******THIS IS A NEW APPENDIX. – PLEASE READ CAREFULLY.******

MIX DESIGN METHOD FOR CIR WITH ENGINEERED EMULSION

The mix design for CIR with engineered emulsion is performed by the Contractor. The primary steps in the mix design process are:

- Process, dry, sieve, and blend the RAP.
- Select the engineered emulsion.
- Prepare, compact, and cure CIR mixture over a range of emulsion contents.
- Determine the engineered emulsion content for the CIR mixture.

1. PREPARE THE RAP SAMPLE

The bulk sample of RAP may require additional crushing to meet the gradation band shown. The RAP is dried in open pans at room temperature, sieved into a minimum of 3 size fractions (+3/8 inch, +1/8 inch, pan)(+9.5 mm, +2.36 mm, pan), and re-blended to achieve uniform samples.

Sieve Size	%passing
1.5 inch (37.5 mm)	100
1.0 inch (25 mm)	100
3/4 inch (19 mm)	85-95
No. 4 (4.75 mm)	40-55
No. 30 (600 µm)	5-15
No. 200 (75 µm)	0.5-3

2. SELECT THE ENGINEERED EMULSION

Standard asphalt binder grades used for asphalt emulsions may not have appropriate characteristics to achieve the desired CIR mixture properties. By trial and error, the designer must select the base asphalt grade for the emulsion.

3. PREPARE MIXTURES

Prepare a blending chart to determine what amounts of engineered emulsion will be added to the RAP. A minimum of three emulsion contents should be selected. The preferred contents are 2.0%, 2.5%, 3.0% and 3.5%.

In addition to the engineered emulsion, 1.5% water is added to represent the water used in the milling process.

The dry RAP sample and 1.5% water are added to the mixing bowl and mixed for 45-60 seconds. The engineered emulsion is added to the damp RAP while the mixer continues to mix the sample. Mixing continues for an additional 60 seconds. A set of three specimens can be prepared in each batch.

4. COMPACT AND CURE MIXTURES

Specimens shall be compacted immediately after mixing. Do not use paper disks. Specimens shall be compacted with a gyratory compactor in a 4-inch (100 mm) mold at 1.25 degree angle, 87 psi (600 kPa) ram pressure, and 30 gyrations. The mold shall not be heated. Extrude specimens from molds immediately after compaction. Place each specimen in a small container to account for material loss from the specimens during curing.

Cure compacted specimens in 140ºF (60ºC) forced draft oven for 48 hours. After curing, cool specimens at ambient temperature for 12 hours.

5. TEST MIXTURES

A. Determine bulk specific gravity (density) of each compacted (cured and cooled) specimen according to ASTM D 2726 or equivalent; however, the mass of the specimen in water (measurement C) should be recorded after 1 minute of submersion.

B. Determine specimen heights according to ASTM D 3549 or equivalent. Alternatively, the height can be obtained from the gyratory compactor readout.

C. Sort the specimens into equal sublots based on height and density for further testing.

D. For the three specimens of one sublot, determine corrected Marshall stability by ASTM D 1559 Part 5 at 100ºF (40ºC) 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.

E. For the three specimens from the other sublot, vacuum saturate to 55% to 75%, soak in a 75ºF (25ºC) water bath for 23 hours, followed by a 1 hour soak at 100ºF (40ºC). Determine corrected Marshall stability.

F. Compute the retained strength as the average moisture conditioned Marshall stability strength divided by the average dry Marshall stability strength.

G. Perform the thermal cracking test for critical cold temperature. The temperature is based on FHWA LTPPBind software for 50% reliability at 3 inches (75 mm) below the pavement surface. The required temperature for the specification is –20ºC. Perform the indirect tensile testing according to AASHTO T 322 with the following exceptions:

1) Specimens shall be 6 inches (150 mm) in diameter and at least 4 1/2 inches (115 mm) in height and compacted to the design density and emulsion content determined from the Marshall Stability Testing. Trial specimens are needed to establish the number of gyrations for compacting the 6-inch (150 mm) specimens. Test specimens shall be cured at 140ºF (60°C) for 72 hours. After curing, two specimens shall be cut from each compacted specimen to 2 inches (50 mm) in height.

2) Measure the bulk specific gravity of each cut specimen.

3) Test two specimens at each of three test temperatures (-20ºC, -10ºC, 0ºC).

4) The tensile strength test shall be carried out on each specimen directly after the tensile creep test at the same temperature as the creep test.

5) The critical cracking temperature is defined as the intersection of the calculated pavement thermal stress curve (derived from the creep data) and the tensile strength line (the line connecting the results of the average tensile strength at the three temperatures).

H. Perform the raveling test. 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 (International Slurry Seal Association; 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 (mass) of the abrasion head and hose in contact with the specimen should be 1.3 pounds ± 0.5 ounce (600 g ± 15 g). The prepared sample must be able to be secured under the abrasion head, and centered for 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 3/8 inch (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. A Raveling Test Adapter can be purchased through Precision Machine and Welding, Salina, KS (785) 823-8760. Please reference the Hobart Model number A-120 when ordering. The C-100 and N-50 Models are not acceptable for this test procedure due to differences in size and speed of rotation.

1) Prepare two samples at the design moisture content and emulsion content. The size of each sample should be sufficient to meet the compacted specimen dimensions described below. (note: 6 pounds (2.7 kg) is an approximate weight (mass) to meet the criteria).

2) After mixing, place the mixture into a 6 inches (150 mm) gyratory compaction mold and compacted to 20 gyrations. The compacted specimen height shall be 2 3/4 inches ± 1/4 inch (70 mm ± 5 mm).

3) Extrude the samples from the compaction mold and placed on a flat pan to cure at a temperature of 50ºF +/- 2ºF (10ºC +/- 1ºC) for 4 hours ± 5 minutes.

4) The specimens shall be weighed after curing, just prior to testing.

5) 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 1/4 inch (5 mm) if abrasion allows.

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

7) The percent raveling loss shall be determined as follows:

$$\text{Raveling Loss} = \frac{(\text{Weight Before Test - Weight After Abrasion})}{\text{Weight Before Test}} \times 100$$

8) The average of the two specimens shall be reported as the Percent Raveling Loss. There should not be a difference of 0.5% Raveling Loss between the two test specimens for proper precision. A difference of > 0.5% will require the test to be repeated. If both of the samples have a Raveling Loss of > 10% the numbers shall be averaged and the precision rule will be waived.

I. Determine if the selected engineered emulsion within the emulsion content range tested meets the following properties. If not, repeat the design with another engineered emulsion.

Test	**Criteria**	**Purpose**
Marshall stability	1,000 lb. (567 kg) min.	Stability under traffic
Retained strength	70% min.	Ability to withstand moisture damage
Thermal Cracking	-20ºC max.	Resist low temperature cracking
Raveling Test	2% max.	Raveling Resistance

6. MIX DESIGN REPORT

The mix design report will provide the following results at the optimum engineered emulsion content:

- Engineered emulsion base asphalt PG grade
- RAP gradation
- Mixture dry density (lb/ft^3 or kg/m^3)
- Marshall stability (lb or kg)
- Percent retained strength (%)
- Critical low temperature (C)
- Percent raveling loss (%)