**405-2 Cold Recycling Mixture Design (Revised 10-24-19)**

1. COLD RECYCLING MIXTURE DESIGN [405] (REVISED 10-24-19)

Description. This procedure is used to determine the asphalt emulsion content for cold recycled plant mix surfacing. Use this procedure when specifying cold recycling - engineered emulsion (CIR-EE).

Mixture Design. Submit a mix design for approval 10 business days before starting the cold recycling operation. Perform the mixture design in accordance with this special provision. Use asphalt emulsion meeting the requirements presented in Table 405-2. Ensure the job mix formula meets Table 405-3 requirements at the design asphalt emulsion content.

TABLE 405-3

JOB MIX FORMULA CRITERIA

|  |  |  |
| --- | --- | --- |
| Property | Criteria | Purpose |
| Compaction effort, Superpave Gyratory Compactor 4” (100 mm) diameter specimens | 1.25° angle, 87 psi (600 kPa) stress, 30 gyrations | Density Indicator |
| Density, MT 314 | Report | Compaction Indicator |
| Gradation for Design Millings, AASHTO T 11 | Report |  |
| Marshall stability, AASHTO T 124 | 1,250-pound (6.7 kN) minimum | Strength Indicator |
| Retained stability based on cured stability, AASHTO T 283, modified in Part f) | 70% minimum | Moisture susceptibility |
| Indirect Tensile Test, AASHTO T 322, Modified in Part g) | Critical Cracking Temperature is -24 ºF(-31 ºC). | Thermal Cracking |
| Raveling Test, ASTM D 7196, Ambient or 50 0F (10 ºC) | 2% maximum | Raveling Resistance |

Sampling and Processing. Collect cores from the area to be recycled. If cores show significant differences over the project length, such as different types of plant mix surfacing, perform separate mix designs for each of these pavement segments. Take cores at regular intervals within the project limits, calculated as follows:

Core Interval, ft. (m) = (Length of Project, ft. (m))/(No. of Cores needed for Mix Design).

Use only the portion of the core that will be recycled for the mix design. Crush cores in the laboratory. Perform a mixture design for each gradation shown in Table 405-4, for a total of two mixture designs.

Table 405-4

Mix Design Gradation Requirements

|  |  |  |
| --- | --- | --- |
| Sieve | Medium | Coarse |
| Percent Passing |
| 1.25-inch (31.5 mm) | 100 | 100 |
| No. 4 (4.75 mm) | 40-50 | 28-38 |
| No. 30 (0.6 mm) | 7-12 | 4-10 |
| No. 200 (0.075mm) | > 1 | > 1 |

After crushing determine the millings gradation using AASHTO T 11 and T 27 (dried at no greater than 104 °F (40 °C)).

A minimum of 150 pounds (68 kg) of usable millings is required for each mix design. The estimated quantities for one mix design is:

* 50 – 4-inch (100 mm) cores, or
* 30 – 6-inch (150 mm) cores

Prepare samples with a sample splitter. An alternative method is to dry, screen and recombine millings in the laboratory to target gradation. The following screen sizes are recommended: ½-inch (12.5 mm), ⅜-inch (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 30 (0.600 mm), and pan.

Scalp oversize aggregate with a 1-inch (25 mm) screen when using 4-inch (100 mm) diameter compaction molds.

Mixing. Mix material for a 4-inch (100 mm) diameter, 2.4-inch to 2.6-inch (61.0 mm to 66.0 mm) tall specimen. Determine sample size for Rice specific gravity testing using MT 321.

Number of specimens:

|  |  |  |
| --- | --- | --- |
| Quantity | Test To Be Performed | Total Number |
| 2 | Moisture Susceptibility @ 3 emulsion contents | 6 |
| 2 | Rice Specific Gravity on highest emulsion content | 2 |
| 2 | Marshall Stability @ 3 emulsion contents | 6 |

Choose three emulsion contents bracketing the estimated design emulsion content. Recommended emulsion contents: 1, 2, and 3%.

Add 0.5% mineral filler.

Mix test specimens in a mechanical bucket mixer. At ambient temperature, mix the millings thoroughly with mineral filler first, then mix with emulsion. Mix one specimen at a time. Do not mix with emulsion more than 60 seconds.

Compaction. Compact specimens immediately after mixing. Compact specimens as specified in Table 405-3. Do not heat the mold.

Curing after compaction. Extrude specimens from molds immediately after compaction. Place specimens in 140 °F (60 °C) forced draft oven with side and top ventilation. Place each specimen in a small container to account for material loss from specimens.

Cure Rice specific gravity specimens to constant weight (less than 0.05% weight loss in two hours). Do not over-dry the specimens.

Cure compacted Marshall and moisture susceptibility specimens to constant weight (less than 0.05% change in weight in two hours) for 16 to 48 hours. After curing, cool specimens at ambient temperature for 12 to 24 hours.

Marshall Stability and Air Voids. Determine bulk specific gravity of each specimen according to MT 314 with one exception. Record the mass of the specimen in water after 1-minute submersion.

Determine specimen heights according to ASTM D3549 or from the SGC readout.

Determine Rice specific gravity, MT 321, except do not break any agglomerates which will not easily reduce with a flexible spatula. Normally the supplemental dry-back procedure is performed to adjust for uncoated particles.

Determine air voids at each emulsion content.

Determine corrected Marshall stability by AASHTO T 124 at 104 °F (40 °C) after 2-hour temperature conditioning in a forced draft oven.

Moisture Susceptibility. Perform moisture susceptibility (AASHTO T 283) with the following changes to the procedure. Vacuum saturate to 55% to 75%, soak in a 77 °F (25  C) water bath for 23 hours, followed by a 1-hour soak at 104 °F (40 °C). Determine corrected Marshall stability and retained stability.

Procedure for performing AASHTO T 322 for Cold Recycling Design Specimens. The critical cold temperature cracking temperature must be equal to or colder than the temperature shown in Table 405-3.

Perform the indirect tensile testing (IDT) meeting AASHTO T 322, except as follows:

Prepare two specimens 6-inch (150 mm) in diameter and at least 4.5 inch (115 mm) in height, compacted to the design air voids (±1%) at the design emulsion content. Cure test specimens at 60 ºC between 48 and 72 hours. After curing 48 hours, ensure that specimen mass changes no more than a 0.05% in 2 hours. After curing, cut two 2-inch (50 mm) specimens from each cured specimen from the center of the specimen (i.e. discard top and bottom of specimen). Perform the bulk specific gravity test after cutting.

A minimum of 2 specimens are required at each of 2 temperatures.

Select two testing temperatures at an 18 ºF (10 ºC) interval bracketing the critical cold cracking temperature. For example, if the required temperature is -13 ºF (-25 ºC), then select testing temperatures of -4 ºF (-20 ºC) and -22 ºF (-30 ºC).

Perform IDT tensile strength test immediately after the IDT tensile creep test at the same temperature as the creep test.

Ensure the environmental chamber can reach -40 ºF (-40 ºC).

The critical cracking temperature is defined as the intersection of the calculated pavement thermal stress curve, derived from creep data, and the tensile strength line. The tensile strength line connects the average tensile strength at the two test temperatures.

Procedures for Performing the Raveling Test on Cold Recycled Specimens. Use a modified A-120 Hobart mixer (or equivalent) and abrasion head (including hose) to perform the raveling test (ASTM D 7196 exceptions stated below). Remove the ring weight from the abrasion head while performing the raveling test. The weight of the abrasion head and hose in contact with the specimen is 1.32 lbs (600 g) ± 0.5 ounces (15 g).

Split two 6 lb. (2700 g) recycled asphalt samples from the medium gradation or field sample. Place sample in a mechanical bucket mixer.

Add water required to reach field or design moisture content and mix for 60 seconds.

Add the design emulsion content and mix for 60 seconds.

Immediately place the samples into a 6-inch (150 mm) gyratory. compaction mold and compact to 20 gyrations. If the sample height is not 2.75-in. (70 mm) ±0.2 inches (5 mm), adjust the recycled asphalt weight and prepare a new specimen.

After compaction, remove the specimen from the compaction mold and place on a flat pan to cure at ambient temperature (65-75 ºF) for 4 hours ±5 minutes.

Weigh specimen after the curing and immediately before testing.

Place specimen on the raveling test apparatus. Ensure the specimen is secured and centered under the abrasion head allowing for free vertical movement of the abrasion head. Provide at least 0.4 in (10 mm) of vertical hose movement for abrasion. For the sample to fit properly for abrasion, it may be necessary to adjust the abrasion head height or sample height. The portion of the hose in contact with the specimen must be unused. It is allowable to rotate the hose to an unworn section for testing.

Abrade sample for 15 minutes. Remove abraded material and weigh sample immediately after testing.

Determine the percent raveling loss as follows:
(Mass Prior to test – Mass After test)/(Mass Prior to test) \* 100.

Report the average results of two specimens as the percent raveling loss. Repeat the test if a difference in raveling loss between the two specimens is greater than 0.5%. If both samples have a Raveling Loss greater than 10%, waive the 0.5% requirement and report results.

Emulsion Content Selection. The design emulsion content is the lowest emulsion content meeting the requirements in Table 405-3.

Report. Include the following minimum information in the mix design report:

RAP Gradation

The amount and gradation of virgin aggregate or RAP added to the cold milled material (if required)

Recommended water content range as percentage of dry RAP

Optimum emulsion content as a percentage of dry RAP

Rice and bulk specific gravity, density, air void level, and absorbed water at optimum emulsion content

Marshall stability and retained stability at design moisture and emulsion content.

The emulsion product name, manufacturer’s name, and plant location. Report the following asphalt properties:

* Residue from distillation, % (AASHTO T 59)
* Oil distillate by distillation, % (AASHTO T 59)
* Sieve Test, % (AASHTO T 59)
* Penetration Range @ 77ºF (25°C), in (mm) (AASHTO T 49)

Provide the type of mineral filler used and furnish a manufacturer’s certificate of compliance.