
*****GENERAL REWRITE – PLEASE READ CAREFULLY.*****

MIX DESIGN METHOD FOR CIR WITH FOAMED ASPHALT

The mix design for CIR with foamed asphalt is performed by the Iowa DOT Central Laboratory. The primary steps in the mix design process are:

- Determine the optimum foaming characteristics of the asphalt binder.
- Determine the optimum moisture content of the RAP for compaction.
- Prepare, compact, and cure CIR mixture over a range of foamed asphalt contents
- Determine the optimum foamed asphalt content for the CIR mixture.

1. DETERMINE THE OPTIMUM FOAMING CHARACTERISTICS

By foaming the asphalt binder, the viscosity of the asphalt is significantly reduced to permit uniform mixing with cold RAP material. The ability to foam asphalt is controlled by the asphalt binder temperature and the amount of water injected into the asphalt. These values generally range from 280 to 320°F (135 to 160°C) and 1.5 to 3.5% injected water. The foam is measured by the expansion ratio and half-life. The foam expansion ratio will increase (5 times to 15 times) as the amount of water injected increases. The half-life of the foam decreases (15 seconds to 5 seconds) as the amount of water injected increases. These conflicting conditions are merged to select the best foam properties for the project. An expansion ratio of 10 and half-life of 10 seconds are suitable for most CIR projects. The specification sets the temperature and injection water at values that are acceptable for most binders used for CIR in Iowa when a mix design is not performed.

2. DETERMINE THE OPTIMUM COMPACTION MOISTURE

CIR mixture is compacted to a maximum density through the lubricating affect of the free moisture in the mixture. This is not the moisture injected into the asphalt binder to create foam. To determine the optimum compaction moisture, a group of RAP samples are compacted with different moisture contents. The resulting dry densities are plotted to determine the optimum moisture required for compaction. Mix designs prepared over the last several years indicate that the moisture required to achieve maximum RAP density is approximately 4 percent.

Once the optimum moisture content is determined, the value is adjusted down slightly to account for the foamed asphalt added to the mixture

3. PREPARE MIXTURES

The bulk sample of RAP may require additional processing to achieve a gradation that passes the 1 inch (25 mm) sieve. The RAP is dried in open pans at room temperature, sieved into 3 size fractions (+3/8 inch, +1/8 inch, pan)(+9.5 mm, +2.36 mm, pan), and re-blended to achieve uniform samples.

Prepare a blending chart to determine what amounts of foamed asphalt will be added to the RAP. A minimum of three foamed asphalt contents should be selected. The preferred contents are 1.5%, 2.0%, 2.5%, and 3.0%.

Each batch should have sufficient mixture to compact three 4 inch (100 mm) gyratory samples. The dry RAP sample and compaction water are added to the mixing bowl and mixed for 45 to 60 seconds. The foamed asphalt is sprayed into the damp RAP while the mixer continues to mix the sample. Continue mixing for an additional 60 seconds.

4. COMPACT AND CURE MIXTURES

The gyratory compactor is used to compact each sample to 25 gyrations. Extrude the specimen and place it in the oven to cure at 105°F (40°C) for 72 hours. Remove the specimens from the oven and allow them to cool to room temperature.

5. TEST MIXTURES

Measure the volume and mass of each specimen and determine the density. Sort the specimens into equal sublots based on height and density for further testing.

Dry condition the samples of one subplot in an oven at 77°F (25°C) for 2 hours. The other subplot of specimens are placed in a 77°F (25°C) water bath for 20 minutes, vacuum saturated (50mm Hg) for 50 minutes, and then allowed to rest in the 77°F (25°C) bath for an additional 10 minutes.

Perform the indirect tensile test (IDT) and calculate the average IDT strength for each subplot. Plot the average IDT wet and dry strength for each foamed asphalt content.

6. MIX DESIGN REPORT

The mix design report will provide the results for optimum foam characteristics, optimum compaction moisture content, and optimum foamed asphalt content. Specific report values include:

- Asphalt binder temperature for foaming (°F or °C)
- Percent injection water for foaming (% of asphalt by weight)
- Optimum compaction moisture content (% of dry RAP by weight)
- Optimum asphalt foam content (% of dry RAP by weight)