

Problem Statement

Many states are now using stone matrix asphalt mixtures (SMA) because they help resist cracking and rutting on heavy traffic roadways. Although the AASHTO standard for designing SMA mixtures (AASHTO PP 41) bases the compaction of volumetric specimens on the Superpave Gyratory Compactor (SGC), many U.S. agencies and contractors continue to use a 50-blow Marshall compaction and are satisfied with the field performance of SMA designed with this method. However, because gyratory compaction is more repeatable and causes less aggregate breakdown compared with the Marshall hammer procedure, there is a desire to establish a compaction level using the Superpave gyratory compactor that provides the same optimum asphalt content as 50-blow Marshall compaction.

Objective

The objective of this research was to determine the number of gyrations with an SGC to match the 50-blow Marshall method using Georgia aggregates. Project work consisted of four tasks:

- 1) Select materials commonly used for SMA in Georgia.
- 2) Conduct SMA mix designs with the materials using four compaction efforts (50-blow Marshall compaction and 50, 75 and 100 SGC gyrations).
- 3) Test the mix designs from Task 2 to evaluate their aggregate breakdown and rutting potential resulting from the laboratory compactive efforts.
- 4) Verify laboratory testing by sampling and testing SMA mixtures produced and placed in Georgia.

Previous Research

In NCHRP 9-8, *Designing Stone Matrix Asphalt Mixtures*, SMA mixtures from 11 projects across the U. S. were sampled and compacted with both the Marshall hammer (50 blows) and with 100 gyrations on the SGC. Based on back-calculated densities in the SGC, it was estimated that on average, 78 gyrations in the SGC would provide the same density as the Marshall hammer.

NCAT also completed an SMA compaction-level study for the Alabama DOT and recommended 70 gyrations for SMA mix design and quality

control. NCAT Test Track cycles have also generated good information on SMA N_{design} , generally indicating that 50 to 75 gyrations can be used to satisfactorily design SMA mixtures.

Description of Study

Materials common in Georgia SMA mixtures were used in this study, including five aggregate sources covering a range of LA abrasion values and flat/elongated percentages, type C fly ash as the mineral filler, cellulose fiber to minimize draindown, 1 percent hydrated lime, and a PG 76-22 binder. The selected materials were combined to produce gradations similar to Georgia DOT-approved mix designs. Optimum asphalt contents yielding 3.5 percent air voids were then determined for each blend gradation using a 50-blow Marshall compaction and 50, 75 and 100 gyrations with the SGC.

Specimens prepared at the respective optimum binder contents corresponding to each N_{design} level were tested in the Asphalt Pavement Analyzer for rutting potential. Aggregate breakdown was also examined by heating and breaking down samples compacted with the Marshall hammer and at each N_{design} level with the SGC. The asphalt was then burned from the aggregate using the NCAT ignition oven, and a sieve analysis was performed on the aggregate.



Figure 1 Labeling of an SMA sample after compaction.

Three SMA projects in Georgia were sampled for verification of the laboratory results. For each project, SMA mix was sampled on four consecutive days to align with typical production variations. The samples were taken at the same time as quality control samples. Four cores corresponding to each sampled lot were also taken after the mix was placed and compacted on the roadway. For each project, the loose

plant mix from each of the four samples was compacted with both a 50-blow Marshall hammer and with the SGC at each N_{design} level. After examining the contractor's quality control data, the core densities and the bulk specific gravities of the lab-compact samples, the two sets of gyratory-compact samples with the greatest range characteristics were chosen for testing in the APA. The samples were tested in the APA under the same test conditions used for the laboratory-designed mixtures. Lab-compact samples were used to evaluate aggregate breakdown.

Key Findings

- 1) The range of gyrations in the SGC to provide the same optimum asphalt content as with 50-blow Marshall compaction for the five lab produced mixtures was 16–79 gyrations, with an average of 35 gyrations. This number of gyrations to achieve the equivalent designs was strongly influenced by the aggregate's resistance to degradation as measured by the LA abrasion test.
- 2) SMA mixes designed with the gyratory compactor yielded lower optimum asphalt contents than the same mix compacted with the Marshall hammer. As the number of gyrations increased from 50 to 75, and from 75 to 100, the optimum asphalt contents dropped an average of 0.5 percent.
- 3) SMA mix designs compacted with the SGC showed good rutting resistance in the APA test, indicating that the rutting potential of the mixtures did not appear to be sensitive to changes in asphalt content.
- 4) Fifty gyrations with the SGC caused slightly less aggregate breakdown compared to compaction with 50 blows of the

Marshall hammer.

- 5) For the field SMA mixtures, an average of 34 gyrations in the SGC provided the same compacted density as 50 blows with the Marshall hammer, verifying the results from the laboratory mix design analysis.
- 6) All field SMA mixtures performed well in the APA.

Conclusions and Recommendations

Results from this study indicate that the relationship between gyrations in the SGC and the 50-blow Marshall hammer procedure is significantly influenced by the resistance of the aggregate to degradation. Because most of the approved SMA aggregates in Georgia have LA abrasion values between 35 and 45, the data indicate that 35 gyrations or fewer would match the compaction provided by 50 blows with the Marshall hammer.

However, that low a compactive effort is outside the range suggested by other SMA N_{design} studies and below the lowest compactive effort used for Superpave mixtures. Fifty gyrations with the SGC are recommended, a number well supported by excellent performance in the laboratory and at the NCAT Test Track. Because using 50 gyrations will reduce the asphalt contents of some SMA mixtures more than others, the minimum asphalt content required by Georgia specifications will control the design asphalt content for those mix designs.

Acknowledgements and Disclaimer

The research reported herein was performed by the National Center for Asphalt Technology, Auburn University. This research synopsis provides a brief summary of the study's final publication. This document is for general guidance and reference purposes only. NCAT, Auburn University, and the listed sponsoring agencies assume no liability for the contents or their use.