# MASON COUNTY ROAD COMMISSION

## SPECIAL PROVISION
## FOR
## COLD IN-PLACE RECYCLING (CIR) WITH FOAMED ASPHALT



**a. Description.** This work consists of cold milling and pulverizing the existing asphalt pavement to the dimensions specified on the plans, processing the reclaimed asphalt pavement (RAP) and mixing with foamed asphalt, water and additives, then paver placing/spreading and compacting the emulsified RAP mixture into a stabilized asphalt base. This work includes sampling and testing existing HMA pavement, performing a mixture design for the emulsified RAP mixture, and quality control testing to ensure the completed emulsified RAP base layer is consistent with the mix design and compaction requirements specified herein. Perform all work according to the Michigan Department of Transportation 2012 Standard Specifications for Construction, except as modified herein.

**b. Materials.** Use materials as specified herein.

1. Asphalt Binder. The asphalt binder performance grade shall be determined by the mixture design but shall have a penetration between 80 dmm and 110 dmm. Throughout the job, the Contractor will shall check the foaming characteristics of the asphalt binder to ensure that the asphalt binder is being adequately dispersed. The asphalt binder shall be no less than 320 °F (160 °C) and no greater than 375 °F (190 °C) at the time of foaming.

2. Cement. If required provide per Section 901.

3. Pulverized/Crushed Existing HMA Pavement. Produce a uniform mixture of pulverized material from the existing HMA pavement surface prior to the addition of the foamed asphalt. Process crushed material with the specified equipment to meet the gradation requirements below:

**Table 1: Cold Pulverized Material Gradation**

| Gradation | Sieve Size and Percent Passing | |
|---|---|---|
| | **1 ½ inch (37.5 mm)** | **1 inch (25 mm)** |
| PM 1 | 100 | |
| PM 2(a) | | 100 |
| a. Use PM 2 only when a finer gradation of RAP is required by the mix design | | |

4. Additional Aggregate. Where specified on the plans or required by the approved mix design, furnish reclaimed asphalt pavement (RAP) from off-site source(s) with a target asphalt content of 5% (-0.5% tolerance) or furnish aggregate of the specified gradation. Furnish RAP and aggregates only from approved sources. Use the same aggregate source and gradation for the mix design that will be used on the project.

5. Fog Seal Emulsion. If required, provide SS-1h per Section 904 or approved equal.

6. Water. Provide water according to Section 911. Include sugar with the injurious substances listed in Section 911.01.

7. Other Additives. Use common commercially available asphalt additives as necessary to meet the requirements in Table 2. Detail all additives, including the type, amount, and tolerances (percent) in the submitted mix design.

**c. Mix Design.** Using the performance requirements in Table 2 below, develop a mix design for each distinct pavement section from a design laboratory possessing a current and valid AASHTO R18 accreditation in both aggregates and HMA. Base the mix design on the actual materials that will be recycled, obtained directly from the project site and the actual source(s) for additional aggregate. Prior to sampling existing pavement for the mix design, furnish the proposed sampling plan for the Engineer's approval, including proposed traffic control and patching method. Perform pavement sampling according to the approved plan. Similar recycled material samples may be combined to provide a single mix design for the combined sample. Provide a separate mix design for recycled materials when the variability of samples indicates that the specified criteria would likely be appreciably affected.

Submit mix designs to the Engineer for review not less than 10 business days prior to the start of the CIR operation. The mix designs shall be the baseline measure for the rate of stabilizing agent application and water blended with the RAP to construct the CIR mixture. The mix design shall indicate the allowable tolerance for field adjustments for the stabilizing agent and/or water.

**Table 2: Mix Design Performance Requirements**

| Test Method | CIR | Test Purpose |
|---|---|---|
| Gradation for Design Millings, AASHTO T 27 | Report | |
| Plasticity Index | < 10 | |
| Modified Proctor, ASTM D1557, Method C | Report | Optimum Moisture for Density and Compaction |
| Design Moisture Content | Report | Optimum Moisture |
| Foamed Asphalt Expansion Ratio | 8 minimum (a) | |
| Foamed Asphalt Half-life, s | 6 minimum | |
| Optimum Foamant Water Content | Report | |
| Bulk Specific Gravity (Density), ASTM D 6752 or ASTM D2726 | Report | Laboratory Density Indicator |
| Rice (Maximum Theoretical) Specific Gravity, ASTM D2041 | Report | Laboratory Density Indicator |
| Air Voids | Report | Laboratory Density Indicator |
| Compaction: Superpave Gyratory Compaction, 1.25° angle, 600 kPa | 30 gyrations at 4 inches (100 mm) | Laboratory Density Indicator |
| Indirect Tensil Strenth, AASHTO T 283 (IL Modified)<br>Dry, psi<br>Wet (Conditioned), psi<br>Tensile Strength Ratio (TSR), % | <br>45 minimum<br>30 minimum<br>70 minimum | |

| Test Method | CIR | Test Purpose |
|---|---|---|
| Additional Additive(s) (b)<br>Coarse Aggregate<br>Fine Aggregate<br>RAP<br>Lime<br>Fly Ash<br>Cement, % | <br>Report<br>Report<br>Report<br>Report<br>Report<br>1.0% maximum | |
| Asphalt Binder (c)<br>PG Grade<br>Penetration, dmm | <br>Report<br>Report | |
| a. If the ambient temperature at the time of construction is expected to be 50 to 77 ºF (10 to 25 ºC) the foamed expansion ratio should increase to 10.<br>b. Report shall include type/gradation and producer/supplier. | | |

**d. Equipment.** Furnish equipment in accordance with Section 501 and as specified herein. Perform the necessary processes for cold-in-place recycling (CIR) utilizing a single unit recycler or multi-unit recycling train.

Whether using a multi-unit or single-unit recycler, the recycling machine shall produce the foamed asphalt at the spray bar in individual expansion chambers into which both the hot asphalt binder and water are injected under pressure through individual and separate orifices that promote atomization. The rate of addition of water into the hot asphalt binder shall be kept at a constant rate (percentage by mass of asphalt binder) by a computerized system. One end of the spray bar shall be fitted with an inspection (or test) nozzle that produces a representative sample of foamed asphalt. The unit shall have an electrical heating system capable of maintaining the temperature of all foamed asphalt flow components above 340 °F (171 °C) and a single asphalt binder feed line installed between the recycling machine and the supply tanker. Circulating systems that incorporate a return line to the supply tanker shall not be used.

1. Multi-Unit Recycling Train.

A. Furnish a self-propelled milling machine that is capable of pulverizing the existing bituminous pavement to the depth shown on the plans and to a minimum full lane width (±12 ft) in a single pass, with automatic depth controls to maintain the cutting depth to within ± ¼ inch of that shown on the plans, and a positive means for controlling cross slope elevations. Using 2 mills in tandem to obtain the desired width is acceptable. Do not use a heating device to soften the pavement.

B. Furnish a material sizing unit having screening and crushing capabilities to reduce the cold pulverized material to the maximum size requirements as specified, utilizing a screening and crushing unit with a closed-circuit system capable of continuously returning oversized material to the crusher.

C. Furnish a mixing unit consisting of an on-board, completely self-contained pug mill, equipped with a belt scale for the continuous weighing of the pulverized and sized bituminous material and a coupled/interlocked computer controlled liquid metering device capable of automatically adjusting the flow of foamed asphalt to compensate for any variation in the weight of pulverized material coming into the mixer. Use the metering device to deliver the amount of foamed asphalt to within ± 0.2 percent of the required amount by weight of pulverized bituminous material (for example, if the design requires

3.0 percent, adjust the metering device to maintain 2.8 percent to 3.2 percent foamed asphalt). Equip the mixer with a pump of sufficient capacity to allow asphalt contents up to 3.5% by weight of pulverized bituminous material. Display automatic digital readings for both the flow rate and total amount of pulverized bituminous material and foamed asphalt in appropriate units of weight and time.

2. Single Unit Recycler. Furnish a single unit recycler consisting of a self-propelled cold milling/recycling machine with a down-cutting drum head, having sufficient power and suitable configuration to pulverize and recycle the existing hot-mix asphalt pavement to a depth of 5 inches and incorporate the prescribed amounts of foamed asphalt and water to produce a homogeneous asphalt base material, and capable of pulverizing and recycling a full lane width (±12 ft) in each pass. Equip the machine with separate systems for adding foamed asphalt and water, with each system having a full width spray bar with a positive displacement pump interlocked to the machine's ground speed to insure that the amount of foamed asphalt and water being added is automatically adjusted with changes to the machine's ground speed; each additive system spray bar shall be fitted with 2 nozzles per foot of spray bar, capable of incorporating up to 5 gallons per square yard of foamed asphalt and/or water, with individual valves on the spray bars capable of being turned off as necessary to minimize foamed asphalt and water overlap on subsequent passes.

3. Additive Distributors. Control additives such as water, lime slurry, etc. introduced at the mill head or mixing unit with liquid metering devices capable of automatically adjusting for the variation in the weight of the pulverized material going into the mixing unit. Provide metering devices capable of delivering the amount of additive to within +/-0.2 percent of the required amount by weight of the pulverized bituminous material. Furnish a water distribution system capable of adding up to 5% water by weight of pulverized bituminous material, if necessary based on environmental and material requirements. Metering of water added at the milling machine to control dust in the screens, belts, or crusher/material sizing unit is not required.

4. Dry Material Spreader. When the mix design indicates the need of Type I Portland Cement; Fly Ash; or Lime; furnish a mechanical cement or fly ash spreader that has an adjustable rate of flow and will distribute the cement uniformly at the required rate in one pass. Pneumatic distribution of dry additives is prohibited. The material must be spread in one pass and systems must be in place to keep the additives within the confines of the job.

5. Elevator. Use a pick-up machine capable of removing the entire windrow of processed RAP down to the remaining underlying material.

6. Paver. Use a separate self-propelled paving machine with independent slope control to distribute and place the recycled pavement material.

7. Rollers. Furnish self-propelled pneumatic-tired roller(s) with a gross weight (mass) of not less than 25 tons. Furnish double drum vibratory roller(s) with a gross operating weight of not less than 10 tons and a minimum width of 78 inches.

8. Power Broom. Furnish a power broom to sweep the completed recycled pavement to maintain the surface prior placing the HMA wearing course.

**e. Construction.**

1. Grading. Prior to performing CIR operations, perform grading or other suitable means to remove grass and other vegetation from the edge of the existing (adjacent) roadbed shoulder areas to prevent contamination of the CIR base.

2. Weather Restrictions. Perform the CIR work only when atmospheric temperature in the shade and away from artificial heat is 50°F (10°C) and rising, with dry (no rain or fog) conditions, and forecast temperatures above freezing within 48 hours after completion of recycled pavement in any portion of the project. The Engineer may restrict work when the heat index is greater than 100°F (38°C).

3. Recycling. Pulverize the profiled pavement by cold milling to the depth and width shown on the plans. Do not disturb the underlying material in the existing roadway. Conduct the pulverizing operation so that the amount of fines occurring along the vertical faces of the cut will not prevent bonding of the cold recycled materials. The pulverized bituminous material shall be processed to the required gradation specified.

Pulverize/cold mill the existing pavement to the depth necessary to achieve the compacted thickness shown on the plans, ± ¼ inch. Adjust the pulverizing depth as necessary following depth checks per paragraph f.3.B below to achieve the specified compacted depth.

If a paving fabric is encountered during the CIR operation, make the necessary adjustments in equipment or operations so that at least ninety percent (90%) of the shredded fabric in the recycled material is no more than 5 square inches, with no fabric piece of any dimension exceeding 4 inches. Adjustments may include, but not be limited to, adjusting the milling rate and adding or removing screens in order to obtain a specification recycled material. Dispose of material containing over-sized pieces of paving fabric as directed by the Engineer. Extra work to handle paving fabric will not be paid for separately, provided the paving fabric is shown or noted on the plans.

4. Mixing. Determine the appropriate amounts of foamed asphalt and water at various portions of the project through the sampling and mix design process. Thoroughly mix pulverized material, foamed asphalt and any additives within the pug mill to produce a homogeneous mixture of recycled material. Incorporate the foamed asphalt into the pulverized asphalt pavement material at an initial rate according to the approved mix design(s). Make field adjustments to the additive application rates between project segments (with different mix designs) and also as necessary within any mix design segment to account for in-situ material and ambient weather condition variations.

5. Spreading and Finishing. Spread the homogeneous asphalt mixture using a self-propelled HMA paver. Use a pick-up machine to transfer the windrowed material into the hopper of the paver. Maintain a maximum distance of 150 feet between the recycler and the paver. Using the paver, spread and finish the mixture without segregation to the lines and grades established by the plans (with adjustments as directed by the Engineer) in one continuous pass.

6. Compaction. Develop a density growth curve within the first half mile of production for each mix design, consisting of a plot of unit weight (lb/ft$^3$) vs. number of roller passes with the project breakdown roller. Maintain consistent roller speed during the growth curve testing as during the normal paving operation. Establish this curve with a nuclear density gauge. Take

nuclear density measurements after each roller pass until a maximum density is achieved. Discontinue the breakdown roller passes after the measured density is confirmed to have passed the peak density (i.e. a second consecutive reduction in density following an incremental roller pass. Use the peak density measured as the target maximum density (TMD). If a peak density is not achieved, furnish a larger breakdown roller such that the peak density can be developed.

The Engineer reserves the right to request an additional growth curve if any of the following conditions apply:

A. Field adjustment(s) are made to the mix design;
B. Significant changes in ambient moisture and temperature occur during the day;
C. The recycled mix is experiencing major displacement or cracking; or
D. The measured densities consistently exceed 102% of the target maximum.

Develop a new growth curve if the breakdown roller used on the initial growth curve is replaced with a different production roller. Use the target density only to the specific gauge used to develop the growth curve. If additional gauges are to be used to determine density specification compliance, establish a unique minimum allowable target density for each gauge from the peak density location of the growth curve.

Use a vibratory roller operating in a static or vibratory mode for breakdown rolling. Use vibratory mode only if it is shown to not damage the pavement. Continue intermediate rolling using self-propelled pneumatic roller(s) until no displacement is observed and a minimum required density of 97% of the TMD is achieved. Complete final rolling with one or more double drum steel rollers operating in static mode to eliminate pneumatic tire marks and to produce a uniform, smooth recycled pavement surface.

Start rolling no more than 30 minutes behind the paver. Complete finish rolling no later than one hour after recycling is completed. Whenever possible, start and stop rolling on previously compacted material or existing pavement.

7. Opening to Traffic. After compaction of the recycled pavement, do not allow public or Contractor traffic for at least two (2) hours. Open the recycled pavement to rolling traffic upon approval of the Engineer, following sufficient curing of the finished surface to resist traffic induced raveling or permanent deformation.

8. Maintenance. After opening to traffic, maintain the surface of the recycled pavement surface in a condition suitable for the safe movement of traffic. Power broom the surface as directed to remove all loose particles that may develop on the recycled pavement surface under traffic, and otherwise maintain the recycled pavement surface in a manner satisfactory to the Engineer until the wearing course has been constructed.

9. Curing. Before placing the wearing course, allow the recycled pavement surface to cure until the moisture content is reduced to 3.0 percent or less. Place the wearing course within ten (10) days of the final curing of the recycled pavement, but not later than November 1, unless otherwise approved by the Engineer. If the recycled pavement is to be left unsurfaced for more than seven (7) days, place a fog coat surface seal. Apply the fog seal at a rate of ±0.20 gallons per square yard.

10. Surface Requirements. Furnish a 12-foot straightedge at the project site and test the completed recycled pavement for smoothness in the wheel paths by checking for surface variations in excess of 3/8 inch. Correct areas that exceed the 3/8-inch tolerance with a cold milling machine. Power broom any loose material from the milled surface prior to opening to traffic.

The Contractor shall furnish a 12-foot straightedge and provide for its jobsite transportation at no additional cost to the Department.

**f. Quality Control.** Perform quality control sampling and testing as specified herein.

1. Tests Methods and Frequency.

A. Pulverized Material Sizing and Gradation. Obtain a sample before addition of foamed asphalt and screen using a 1 ½ inch (37.5mm) sieve (or smaller sieve if required) to determine if it meets the maximum particle size requirement. Perform gradation testing on the moist millings each day using the following sieves: 1 ½ inch, 1 inch, ¾ inch, ½ inch, 3/8-inch, No. 4, No. 8, No. 16, and No. 30. Compare the resulting gradation to the mix design gradations to determine any necessary changes to foamed asphalt content.

B. Depth of Compacted Recycled Pavement. Measure the nominal depth at the centerline and midpoint of the outside lane. Check the depth any time depth changes are made or equipment is idle.

Obtain samples according to ASTM D979 or AASHTO T168. When the Engineer determines the location for a gradation sample, cease addition of foamed asphalt and mark the location, continuing to pulverize the hot-mix asphalt pavement until the Engineer is satisfied with the length of material pulverized without the addition of the foamed asphalt (100 feet maximum). After obtaining gradation samples, back up the recycling machine location where the addition of foamed asphalt was discontinued, then re-pulverize this material adding the required amount of foamed asphalt to the pulverized material.

C. Foamed asphalt Content. Notify the Engineer any time foamed asphalt content is changed. The foamed asphalt content shall be checked and recorded for each segment in which the percentage is changed. Foamed asphalt content changes shall be made based upon mix design recommendations, which are based upon different mix designs for road segments of varying construction. The foamed asphalt content shall be checked from the belt scale totalizer or foamed asphalt pump totalizer.

D. Water Content. Notify the Engineer any time the water content is changed. Check and record the water content at the milling head for each segment in which the percentage is changed. Gather this information from the water metering device, which can be checked from the belt scale totalizer to verify daily quantities used. Make water content changes as approved, based on mixture consistency, coating, and dispersion of the recycled materials.

E. Compacted Density. Determine wet density using a nuclear moisture-density gauge generally following the procedures for ASTM D2950, backscatter measurement. Compare this measurement to the target density obtained by the growth curve. Where the measured density is less than the minimum specified (97% of TMD), immediately take appropriate steps to increase the in-place density to meet the specified minimum.

F. Frequency. Perform quality control testing according to the frequency shown in Table 3; however, the Engineer may increase the testing frequency if the construction process is experiencing problems or unforeseen conditions are encountered.

**Table 3 – QC/QA Testing Frequency**

| **Test** | **QC Frequency**(a) | **QA Frequency**(a) |
|---|---|---|
| Depth of Pulverization | 1 per 1000 feet | 1 per 2000 feet |
| Pulverized Material Sizing and Gradation | 1 per ½ day production | 1 per day |
| Emulsified Asphalt Content | 1 per 1000 feet | 1 per 2000 feet |
| Water Content | 1 per 1000 feet | 1 per 2000 feet |
| Compacted Density | 1 per ¼ mile | 1 per mile |
| a. Contractor shall perform a set of all QC tests within the first 500 feet (75 m) after startup or any change in the mix. The Engineer may also run the split samples at these locations. | | |

2. Quality Control (QC) by the Contractor. Perform (or subcontract) the inspection and tests required to assure conformance to contract requirements. Control includes the recognition of obvious defects and their immediate correction. This may require increased testing, expedited communication of test results to the job site (including the Engineer), modification of operations, suspension of the work, or other actions as appropriate. Immediately notify the Engineer any failing tests and subsequent remedial action. Report passing tests to the Engineer no later than the start of the next work day.

3. Quality Assurance (QA) 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. At the discretion of the Engineer, QC tests may be accepted for QA testing.

**g. Measurement and Payment.** The completed work as measured will be paid for at the contract unit price for the following contract items (pay items):

| **Contract Item (Pay Item)** | **Pay Unit** |
|---|---|
| Cold in Place Recycling, __ inch | Square Yard |

The Engineer will measure **Cold In-Place Recycling**, of the thickness specified, longitudinally along the pavement surface and will use the transverse dimension shown on the plans. The unit price for **Cold In-Place Recycling** includes the cost of the following:

1. Sampling the existing pavement and preparing a mix design;
2. Profile milling, pulverizing and processing the existing HMA pavement with water, foamed asphalt and other additives consistent with the mix design requirements;
3. Placing the processed RAP mixture with a paver;

4. Developing required density growth curves and compacting the processed RAP mixture;
5. Performing quality control sampling and testing, and providing the Engineer with reports;
6. Performing any corrective measures necessary to meet the specified profile requirements.

Maintenance and/or repairs to the recycled pavement surface related to the Contractor's construction procedures or quality of work are included in the payment for **Cold In-Place Recycling** and will not be paid for separately.

**MASON COUNTY ROAD COMMISSION**

**SPECIAL PROVISION**
**FOR**
**COLD IN-PLACE RECYCLING (CIR) WITH ENGINEERED EMULSION**



**a. Description.** This work consists of cold milling and pulverizing the existing asphalt pavement to the dimensions specified on the plans, processing the reclaimed asphalt pavement (RAP) and mixing with emulsified asphalt, water and additives, then paver placing/spreading and compacting the emulsified RAP mixture into a stabilized asphalt base. This work includes sampling and testing existing HMA pavement, performing a mixture design for the emulsified RAP mixture, and quality control testing to ensure the completed emulsified RAP base layer is consistent with the mix design and compaction requirements specified herein. Perform all work according to the Michigan Department of Transportation 2012 Standard Specifications for Construction, except as modified herein.

**b. Materials.** Use materials as specified herein.

1. Asphalt Emulsion. Provide an engineered asphalt emulsion of the type and grade as determined by the Contractor’s mixture design in order to meet the requirements in Table 3 and as specified in Table 1, below. Furnish emulsified asphalt having a penetration within ±25% of the emulsified asphalt selected for the mix design, but not outside the range specified in Table 1. Deliver the asphalt emulsion to the job site at a temperature no greater than 120ºF. Provide a representative from the asphalt emulsion supplier at the job site for a minimum of the first full day of emulsion treatment, and available throughout the recycling process to: monitor the characteristics and performance of the asphalt emulsion; to adjust the asphalt emulsion formulation as required; and to resolve any emulsion related problems with the cold in place recycling process.

**Table 1: Engineered Asphalt Emulsion Requirements**

| Test | Method | Minimum | Maximum |
|---|---|---|---|
| Viscosity,<br>Saybolt Furol, at 77°F (25°C), SFS | AASHTO T59<br>(ASTM D244) | 20 | 100 |
| Sieve Test,<br>Retained on #20 (0.85 mm), % | AASHTO T59<br>(ASTM D244) | | 0.1 |
| Storage Stability Test, 24 hr, % | AASHTO T59<br>(ASTM D244) | | 1.0 |
| Distillation Test,<br>Residue from distillation to 177°C, % | AASHTO T59<br>(ASTM D244) (a) | 64 | |
| Oil distillate by volume, % | AASHTO T59<br>(ASTM D244) (a) | | 1.0 |
| Penetration (b), 25°C, 100g, 5 s, dmm | AASHTO T49 | 75 | 200 |
| a. Modified AASHTO T59 procedure – distillation temperature of 177 °C with a 20-minute hold.<br>b. Penetration value To Be Determined by the Mix Design Requirements in Table 3. | | | |

2. Pulverized/Crushed Existing HMA Pavement. Produce a uniform mixture of pulverized material from the existing HMA pavement surface prior to the addition of the asphalt emulsion. Process crushed material with the specified equipment to meet the gradation requirements below:

**Table 2: Cold Pulverized Material Gradation**

| Gradation | Sieve Size and Percent Passing | |
|---|---|---|
| | 1 ½ inch (37.5 mm) | 1 inch (25 mm) |
| PM 1 | 100 | |
| PM 2(a) | | 100 |
| a. Use PM 2 only when a finer gradation of RAP is required by the mix design | | |

3. Additional Aggregate. Where specified on the plans or required by the approved mix design, furnish reclaimed asphalt pavement (RAP) from off-site source(s) with a target asphalt content of 5% (-0.5% tolerance) or furnish aggregate of the specified gradation. Furnish RAP and aggregates only from approved sources. Use the same aggregate source and gradation for the mix design that will be used on the project.

4. Fog Seal Emulsion. If required, provide SS-1h per Section 904 or approved equal.

5. Water. Provide water according to Section 911. Include sugar with the injurious substances listed in Section 911.01.

6. Other Additives. Use common commercially available asphalt additives as necessary to meet the requirements in Table 3. Detail all additives, including the type, amount, and tolerances (percent) in the submitted mix design.

**c. Mix Design.** Using the performance requirements in Table 3 below, submit a mix design for each distinct pavement section from a design laboratory possessing a current and valid AASHTO R18 accreditation in both aggregates and HMA. Base the mix design on the actual materials that will be recycled, obtained directly from the project site and the actual source(s) for additional aggregate. Prior to sampling existing pavement for the mix design, furnish the proposed sampling plan for the Engineer's approval, including proposed traffic control and patching method. Perform pavement sampling according to the approved plan. Similar recycled material samples may be combined to provide a single mix design for the combined sample. Provide a separate mix design for recycled materials when the variability of samples indicates that the specified criteria would likely be appreciably affected.

Develop and submit a Job Mix Formula (JMF) to the Engineer for review not less than 10 business days prior to the start of the CIR operation. The JMF shall be the baseline measure for the rate of stabilizing agent application and water blended with the RAP to construct the CIR mixture. The mix design shall indicate the allowable tolerance for field adjustments for the stabilizing agent and/or water.

**Table 3: Mix Design Performance Requirements**

| Test Method | CIR | Test Purpose |
|---|---|---|
| Gradation for Design Millings, AASHTO T 27 | Report | |
| Design Moisture Content | Report | Dispersion of Emulsion |
| Superpave Gyratory Compaction, 1.25° angle, 600 kPa | 30 gyrations at 4 inches (100 mm) (a) | Laboratory Density Indicator |

| Test Method | CIR | Test Purpose |
|---|---|---|
| Bulk Specific Gravity (Density), ASTM D 6752 or ASTM D2726 | Report | Laboratory Density Indicator |
| Rice (Maximum Theoretical) Specific Gravity, ASTM D2041 | Report | Laboratory Density Indicator |
| Air Voids | Report | Laboratory Density Indicator |
| Raveling Test, ASTM D 7196 | 2% maximum | Raveling Resistance |
| Indirect Tensil Strenth, AASHTO T 283 (IL Modified) | | |
| Dry, psi | 45 minimum | |
| Wet (Conditioned), psi | 30 minimum | |
| Tensile Strength Ratio (TSR), % | 70 minimum | |
| Additional Additive(s) (b) | | |
| Coarse Aggregate | Report | |
| Fine Aggregate | Report | |
| RAP | Report | |
| Fly Ash | Report | |
| Cement | 1.0% maximum | |
| Emulsified Asphalt (a) | | |
| Distillation Residue % | Report | |
| Residue Penetration, dmm | Report | |
| Optimum Emulsion Content, % | Report | |
| Residual Asphalt to Cement Content Ratio | 3:1 minimum | |
| a. Report shall include type/gradation and producer/supplier. | | |

**d. Equipment.** Furnish equipment in accordance with Section 501 and as specified herein. Perform the necessary processes for cold-in-place recycling (CIR) utilizing a single unit recycler or multi-unit recycling train.

1. Multi-Unit Recycling Train.

A. Furnish a self-propelled milling machine that is capable of pulverizing the existing bituminous pavement to the depth shown on the plans and to a minimum full lane width (±12 ft) in a single pass, with automatic depth controls to maintain the cutting depth to within ± ¼ inch of that shown on the plans, and a positive means for controlling cross slope elevations. Using 2 mills in tandem to obtain the desired width is acceptable. Do not use a heating device to soften the pavement.

B. Furnish a material sizing unit having screening and crushing capabilities to reduce the cold pulverized material to the maximum size requirements as specified, utilizing a screening and crushing unit with a closed-circuit system capable of continuously returning oversized material to the crusher.

C. Furnish a mixing unit consisting of an on-board, completely self-contained pug mill, equipped with a belt scale for the continuous weighing of the pulverized and sized bituminous material and a coupled/interlocked computer controlled liquid metering device capable of automatically adjusting the flow of emulsified asphalt to compensate for any variation in the weight of pulverized material coming into the mixer. Use the metering device to deliver the amount of emulsified asphalt to within ± 0.2 percent of the required amount by weight of pulverized bituminous material (for example, if the design requires 3.0 percent, adjust the metering device to maintain 2.8 percent to 3.2 percent emulsion).

Equip the mixer with an emulsified asphalt pump of sufficient capacity to allow emulsion contents up to 3.5% by weight of pulverized bituminous material. Display automatic digital readings for both the flow rate and total amount of pulverized bituminous material and emulsified asphalt in appropriate units of weight and time.

2. Single Unit Recycler. Furnish a single unit recycler consisting of a self-propelled cold milling/recycling machine with a down-cutting drum head, having sufficient power and suitable configuration to pulverize and recycle the existing hot-mix asphalt pavement to a depth of 5 inches and incorporate the prescribed amounts of emulsified asphalt and water to produce a homogeneous asphalt base material, and capable of pulverizing and recycling a full lane width (±12 ft) in each pass. Equip the machine with separate systems for adding emulsified asphalt and water, with each system having a full width spray bar with a positive displacement pump interlocked to the machine's ground speed to insure that the amount of emulsified asphalt and water being added is automatically adjusted with changes to the machine's ground speed; each additive system spray bar shall be fitted with 2 nozzles per foot of spray bar, capable of incorporating up to 7 gallons per square yard of emulsified asphalt and/or water, with individual valves on the spray bars capable of being turned off as necessary to minimize emulsion and water overlap on subsequent passes.

3. Additive Distributors. Control additives such as water, lime slurry, etc. introduced at the mill head or mixing unit with liquid metering devices capable of automatically adjusting for the variation in the weight of the pulverized material going into the mixing unit. Provide metering devices capable of delivering the amount of additive to within +/-0.2 percent of the required amount by weight of the pulverized bituminous material. Furnish a water distribution system capable of adding up to 5% water by weight of pulverized bituminous material, if necessary based on environmental and material requirements. Metering of water added at the milling machine to control dust in the screens, belts, or crusher/material sizing unit is not required.

4. Elevator. Use a pick-up machine capable of removing the entire windrow of processed RAP down to the remaining underlying material.

5. Paver. Use a separate self-propelled paving machine with independent slope control to distribute and place the recycled pavement material.

6. Rollers. Furnish self-propelled pneumatic-tired roller(s) with a gross weight (mass) of not less than 25 tons. Furnish double drum vibratory roller(s) with a gross operating weight of not less than 10 tons and a minimum width of 78 inches.

7. Power Broom. Furnish a power broom to sweep the completed recycled pavement to maintain the surface prior placing the HMA wearing course.

**e. Construction.**

1. Grading. Prior to performing CIR operations, perform grading or other suitable means to remove grass and other vegetation from the edge of the existing (adjacent) roadbed shoulder areas to prevent contamination of the CIR base.

2. Weather Restrictions. Perform the CIR work only when atmospheric temperature in the shade and away from artificial heat is 50°F (10°C) and rising, with dry (no rain or fog) conditions, and forecast temperatures above freezing within 48 hours after completion of recycled pavement in any portion of the project. The Engineer may restrict work when the heat index is greater than 100°F (38°C).

3. Recycling. Pulverize the profiled pavement by cold milling to the depth and width shown on the plans. Do not disturb the underlying material in the existing roadway. Conduct the pulverizing operation so that the amount of fines occurring along the vertical faces of the cut will not prevent bonding of the cold recycled materials.

Pulverize/cold mill the existing pavement to the depth necessary to achieve the compacted thickness shown on the plans, ± ¼ inch. Adjust the pulverizing depth as necessary following depth checks per paragraph f.3.B below to achieve the specified compacted depth.

If a paving fabric is encountered during the CIR operation, make the necessary adjustments in equipment or operations so that at least ninety percent (90%) of the shredded fabric in the recycled material is no more than 5 square inches, with no fabric piece of any dimension exceeding 4 inches. Adjustments may include, but not be limited to, adjusting the milling rate and adding or removing screens in order to obtain a specification recycled material. Dispose of material containing over-sized pieces of paving fabric as directed by the Engineer. Extra work to handle paving fabric will not be paid for separately, provided the paving fabric is shown or noted on the plans.

4. Mixing. Determine the appropriate amounts of emulsified asphalt and water at various portions of the project through the sampling and mix design process. Thoroughly mix pulverized material, emulsified asphalt and any additives within the pug mill to produce a homogeneous mixture of recycled asphalt stabilized base material. Incorporate the emulsified asphalt into the pulverized asphalt pavement material at an initial rate according to the approved mix design(s). Make field adjustments to the additive application rates between project segments (with different mix designs) and also as necessary within any mix design segment to account for in-situ material and ambient weather condition variations.

5. Spreading and Finishing. Spread the homogeneous asphalt mixture using a self-propelled HMA paver. Use a pick-up machine to transfer the windrowed material into the hopper of the paver. Maintain a maximum distance of 150 feet between the recycler and the paver. Using the paver, spread and finish the mixture without segregation to the lines and grades established by the plans (with adjustments as directed by the Engineer) in one continuous pass.

6. Compaction. Develop a density growth curve within the first half mile of production for each mix design, consisting of a plot of unit weight ($lb/ft^3$) vs. number of roller passes with the project breakdown roller. Maintain consistent roller speed during the growth curve testing as during the normal paving operation. Establish this curve with a nuclear density gauge. Take nuclear density measurements after each roller pass until a maximum density is achieved. Discontinue the breakdown roller passes after the measured density is confirmed to have passed the peak density (i.e. a second consecutive reduction in density following an incremental roller pass. Use the peak density measured as the target maximum density (TMD). If a peak density is not achieved, furnish a larger breakdown roller such that the peak density can be developed.

The Engineer reserves the right to request an additional growth curve if any of the following conditions apply:

A. Field adjustment(s) are made to the mix design;
B. Significant changes in ambient moisture and temperature occur during the day;
C. The recycled mix is experiencing major displacement or cracking; or
D. The measured densities consistently exceed 102% of the target maximum.

Develop a new growth curve if the breakdown roller used on the initial growth curve is replaced with a different production roller. Use the target density only to the specific gauge used to develop the growth curve. If additional gauges are to be used to determine density specification compliance, establish a unique minimum allowable target density for each gauge from the peak density location of the growth curve.

Use a vibratory roller operating in a static or vibratory mode for breakdown rolling. Use vibratory mode only if it is shown to not damage the pavement. Continue intermediate rolling using self-propelled pneumatic roller(s) until no displacement is observed and a minimum required density of 97% of the TMD is achieved. Complete final rolling with one or more double drum steel rollers operating in static mode to eliminate pneumatic tire marks and to produce a uniform, smooth recycled pavement surface.

Start rolling no more than 30 minutes behind the paver. Complete finish rolling no later than one hour after recycling is completed. Whenever possible, start and stop rolling on previously compacted material or existing pavement.

7. Opening to Traffic. After compaction of the recycled pavement, do not allow public or Contractor traffic for at least two (2) hours. Open the recycled pavement to rolling traffic upon approval of the Engineer, following sufficient curing of the finished surface to resist traffic induced raveling or permanent deformation.

8. Maintenance. After opening to traffic, maintain the surface of the recycled pavement surface in a condition suitable for the safe movement of traffic. Power broom the surface as directed to remove all loose particles that may develop on the recycled pavement surface under traffic, and otherwise maintain the recycled pavement surface in a manner satisfactory to the Engineer until the wearing course has been constructed.

9. Curing. Before placing the wearing course, allow the recycled pavement surface to cure until the moisture content is reduced to 3.0 percent or less. Place the wearing course within ten days of the final curing of the recycled pavement, but not later than November 1, unless otherwise approved by the Engineer. If the recycled pavement is to be left unsurfaced for more than seven (7) days, place a fog coat surface seal. Apply the fog seal at a rate of ±0.20 gallons per square yard.

10. Surface Requirements. Furnish a 12-foot straightedge at the project site and test the completed recycled pavement for smoothness in the wheel paths by checking for surface variations in excess of 3/8 inch. Correct areas that exceed the 3/8-inch tolerance with a cold milling machine. Power broom any loose material from the milled surface prior to opening to traffic.

The Contractor shall furnish a 12-foot straightedge and provide for its jobsite transportation at no additional cost to the Department.

**f. Quality Control.** Perform quality control sampling and testing as specified herein.

1. Tests Methods and Frequency.

A. Pulverized Material Sizing and Gradation. Obtain a sample before addition of emulsion and screen using a 1 ½ inch (37.5mm) sieve (or smaller sieve if required) to determine if it meets the maximum particle size requirement. Perform gradation testing on the moist millings each day using the following sieves: 1 ½ inch, 1 inch, ¾ inch, ½ inch, 3/8-inch, No. 4, No. 8, No. 16, and No. 30. Compare the resulting gradation to the mix design gradations to determine any necessary changes to emulsion content.

B. Depth of Compacted Recycled Pavement. Measure the nominal depth at the centerline and midpoint of the outside lane. Check the depth any time depth changes are made or equipment is idle.

Obtain samples according to ASTM D979 or AASHTO T168. When the Engineer determines the location for a gradation sample, cease addition of the asphalt emulsion and mark the location, continuing to pulverize the hot-mix asphalt pavement until the Engineer is satisfied with the length of material pulverized without the addition of the engineered emulsion (100 feet maximum). After obtaining gradation samples, back up the recycling machine location where the addition of emulsion was discontinued, then re-pulverize this material adding the required amount of engineered emulsion to the pulverized material.

C. Emulsified Asphalt Content. Furnish a one-gallon sample per day of production to the Engineer. Notify the Engineer any time emulsified asphalt content is changed. Check and record the emulsified asphalt content for each segment in which the percentage is changed. Make changes to the emulsified asphalt content according to the approved mix designs or as otherwise directed by the Engineer. Check the emulsified asphalt content from the belt scale totalizer or asphalt pump totalizer.

D. Water Content. Notify the Engineer any time the water content is changed. Check and record the water content at the milling head for each segment in which the percentage is changed. Gather this information from the water metering device, which can be checked from the belt scale totalizer to verify daily quantities used. Make water content changes as approved, based on mixture consistency, coating, and dispersion of the recycled materials.

E. Compacted Density. Determine wet density using a nuclear moisture-density gauge generally following the procedures for ASTM D2950, backscatter measurement. Compare this measurement to the target density obtained by the growth curve. Where the measured density is less than the minimum specified (97% of TMD), immediately take appropriate steps to increase the in-place density to meet the specified minimum.

F. Frequency. Perform quality control testing according to the frequency shown in Table 3; however, the Engineer may increase the testing frequency if the construction process is experiencing problems or unforeseen conditions are encountered.

**Table 3 – QC/QA Testing Frequency**

| **Test** | **QC Frequency**(a) | **QA Frequency**(a) |
|---|---|---|
| Depth of Pulverization | 1 per 1000 feet | 1 per 2000 feet |
| Pulverized Material Sizing and Gradation | 1 per ½ day production | 1 per day |
| Emulsified Asphalt Content | 1 per 1000 feet | 1 per 2000 feet |
| Water Content | 1 per 1000 feet | 1 per 2000 feet |
| Compacted Density | 1 per ¼ mile | 1 per mile |
| a. Contractor shall perform a set of all QC tests within the first 500 feet (75 m) after startup or any change in the mix. The Engineer may also run the split samples at these locations. | | |

2. Quality Control by the Contractor. Perform (or subcontract) the inspection and tests required to assure conformance to contract requirements. Control includes the recognition of obvious defects and their immediate correction. This may require increased testing, expedited communication of test results to the job site (including the Engineer), modification of operations, suspension of the work, or other actions as appropriate. Immediately notify the Engineer any failing tests and subsequent remedial action. Report passing tests to the Engineer no later than the start of the next work day.

3. 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. At the discretion of the Engineer, QC tests may be accepted for QA testing.

**g. Measurement and Payment.** The completed work as measured will be paid for at the contract unit price for the following contract items (pay items):

| **Contract Item (Pay Item)** | **Pay Unit** |
|---|---|
| Cold in Place Recycling, __ inch…………………………………………………… | Square Yard |

The Engineer will measure **Cold In-Place Recycling**, of the thickness specified, longitudinally along the pavement surface and will use the transverse dimension shown on the plans. The unit price for **Cold In-Place Recycling** includes the cost of the following:

1. Sampling the existing pavement and preparing a mix design;
2. Profile milling, pulverizing and processing the existing HMA pavement with water, engineered asphalt emulsion and other additives consistent with the mix design requirements;
3. Placing the processed RAP mixture with a paver;
4. Developing required density growth curves and compacting the processed RAP mixture;

5. Performing quality control sampling and testing, and providing the Engineer with reports;
6. Performing any corrective measures necessary to meet the specified profile requirements.

Maintenance and/or repairs to the recycled pavement surface related to the Contractor’s construction procedures or quality of work are included in the payment for **Cold In-Place Recycling** and will not be paid for separately.

**MASON COUNTY ROAD COMMISSION**

**SPECIAL PROVISION**
**FOR**
**COLD IN-PLACE RECYCLING (CIR) AND FULL-DEPTH RECLAMATION (FDR)**
**WITH FOAMED ASPHALT MIX DESIGN PROCEDURES**



**Laboratory Temperature and Humidity Control**
Each laboratory performing mix designs shall have heating, ventilation, and air conditioning (HVAC) equipment that maintains a room temperature of 68 to 86 ºF (20 to 30 ºC) and relative humidity of less than 60 percent.

**Sampling and Processing**
A minimum sample size of 350 lb (160 kg) is needed for each mix design. Bulk samples of the recycled layer thickness shall be obtained from either test pits or cores. Each layer shall be examined to confirm thickness and material.

The bituminous layers shall be crushed. A washed gradation of the crushed bituminous layer(s) shall be performed according to AASHTO T 27 and reported and meet the following requirement(s).

| Sieve Size | | Percent Passing | |
|---|---|---|---|
| | | Crushed Gradations | |
| | | Ideal | Less Suitable |
| 2 in. | 50 mm | 100 | |
| 1 ½ in | 37.5 mm | 87-100 | |
| 1 in. | 25 mm | 77-100 | 100 |
| ¾ in. | 19 mm | 66-99 | 99-100 |
| ½ in. | 12.5 mm | 67-87 | 87-100 |
| 3/8 in. | 9.5 mm | 49-74 | 74-100 |
| No. 4 | 4.75 mm | 35-56 | 56-95 |
| No. 8 | 2.36 mm | 25-42 | 42-78 |
| No. 6 | 1.18 mm | 18-33 | 33-65 |
| No. 50 | 300 µm | 10-24 | 24-43 |
| No. 200 | 75 µm | 4-10 | 10-20 |

Washed gradation (AASHTO T 27) and sand equivalent (ASTM D 2419, Method B) shall be performed and reported for any granular layer. The washed gradation (AASHTO T 27) of combined layers shall be performed and reported. If combined layers include an aggregate layer, the sand equivalent (ASTM D 2419, Method B) shall be performed and reported.

All washed gradations shall be dried at no greater than 104 °F (40 °C).

| Sieve Size | | Percent Passing | | |
|---|---|---|---|---|
| | | Crushed Gradations | | |
| | | Fine | Medium | Coarse |
| 1 ½ in | 37.5 mm | 100 | 100 | 100 |
| 1 in. | 25 mm | 100 | 100 | 85-100 |
| ¾ in. | 19 mm | 95-100 | 85-96 | 75-92 |
| No. 4 | 4.75 mm | 55-75 | 40-55 | 30-45 |
| No. 30 | 600 µm | 15-35 | 4-14 | 1-7 |
| No. 200 | 75 µm | 1-7 | 0.6-3 | 0.1-3 |

**Active filler requirements**
Foamed asphalt stabilization is normally carried out in combination with a small amount of active filler (cement, fly ash, or lime) to enhance the dispersion of the foamed asphalt. The following application rates (by mass) of cement, fly ash, or lime should be used as a guide:

| Plasticity Index: < 10 | Plasticity Index: > 10 |
|---|---|
| Add 1 percent ordinary portland cement or 1 percent lime (material dependent) | Pre-treat with minimum 2 percent lime. The initial consumption of lime (ICL) has to be satisfied. |

Pre-treatment requires that the lime and water be added at least four hours prior to the addition of the foamed asphalt. The treated material must be placed in an air-tight container to retain moisture. However, due to the hydration process, the moisture content should always be checked and, if necessary, adjusted prior to adding the foamed asphalt.

Note: Additional tests without active filler should always be carried out as part of the mix design process. The results of these tests allow a decision to be made as to whether the addition of an active filler is warranted.

**Mixing and Compaction**
The Optimum Fluid Content (OFC) and the Maximum Dry Density (MDD) of the stabilized material is determined using modified compaction effort (Modified Proctor, ASTM D 1557, Method C).

**Determination of Expansion Ratio and Half-Life**
The foaming properties of asphalt are characterized by:

- Expansion Ratio. A measure of the viscosity of the foamed bitumen, calculated as the ratio of the maximum volume of the foam relative to the original volume of bitumen.

- Half-Life. A measure of the stability of the foamed bitumen, calculated as the time taken in seconds for the foam to collapse to one-half of its maximum volume.

The objective is to determine the temperature and percentage of water addition that is required to produce the best foam properties (maximum expansion ratio and half-life) for a particular source of bitumen. This is achieved at three different bitumen temperatures not exceeding 380 °F (195 °C) with the following procedure.

1. Heat the bitumen in the kettle foaming laboratory unit with the pump circulating the bitumen through the system until the required temperature is achieved normally starting with 320°F (160 °C). Maintain the required temperature for at least five minutes prior to commencing with testing.

2. Calibrate the discharge rate of the bitumen and set the timer on the foaming laboratory unit to discharge 500 g of bitumen ($Q_{bitumen}$).

3. Set the water flow-meter to achieve the required water injection rate normally starting with 2 percent by mass of the bitumen.

4. Discharge foamed bitumen into steel drum preheated to ± 135 °F (± 75 °C) of the bitumen for a calculated spray time for 500 g of bitumen. Immediately after the foam discharge stops, start a stopwatch.

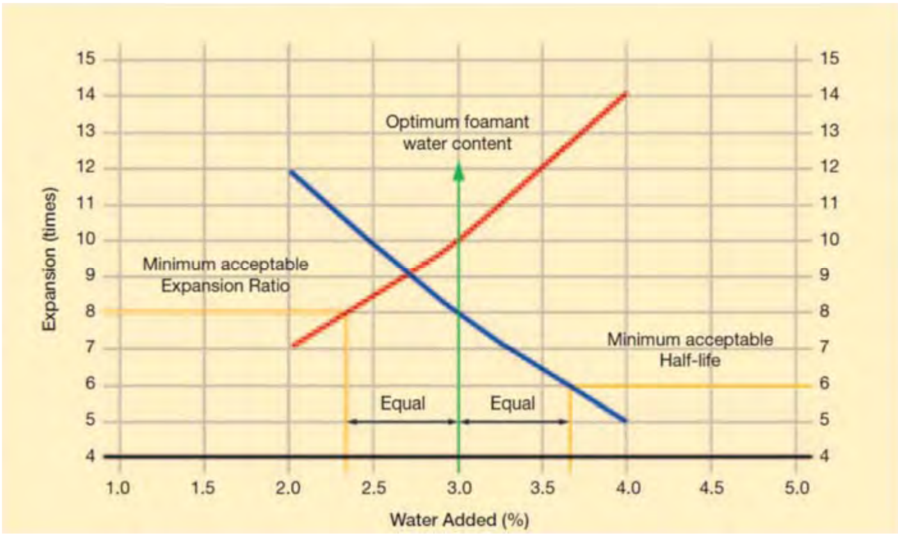
5. Using the calibrated dipstick supplied with the foaming laboratory unit measure the maximum height the foamed bitumen achieves in the drum. This is recorded as the maximum volume.

6. Use the stopwatch to measure the time in seconds that the foam takes to dissipate to one-half of its maximum volume. This is recorded as the foamed bitumen's half-life.

7. Repeat the above procedures three times or until similar readings are achieved.

8. Repeat Steps 3 through 7 for a range of at least three water injection rates. Typically, values of 2 percent, 3 percent and 4 percent by mass of bitumen are used.

9. Plot a graph of the expansion ratio versus half-life at the different water injection rates on the same set of axes (see an example in the graph below). The optimum water addition is chosen as an average of the two water contents required to meet these minimum criteria.




Repeat Steps 1 through 9 for two other bitumen temperatures normally 340 °F (170 °C) and 360 °F (180 °C). The temperature and optimum water addition that produces the best foam is then used in the mix design procedure described below.

**Sample preparation for foamed bitumen treatment**

Prepare the material for foamed bitumen treatment as follows:

1. Place 20 to 25 kg of prepared sample into the pug mill mixer.

2. Determine the dry mass of the sample using the following equation:

$$m_{sample} = \frac{m_{air-dry}}{\left(1+\left(\frac{w_{air-dry}}{100}\right)\right)}$$

Where: $m_{sample}$ = dry mass of the sample in grams
$m_{air-dry}$ = air-dried mass of the sample in grams
$w_{air-dry}$ = moisture content of air-dried sample in percent by mass

3. Determine the required percentage of active filler (lime, cement, or fly ash) using the following equation:

$$m_{cement} = \left(\frac{w_{c-add}}{100}\right) m_{sample}$$

Where: $m_{cement}$ = mass of lime, cement, or fly ash to be added in grams
$w_{c-add}$ = percentage of lime, cement, or fly ash required in percent by mass
$m_{sample}$ = dry mass of the sample in grams

4. Determine the percentage of water to be added for optimum mixing moisture and the amount of water to be added to the sample using the following equations:

$$W_{add} = 0.75W_{OMC} - W_{air-dry}$$

$$m_{water} = \left(\frac{w_{add}}{100}\right)\left(m_{sample} - m_{cement}\right)$$

Where: $W_{add}$ = mass of lime, cement, or fly ash to be added in grams
$W_{OMC}$ = percentage of lime, cement, or fly ash required in percent by mass
$W_{air-dry}$ = dry mass of the sample in grams
$m_{water}$ = mass of lime, cement, or fly ash to be added in grams
$m_{sample}$ = percentage of lime, cement, or fly ash required in percent by mass
$m_{cement}$ = dry mass of the sample in grams

5. Mix the material, active filler, and water in the mixer until uniform.

Note: Inspect the sample after mixing to ensure that the mixed material is not packed against the sides of the mixer. If this situation occurs, mix a new sample at a lower moisture content. Check to see that the material mixes easily and remains in a “fluffed” state. If any dust is observed at the end of the mixing process, add small amounts of water and remix until a “fluffed” state is achieved with no dust.

6. Determine the amount of foamed bitumen to be added using the following equation:

$$m_{bitumen} = \left(\frac{w_{b-add}}{100}\right)(m_{sample} - m_{cement})$$

Where: $m_{bitumen}$ = mass of foamed bitumen to be added in grams
$W_{b-add}$ = foamed bitumen content in percent by mass
$m_{sample}$ = dry mass of the sample in grams
$m_{cement}$ = mass of lime, cement or fly ash to be added in grams

7. Determine the timer setting on the foaming laboratory unit using the following equation:

$$t = \frac{m_{bitumen}}{Q_{bitumen}}$$

Where: t = time to be set on the foaming laboratory unit timer
$m_{bitumen}$ = mass of foamed bitumen to be added in grams
$Q_{bitumen}$ = bitumen flow rate for the foaming laboratory unit in grams/second

8. Position the mixer adjacent to the foaming unit so that the foamed bitumen can be discharged directly into the mixing chamber.

9. Start the mixer and allow it to mix for at least 10 seconds before discharging the required mass of foamed bitumen into the mixing chamber. After the foamed bitumen has discharged into the mixer, continue mixing for an additional 30 seconds or until uniformly mixed.

10. The moisture content of the material is to be adjusted to 90 percent of optimum moisture content.

11. Add the additional water and mix until uniform.

12. Transfer the foamed bitumen treated material into a container and immediately seal the container to retain moisture. To minimize moisture loss from the prepared sample, compact the specimens as soon as possible.

Repeat the above steps for at least four different foamed asphalt contents.

**Compaction**

Six specimens are manufactured for each sample at the different bitumen contents. Compact the specimens as follows:

1. Prepare the Gyratory mold, ensuring the mold is clean.

   Note: The compaction equipment must not be heated but kept at ambient temperature.

2. Weigh sufficient material to achieve a compacted height of 2.5 ± 0.125 in. (63.5 ± 1.5 mm) (usually 1150 g is adequate). Poke the mixture with a spatula 15 times around the perimeter and 10 times on the surface, leaving the surface slightly rounded.

3. Compact the mixture by applying 30 gyrations in a 100 mm mold with an angle of 1.12 degree and 600 kPa pressure.

4. Take ± 1000 g representative samples after compaction of the second and fifth specimen and dry to a constant mass at 220 to 230 °F (105 to 110 °C). Determine the molding moisture using the following equation:

$$w_{mold} = \left(\frac{m_{moist} - m_{dry}}{m_{dry}}\right)100$$

Where: $w_{mold}$ = molding moisture content in percent by mass
$m_{moist}$ = mass of moist material in grams
$m_{dry}$ = mass of dry material in grams

5. Remove the specimen from the gyratory mold. Measure the height of the specimen and adjust the amount material if the height is not within the required limits.

Note: With certain materials lacking cohesion, it may be necessary to leave the specimen in the mold for 24 hours, allowing sufficient strength to develop before extracting.

**Curing after Compaction**
Specimens shall be cured for 72 hours at 104 °F (40 °C). The bottom of the specimens shall rest on racks with slots or holes for air circulation. After curing, specimens for moisture conditioning shall be cooled at ambient temperature a maximum of 24 hours; specimens for dry strength shall cool at ambient temperature or 77 °F (25 °C) and be tested at the same time as moisture-conditioned specimens.

Specimens for Rice (maximum theoretical) specific gravity shall be cured at the same conditions as the compacted specimens, except they can be tested after cooling a maximum of 24 hours.

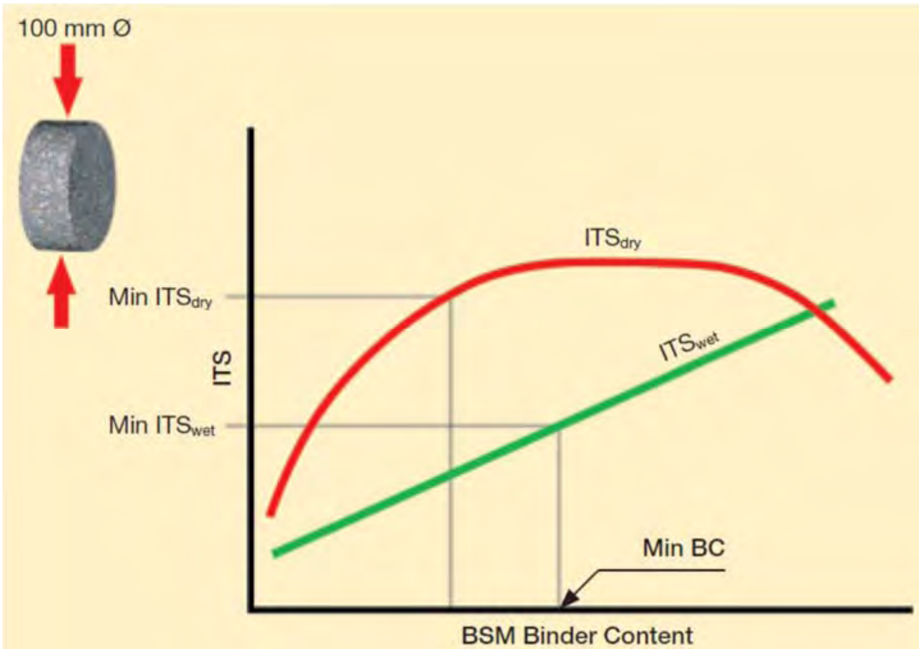
**Volumetric Measurements**
Determine bulk specific gravity (ASTM D 6752) of the specimens. Keep specimens in bags until testing or vacuum saturation is performed. ASTM D 2726 may be used to determine bulk specific gravity if specimens' absorption is less than or equal to 2 percent of water by volume.

Determine Rice (maximum theoretical) specific gravity (ASTM D 2041).

Determine air voids at all foamed asphalt contents used in the design.

**Mechanical Measurements**
Perform ITS testing according to AASHTO T 283. Specimens shall be conditioned at 77 °F (25 °C) for two hours before testing. Vacuum saturate one-half of the specimens at each foamed asphalt content to a minimum 55 percent of the voids filled with water. Soak for 24 hours at 77 °F (25 °C) before testing.

**Foamed Asphalt Content Selection**
The results of the respective soaked and unsoaked ITS test results are plotted against the relevant bitumen content that was added. The added bitumen content that best meets the desired Bitumen Stabilized Material (BSM) classification is selected as the amount of bitumen to be added, as shown in the example below.




**Report**
All mix design test results shall be reported to the Department. All additional additives and bituminous material shall be reported to the Department.

# FOAMED BITUMEN MIX DESIGN - WORKSHEET

| | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | | | | Date | | |
| | | | | | | |
| Sample / Mix No.: | | | | Location | | |
| Material Description: | | | | | | |
| Maximum dry density | | | | Optimum moisture content | | |
| Percentage < 0.075mm | | | Grading: | Coarse | Medium | Fine |
| Plasticity Index | | | | | | |
| Bitumen Source | | | | Bitumen Type | | |
| Active Filler Type | | | | Filler Source | | |

| **MOISTURE DETERMINATION** | | | Specimen manufacture | | After Curing | |
|---|---|---|---|---|---|---|
| | | Hygroscopic | Sample 1 | Sample 2 | Dry | Soaked |
| Pan No. | | | | | | |
| Mass wet sample + pan | $m_1$ | | | | | |
| Mass dry sample + pan | $m_2$ | | | | | |
| Mass pan | $m_p$ | | | | | |
| Mass Moisture | $m_1 - m_2 = M_m$ | | | | | |
| Mass dry sample | $m_2 - m_p = M_d$ | | | | | |
| Moisture Content | $M_m / M_d \times 100 = M_h$ | | | | | |

| | | | |
|---|---|---|---|
| Mass of air-dried sample placed in the mixer (kg) | | | |
| Percentage of water added to sample for mixing: | | Amount of water added: | |
| Percentage water added to sample for compaction | | Amount of water added: | |
| Total percentage water added: | | Total Water added: | |

| | | | | | |
|---|---|---|---|---|---|
| Foamed bitumen added (%) | | | | Active filler added (%) | |
| Foam water injection rate (%) | | | | | |
| Temperatures (°C) Material: | | Bitumen: | | Water: | |

| **SPECIMAN DETAILS** | | | | | | |
|---|---|---|---|---|---|---|
| Speciman ID | | | | | | |
| Date Moulded | | | | | | |
| Date removed from oven | | | | | | |
| Date tested | | | | | | |
| Diameter (mm) | | | | | | |
| | | | | | | |
| Individual height | | | | | | |
| measurements (mm) | | | | | | |
| | | | | | | |
| Average height (mm) | | | | | | |
| Mass after curing (g) | | | | | | |
| Bulk Density (kg/m$^3$) | | | | | | |
| Average bulk density | | | | | | |
| Dry density (kg/m$^3$) | | | | | | |

| **ITS TEST** | | | | | | |
|---|---|---|---|---|---|---|
| Specimen condition | Unsoaked ($ITD_{DRY}$ / $ITS_{EQUIL}$) | | | Soaked ($ITD_{WET}$ / $ITS_{SOAK}$) | | |
| Maximum load (kN) | | | | | | |
| Internal temperature °C | | | | | | |
| Deformation (mm) | | | | | | |
| **ITS (kPA)** | | | | | | |
| **Average ITS (kPa)** | | | | | | |
| **TSR (%)** | | | | | | |

# FOAMED BITUMEN MIX DESIGN REPORT (Dry curing)

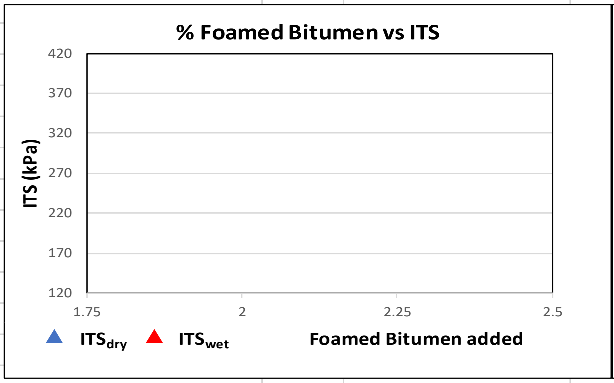
| | | | | | |
|---|---|---|---|---|---|
| **Project** | | | | Date | |
| | | | | | |
| Sample / Mix No.: | | | Location | | |
| Material Description: | | | | | |
| Maximum dry density | | | Optimum moisture content | | |
| Percentage < 0.075mm | | Grading: | Coarse | Medium | Fine |
| Plasticity Index | | | | | |
| Bitumen Source | | | Bitumen Type | | |
| Active Filler Type | | | Filler Source | | |

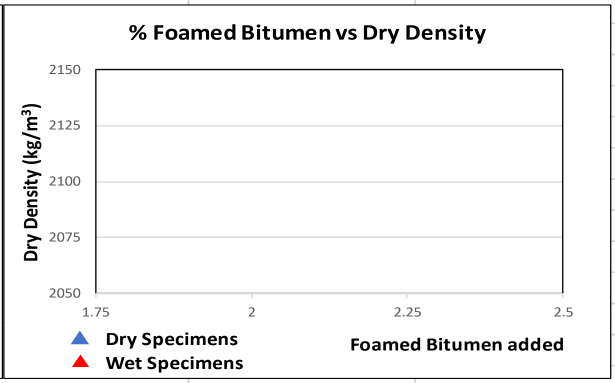
***FOAMED BITUMEN STABILISED MATERAL SPECIMENS***

| | | | | | |
|---|---|---|---|---|---|
| Compactive effort | | | | mm | specimen diameter |
| Date moulded | | | | | |
| Date tested | | | | | |
| Foamed Bitumen added | (%) | | | | |
| Active filler added | (%) | | | | |
| Moulding moisture content | (%) | | | | |

***TEST RESULTS***

| | | | | | |
|---|---|---|---|---|---|
| **$ITS_{DRY}$** | (kPa) | | | | |
| Moisture content at break | (%) | | | | |
| Dry Density | ($kg/m^3$) | | | | |
| Average deformation | (mm) | | | | |
| Temperature at break | (°C) | | | | |
| | | | | | |
| **$ITS_{WET}$** | (kPa) | | | | |
| Moisture content at break | (%) | | | | |
| Dry Density | ($kg/m^3$) | | | | |
| Average deformation | (mm) | | | | |
| Temperature at break | (°C) | | | | |
| | | | | | |
| Tensile Strength Retained | (%) | | | | |
| | | | | | |
| Material Classification | | | | | |




**Comments**

**MASON COUNTY ROAD COMMISSION**

**SPECIAL PROVISION**
**FOR**
**COLD IN-PLACE RECYCLING (CIR) AND FULL DEPTH RECLAMATION (FDR)**
**WITH EMULSIFIED ASPHALT MIX DESIGN PROCEDURES**



**Laboratory Temperature and Humidity Control**
Each laboratory performing mix designs shall have heating, ventilation, and air conditioning (HVAC) equipment that maintains a room temperature of 68 to 86 ºF (20 to 30 ºC) and relative humidity of less than 60 percent.

**Sampling and Processing**
A minimum sample size of 350 lb (160 kg) is needed for each mix design. Bulk samples of the recycled layer thickness shall be obtained from either test pits or cores. Each layer shall be examined to confirm thickness and material.

The bituminous layers shall be crushed. A washed gradation of the crushed bituminous layer(s) shall be performed according to AASHTO T 27 and reported and meet the following requirement(s).

| Sieve Size | | Percent Passing | |
|---|---|---|---|
| | | Crushed Gradations | |
| | | Ideal | Less Suitable |
| 2 in. | 50 mm | 100 | |
| 1 ½ in. | 37.5 mm | 87-100 | |
| 1 in. | 25 mm | 77-100 | 100 |
| ¾ in. | 19 mm | 66-99 | 99-100 |
| ½ in. | 12.5 mm | 67-87 | 87-100 |
| 3/8 in. | 9.5 mm | 49-74 | 74-100 |
| No. 4 | 4.75 mm | 35-56 | 56-95 |
| No. 8 | 2.36 mm | 25-42 | 42-78 |
| No. 6 | 1.18 mm | 18-33 | 33-65 |
| No. 50 | 300 µm | 10-24 | 24-43 |
| No. 200 | 75 µm | 4-10 | 10-20 |

Washed gradation (AASHTO T 27) and sand equivalent (ASTM D 2419, Method B) shall be performed and reported for any granular layer. The washed gradation (AASHTO T 27) of combined layers shall be performed and reported. If combined layers include an aggregate layer, the sand equivalent (ASTM D 2419, Method B) shall be performed and reported.
All washed gradations shall be dried at no greater than 104 °F (40 °C).

| Sieve Size | Percent Passing |
|---|---|

| | | Crushed Gradations | | |
|---|---|---|---|---|
| | | Fine | Medium | Coarse |
| 1 ½ in. | 37.5 mm | 100 | 100 | 100 |
| 1 in. | 25 mm | 100 | 100 | 85-100 |
| ¾ in. | 19 mm | 95-100 | 85-96 | 75-92 |
| No. 4 | 4.75 mm | 55-75 | 40-55 | 30-45 |
| No. 30 | 600 µm | 15-35 | 4-14 | 1-7 |
| No. 200 | 75 µm | 1-7 | 0.6-3 | 0.1-3 |

**Mixing and Compaction**

1. FDR with Emulsified Asphalt. Perform Modified Proctor compaction according to ASTM D 1557, Method C to determine optimum moisture content (OMC) at peak dry density. OMC shall be defined by a best-fit curve from a minimum of four points. Material containing 20 percent or more passing the No. 200 sieve shall be mixed with target moisture, sealed, and set aside a minimum of 12 hours. All other material shall be set aside a minimum of 3 hours. If a material contains less than 4 percent passing the No. 200 sieve, then this testing is not required.

   Select the water content of specimens, not including water in the emulsified asphalt, based on sand equivalent value (SE) from the combined materials.

   - 60 to 75 percent of OMC if SE ≤ 30
   - 45 to 65 percent of OMC if SE > 30

   If a material contains less than 4 percent passing the No. 200 sieve or if no peak develops with the OMC curve, then fix the moisture content between 2 and 3 percent.

   Specimens shall be mixed with the required amount of water before the addition of emulsified asphalt. Specimens shall be mixed with the appropriate amount of water and allowed to sit sealed according to the same guidelines as used for Modified Proctor specimens.

   Samples shall have a weight before addition of water and emulsfied asphalt to produce 2.75 to 3.25 in. (70 mm to 80 mm) tall compacted specimens.

   Choose four emulsified asphalt contents that will bracket the design emulsified asphalt content. Recommended emulsified asphalt content percentages: 1.5, 2.0, 2.5, 3.0, 3.5, or 4.0. The following specimens shall be created:

   - A minimum of two specimens at each of four emulsified asphalt contents shall be produced for short-term strength testing.

   - Four specimens at each of four emulsified asphalt contents shall be produced for the strength and retained strength tests.

   - Two specimens shall be produced for maximum specific gravity.

A mechanical mixer shall be used that has a bowl with a diameter of 10 to 12 in. (250 to 300 mm). It shall rotate on its axis at 50 to 75 revolutions per minute. A mixing paddle which makes contact with the bottom and side of the bowl shall rotate on its axis at twice the bowl rotation rate and in the opposite rotation direction as the bowl.

Aggregate material and emulsified asphalt shall be mixed at a temperature of 68 to 79 °F (20 to 26 °C). Water shall be mixed for 60 seconds. Emulsified asphalt shall be mixed for 60 seconds. If other materials are added, such as lime or cement, then they shall be introduced in a similar manner as they will be on the project. For example, if lime is incorporated a day or more before emulsified asphalt addition, then it shall be added to the wet aggregate a day or more before mixing with emulsified asphalt. If lime is incorporated as a slurry, then it shall be incorporated as a slurry in the laboratory.

Loose specimens shall be cured individually in plastic containers of 4 to 7 in. (100 to 175 mm) height and 6 in. (150 mm) diameter. Specimens shall be cured at 104 °F (40 °C) for 30 ± 3 minutes. No further mixing or aeration shall occur during this time.

Specimens shall be compacted in a Superpave gyratory compactor (SGC) at a vertical pressure of 87 psi (600 kPa), an angle of 1.25°, and a mold of 6 in. (150 mm) diameter for 30 gyrations. After the last gyration, 87 psi (600 kPa) ram pressure shall be applied for 10 seconds. The mold shall not be heated.

2. CIR with Emulsified Asphalt. The specimen size shall be the amount that will produce a 2.4 to 2.6 in. (60 to 65 mm) tall specimen.

   Choose three emulsified asphalt contents that bracket the estimated recommended emulsified asphalt content. Recommended emulsified asphalt content percentages: 1.5, 2.0, 2.5, 3.0, 3.5, 4.0. The following specimens shall be created:

   - Four per emulsified asphalt content for a total of 6 for long-term stability and 6 for moisture testing for 3 emulsified asphalt contents.

   - Two specimens are required for Rice specific gravity; test at the highest emulsified asphalt content in the design and back calculate for the lower emulsified asphalt contents.

   Add moisture that is expected to be added at the milling head, typically 1.5 to 2.5 percent.

   If any additives are in the mixture, introduce the additives in a similar manner that they will be added during field production.

   Mixing of test specimens shall be performed with a mechanical bucket mixer. Mix the CIR-RAP millings thoroughly with water first, then mix with emulsified asphalt. Mixing shall occur at ambient temperature. One specimen shall be mixed at a time. Mixing time with emulsified asphalt should not exceed 60 seconds.

   Specimens shall be compacted immediately after mixing. Place paper disks on the top and bottom of the specimen before compaction.

Specimens shall be compacted with a Superpave gyratory compactor (SGC) in a 4 in. (100 mm) mold at 1.25° angle, 87 psi (600 kPa) ram pressure, and 30 gyrations. The mold shall not be heated.

**Curing after Compaction**

1. FDR with Emulsified Asphalt. Specimens (except STS specimens) shall be cured for 72 hours at 104 °F (40 °C). The bottom of the specimens shall rest on racks with slots or holes for air circulation. After curing, specimens for moisture conditioning shall be cooled at ambient temperature a maximum of 24 hours; specimens for dry strength shall cool at ambient temperature or 77 °F (25 °C) and be tested at the same time as the moisture-conditioned specimens.

   Specimens for Rice (maximum theoretical) specific gravity shall be cured at the same conditions as the compacted specimens, except they can be tested after cooling a maximum of 24 hours.

2. CIR with Emulsified Asphalt. Extrude specimens from molds immediately after compaction. Carefully remove paper disks.

   Place specimens in 140 °F (60 °C) forced draft oven with ventilation on sides and top. Place each specimen in a small container to account for material loss from the specimens.

   Specimens for Rice (maximum theoretical) specific gravity should be dried to constant weight (less than 0.05 percent weight loss in 2 hours). Care should be taken not to over-dry the specimens.

   Cure compacted specimens to constant weight (less than 0.05 percent weight loss in 2 hours), but no more than 48 hours and no less than 16 hours. After curing, cool specimens at ambient temperature a minimum of 12 hours and a maximum of 24 hours.

**Short-Term Strength (STS) Test (FDR with Emulsified Asphalt Only)**

A modified Hveem cohesiometer apparatus shall be used to test early strength (1 hour). This apparatus and procedure generally conforms to ASTM D 1560, Section 13 with the following exceptions:

- It shall have the capability of testing 6 in. (150 mm) diameter specimens.
- It shall have a shot flow rate of 5.95 ± 0.11 lb/min (2700 ± 50 g/min).
- Specimens shall be cured before compaction according to Section 5, and cure each specimen at each emulsified asphalt content for 60 ± 5 min at 77 °F (25 °C) and 10 to 70 percent humidity after compaction and before testing.

The following calibrations shall be made.

- The counter balance should be positioned exactly so that the hinged plate just barely remains horizontal when the top brackets and empty bucket are in place. This ensures that there is no force on the sample until shot begins to flow into the bucket.

- The gap between the bars of the switch that turns off the flow of shot should have a gap of 0.75 in. (18 mm) when there is 3000 g of shot in the bucket. During this adjustment the locking bolt that prevents the plate from moving is in place.

Cohesion shall be tested as follows.

1. Tare the balance with the empty bucket weight.
2. Center the specimen on the unit.
3. Place plates on top of sample and press down while adjusting the outer lower nuts up until they just contact the bottom of the plate.
4. Use a torque wrench or torque-meter to tighten the nuts on the specimen to a maximum of 1.6 foot pound 2.6 (N m).
5. Gently support the bar so the unit does not move when the pin is pulled releasing the hinged plate.
6. Pull pin and push open valve to start the flow of shot.
7. After the unit shuts off the flow of shot, immediately put the locking pin in place and then record the weight of shot.
8. Loosen top nuts to remove plates and rotate specimen 90°.
9. Repeat procedure on the other axis of the specimen.
10. Calculate short-term strength as follows:

$$STS = \frac{SW}{15\,(0.031h + 0.0027h^2)}$$

Where: $SW$ = Shot Weight in grams
$h$ = Height in cm

11. A total of two results will be obtained for each specimen at each emulsified asphalt content, and a total of four results will be obtained at each emulsified asphalt content.

**Volumetric Measurements**
Determine bulk specific gravity (ASTM D 6752) of the specimens. Keep specimens in bags until testing or vacuum saturation is performed. ASTM D 2726 may be used to determine bulk specific gravity if specimens' absorption is less than or equal to 2 percent of water by volume.

Determine Rice (maximum theoretical) specific gravity (ASTM D 2041) except as noted in the Mixing, Compaction, and Curing after Compaction sections.

Determine air voids at all emulsified asphalt contents used in the design.

**Mechanical Measurements**

1. FDR with Emulsified Asphalt. Perform ITS testing according to ASTM D 4867. Specimens shall be conditioned at 77 °F (25 °C) for two hours before testing. Vacuum saturate half the specimens at each emulsified asphalt content to a minimum 55 percent of the voids filled with water. Soak for 24 hours at 77 °F (25 °C) before testing.

2. CIR with Emulsified Asphalt. Determine corrected Marshall Stability (ASTM D 1559) at 104 °F (40 °C) after 2 hour temperature conditioning in a forced draft oven. This testing shall be performed at the same time that the moisture conditioned specimens are tested.

   Perform same conditioning and volumetric measurements on moisture-conditioned specimens as on other specimens. Vacuum saturate to 55 to 75 percent; and soak in a 77 °F (25 °C) water bath for 23 hours, followed by a one hour soak at 104 °F (40 °C). Determine corrected Marshall Stability. The average moisture conditioned specimen strength divided by the average dry specimen strength is referred to as retained stability.

**Raveling Test (CIR with Emulsified Asphalt Only)**

The apparatus used for the raveling test is a modified A-120 Hobart mixer and abrasion head (including hose) used in the Wet Track Abrasion of Slurry Surfaces Test (ISSA TB-100). The rotation speed for the raveling test is not modified from ISSA TB-100. The ring weight is removed from the abrasion head for the raveling test below. The weight of the abrasion head and hose in contact with the specimen should be 600 g ± 15 g. The prepared sample must be able to be secured under the abrasion head, and centered for an accurate result, allowing for free movement vertically of the abrasion head. The device used for securing and centering the sample must allow a minimum of 0.4 in. (10 mm) of the sample to be available for abrasion. The Hobart mixer will need to be modified to allow the sample to fit properly for abrasion. The modification may be accomplished by adjusting the abrasion head height, or the height of the secured sample. The Hobart C-100 and N-50 Models are not acceptable for this test procedure due to differences in size and speed of rotation.

1. Split out two recycled asphalt samples from the medium gradation, or field sample, to a quantity of 2700 g in mass. The 2700 g is an approximate weight to give 2.8 ± 0.2 in. (70 ± 5 mm) of height after compaction.

2. The recycled asphalt sample should be placed in a container of adequate size for mixing.

3. Field or design moisture contents should be added to each of the recycled asphalt samples and mixed for 60 seconds.

4. The design emulsified asphalt content shall be added to each of the recycled asphalt samples and mixed for 60 seconds.

5. The samples shall be placed immediately into a 6 in. (150 mm) gyratory compaction mold and compacted to 20 gyrations. If the sample height is not 2.8 ± 0.2 in. (70 ± 5 mm), the recycled asphalt weight should be adjusted.

6. After compaction, the samples shall be removed from the compaction mold and placed on a flat pan to cure at the specified temperature and humidity (if required) for 240 ± 5 minutes. The temperature shall be maintained at 50 ± 3.5 ºF (10 ± 2 ºC).

7. The specimens shall be weighed after the curing, just prior to testing.

8. The specimens shall be placed on the raveling test apparatus. Care should be taken that the specimen is centered and well supported. The area of the hose in contact with the specimen should not have been previously used. It is allowable to rotate the hose to an unworn section for testing. The abrasion head (with hose) shall be free to move vertically downward a minimum of 0.2 in. (5 mm) if abrasion allows.

9. The samples shall be abraded for 15 minutes and immediately weighed.

10. The Percent Raveling Loss shall be determined as follows:

$$PRL = 100 \text{ x } \frac{w_p - w_A}{w_p}$$

Where: $PRL$ = Percent Raveling Loss
$w_p$ = Weight of Sample Prior to Testing
$w_A$ = Weight of Sample After Testing

11. The average of the two specimens shall be reported as the Percent Raveling Loss. If there is a difference of > 0.5 percent raveling loss between the two test specimens, the Raveling Test shall be repeated. If both of the test specimens have a Percent Raveling Loss of >10 percent, the two test results shall be averaged and the maximum 0.5 percent difference between test specimens shall not be required.

*Note: If field mix samples are taken, Steps 2, 3, and 4 shall be omitted.*

**Emulsified Asphalt Content Selection**
The emulsified asphalt content selected shall result in the mixture meeting the mix design requirements of the FDR or CIR with emulsified asphalt special provision.

**Report**
All mix design test results shall be reported to the Department. All additional additives and bituminous material shall be reported to the Department.

# BITUMEN EMULSION MIX DESIGN - WORKSHEET

| | | | | | | |
|---|---|---|---|---|---|---|
| **Project** | | | | Date | | |
| | | | | | | |
| Sample / Mix No.: | | | | Location | | |
| Material Description: | | | | | | |
| Maximum dry density | | | | Optimum fluid content | | |
| Percentage < 0.075mm | | | Grading: | Coarse | Medium | Fine |
| Plasticity Index | | | | | | |
| Emulsion Source | | | | Emulsion Type | | |
| Active Filler Type | | | | Filler Source | | |

| **MOISTURE DETERMINATION** | | | Specimen manufacture | | After Curing | |
|---|---|---|---|---|---|---|
| | | Hygroscopic | Sample 1 | Sample 2 | Dry | Soaked |
| Pan No. | | | | | | |
| Mass wet sample + pan | $m_1$ | | | | | |
| Mass dry sample + pan | $m_2$ | | | | | |
| Mass pan | $m_p$ | | | | | |
| Mass Moisture | $m_1 - m_2 = M_m$ | | | | | |
| Mass dry sample | $m_2 - m_p = M_d$ | | | | | |
| Moisture Content | $M_m / M_d \times 100 = M_h$ | | | | | |

| | | | |
|---|---|---|---|
| Mass of air-dried sample placed in the mixer (kg) | | | |
| Percentage of water added to sample for mixing: | | Amount of water added: | |
| Total percentage water added: | | Total Water added: | |

| | | | | | |
|---|---|---|---|---|---|
| Bitumen emulsion added (%) | | | | Active filler added (%) | |
| Residual bitumen added (%) | | | | | |
| Temperatures (°C) | Material: | | Bitumen: | Water: | |

**SPECIMAN DETAILS**

| | | | | | | |
|---|---|---|---|---|---|---|
| Speciman ID | | | | | | |
| Date Moulded | | | | | | |
| Date removed from oven | | | | | | |
| Date tested | | | | | | |
| Diameter (mm) | | | | | | |
| | | | | | | |
| Individual height | | | | | | |
| measurements (mm) | | | | | | |
| | | | | | | |
| Average height (mm) | | | | | | |
| Mass after curing (g) | | | | | | |
| Bulk Density (kg/m$^3$) | | | | | | |
| Average bulk density | | | | | | |
| Dry density (kg/m$^3$) | | | | | | |

**ITS TEST**

| | | | | | | |
|---|---|---|---|---|---|---|
| Specimen condition | Unsoaked ($ITD_{DRY}$ / $ITS_{EQUIL}$) | | | Soaked ($ITD_{WET}$ / $ITS_{SOAK}$) | | |
| Maximum load (kN) | | | | | | |
| Internal temperature °C | | | | | | |
| Deformation (mm) | | | | | | |
| **ITS (kPA)** | | | | | | |
| **Average ITS (kPa)** | | | | | | |
| **TSR (%)** | | | | | | |

# BITUMEN EMULSION MIX DESIGN REPORT (Dry curing)

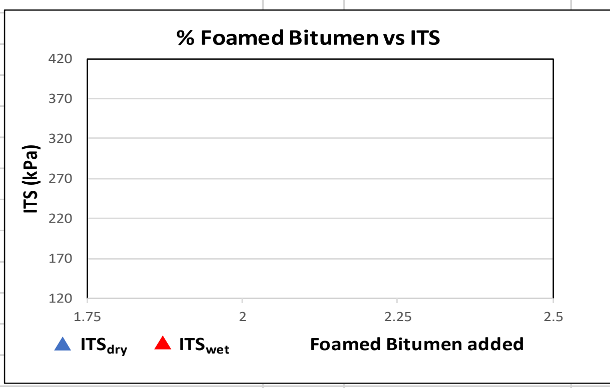
| | | | | | |
|---|---|---|---|---|---|
| **Project** | | | | Date | |
| Sample number: | | | Location | | |
| Material Description: | | | | | |
| Maximum dry density | | | Optimum fluid content | | |
| Percentage < 0.075mm | | Grading: | Coarse | Medium | Fine |
| Plasticity Index | | | | | |
| Bitumen Emulsion Type | | | | | |
| Emulsion Supplier | | | Residual Bitument (%) | | |
| Active Filler Type | | | Filler Source | | |

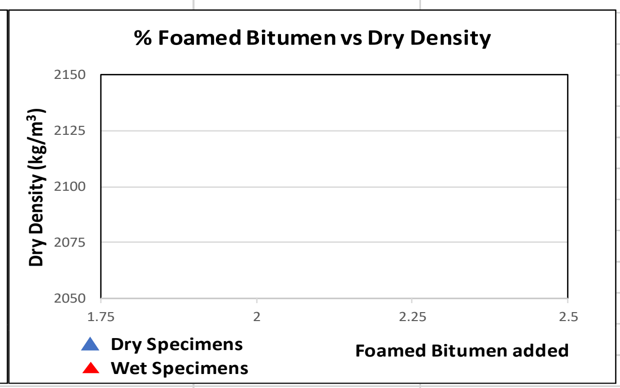
***BITUMEN EMULSION STABILISED MATERAL SPECIMENS***

| | | | | | |
|---|---|---|---|---|---|
| Compactive effort | | | | mm | specimen diameter |
| Date moulded | | | | | |
| Date tested | | | | | |
| Bitumen emulsion added | (%) | | | | |
| Residual bitumen added | (%) | | | | |
| Active filler added | (%) | | | | |
| Moulding moisture content | (%) | | | | |

***TEST RESULTS***

| | | | | | |
|---|---|---|---|---|---|
| $ITS_{DRY}$ | (kPa) | | | | |
| Moisture content at break | (%) | | | | |
| Dry Density | ($kg/m^3$) | | | | |
| Average deformation | (mm) | | | | |
| Temperature at break | (°C) | | | | |
| $ITS_{WET}$ | (kPa) | | | | |
| Moisture content at break | (%) | | | | |
| Dry Density | ($kg/m^3$) | | | | |
| Average deformation | (mm) | | | | |
| Temperature at break | (°C) | | | | |
| Tensile Strength Retained | (%) | | | | |
| Material Classification | | | | | |




**Comments**