FHWA Mobile Asphalt Testing Trailer Program

AZ 15102 PROJECT: Executive Summary

About the Program

To provide a long lasting, safe and efficient highway network, the Federal Highway Administration (FHWA) uses the Mobile Asphalt Testing Trailer (MATT) to respond to stakeholder needs (State and local highway agencies, FHWA division offices, and industry). One of the main MATT functions is to refine and standardize innovations in the asphalt pavement industry. The MATT:

- showcases and validates innovative asphalt pavement materials and procedures;
- performs asphalt material test improvement, refinement, and validation; and
- provides demonstration of on-site guidance for asphalt mixture quality assurance.

Activities include data collection, data mining and analysis, data statistical evaluations, workshops, training, and technical assistance. The information gleaned from this effort provides perspective on the state-of-the-practice in materials technology and quality assurance; resulting in an informed position to develop policies and guidance. This is crucial to the effective implementation, and adoption, of new and innovative procedures, materials, and evaluation technologies by both industry and agencies.

The Study

In May 2015, the Arizona Department of Transportation (ADOT) and Nesbitt Contracting Co., Inc. invited MATT to participate in a study to assess the field performance of rubber- and polymer-modified Open Graded Friction Course (OGFC) mixtures. OGFC mixtures typically contain only a small portion of fine aggregate, creating a pavement with a relatively large percentage of air voids that provides improved surface drainage during rainfall. These mixtures also provide improved friction values on wet pavements. This project offered the opportunity for FHWA to evaluate the volumetric and performance properties of open-graded asphalt mixtures (air voids of 20 to 30 percent).

The project also presented a limited opportunity to assess the advantages and disadvantages of using polymer modifiers such as styrene-butadiene-styrene (SBS) or ground tire rubber (GTR) in OGFC mixtures with regard to laboratory-determined material properties.

The plant-produced asphalt mixtures were used in the friction course of the pavement structure on U.S. Route 180 between Columbus Avenue and Snow Bowl Road. The mixtures were produced at Vulcan Materials Company’s drum plant located in Flagstaff, AZ. Three mixtures, which were composed of the same aggregates, similar aggregate structure, and blended with three different terminal-blended asphalt rubbers were considered. The three types of asphalt-rubber used in this project were:

PG70-22 TR+ (contains 8 percent of GTR and 2 percent of SBS with solubility limit of 97 percent)
PG70-22 TR+S92 (contains 8 percent of GTR and 2 percent of SBS with solubility limit of 92 percent)

PG70-22 TR+ SBS (contains SBS)

In addition, all the mixtures contain 1 percent of admixture (cement Type II) produced by Cemex in Victorville, CA. The laydown operations were performed by Nesbitt, the general contractor. The contractor completed the project in seven production days and samples were collected from each production day for testing. These plant-mixed laboratory-compacted (PMLC) samples include:

1. PG70-22 TR+S92 for first three days of paving (PMLC1 to 3)
2. PG70-22 TR+ SBS for next two production days (PMLC4 and 5)
3. PG70-22 TR+ for last two days of production (PMLC6 and 7).

The work plan involved testing of aggregates, binders, and asphalt mixtures. The MATT sampled and evaluated the mixtures through Superpave volumetric and evaluation of durability performance using the Cantabro test. The trailer sampled, tested, and documented the properties of the individual aggregate stockpiles and the extracted aggregates. The shape and texture properties of the aggregates were also analyzed using the Aggregate Image Measurement System (AIMS). Solubility and separation tests evaluated binder stability and quality. The rheological properties of the binder were characterized using dynamic shear rheometer (DSR) to run a strain or amplitude sweep test, frequency sweep test, and multiple stress creep and recovery (MSCR) test; as well as low temperature characterization using the bending beam rheometer (BBR) and Asphalt Binder Cracking Device (ABCD). The main conclusions follow:

**Asphalt Rubber Binder**

Solubility was measured using AASHTO T 44 and modifications to AASHTO T 44 based on recommendations from the Modified Asphalt Research Center at the University of Wisconsin-Madison. Based on the three modified binders from this project, all having solubility measured by AASHTO T 44 greater than 96 percent, toluene was found to be an acceptable alternative to trichloroethylene as a solvent for solubility testing. However, the use of an analytical filters aid is not needed and may result in lower solubility when used with modified binders having solubility greater than 96 percent.

Separation tests conducted in accordance with ASTM D7173 showed that the PG 70-22 TR+ (S 92) binder tends to separate with the GTR particles sinking to the bottom of the storage container. This indicates potential issues associated with storage of the binder during production and construction if the GTR particles do not stay in suspension over time.

Based on AASHTO M 320, Table 1, the PG 70-22 TR+ (S 92) has the largest useful temperature range of 112.7 °C, continuous performance grade of PG 80.7 (13.1) -32.0. The PG 70-22 TR+ has the smallest useful temperature range of 104.3 °C, continuous performance grade of PG 75.5 (20.7) -28.8. The useful temperature range of the PG 70-22 (SBS) is 106.5 °C, corresponding to continuous performance grades of PG 75.6 (15.1) -30.9.
The PG 70-22 TR+ and the PG 70-22 TR+ (S 92) binders are stress-sensitive based on the $J_{\text{ndiff}}$ criterion in AASHTO T 332, while the PG 70-22 (SBS) binder is not stress-sensitive and can be classified as a PG 58E-28 binder. The $J_{\text{nr}}$ values for the PG 70-22 TR+ and PG 70-22 TR+ (S 92) meet the requirements for PG 58E, but the stress sensitivity makes them unacceptable. As expected, considering the modifiers used, the percent recovery for all three binders is well above the AASHTO M 332 minimum criterion for significant elastic response classification. Generally, GTR modification increases the binder’s elastic behavior and its ability to recover its original form after deformation. This behavior may be helpful to resist rutting. However, the MSCR criterion was developed based on polymer modified binders and not GTR modified binders; therefore, using the current recovery criteria for GTR warrants further evaluation.

Low temperature properties based on AASHTO M 320, Table 1 are stiffness controlled for the PG 70-22 TR+ binder and m-value-controlled for the PG 70-22 TR+ (S 92) and the PG 70-22 (SBS) binders. Results using AASHTO M 320, Table 1, AASHTO M 320, Table 2, and the ABCD showed reasonable agreement for the low temperature continuous grade of the three modified binders using standard 20 h pressurized aging vessel (PAV) conditioning at 110 °C.

For extended PAV (40 h) conditioning, AASHTO M 320, Table 1 showed greater change in properties, with the binders becoming highly m-valued-controlled compared to AASHTO M 320, Table 2 and the ABCD. The ABCD low temperature grade showed the smallest change due to extended PAV conditioning. The AASHTO M 320, Table 1 changes indicate that the in-service aging will likely be greater for the PG 70-22 TR+ (S 92) and PG 70-22 (SBS) binders compared with the PG 70-22 TR+ binder.

After standard PAV conditioning, all three binders have Glover-Rowe parameters below the recommended limit of 180 kPa, which according to the literature corresponds to the onset of damage. After 40 hours of PAV conditioning, all binders have Glover-Rowe parameters above the recommended limit for the onset of cracking, but below the recommended limit of 450 kPa for significant cracking.

**Aggregate**

The 2D form of the aggregates in the project was found to be highly circular. The aggregate extracted from PMLC1 sample was the most circular; whereas all the stockpiles had the same relative level of elongation in the aggregate shape.

The gradient angularity measurements indicated that the aggregates were fairly rounded. All the aggregates yielded higher angularity index compared with aggregates obtained by extraction from mixture sample PMLC1.

The texture index indicated that the aggregates from mixture sample PMLC1 seemed to be smoother than the aggregates used to prepare the mixture. This observation suggests that the roughness of the aggregates is decreased by one or all of the following processes: mixing (in plant), compaction (in lab), and extraction.

The Sphericity Index indicated that all the aggregates had a cubicallike (equal dimensions) shape.

**Asphalt Mixture**

The asphalt binder contents of the mixtures as determined by the ignition oven method matched closely to the respective design target values for all the mixtures except PMLC6. The measured
binder content value for PMLC6 deviated more than 5 percent from the target and fell under asphalt design values.

The $G_{mm}$ measured by the “with dry-back” method according to AASHTO T 209 were generally very close to the mix design targets. Overall, for all the mixtures, the “with dry-back” $G_{mm}$ falls in between 5 percent from the target values.

The $G_{mb}$ measured were generally close to the mix design job mix formula (JMF) targets too, with only PMLC6 yielding differences from the target values of more than 5 percent.

PMLC1, 2, and 3 have the same mix designs and resulted in very similar values for air voids ($V_a$) (17 percent). PMLC6 is the mix that showed the highest air voids value (22.5 percent). Higher air void values are generally more desirable for OGFC applications as it holds a direct relation to the permeability of the mixture and its ability to move rainwater away from the surface and decrease traffic splash and spray.

OGFC performance is difficult to quantify using traditional asphalt mixture performance tests. The Cantabro test may provide an indication of OGFC durability. The Cantabro loss for all PMLC samples tested was below 5 percent which generally indicates these are durable mixtures. PMLC6 showed the highest loss percentage with the highest variability, which could be related to its volumetric results. PMLC6 was also the only mixture that resulted in asphalt binder content and $G_{mb}$ values out of the 5 percent tolerance from the target.