Colorado Procedure – Laboratory 5111-15

Standard Method of Test for

Determining the Percent of Recycling Agent to Use for Cold Recycling of Asphalt Concrete

1. SCOPE

1.1 This procedure is used to determine the percent of recycling agent for asphalt concrete when the cold method of recycling is used.

2. APPARATUS

2.1 *Jaw crusher* - which can be adjusted to produce material passing the No. 4 sieve. A sledge hammer may be used to reduce oversize particles enough to permit the material to be fed into the crusher.

2.2 *Two ovens* - one forced draft oven capable of maintaining a temperature of 140° F ± 5° (60°C ± 2.8°) and another capable of maintaining a temperature of 300°F ± 9° (149°C ± 5°).

2.3 *Balance* - 5 kg capacity, accurate to one gram.

2.4 *Sieves* - U.S. Standard sizes; 1 ¼ in. (31.5 mm), 1 in. (25.0 mm), 3/4 in. (19.0 mm), 1/2 in. (12.5 mm), 3/8 in. (9.5 mm), No. 4, No. 8, No. 16, No. 30, No. 100, No. 200.

2.5 *Sample splitter* - suitable for splitting aggregates up to 1 ¼ in. (31.5 mm).

2.6 *Pans* - approximately 10 in. (250 mm) diameter, 3 in. (75 mm) deep.

2.7 *Trowels* and other small tools.

3. MATERIALS

3.1 Emulsified recycling agent, either HFMS-2sP, or as specified.

3.2 Take a minimum of 50 pounds of the pavement to be recycled. At a minimum, one full-depth 6" diameter core shall be taken every half-mile of each lane (between wheel paths). Cores should also be taken in the shoulder, if the shoulders are to be recycled. More samples should be taken if visual observations show significant variations in the existing mat. Significant variations may be defined by pavement condition, thickness, surface course, etc. Samples are required for a separate design of each significant variation in the pavement. In order to properly design for a 4" recycle depth, a minimum of 20 cores (4" thick - 6"diameter) are required for each significant variation in the existing mat. If the recycle depth is only 2" in depth, 40 cores (2" thick - 6" diameter) are required. If the material is sampled by milling, the milling machine shall be similar to the type of milling machine that will be used during the recycling process. Small milling machines are not recommended. Milled material shall be approximately 50 pounds (23 kg) of each pavement type to be recycled.

4. PREPARATION OF SAMPLES

4.1 Crushing

A. Pavement cores or chunks
   1. Trim samples so that only the portion designated for recycling remains.
   2. Crush the material proposed for recycling to minus 1 1/4 in. (31.5 mm).

B. Milled pavement is preferable to cores for cold recycle design.
   (If milled pavement of the proposed production milling operation is available)
   1. Crush oversized material so that the sample is 100% passing the 1 1/4 in. (31.5 mm).

4.1.1 Perform a mix design on the material as received after crushing, preferably at a medium gradation as defined below. It may be necessary to recombine millings in the laboratory to target these established gradation ranges.

Sieve Sizes	Fine	Medium	Coarse
31.5 mm (1.25”)	100	100	100
25 mm (1”)	100	100	90-100
19 mm (3/4”)	95-100	85-96	75-92
4.75 mm (No. 4)	55-75	40-55	30-45
600 μm (No. 30)	15-35	4-14	1-7
75 μm (No. 200)	1-7	0-3	0-3

5. PROCEDURE

5.1 Prepare one sample to be used for determination of asphalt content and aggregate gradation according to CP-L 5120, *Determination of the Asphalt Binder Content of Bituminous Mixtures by the Ignition Method*. Sample size is determined by Nominal Maximum Aggregate size.

5.2 Prepare one sample in accordance with Subsection 4.1 to be used to determine the maximum theoretical specific gravity in accordance with CP 51 of the unmixed material.

5.2.1 Dry the unmixed sample to a constant mass at 250°F for 2 hours ± 30 minutes.

5.2.2 Determine the maximum specific gravity of the sample according to CP 51. Do not break down agglomerates that will not break easily with a spatula.

Note 1: The specific gravity of the unmixed sample will require that the dry-back procedure be used.

5.3 Prepare one sample in accordance with Subsection 4.1 to be used to determine the maximum theoretical specific gravity in accordance with CP 51 for the mixed material.

5.3.1 Add 2% by weight (mass) of water to this sample.

5.3.2 Add 2.4% emulsion by weight (mass) if HFMS-2sP is used. Add 3.5% emulsion by weight (mass) if CSS Special is used.

5.3.3 Mix the RAP and water first prior to the addition of the emulsion. Mixing with a mechanical mixer is preferred to hand mixing. Mixing time should not exceed 60 seconds.

5.3.4 Dry the mixed sample to a constant mass at 250°F for 2 hours ± 30 minutes.

5.3.5 Determine the maximum specific gravity of the sample according to CP 51. Do not break down agglomerates that will not break easily with a spatula.

5.3.6 Other maximum specific gravities will be back-calculated based on the emulsion content. (See Section 6 if lime is added to samples.)

5.4 A minimum of three emulsion contents is recommended for each mix design evaluation. Prepare a total of 27 specimens in accordance with Subsection 4.1. At the proposed emulsion content, a set of nine specimens will be needed. Three specimens will be required for Hveem Stability Testing in accordance with Section 7 and six specimens will be required for Moisture Susceptibility Testing (Lottman) in accordance with Section 9. Specimen size will be the amount of material necessary to produce a 61.0 mm to 66.0 mm tall puck. (Approximately 470 x Rice Value)

5.4.1 If the mix is initially evaluated without lime, it will be necessary to prepare ten additional samples for comparisons at optimal emulsion content, one for specific gravity, three for stability, and six for Lottman. See Section 6, Lime.

5.5 Dry the 27 specimens for compaction to a constant weight (mass) at 140°F (60°C).

5.5.1 Remove specimens from oven and cool at room temperature for 2 hours ± 30 minutes.

5.6 Add 2% water by weight (mass) to a dry specimen and mix thoroughly (hand mixing is acceptable, but mechanical mixing is preferred).

5.7 Add the initial emulsion content, normally 0.8% emulsion (HFMS-2sP) or 2.0% CSS Special, by weight (mass) and thoroughly mix at room temperature, 75 ± 5°F (24 ± 2.8°C) (mechanical mixing preferred). Mixing time should not exceed 60 seconds.

5.7.1 Immediately after mixing, compact the specimen in accordance with CP-L 5115 for 30 gyrations. The compaction should be done at room temperature 75°F ± 5° (24°C ± 2.8°), and the mold shall not be heated.

5.7.2 Extrude specimen immediately after compaction and carefully remove paper disks. Place pucks in a flat pan. Dry in a forced air oven at 140°F (60°C) to a constant mass, but for no more than 48 hours and no less than 16 hours. After curing, cool the puck at room temperature 75°F ± 5° (24°C ± 2.8°), for 12 to 24 hours.

5.8 Repeat step (Subsections) 5.6 and 5.7 for the remaining eight specimens needed for the specified emulsion content.

5.9 Repeat step (Subsection) 5.6 and in step (Subsection) 5.7, increase the amount of emulsion to 1.3% for HFMS-2sP or 2.5% for CSS for the next nine specimens.

5.10 Repeat step (Subsection) 5.6 and in step (Subsection) 5.7, increase the amount of emulsion to 1.8% for HFMS-2sP or 3.0% for CSS for the next nine specimens.

5.11 If needed, repeat step (Subsection) 5.9 by increasing the emulsion (HFMS-2sP or CSS) in increments of 0.5% for the next nine specimens.

Note 2: If virgin aggregate is added, greater amounts of emulsion may be required.

6. LIME

6.1 If lime is specified by the Engineer, 1.5 % by weight (mass) should be added to all samples in Section 5.

6.1.1 The lime slurry will be a homogeneous slurry mix heated to 140°F (60°C) and have a dry solids content of not less than 30 percent.

6.2 If it is not specified by the Engineer, it is recommended to add 1.5 % by weight (mass) to a set of nine specimens at the optimum emulsion content as determined in Section 11 and prepared in accordance with Subsections 5.6 and 5.7.

6.2.1 Compare the results from the mix with lime to the results from the mix without lime at the optimal emulsion content in order to determine if the addition of lime is beneficial.

7. BULK SPECIFIC GRAVITY OF COMPACTED SAMPLES

7.1 Specific Gravity - Use CP 44 to calculate air voids for each compacted sample.

8. HVEEM STABILITY

8.1 Three compacted specimens from Section 5 will be used for Hveem Stability testing, in accordance with CP-L 5106 for each emulsion content.

8.2 Stabilometer Test - Test for Stabilometer value at room temperature 75°F ± 5° (24°C ± 2.8°), in accordance to CP-L 5106, Subsection 5.1.

9. RESISTANCE TO MOISTURE INDUCED DAMAGE – LOTTMAN TESTING.

9.1 Six compacted specimens from Section 5 will be used for Lottman testing in accordance with CP-L 5109 for each emulsion content.

Note 3: These samples were compacted at 30 gyrations without regard to target void content.

10. REPORTING OF RESULTS

10.1 There is no designated CDOT Form used for recording / reporting information for this CP-L.

10.2 Report percent asphalt and gradation of aggregate.

10.3 Report the type and percent of recycling agent used for each set of specimens.

10.4 Report printout from Flex program showing Voids, Stability, Maximum Specific Gravity, Bulk Specific Gravity, TSR from Lottmans, etc from each compacted sample.

11. RECOMMENDATION

11.1 The optimal emulsion content is determined as the highest emulsion content providing the highest stability, with the highest TSR from Lottman testing, and voids between 6% and 12% in the compacted sample, with no evidence of surface flushing or bleeding.

Note 4: Slight flushing is considered no flushing.

11.1.1 It is recommended that raveling be less than 2% loss for high traffic areas.

11.2 If a mix is evaluated with and without lime, it is recommended that a 10% difference in TSR is significant and would warrant the use of lime in the mix design.

11.3 It is recommended that once the mix design is completed, a separate mix design be developed either using a fine or coarse gradation using the target criteria found in Subsection 4.1.1. This information will be used to make field adjustments as necessary to the optimal emulsion content.

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