

TB - 009

MODEL ECR SPECIFICATION

Although early paving experience clearly suggested that tire rubber can be used as a binder modifier (wet process rubber), the dry process was/is designed to use rubber as a mechanical mix modifier. Early testing at NCAT (Willis, 2015) clearly indicated that rubber's primary impact on binder rheology and mix behavior was mechanical. Like fibers, rubber will reduce/eliminate drain-down, but unlike fibers, rubber will promote greater resistance to cracking and rutting by stiffening the mix and interfering with crack propagation. Georgia DOT started using binder modification standards as a part of the use of dry process rubber, but as field data demonstrated that rubber worked without satisfactory binder modification (high MSCR JDIF scoring), the specification focus evolved to a precursor of BMD: rubber quality, minimum/tracked rubber content, verification of rubber addition. As BMD was introduced with dry process rubber in multiple states, mix performance standards were added to the pre-existing rubber quality and feed rate requirements. Dry process rubber has been permitted as an alternative to other forms of modified binder mix designs. It has never been mandated by a DOT.

These specifications can be broken up into six interrelated elements:

1. Product quality requirements
 - a. Physical Property Requirements
 - b. Chemical Property Requirements
 - c. Shipping and Storage Standards
2. Quality Product List designation,
3. Mix design, volumetrics,
4. GTR addition rates
5. Verification of mix modifier (rubber) addition
 - a. Plant engineering requirements
 - b. Plant recordkeeping requirements
6. Mix performance requirements (density, Hamburg LWT, crack testing or other testing as required).

Here is a basic outline of a model specification that can serve as a basis for full specification development.

1. Product Quality Requirements

- a. Physical Property Requirements
 - i. Product sizing: ASTM 30 mesh material (ASTM D 5644.1)
 - ii. Mixed truck and auto tires
 - iii. Specific Gravity >1.02, <1.2

- iv. Product cleanliness: Metal: <0.01% (ASTM D 5603)
 - v. Product cleanliness: Fiber <0.5% (ASTM D 5603)
 - vi. Product moisture content: <1.25% using ASTM D 1503. Note: slightly smaller moisture content values have been used, but three and four-season production of crumb rubber from scrap tires will show slightly higher moisture levels during cooler seasons of the year
 - vii. Mineral Filler: ≤4.0% (AASHTO M 17)
 - viii. Mix Modifier Product Rubber Content Requirement: >95%. Note: There is a direct relationship between the addition of rubber to a mix and enhanced mix performance. There are a number of crumb rubber-based products with highly variable levels of rubber content (as low as 50-60%) and with the presence of other additives designed to modify the binder rheology. These technologies are largely untested in the field and should be considered as separate products requiring separate evaluation/approval processes and standards.
- b. Chemical Property Requirements: Note: These standards were originally developed by the Florida DOT and shared with numerous wet and dry process states.
- i. Acetone Extract: ≤ 25% (ASTM D297)
 - ii. Rubber Hydrocarbon Content: 40-60% (ASTM D297)
 - iii. Ash Content: ≤ 8% (ASTM D297)
 - iv. Carbon Black Content: 20-40% (ASTM D297)
 - v. Natural Rubber: 16 – 45% (ASTM D297)
- c. Shipping and Storage Standards
- i. Ship in either bulk tankers or in water-resistant polypropylene bulk bags
 - ii. Label each bag with product name, size, weight and manufacturer's tracking number

2. Quality Product List (QPL) Designation

- a. All GTR (Ground Tire Rubber) products used as either a binder or mix modifier shall be required to be added to the QPL before use is permitted in DOT Projects
- b. QPL inclusion will require evidence of five years of field testing acceptable to the permitting agency.

3. Mix Design, Volumetrics

- a. Where appropriate, mix designers shall follow the manufacturer's instructions for the use of their product in a mix design.
- b. Mix design volumetric equations shall be modified as follows:
 - i. Additional virgin binder added to offset added GTR surface area and absorption of binder shall be counted as part of the mix virgin binder for volumetrics calculations,
 - ii. GTR shall be included as part of the aggregate when calculating VMA of the mix.
 - iii. GTR SPG shall be 1.15,
 - iv. VMA shall be calculated as follows:

$$VMA=100-G_{mb}(P_s/G_{sb}+P_{GTR}/G_{GTR}), \text{ where}$$

P_s =percent aggregate by total mixture weight

P_{GTR} =percent GTR by total mixture weight

G_{sb} =bulk specific gravity of the combined aggregate

G_{GTR} =GTR specific gravity

- v. G_{se} shall be calculated as follows:

$$G_{se} = (100 - P_b - P_{GTR}) / (100 / G_{mm} - P_b / G_b - P_{GTR} / G_{GTR})$$

P_{be} shall be calculated as follows: $P_{be} = P_b - P_{ba} / 100 * (P_s + P_{GTR})$

- vi. Samples of prepared design mix shall be provided to the DOT Central Lab at least 15 days before the start of paving.

4. GTR addition rates

- a. In general, 5 and 10% additions of approved GTR products as a fraction of neat binder content are sufficient to significantly increase mix stiffness, roughly equivalent to the stiffening caused by the use of one and two grade bump modified asphalts in a mix design.
- b. Verification of mix stiffness can be achieved by the use of HLWT or equivalent analysis. If the mix stiffness is too low or too high, the contractor will be required to adjust the GTR content to provide the desired stiffness.
- c. Varying percentage blends of GTR and other approved additives may be approved by the supervising DOT engineer in order to meet the specific requirements of the contract.
- d. Samples of modified blends of approved GTR products and binder will be provided to the Central Lab of the DOT at least 15 days before the start of pavement construction.

5. Verification of mix modifier (rubber) addition

- a. Plant engineering requirements
 - i. The contractor shall use a loss-in-weight feeder system to feed the approved product into the plant during mix production.
 1. In the case of a drum plant,
 - a. During normal production, the feeder will receive a signal from the binder pump or equivalent that will allow the GTR feed rates to adjust as the plant accelerates or slows mix production. The feeder will record the GTR product input rate at a frequency acceptable to the DOT.
 - b. The feeder shall be accurate to within 2% of the JMF over a period of 8 hours.
 - c. Tracking records for GTR inputs shall be kept as a portion of the project record and shall be provided to the supervising engineer on request.
 2. In the case of a batch plant
 - a. Approved GTR inputs will be tracked through the load cells in the batch mixer.
 - b. GTR additions will be tracked as a part of all mix tracking in the plant by batch.

- c. Tracking records for GTR inputs shall be kept as a portion of the project record and shall be provided to the supervising engineer on request.
 - b. Plant recordkeeping requirements
 - i. The producer shall keep records of all approved GTR product deliveries,
 - ii. The producer shall keep records of all mix production and GTR additions during mix production. Those records should comply with the tracking records discussed above.
- 6. Mix performance requirements**
 - a. Each mix design shall comply with mix testing (BMD) requirements designated by the DOT or other appropriate regulatory authorities.