the 4-inch diameter sample size. If both 4-inch and 6-inch diameter specimen sizes were to be included in the mix design methods, it is recommended to adjust the pass/fail thresholds for the 6 inch diameter specimens to a minimum of 35 psi for dry specimens and a minimum of 22.5 psi for submerged specimens.
- For **compaction**. the number of gyrations should be fixed. While the data suggests 100 to 150 gyrations should be used to compact to target density, given that N = 100 yielded IDT strength values closely aligned with the ones obtained when compacting to target density, and N = 150 was the average number of gyrations required to achieve compaction to target density for the control specimens, in discussion with stakeholders, a decision was made to instead require a moisture density curve on treated material, and then use 75 gyrations for compacting treated IDT mix design specimens.
- **Curing time** should remain minimum 72 hrs. at 104°F given that curing to constant mass required less than the control 72 hrs., which yielded lower IDT strength values. However, an upper limit should be considered to avoid obtaining larger IDT strength values.
- **Curing temperature** should also remain at 104°F given that curing at an elevated temperature of 140°F significantly increased the IDT strength.
- The **IDT test temperature** should be recorded, and the allowable temperature range tightened to 72° ± 2°F. However, in discussion with stakeholders, the tighter temperature tolerance was deemed difficult to implement. An adjustment factor could be considered for cases when the testing temperature exceeds the revised upper limit.

The updated draft mix design procedures for FDR with emulsified asphalt and foamed asphalt are shown in the next sections. The current/approved version of these procedures can be found in TxDOT's Test Procedures 100-E Series website at:
https://www.dot.state.tx.us/apps-cg/test_procedures/tms_series.htm?series=100-E

DRAFT MIX DESIGN PROCEDURE FOR EMULSIFIED ASPHALT

The following pages present the updated draft mix design procedure for emulsified asphalt.

Test Procedure for

EMULSIFIED ASPHALT TREATMENT MIXTURE DESIGN

TxDOT Designation: Tex-122-E

Effective Date: XXXX 2023

1. SCOPE

1.1 Use this test procedure to develop a laboratory mixture design for the full depth reclamation (FDR) of roadways using emulsified asphalt (emulsion). This procedure will determine a moisture-density curve, optimum emulsion content, and when necessary, a target additive content based on the indirect tensile (IDT) strength of unconditioned and moisture conditioned test specimens.

1.2 This procedure requires a Superpave Gyratory Compactor (SGC) for molding IDT test specimens using 75 gyrations. Test specimens are compacted to 4 inches in diameter and 2 inches in height. The automatic tamper (compaction) device is required for compacting samples to 6 inches in diameter and 8 inches in height for a moisture-density curve.

1.3 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use*.

2. APPARATUS

2.1 *Balance,* Class G2 in accordance with Tex-901-K, minimum capacity 35 lb.

2.2 *Container*, adequate height and volume to completely submerge compacted specimen.

2.3 *Mechanical mixer*, capable of mixing virgin and reclaimed materials with emulsion to produce a homogenous blend for laboratory compaction and testing.

2.4 *Temperature Chamber or Heating Oven,* capable of maintaining a temperature of 104 ± 5°F.

2.5 *Thermometer*, digital, handheld, infrared, and non-contact capable of measuring the temperature specified in this test procedure.

3. REPORTING AND DOCUMENTATION

3.1 Contact the Soils and Aggregates Section of the Materials and Tests Division to request a spreadsheet to calculate test results and to report and document pertinent information to this mixture design.

3.2 This spreadsheet includes worksheets for the following.

3.2.1 Gradation and weigh-up worksheets to batch samples.

3.2.2 Moisture-Density curve.

3.2.3 Indirect Tensile strength.

3.2.4 Mixture design summary including the optimum emulsion content.

4. MATERIAL SAMPLING AND PREPARATION

4.1 Obtain a minimum of 2 gallons of emulsion from the material supplier sampled in accordance with Tex-500-C.

4.1.1 Measure the percent residue by distillation in accordance with AASHTO T59.

4.2 Obtain a minimum of 1 gallon of additive (cement or lime) in a sealed one gallon can from a fresh supply of an approved source from TxDOT's Material Producer List.

4.3 Sample a minimum of 400 lbs. of in-place roadway material to the depth as shown on plans. Use equipment to produce a gradation similar to the gradation of the material reclaimed from the full depth reclamation process in the field.

4.3.1 Reclaimed roadway material may include flexible base, seal coat, and reclaimed asphalt pavement (RAP).

4.3.2 When the reclaimed base for sampling and testing is greater than 1-3/4 in., resize the material to pass the 1-3/4 in. sieve.

4.3.3 When RAP is greater than 1-3/4 in., break up and resize the RAP to pass the 1-3/4 in. sieve. If necessary, heat the RAP to a maximum temperature of 140°F to help break up and resizing it.

4.4 When the thickness of the asphalt pavement is greater than 2 in., separate the reclaimed asphalt material from the material sampled.

4.5 When applicable, sample a minimum of 150 lbs. of additional material of flexible base or RAP in accordance with Tex-400-A.

4.6 Prepare the material sampled in accordance with Tex-101-E, Part II '*Preparing Samples for Compaction and Triaxial Tests.*'

PART I — MOISTURE-DENSITY CURVE

5. PROCEDURE

5.1 Determine the optimum moisture content and maximum dry density for the material prepared from Section 4 in accordance with Tex-113-E.

5.1.1 Determine the moisture-density (M-D) curve for the material treated with 4% emulsion or a different percentage as deemed necessary.

5.1.1.1 When shown on the plans or approved by the Engineer, select an additive type and content. Include the additive in the M-D curve when applicable.

5.1.2 Determine a percentage for each material from Section 4 and when applicable including an additive. Calculate the gradation of the blend using these percentages.

5.1.3 Estimate the weight of air-dry material and a moisture content.

5.1.4 Weigh a trial sample. When applicable, add lime additive.

5.1.5 Weigh the amount of water in a sprinkling jar on a tared scale.

5.1.6 Place the total sample in the mixing pan, mix thoroughly, and wet with the appropriate amount of mixing water by sprinkling water in increments onto the sample during mixing.

5.1.6.1 Mix thoroughly, breaking up soil lumps. Do not break any aggregate particles in the sample.

5.1.7 After it is thoroughly mixed, scrape all material off the mixing trowel into the pan. Weigh the sample and pan and record the weight.

5.1.8 Cover the mixture with a non-absorptive lid to prevent moisture evaporation and allow to stand for 18–24 hours.

5.1.9 Prior to mixing with emulsion, weigh the sample (without the lid), replace evaporated water, and thoroughly mix to ensure even distribution of water throughout the sample. Scrape material off mixing tools and into pan.

5.1.10 Place sample in mechanical mixer from Section 2.3.

5.1.11 When applicable, add the cement additive and mix thoroughly to ensure even distribution of the additive throughout the sample.

5.1.12 While mixing, add emulsion to each sample and mix thoroughly to ensure even distribution of the emulsion throughout the sample.

5.1.13 Scrape as much material as possible off the mixing paddle(s) of the mechanical mixer and place the mixture into a pan.

5.1.13.1 Do not allow the mixture to stand for any period of time after mixing. Start the compaction process immediately after mixing.

5.1.14 Mold the trial sample in accordance with the applicable sections of Tex-113-E.

5.1.15 Measure and record the trial sample weight and height.

5.1.16 Correct the weight from the trial sample to a height of 8.000 in. using equation 7.2. Use this weight to estimate weights of four samples.

5.1.17 Compact at moisture contents such that two are on the dry-side of the curve and two are on the wet-side of the curve.

5.1.18 Weigh the four samples.

5.1.19 Repeat Sections 5.1.5 to 5.1.13.1 to mix each sample.

5.1.20 Follow the applicable sections of Tex-113-E to compact the four samples and to determine the moisture-density curve.

PART II — MIXTURE DESIGN

6. PROCEDURE

6.1 Select a minimum of three emulsion contents for the mixing and compaction of Indirect Tensile (IDT) strength test specimens.

6.2 Use equation from Section 7.1 to calculate the moisture content for samples with different emulsion contents.

6.3 Produce a minimum of 18 lbs. sample for each emulsion content. Determine the weight of each material, water, emulsion, and when applicable an additive.

6.3.1 Replace aggregate retained on the 7/8 in. sieve with an equivalent amount of material retained on the 5/8 in. sieve.

6.3.2 When applicable, add lime additive.

6.3.3 Weigh the amount of water for the moisture content determined from Section 6.2.

6.3.4 Place the total sample in the mixing pan, mix thoroughly, and wet with the appropriate amount of mixing water by sprinkling water in increments onto the sample during mixing.

6.3.4.1 Mix thoroughly, breaking up soil lumps. Do not break any aggregate particles in the sample.

6.3.5 Turn the wet material over with the mixing trowel to allow the aggregate particles to absorb water.

6.3.6 After it is thoroughly mixed, scrape all material off the mixing trowel into the pan. Weigh the sample and pan and record the weight.

6.3.7 Cover the mixture with a non-absorptive lid to prevent moisture evaporation and allow to stand for 18–24 hours.

6.3.8 Prior to mixing with emulsion, weigh the sample (without the lid), replace evaporated water, and thoroughly mix to ensure even distribution of water throughout the sample. Scrape material off mixing tools and into pan.

6.3.9 Place sample in mechanical mixer from Section 2.3.

6.3.10 When applicable, add the cement additive and mix thoroughly to ensure even distribution of the additive throughout the sample.

6.3.11 While mixing, add emulsion to each sample and mix thoroughly to ensure even distribution of the emulsion throughout the sample.

6.3.12 Scrape as much material as possible off the mixing paddle(s) of the mechanical mixer and place the mixture into a pan.

6.3.13 Do not allow the mixture to stand for any period after mixing. Start the compaction process immediately after mixing.

6.3.14 Estimate a weight for the trial height sample and weigh up this amount of material.

6.3.15 Configure the SGC to compact to 75 gyrations and compact the trial height sample using an unheated mold in accordance with Tex-241-F.

6.3.16 Measure and record the weight to the nearest 0.001 lbs. and height to the nearest 0.01 in. of the compacted trial sample.

6.3.16.1 When the height does not meet the requirements of 2 ± 0.10 in., use equation 7.2 to calculate a corrected weight of material for a height of 2 in.

6.3.17 Weigh the other samples from the mixed material and compact a minimum of six specimens in accordance with Section 6.3.15.

6.3.18 Measure and record the weight to the nearest 0.001 lbs. and height to the nearest 0.01 in. for each compacted specimen.

6.3.19 When the height of any specimen does not meet 2 ± 0.10 in., confirm if the weight was approximately the weight from Section 6.3.17 or corrected from the trial sample. Mix additional material and compact as many samples as needed to replace those that did not meet the height requirement.

6.3.20 Label each specimen appropriately and proceed to Section 6.4 to cure the compacted IDT specimens.

6.4 ***Curing***

6.4.1 Cure the test specimens in an oven at 104 ± 5 °F for a minimum of 72 hours.

6.4.2 Remove the test specimens from the oven and allow to cool to 72 ± 5 °F.

6.4.3 Store a minimum of three IDT specimens that will not be moisture conditioned in an area or room at a temperature of 72 ± 5 °F for 24 ± 1 hrs.

6.4.4 Proceed to Section 6.5 to moisture condition the other IDT specimens. A minimum of three specimens must be moisture conditioned.

6.5 ***Moisture Conditioning by 24-hr. Submersion***

6.5.1 Place each individual specimen into the container from Section 2.2.

6.5.2 Fill the container to approximately ½ to 1 in. above the top of the specimens with tap water in a manner that does not disturb and contact the specimens.

6.5.3 Soak each specimen in the container at a water temperature of 72 ± 5 °F for 24-hrs ± 15 minutes.

6.5.4 Remove each specimen from the container and use an absorptive cloth or paper towel to remove free water on the surface of the specimen.

6.5.5 Proceed to Section 6.6 for IDT strength testing.

6.6 ***IDT Strength Testing***

6.6.1 Measure and record the surface temperature of the test specimen using a thermometer from Section 2.5. Temperature of each test specimen must be 72 ± 5 °F.

6.6.2 Measure and record the IDT strength of the moisture conditioned and the unconditioned test specimens following Sections 4.5 to 4.11 of Tex-226-F using the appropriate loading strips for 4 in. diameter test specimens.

6.6.3 When the test results do not meet specifications, modify the mixture design as deemed necessary.

6.6.3.1 When adjusting the percent asphalt or additive content proceed to Section 6.2. A new M-D curve is not required.

6.6.3.2 When adjusting the percentages of reclaimed base, RAP, and when applicable, additional material of flexible base or choosing to add additional material of flexible base proceed to Section 5. A new M-D curve is required.

6.7 Proceed to Section 8 when the test results meet specifications.

7. CALCULATIONS

7.1 Use the following equation to calculate the moisture content of the sample when using additive or emulsion contents that are different from the Moisture-Density (M-D) curve from Section 5.

$$MC = OMC + [0.25 \times (ADTV_1 - ADTV_0)] - \left[1 - \left(\frac{RES}{100}\right)\right] \times (EM_1 - EM_0)$$

Where:

MC = Moisture Content of the sample.

OMC = Optimum Moisture Content, % from M-D curve.

$ADTV_1$ = New additive content, %.

$ADTV_0$ = Additive content, % from the M-D curve.

RES = Residue by distillation of the emulsion, %.

EM_1 = New emulsion content, %.

EM_0 = Emulsion content, % from the M-D curve.

0.25 = Adjustment factor from Tex-120-E, Section 8.1.

7.2 Use the following equation to calculate the corrected weight of material for a compacted specimen when the height is less or more than the target height.

$$Corrected\ Weight = Target\ Height \times \left(\frac{Weight}{Height}\right)$$

Where:

Target Height = 2.0 in. for an IDT sample or 8.000 in. for a M-D curve sample;

Weight = Weight of compacted sample, lbs.; and

Height = Height of compacted sample, in.

8. TEST REPORT

8.1 Report the type of emulsion.

8.2 Report the type of additive, if applicable.

8.3 Report the following information to the nearest 0.1:

- Additive content, when applicable;
- Design emulsion content;
- Gradation of aggregate blend;
- Maximum dry density; and
- Optimum moisture content.

8.4 Report the following information to the nearest whole number:

- Average IDT strength for unconditioned test specimens;
- Average IDT strength for moisture conditioned test specimens;
- Percent of additional material when applicable;
- Percent of existing material; and
- Residue by distillation of the emulsion.

DRAFT MIX DESIGN PROCEDURE FOR FOAMED ASPHALT

The following pages present the updated draft mix design procedure for foamed asphalt.

Test Procedure for

FOAMED ASPHALT MIXTURE DESIGN

TxDOT Designation: Tex-134-E

Effective Date: XXXX 2023

1. SCOPE

1.1 Use this test procedure to develop a laboratory mixture design for full depth reclamation (FDR) of roadways using foamed asphalt binder. This procedure will determine a moisture-density curve, optimum foamed asphalt content, and when necessary, a target additive content based on the indirect tensile (IDT) strength of unconditioned and moisture conditioned test specimens.

1.2 This procedure requires a Superpave Gyratory Compactor (SGC) for molding IDT test specimens using 75 gyrations. Test specimens are compacted to 4 inches in diameter and 2 inches in height. The automatic tamper (compaction) device is required for compacting samples to 6 inches in diameter and 8 inches in height for a moisture-density curve.

1.3 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

2. APPARATUS

2.1 *Balance,* Class G2 in accordance with Tex-901-K, minimum capacity 35 lb.

2.2 *Container*, adequate height and volume to completely submerge compacted specimens.

2.3 *Digital or mercury thermometer*, marked in 1 °F (0.5 °C) divisions capable of measuring the temperatures specified in the test procedure.

2.4 *Dipstick and 275 mm diameter steel bucket*.

2.5 *Laboratory Foaming System (Foaming System),* capable of the following:

2.5.1 Heated asphalt reservoir tank with a minimum capacity of 2.5 gallons, asphalt temperature adjustable from 212 to 392 °F (100 to 200 °C), and built-in circulation pump.

2.5.2 Foam water percentage adjustable from 1 to 5%.

2.5.3 Air with the source equipped with a pressure gauge and drying desiccator.

2.5.4 Water pressure adjustable from 0 to 115 psi.

2.5.5 Displays for reading working parameters.

2.6 *Mechanical mixer*, capable of mixing virgin and reclaimed materials with foamed asphalt to produce a homogenous blend for laboratory compaction and testing.

2.7 *Temperature Chamber or Heating Oven,* capable of maintaining a temperature of 104 ± 5 °F.

2.8 *Thermometer*, digital, handheld, infrared, and non-contact capable of measuring the temperature specified in this test procedure.

2.9 *Timer or stopwatch*, capable of measuring to the nearest 0.1 second.

3. REPORTING AND DOCUMENTATION

3.1 Contact the Soils and Aggregates Section of the Materials and Tests Division to request a spreadsheet to calculate test results and to report and document pertinent information to this mixture design.

3.2 This spreadsheet includes worksheets for the following.

3.2.1 Verification of the foaming system.

3.2.2 Determining half-life and expansion ratio of the foamed asphalt.

3.2.3 Gradation and weigh-up worksheets to batch samples.

3.2.4 Moisture-Density curve.

3.2.5 Indirect Tensile strength.

3.2.6 Mixture design summary including the optimum foamed asphalt content.

4. MATERIAL SAMPLING AND PREPARATION

4.1 Obtain a minimum of 10 gallons of asphalt binder from the material supplier sampled in accordance with Tex-500-C. Sample the asphalt using 10 one-gallon cans.

4.2 Obtain a minimum of one gallon of additive (cement or lime) in a sealed one gallon can from a fresh supply of an approved source from TxDOT's Material Producer List.

4.3 Sample a minimum of 400 lbs. of in-place roadway material to the depth as shown on plans using equipment that produces a gradation similar to the gradation of the material reclaimed from the FDR process in the field.

4.3.1 Reclaimed roadway material may include flexible base, seal coat, and reclaimed asphalt pavement (RAP).

4.3.2 When the reclaimed base for sampling and testing is greater than 1-3/4 in., resize the material to pass the 1-3/4 in. sieve.

4.3.3 When RAP is greater than 1-3/4 in., break up and resize the RAP to pass the 1-3/4 in. sieve. If necessary, heat the RAP to a maximum temperature of 140 °F to help break up and resizing it.

4.4 When the thickness of the asphalt pavement is greater than 2 in., separate the reclaimed asphalt material from the material sampled.

4.5 When applicable, sample a minimum of 150 lbs. of additional material of flexible base or RAP in accordance with Tex-400-A.

4.6 Prepare the material sampled in accordance with Tex-101-E, Part II '*Preparing Samples for Compaction and Triaxial Tests*'.

5. LABORATORY FOAMING SYSTEM VERIFICATION

5.1 Prepare and use the laboratory foaming system (foaming system) from Section 2.5 in accordance with the manufacturer's recommendations.

5.1.1 When the test procedure is different from the manufacturer's recommendations, perform the procedure in accordance with the manufacturer's recommendations.

5.1.2 Verify the foaming water discharge and asphalt temperature in accordance with the manufacturer's recommended frequency.

5.1.3 Verify the asphalt discharge every day prior to testing and any time the asphalt temperature is changed in the foaming system.

5.2 ***Foaming Water Discharge Verification***

5.2.1 Start the verification with the foaming system at room temperature and the heating elements off.

5.2.2 Fill the water reservoir of the foaming system completely.

5.2.3 Set the air and water pressure regulators to 4.5 bar.

5.2.4 Place a clean one gallon can on a balance and tare the balance.

5.2.5 Verify the water discharge at 1, 2, 3 and 4% which is equivalent to 3.7, 7.3, 10.9, and 14.5 L/h.

5.2.6 Set the water flow rate to 1% or 3.7 L/hr.

5.2.7 Manually discharge *water with air* into a tared gallon can for 60 seconds.

5.2.8 Use a timer or stopwatch from Section 2.9 and record the total time of the observed flow rate from the flow meter while discharging the water with air.

5.2.9 If the air supply is insufficient to maintain a flow rate within ± 0.2 L/hr. over 60 seconds, reduce discharge time to 30 seconds.

5.2.10 Weigh the gallon can and record the mass of water discharged. Calculate the observed foam water (%), the actual flow rate (L/hr), and the actual foam water (%).

5.2.11 Perform an additional reading by repeating Sections 5.2.7 through 5.2.10. A total of two readings are required at each water flow rate.

5.2.12 Increase the water flow rate by 1% and repeat Sections 5.2.7 through 5.2.11. Proceed to Section 5.2.13 after verifying the water flow rate at 4%.

5.2.13 When the calculated actual foam water percentage is not within 0.15 percentage points of the observed foam water percentage, repeat this procedure to verify. If the verification is not within 0.15 percentage points, contact the manufacturer for service.

5.2.14 When the foaming system is expected to not be in use for more than a month, completely drain water from the system after use.

5.3 ***Asphalt Binder Preparation***

5.3.1 Place asphalt into an oven at a maximum temperature of 320 ± 5 °F until the asphalt may be poured into the foaming system. The amount of asphalt will vary depending on the tests. Table 1 lists the approximate amounts of asphalt needed per test.

Table 1 – Minimum Asphalt Quantity per Test

Test	Approximate Minimum Asphalt Required
Asphalt Temperature Verification	2 gallons
Asphalt Discharge Calibration	2 gallons
Optimum Foaming Water Percentage	4 gallons
Mixture Design Specimen	2 gallons

5.3.2 Pour the asphalt into the foaming system.

5.3.3 Configure the foaming system to the desired temperature.

5.3.4 When the temperature readings of foaming system read greater than 285 °F (140 °C), the asphalt pump may be turned on to circulate asphalt in the foaming system.

5.3.5 Prior to testing, maintain the desired asphalt temperature with the asphalt pump circulating for a minimum of 5 minutes.

5.4 ***Asphalt Temperature Verification***

5.4.1 Prepare the foaming system and asphalt binder according to Sections 5.1 and 5.3.

5.4.2 Once temperature equilibrium has been achieved, verify the asphalt temperature using a thermometer from Section 2.3 by placing the end of the thermometer into the liquid asphalt without contacting the sides of the asphalt pot. Record the controller temperature of the asphalt pot and the measured temperature.

5.4.3 If the temperature from the reference thermometer is not within ± 3.6 °F (± 2 °C) of the set value, contact the manufacturer for service.

5.5 ***Asphalt Discharge Verification***

5.5.1 Prepare the foaming system and asphalt binder according to Sections 5.1 and 5.3.

5.5.2 Place a clean one-gallon container on a balance and tare the balance.

5.5.3 Set an asphalt discharge amount. Typical discharge rates are 200g when preparing for mixing materials with foamed asphalt, or 500g when preparing for expansion ratio and half-life tests.

5.5.4 Discharge the asphalt without any foaming water from the foaming system into the clean container.

5.5.5 Weigh the container and record the mass of asphalt discharged.

5.5.6 When the discharged amount of asphalt is not within ± 5g of the set value, adjust the metering knob and repeat Sections 5.5.2 to 5.5.5.

5.5.7 If the asphalt discharge amount cannot be adjusted within ± 5 g of the set value, the foaming system cannot be used. Contact the manufacturer.

5.5.8 When testing is complete, turn off the asphalt circulation pump and drain the asphalt reservoir.

5.5.9 Drain the asphalt pump and circulation lines by reversing flow of the asphalt pump. Asphalt drained from the foaming system that has not been foamed may be reused two additional times.

6. OPTIMUM FOAMING WATER PERCENTAGE AND TEMPERATURE

6.1 Prepare and use the laboratory foaming system (foaming system) from Section 2.5 in accordance with the manufacturer's recommendations.

6.1.1 When the test procedure is different from the manufacturer's recommendations, perform the procedure in accordance with the manufacturer's recommendations.

6.2 Place approximately 4 gallons of asphalt from Section 4.1 into an oven at a maximum temperature of 320 ± 5 °F (160 ± 2.8 °C) until the asphalt may be poured into the foaming system.

6.3 Pour the asphalt into the foaming system.

6.4 Configure the foaming system to 320 °F (160 °C) and maintain this temperature for a minimum of 5 minutes.

6.5 ***Asphalt Discharge Verification***

6.5.1 Perform asphalt discharge verification in accordance with Section 5.

6.6 ***Optimum Foaming Water Percentage***

6.6.1 Preheat the steel bucket from Section 2.4 in an oven to a minimum temperature of 140 °F (60 °C).

6.6.2 Ensure the pump of the foaming system is circulating prior to testing.

6.6.3 Configure the water-flow meter to achieve 1% foaming water.

6.6.4 Discharge 500g of foamed asphalt into the preheated bucket.

6.6.5 Measure the expansion ratio and half-life of the foamed asphalt binder in accordance with the manufacturer's recommendations.

6.6.5.1 Measure the expansion ratio as the ratio of the maximum volume of foam relative to its original volume.

6.6.5.2 Measure the half-life as the time for the foamed asphalt to collapse to half of its maximum volume from the time the foam nozzle shuts off.

6.6.6 Record the foaming water percentage, expansion ratio, and half-life.

6.6.7 Discard asphalt from the bucket.

6.6.8 Repeat steps 6.6.4 to 6.6.7 using 2% and 3% foaming water. Use other percentages of foaming water as deemed necessary.

6.6.9 Determine the optimum foaming water percentage at 335 °F (168 ºC) and 350 °F (177 ºC) by repeating Sections 6.6.1 to 6.6.8 for each temperature. Additional temperatures may be tested as deemed necessary.

6.6.10 Determine the optimum foaming water percentage and temperature.

6.6.11 Proceed to Section 7 when the asphalt meets the specification or approved by the Engineer.

PART I — MOISTURE-DENSITY CURVE

7. PROCEDURE

7.1 Determine the optimum moisture content and maximum dry density for the material prepared from Section 4 in accordance with Tex-113-E.

7.1.1 Determine the moisture-density (M-D) curve for the material treated with 2.4% foamed asphalt or a different percentage as deemed necessary.

7.1.1.1 When shown on the plans or approved by the Engineer, select an additive type and content. Include the additive in the M-D curve when applicable.

7.1.2 Determine a percentage for each material from Section 4 and when applicable including an additive. Calculate the gradation of the blend using these percentages.

7.1.3 Estimate the weight of air-dry material and moisture content.

7.1.4 Weigh a trial sample. When applicable, add lime additive.

7.1.5 Weigh the amount of water in a sprinkling jar on a tared scale.

7.1.6 Place the total sample in the mixing pan, mix thoroughly, and wet with the appropriate amount of mixing water by sprinkling water in increments onto the sample during mixing.

7.1.6.1 Mix thoroughly, breaking up soil lumps. Do not break any aggregate particles in the sample.

7.1.7 After it is thoroughly mixed, scrape all material off the mixing trowel into the pan. Weigh the sample and pan and record the weight.

7.1.8 Cover the mixture with a non-absorptive lid to prevent moisture evaporation and allow to stand for 18–24 hours.

7.1.9 Prior to mixing with foamed asphalt, weigh the sample (without the lid), replace evaporated water, and thoroughly mix to ensure even distribution of water throughout the sample. Scrape material off mixing tools and into pan.

7.1.10 Place sample in mechanical mixer from Section 2.6.

7.1.11 When applicable, add the cement additive and mix thoroughly to ensure even distribution of the additive throughout the sample.

7.1.12 While mixing, add foamed asphalt to each sample and mix thoroughly to ensure even distribution of the asphalt throughout the sample.

7.1.13 Scrape as much material as possible off the mixing paddle(s) of the mechanical mixer and place the mixture into a pan.

7.1.13.1 Do not allow the mixture to stand for any period of time after mixing. Start the compaction process immediately after mixing.

7.1.14 Mold the trial sample in accordance with the applicable sections of Tex-113-E.

7.1.15 Measure and record the trial sample weight and height.

7.1.16 Correct the weight from the trial sample to a height of 8.000 in. using equation 9.2. Use this weight to estimate weights of four samples.

7.1.17 Compact at moisture contents such that two are on the dry-side of the curve and two are on the wet-side of the curve.

7.1.18 Weigh the four samples.

7.1.19 Repeat Sections 7.1.5 to 7.1.13.1 to mix each sample.

7.1.20 Follow the applicable sections of Tex-113-E to compact the four samples and to determine the moisture-density curve.

PART II — MIXTURE DESIGN

8. PROCEDURE

8.1 Select a minimum of three asphalt contents for the mixing and compaction of Indirect Tensile (IDT) strength test specimens.

8.2 Use equation from Section 9.1 to calculate the moisture content for samples with different foamed asphalt contents.

8.3 Produce a minimum of 18 lbs. for each foamed asphalt content. Determine the weight of each material, water, asphalt binder, and when applicable an additive.

8.3.1 Replace aggregate retained on the 7/8 in. sieve with an equivalent amount of material retained on the 5/8 in. sieve.

8.3.2 When applicable, add lime additive.

8.3.3 Weigh the amount of water for the moisture content calculated from Section 9.1.

8.3.4 Place the total sample in the mixing pan, mix thoroughly, and wet with the appropriate amount of mixing water by sprinkling water in increments onto the sample during mixing.

8.3.4.1 Mix thoroughly, breaking up soil lumps. Do not break any aggregate particles in the sample.

8.3.4.2 Turn the wet material over with the mixing trowel to allow the aggregate particles to absorb water.

8.3.5 After it is thoroughly mixed, scrape all material off the mixing trowel into the pan. Weigh the sample and pan and record the weight.

8.3.6 Cover the mixture with a non-absorptive lid to prevent moisture evaporation and allow to stand for 18–24 hours.

8.3.7 Place approximately 2 gallons of asphalt from Section 4.1 into an oven at 320 ± 5 °F (160 ± 2.8 °C) until the asphalt may be poured into the foaming system.

8.3.8 Pour the asphalt into the foaming system.

8.3.9 Configure the foaming system to the optimum foaming water percentage and temperature determined from Section 6.6 and maintain this temperature for a minimum of 5 minutes.

8.3.10 Prior to mixing with foamed asphalt, weigh the sample (without the lid), replace evaporated water, and thoroughly mix to ensure even distribution of water throughout the sample. Scrape material off mixing tools and into pan.

8.3.11 Place sample in mechanical mixer from Section 2.6.

8.3.12 When applicable, add the cement additive and mix thoroughly to ensure even distribution of the additive throughout the sample.

8.3.13 While mixing, add foamed asphalt to each sample and mix thoroughly to ensure even distribution of the foamed asphalt throughout the sample.

8.3.14 Scrape as much material as possible off the mixing paddle(s) of the mechanical mixer and place the mixture into a pan.

8.3.14.1 Do not allow the mixture to stand for any period after mixing. Start the compaction process immediately after mixing.

8.3.15 Estimate a weight for the trial height sample and weigh up this amount of material.

8.3.16 Configure the SGC to compact to 75 gyrations and compact the trial sample using an unheated mold in accordance with Tex-241-F.

8.3.17 Measure and record the weight to the nearest 0.001 lb. and height to the nearest 0.01 in. of the compacted trial specimen.

8.3.17.1 When the height does not meet the requirements of 2 ± 0.10 in., use equation 9.2 to calculate a corrected weight of material for a height of 2 in.

8.3.18 Weigh the other samples from the mixed material and compact a minimum of six specimens with a SGC in accordance with Section 8.3.16.

8.3.19 Measure and record the weight to the nearest 0.001 lb. and height to the nearest 0.01 in. for each compacted specimen.

8.3.20 When the height of any specimen does not meet 2 ± 0.10 in., confirm if the weight was approximately the weight from Section 8.3.18 or corrected from the trial sample. Mix additional material and compact as many samples as needed to replace those that do not meet the height requirement.

8.3.21 Label each specimen appropriately and proceed to Section 8.4 to cure the compacted IDT specimens.

8.4 ***Curing***

8.4.1 Cure the test specimens in an oven at 104 ± 5 °F for a minimum of 72 hours.

8.4.2 Remove the test specimens from the oven and allow to cool to 72 ± 5 °F.

8.4.3 Store a minimum of three IDT specimens that will not be moisture conditioned in an area or room at a temperature of 72 ± 5 °F for 24 ± 1 hr.

8.4.4 Proceed to Section 8.5 to moisture condition the other IDT specimens. A minimum of three specimens must be moisture conditioned.

8.5 ***Moisture Conditioning by 24-hr. Submersion***

8.5.1 Place each individual specimen into the container from Section 2.2.

8.5.2 Fill the container to approximately ½ to 1 in. above the top of the specimens with tap water in a manner that does not disturb and contact the specimens.

8.5.3 Soak each specimen in the container at a water temperature of 72 ± 5 °F for 24-hrs ± 15 minutes.

8.5.4 Remove each specimen from the container and use an absorptive cloth or paper towel to remove free water on the surface of the specimen.

8.5.5 Proceed to Section 8.6 for IDT strength testing.

8.6 ***IDT Strength Testing***

8.6.1 Measure and record the surface temperature of the test specimen using a thermometer from Section 2.8. Temperature of each test specimen must be 72 ± 5 °F.

8.6.2 Measure and record the IDT strength of the moisture conditioned and the unconditioned test specimens following Sections 4.5 to 4.11 of Tex-226-F using the appropriate loading strips for 4 in. diameter test specimens.

8.6.3 When the test results do not meet specifications, modify the mixture design as deemed necessary.

8.6.3.1 When adjusting the percent asphalt or additive content proceed to Section 8.2. A new M-D curve is not required.

8.6.3.2 When adjusting the percentages of reclaimed base, RAP, and when applicable, additional material of flexible base or choosing to add additional material of flexible base proceed to Section 7. A new M-D curve is required.

8.7 Proceed to Section 10 when the test results meet specifications.

9. CALCULATIONS

9.1 Use the following equation to calculate the moisture content of the sample when using additive or foamed asphalt contents that are different from the Moisture-Density (M-D) curve from Section 7.

$$MC = OMC + (0.25 \times (ADTV_1 - ADTV_0))$$

Where:

MC = moisture content of the sample.

OMC = Optimum Moisture Content, % from M-D curve.

$ADTV_1$ = New additive content (%).

$ADTV_0$ = Additive content (%) used in the M-D curve.

0.25 = Adjustment factor from Tex-120-E, Section 8.1.

9.2 Use the following equation to calculate the corrected weight of material for a compacted specimen when the height is less or more than the target height.

$$Corrected\ Weight = Target\ Height \times \left(\frac{Weight}{Height}\right)$$

Where:

Target Height = 2.0 in. for an IDT sample or 8.000 in. for a M-D curve sample;

Weight = Weight of compacted sample, lbs.; and

Height = Height of compacted sample, in.

10. TEST REPORT

10.1 Report the type of asphalt binder and when applicable, the type of additive.

10.2 Report the laboratory foaming system verification results.

10.3 Report the following information to the nearest 0.1:

- Additive content, when applicable;
- Design foamed asphalt binder content;

- Gradation of aggregate blend;
- Maximum dry density;
- Optimum foaming water percentage; and
- Optimum moisture content.

10.4 Report the following information to the nearest whole number:

- Average IDT strength for unconditioned test specimens;
- Average IDT strength for moisture conditioned test specimens;
- Foamed asphalt properties, half-life and expansion ratio;
- Optimum foaming temperature;
- Percent of additional material when applicable; and
- Percent of existing material.