5.3.4. MIX DESIGN PROCEDURES FOR CIR (COLD-IN-PLACE RECYCLING) MATERIAL

1. Mixtures Containing an Emulsion.

1.1. Scope.

This method covers the procedure for obtaining materials and the preparation, either by the Contractor or the emulsion supplier, of a mix design as specified in the following manner.

1.2. Sampling and Processing

Obtain cores from the areas to be recycled. If cores show significant differences in various areas, such as different type or thickness of layers between cores, then separate mix designs shall be performed for each of these pavement segments. It is recommended to take, at a minimum, one core for every 1.2 miles (2 kilometers) of lane and where visual differences in the pavement are noticed. Cores shall be cut in the laboratory to the depth specified for the CIR project. Cores shall be crushed in the laboratory. Perform a mix design using the medium gradation and a minimum of one of the fine or coarse gradations using the following recycled asphalt pavement millings criteria.

	Fine	Medium	Coarse
1¼ in (31.5 mm)	0	0	0
1 in (25 mm)	0	0	0-15
¾ in (19 mm)	0-5	4-15	8-25
#4 (4.75 mm)	25-45	45-60	55-70
#30 (600 µm)	65-85	86-96	93-99
#200 (75 µm)	93-99	97-99.4	97-99.9

The mix design shall be performed on these crushed millings. Gradation of the millings after crushing shall be determined by **KT-1**, **KT-2**, and **KT-3** (dried at 104° F (40° C) or less). An alternative method is to dry, screen, and recombine millings in the laboratory to target gradation. Suggested screens are ½ in (12.5 mm), ⅜ in (9.5 mm), #4 (4.75 mm), #8 (2.36 mm), #30 (600 µm), and pan. Scalp oversize material with a 1 in (25 mm) screen when using 4 in (100 mm) diameter compaction molds.

1.3. Asphalt Emulsion (CSS)(SPECIAL)

The contractor shall purchase and use asphalt emulsion that meets the following requirements.

Test		Minimum	Maximum
Residue from distillation, %	ASTM D244[1]	64.0	66.0
Oil distillate by distillation, %	ASTM D244[1]		0.5
Sieve Test, %	ASTM D244[1]		0.1
Penetration (TBD[2]), 25°C, dmm	ASTM D5	-25%	+25%

[1] Modified **ASTM D 244** procedure – distillation temperature of 350°F (177°C) with a 20 minute hold. The **ASTM D 244** vacuum distillation procedure may be substituted once the maximum oil distillate is satisfied.

[2] TBD – to be determined by the CIR design prior to emulsion manufacture for the project. Penetration range will be determined on the design requirements for the project and will be submitted to the District Materials Engineer and Chief Chemist (Materials and Research Center) for approval prior to project start.

1.4. Mixing

Specimen size: the amount that will produce a 2.40 to 2.60 in (61 mm to 66.0 mm) tall specimen; use **KT-39** to determine the size for Rice specific gravity.

Number of specimens: 4 plugs per emulsion content for a total of 6 sets for long-term stability, and 6 plugs for moisture testing at 3 emulsion contents. Two specimens are required for Rice specific gravity; test at the highest emulsion content in the design and back calculate for the lower emulsion contents. Recommended emulsion contents: 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, and 4.0%. Choose three emulsion contents that bracket the estimated recommended emulsion content.

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

If any lime is in the mixture, introduce the lime in a similar manner as 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 emulsion. Mixing shall occur at ambient temperature. One specimen shall be mixed at a time. Mixing time with emulsion should not exceed 60 seconds.

1.5. Compaction

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

Specimens shall be compacted with a Superpave gyratory compactor (SGC) in a 4 in (100 mm) mold as specified in **KT-58** for 30 gyrations. The mold shall not be heated.

1.6. Curing after compaction

Extrude specimens from molds immediately after compaction. Carefully remove paper disks.

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

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

Cure compacted specimens to constant mass but no more than 48 hours and no less than 16 hours. Constant mass is defined as no more than 0.05% change in mass in 2 hours. After curing, cool specimens at ambient temperature for 18 ± 6 hours.

1.7. Measurements

Determine bulk specific gravity (density) of each compacted (cured and cooled) specimen according to **KT-15**, procedure III; however, the mass of the specimen in water (measurement C) can be recorded after one minute submersion.

Determine specimen heights according to **KT-14** or equivalent. Alternatively, the height can be obtained from the SGC printed copy, at 30 gyrations.

Determine Rice (maximum theoretical) specific gravity, **KT-39**, except as noted in Item 5 of this procedure, and do not break any agglomerates which will not easily reduce with a flexible spatula. It is normally necessary to perform the supplemental dry-back procedure outlined in **AASHTO T 209** to adjust for uncoated particles.

Determine air voids at each emulsion content.

Determine corrected Marshall stability by **KT-14** 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.

1.8. Moisture Susceptibility

Perform same conditioning and volumetric measurements on moisture-conditioned specimens as on other specimens. Vacuum saturate to 55 to 75 percent, 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.

1.9. Thermal Cracking

See **KTMR- 37**.

1.10. Raveling

See **KTMR- 38**.

1.11. Emulsion Content Selection

The properties of the specimens at design emulsion content shall meet the properties in Table A1.

1.12. Report

The report shall contain the following information: Gradation of RAP; percent lime, recommended water content range as a percentage of dry RAP; optimum emulsion content as a percentage of dry RAP and corresponding density, air void level, and absorbed water; Marshall stability and retained stability at recommended moisture and emulsion contents, Raveling %, and Thermal Cracking initiation temperature. Include the emulsion designation, company name, plant location, and residue content.

1.13. Mixture Design Criteria

1.13.1. A preconstruction mix design shall be submitted by the Cold In-Place contractor tested in accordance with this section using materials obtained directly from the project site. Based on cores taken before the project, more than one mix may be required. The job mix formula shall meet the criteria of Table A1 and be approved by the District Materials Engineer.

1.13.2. Table A1

Mix Design Criteria	
4 in (100 mm) specimens shall be prepared in a Superpave Gyratory compactor. The mixture should meet the following criteria at the selected design asphalt emulsion content:	
Property	**Criteria**
Compaction effort, Superpave Gyratory Compactor	Refer to **KT-58**
Density, **KT-15**	Report
Gradation for Design Millings, **KT-3**	Report
Marshall stability *, **KT-14**, 104^{o} F (40^{o} C)	5.56 kN, min.
Retained stability based on cured stability **	70 % min.
Indirect Tensile Test, **AASHTO T 322**, Modified in **KTMR-37**	See note in **KTMR-37**
Raveling Test, Ambient, **KTMR-38**	2 % max.

* Cured stability tested on compacted specimens after 140^{0} F (60^{0} C) curing to constant mass.
** Vacuum sat. of 55 to 75 percent, water bath 77^{0} F (25^{o} C) @ 23 hours, last hour at 104^{0} F (40^{0} C) water bath.