



Project Summary Report 0-4203-S

URL: <http://tti.tamu.edu/documents/0-4203-S.pdf>Project 0-4203: Strategic Study for Resolving
Hot Mix Asphalt Related Issues

Authors: Joe W. Button, Arif Chowdhury, and Amit Bhasin

Recommended Resolutions to Selected
Hot Mix Asphalt Related Issues

Approximately 94 percent of paved roads in Texas are asphalt pavements. Each year, rehabilitation of existing roads and construction of new roads require about 12 million tons of hot mix asphalt (HMA), which equates to approximately \$500,000,000. Since 1970, some highways have experienced a 20 percent annual increase in truck traffic, which equates to a 600 percent increase in the number of equivalent single-axle loads (ESALs). Therefore, small improvements in HMA performance correspond to huge economic benefits.

Many changes have recently occurred and continue to occur in the hot mix industry. New HMA mixture design procedures provide significantly more insight into HMA performance than current Texas Department of Transportation (TxDOT) design procedures. New laboratory protocols have improved the ability to identify inferior HMA mixtures. New pavement structural design procedures appear on the horizon. State-

of-the-art protocols need to be evaluated using a wide variety of materials and compared to current TxDOT protocols. TxDOT needs advice on how to proceed regarding these new developments. Databases need to be developed to help validate new processes.

The overall objective of this multi-task project was to recommend improved tools for use by TxDOT to design and control HMA materials for pavements that will meet increasing performance demands. The researchers are confident that properly designed and constructed HMA can provide acceptable service on any highway pavement regardless of the traffic demands. Specific objectives of this project included:

1. Develop laboratory protocols for using the Superpave gyratory compactor (SGC) instead of the Texas gyratory compactor (TGC) (Tex-204-F) to design essentially all of the TxDOT dense-graded HMA paving mixtures.
2. Identify and validate laboratory test protocols for measuring rut susceptibility of HMA mixtures.
3. Identify the best available laboratory test protocol(s) for predicting moisture susceptibility of HMA paving mixtures.
4. Determine the effect of aggregate angularity and nominal maximum size of siliceous river gravel aggregates on performance of selected HMA surface pavement mixtures. That is, investigate whether it is better to use smaller nominal maximum aggregate size (NMAS) with higher coarse aggregate angularity (CAA) (i.e., more crushed faces) or larger NMAS with lower CAA.
5. Measure as-built properties of test pavements and populate a database to be used in a future project for evaluating relationships between pavement performance and measured properties during construction.
6. Obtain and measure certain properties of



several plant-produced mixes for production verification and lab-compacted plant mixes to develop a mixture database for use in evaluating the forthcoming mechanistic-empirical pavement design guide.

All of the activities and recommendations from this comprehensive research project cannot be discussed in this summary report. However, some of them are highlighted below.

What We Did...

Objective 1. The specific goal was to recommend a design number of gyrations (N_{design}) using the SGC for each TxDOT mixture type that will provide acceptable performance. The project addressed the following types of TxDOT HMA mixtures: Type A, Type B, Type C, Type D, Type Coarse Matrix High Binder (CMHB)-C, and Type CMHB-F. During Phase I of this work, the researchers discovered that the TGC and the number of SGC gyrations to match the TGC designs produced mixtures with comparatively low asphalt contents that may yield poor performance (i.e., susceptible to cracking, raveling, aging, and moisture damage). Therefore, a Phase II test program was developed and implemented to determine an acceptable SGC design procedure using fewer gyrations than those proposed following Phase I. More than 60 HMA mixture designs with related materials that TxDOT personnel had designed using the TGC were studied using the SGC.

Objective 2. Twelve field mixes and three laboratory mixtures were tested using the asphalt pavement

analyzer (APA), Hamburg, dynamic modulus, flow time, flow number, and simple shear at constant height for the evaluation of rutting tests (see [Figure 1](#)). Several mixture parameters derived from these tests were ranked and compared with APA rut depth as a base. Rankings of the different parameters were analyzed using statistical techniques.

Objective 3. Nine mixtures were tested using the Hamburg test. Surface energies of the individual aggregates and binders from these mixtures were measured using the Universal Sorption Device and Wilhelmy Plate methods, respectively. Mixtures with and without antistripping agents such as hydrated lime and commercially available liquid antistripping agents were tested.

Objective 4. The primary locally available aggregates in the south Texas districts for highway construction are siliceous river gravels, which typically exhibit a rounded shape. The warm south Texas climate combined with heavy truck traffic related to NAFTA further aggravates any rutting problems that may occur due to the use of low angularity aggregates in HMA paving mixtures. Aggregates, binders, and mixture designs were obtained from the Corpus Christi, Laredo, and Pharr Districts. The selected aggregates were characterized using image analysis, crushed face count, flat and elongated particles, and Micro-Deval tests. Researchers assessed performance of the HMA based on the simple performance tests and the Hamburg test. Comparisons of aggregate properties with mixture performance yielded important information about optimal design



Figure 1. Setup for Simple Performance Tests (Dynamic Modulus, Flow Time, and Flow Number).

of mixtures containing siliceous gravels.

Objective 5. This task was accomplished by obtaining and testing mixtures from nine test pavements on IH-20 in the Atlanta District. Mixtures included Types B, C, and CMHB-C and Superpave. Tests on cores and lab-compacted mixes included APA, indirect tension, permeability, and mix proportions. All mixtures exhibited good quality. The resulting data were placed in a database for future use in evaluating relationships between materials properties and pavement performance.

Objective 6. In response to this objective, about 30 plant-produced mixes and 50 lab-produced field mixes were tested using the Hamburg and dynamic modulus devices. Plant-produced mixes were tested for production



verification, and lab-produced mixes were tested to develop a mixture database for future use, particularly as an aid in verifying the forthcoming national mechanistic-empirical design guide.

What We Found...

Researchers determined that mixtures can be designed using a considerably lower number of SGC gyrations than the number that will match optimum asphalt contents from the TGC and still indicate good performance in the Hamburg test. The final recommended SGC design gyrations from this project should accommodate adequate asphalt in the mixture to improve resistance to cracking, raveling, and aging as well as decrease permeability while providing acceptable rutting resistance.

Findings from the rutting task indicate that flow time and flow number tests capture fundamental material properties and should be considered for inclusion in the mixture design and selection processes. The Hamburg test appears to be conservative and identifies mixtures that are susceptible to rutting as well as moisture damage. Correlations of the Hamburg test with flow time and flow number tests were better than correlations of the Hamburg with dynamic modulus. One should exercise caution when estimating rut susceptibility of mixes based on the dynamic modulus parameters, particularly when evaluating mixtures containing polymer-modified asphalts. The dynamic modulus test does not account for the rebound of mixtures containing polymer-modified asphalt.

Within groups of controlled mixtures, the calculated bond strengths, based on surface energy measurements, related well with the deformation data from the Hamburg test. These findings help validate use of the Hamburg test for mixture acceptance. Measuring surface energy of asphalt is much faster than measuring that of aggregates.

Findings from the south Texas aggregate study do not support the use of finer gravel aggregates (Type D and 9.5 mm) with more crushed faces in the coarse aggregate to maximize rutting resistance. In fact, the finer mixes most often demonstrated the least rutting resistance in the simple performance tests. A decrease in NMAS may adversely affect HMA rutting resistance unless it is offset by improved aggregate shape characteristics. Type C and 12.5 mm materials generally demonstrated the optimum rutting performance in the simple performance tests; however, the fine-graded 12.5 mm mixture performed poorly in the Hamburg test. The change in NMAS did not significantly affect cracking resistance of the mixes.

All of the plant-produced mixtures tested in this project passed the TxDOT criteria.

The Researchers Recommend...

Designers should use the numbers of SGC gyrations indicated in [Table 1](#) to produce good quality HMA mixtures. As a mix design check, HMA mixtures should be compacted to refusal density using the SGC and ensure that the air void content is not less than 2 percent.

Since dynamic modulus is a key input for the proposed mechanistic-empirical pavement design guide, TxDOT should expand the dynamic modulus database to include a wide variety of HMA mixtures from all regions of the state.

To obtain and validate improved performance prediction models, TxDOT should construct test pavements with poor to good quality. Constructing low-quality pavements is not normally an option on public highways.

A study is needed to develop HMA mixture designs using crushed south Texas gravel aggregates composed primarily of coarse aggregates that provide a strong skeleton (e.g., coarse matrix high binder, stone mastic asphalt, and stone-filled gradations).

Table 1. Final Recommendation for Design SGC Compaction Level.

Mixture Type	No. of SGC Gyrations ¹
Type A	90
Type B	90
Type C	120
Type D	120
CMHB-C	120

¹ These values were selected based on tests using primarily limestone and river gravel aggregate, and they may vary significantly depending on aggregate properties.



For More Details...

The research is documented in:

- Report 0-4203-1, *Design of TxDOT Asphalt Mixtures Using the Superpave Gyratory Compactor*
- Report 0-4203-2, *As-Built Properties of Test Pavements on IH-20 in Atlanta District*
- Report 0-4203-3, *Evaluation of Selected Laboratory Procedures and Development of Databases for HMA*
- Report 0-4203-4, *Analysis of South Texas Aggregates for Use in Hot Mix Asphalt*

Research Supervisor: Joe W. Button, TTI, j-button@tamu.edu, (979) 845-9965

Key Researchers: Arif Chowdhury, TTI, a-chowdhury@tamu.edu, (979) 458-3350
Amit Bhasin, TTI, b-bhasin@tamu.edu, (979) 862-3647

TxDOT Project Director: Dale Rand, Construction Division, drand@dot.state.tx.us, (512) 506-5836

TxDOT Research Engineer: German Claros, Research & Technology Implementation Office,
gclaros@dot.state.tx.us, (512) 465-7403

To obtain copies of reports, contact Nancy Pippin, Texas Transportation Institute, TTI Communications, at (979) 458-0481 or n-pippin@ttimail.tamu.edu. See our online catalog at <http://tti.tamu.edu>.

YOUR INVOLVEMENT IS WELCOME!

Disclaimer

This research was performed in cooperation with Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement.