An Executive Summary of the Superpave System

Superpave, The Future of Hot Mix Asphalt Pavements

By Tim Murphy,
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The use of Superior Performing Asphalt Pavement technology or Superpave is increasing around the country. Nearly every state in the US is making some commitment to implement part or all of Superpave technology. From the point of view of many in the highway community, Superpave is the future of hot mix pavements.

Superpave was created to make the best use of asphalt paving technology and to present a system that would optimize asphalt mixture resistance to permanent deformation, fatigue cracking and low temperature cracking.

The key parts of this process are the Performance Graded (PG) system for specifying the properties of the asphalt binder and the volumetric and densification characteristics determined by the Superpave Gyratory Compactor (SGC). The system was developed and calibrated for a wide range of applications—from farm-to-market roads all the way through high-volume interstate roads.

Superpave Versus Conventional Design

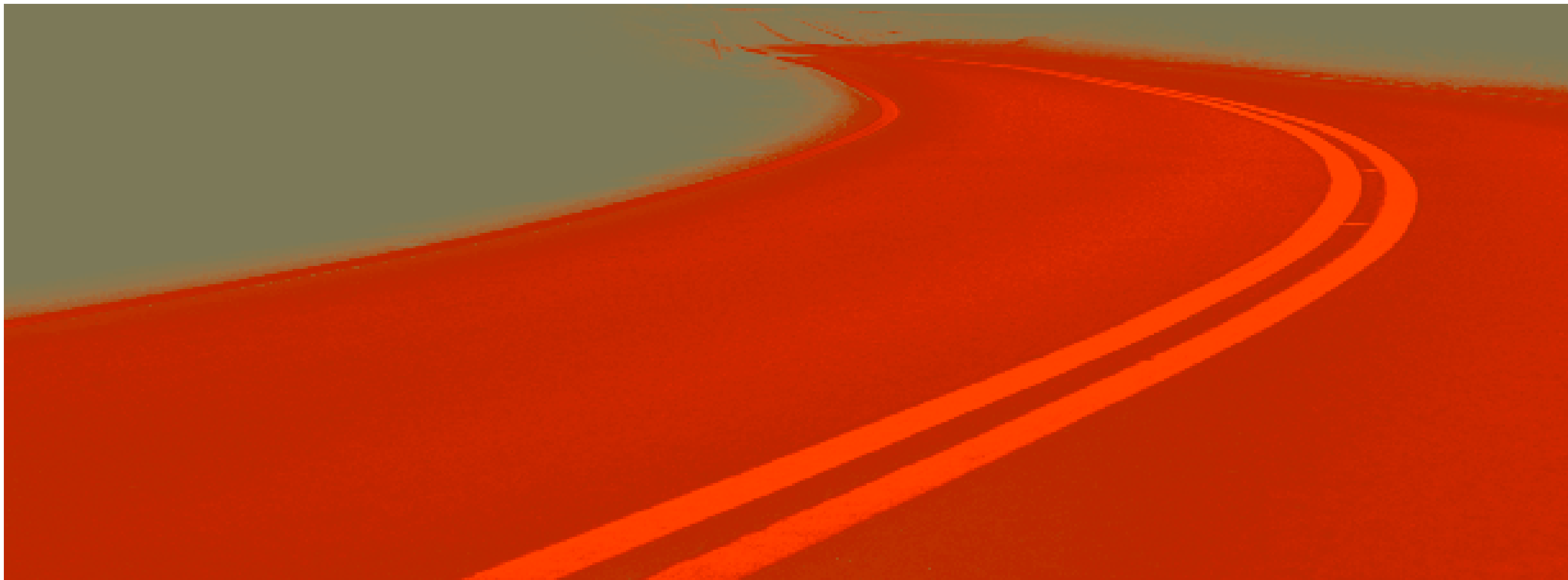
How does Superpave compare with current technology? The conventional mix design system, known as the Marshall method of mix design, primarily addresses the determination of asphalt binder content, while Superpave addresses all the elements of mix design. The primary elements of Superpave volumetric design are:

- Selection of component materials,
- Volumetric proportioning of aggregate and binder, and
- Evaluation of the compacted mixture.

Selecting Materials

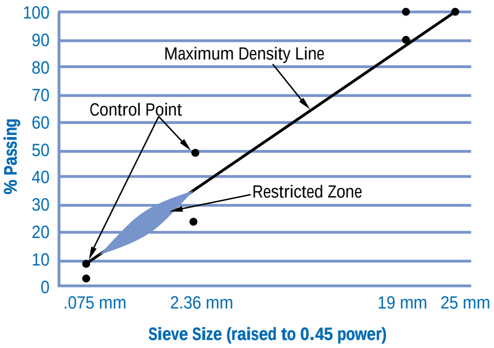
Selection of component materials consists of determining the acceptability of mineral aggregates, asphalt binders, and any modifiers for use in a mix design. Traffic data is used for asphalt binder selection, mineral aggregate selection, and mixture testing criteria.

Aggregate gradation selection is also a part of the Superpave system. Superpave requires different gradation limits for different types of mix-



tures. A helpful tool in the design phase is the 0.45-power gradation chart (Figure 1) that uses four control sizes and a restricted zone. The control sizes used are:

Figure 1: Superpave Gradation for a 19.0 mm Mixture



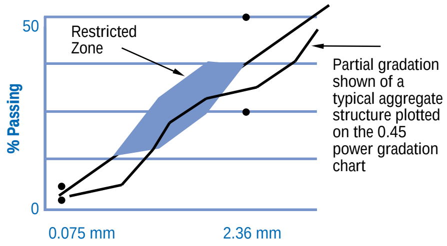
- Maximum sieve size
- Nominal maximum sieve size
- 2.36-millimeter sieve
- 0.075-millimeter sieve.

The restricted zone is an area surrounding the maximum density line from the 2.36-millimeter sieve to the 0.3-millimeter sieve. Gradations should avoid passing through the restricted zone. The control points, along with the restricted zone, are used to control the shape of the gradation curve.

The restricted zone is used for two purposes. Gradations passing through the restricted zone have been observed to have problems meeting some compacted mixture properties, specifically the percentage of voids in the mineral aggregate (VMA). This mixture property is used as an important indicator of mix durability.

The restricted zone also serves to prevent gradations having a "hump" around the 1.18 and 0.6-millimeter sieves, as in Figure 2. A humped gradation is generally associated with a high percentage of fine, rounded sand in the mix. In effect, the zone restricts the use of a high percentage of rounded sands. This is advantageous because excessively rounded aggregates are generally associated with poor shear resistance, a major cause of rutting in asphalt mixes.

Figure 2: The Sand Hump Phenomenon



Selection of Design Aggregate Structure

Several (3 or 4) trial combinations of aggregates are evaluated to determine an appropriate aggregate structure (suitable volumetric and densification properties). Once trial gradations are determined, specimens are mixed and compacted using the SGC procedures.

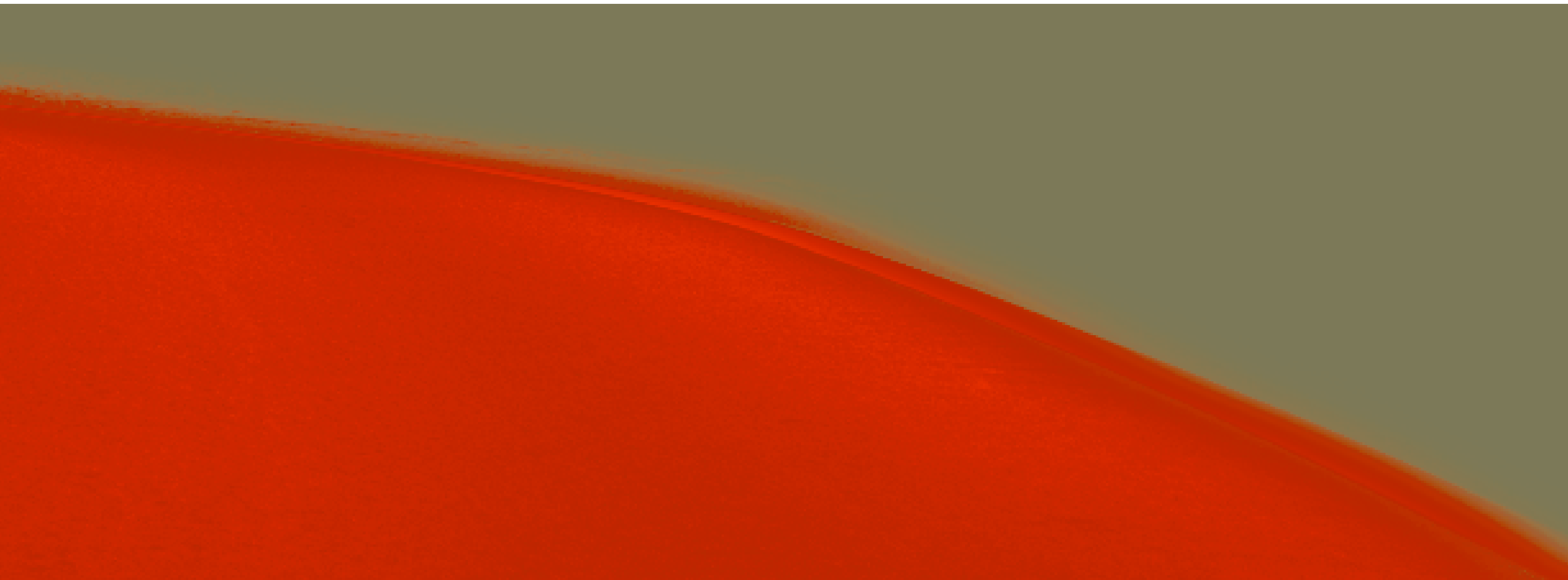
Volumetric and densification properties of the compacted mix specimens are then determined and the trial gradations are compared with mix criteria. Volumetric criteria consists of

- percent air voids
- voids in the mineral aggregate (VMA)
- voids in the mineral aggregate filled with asphalt binder (VFA).

Volumetric properties can be determined based on the densification curves. Of the volumetric properties, the percentage of air voids is the most important. The criterion is fixed at four percent for all mixtures and traffic levels. The percentage of VMA criterion changes as the nominal maximum particle size of the mixture changes. The percentage VFA criterion changes as a function of traffic.

Traffic Function

Increasing traffic results in a lower allowable percentage of VFA. Lower volume roads would and should require higher VFA ranges to increase the durability of roadways. Any trial gradation that meets all compacted mixture criteria may be selected as the design aggregate structure. The purpose of this step is to determine an economic blend of mineral aggregates and asphalt binder that will yield long-lasting, successful performance in a pavement structure.

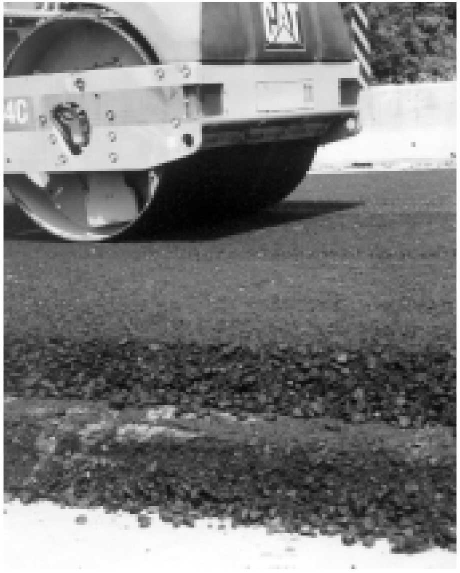


Number of Gyrations

The main feature of this phase is the use of the Superpave Gyratory Compactor. The SGC compacts mixture in a mold through a combination of constant vertical pressure and a constant angle of gyration. The angle of gyration, in conjunction with the vertical pressure, produces a kneading action that compacts the asphalt mixture specimen. Specimen height data is gathered during compaction that allows the designer to measure the rate of densification.

Number of Gyrations

The appropriate number of gyrations ($N_{variable}$) is determined based on traffic and project site high temperature conditions. All of the design volumetric parameters listed above are determined on compacted mixture specimens at N_{design}. The number of gyrations increases as traffic and temperature increases. Therefore, a major highway in Chicago would have a higher number of required gyrations than would a secondary road in McHenry County. Similarly, mixture for a highway in south Texas would require a higher number of gyrations than would a mix for a pavement having the same traffic in Chicago.



This procedure of increasing the required number of gyrations for increased traffic results in changing the asphalt mixture properties and design asphalt binder contents for a given mixture. The increased traffic levels may also require the use of a different type of asphalt cement, or Performance-Graded (PG) liquid binder as is defined in Superpave, for the roadway (ref. Asphalt, *Polymer Asphalt Pavements on the Illinois Tollway*, Fall 1995).

Finally, there is a criterion for the dust proportion of the mixture. This is a calculation that identifies the ratio of material finer than the 0.075-millimeter sieve to the effective asphalt binder content. The criterion is constant for all mixtures and traffic levels. If no trial gradation meets all the criteria, then additional blends of aggregates, or different sources of aggregates, may be necessary.

Design Asphalt Binder Content

After the selection of the design aggregate structure is completed, the designer will need to determine the design asphalt binder content for the mixture. This phase involves mixing and compacting design aggregate structure specimens at several asphalt binder contents. Generally, four asphalt binder contents are used, centered around the estimated design asphalt binder content determined from the design aggregate structure phase of testing.

Mix properties are determined for each asphalt binder content, and graphs are generated showing the change in mix properties with changes in the asphalt binder content of the mixture. The design asphalt binder content can be selected from this data. This is the asphalt binder content corresponding to four

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percent air voids at N_{design}.

All other mix properties are determined at this asphalt binder content. If the mix meets all criteria, then the design asphalt binder content is selected. The combination of design aggregate structure and design asphalt binder content then becomes the design asphalt mixture.

Moisture Sensitivity

The final step in the Superpave volumetric mix design system is an evaluation of the moisture sensitivity of the design asphalt mixture. Design asphalt mixtures having tensile strength ratios (TSRs), as defined in AASHTO T-283, less than 0.8 may be sensitive to moisture damage. While moisture damage is not a distress form by itself, it can accelerate the development and propagation of actual forms of distress.

In summary, the Superpave mix design system provides more information and a more rational mix design procedure than traditional mix designs. The system is suitable for field control of hot mix asphalt and provides substantially more information than the current method used.▲

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verification of the Superpave volumetric mixture design process.

The test track consists of 34 test sections, each 70 meters in length. The original mixtures placed were constructed with a single asphalt binder and a single primary aggregate. Three gradations were placed—*fine, fine-plus, and coarse.* For each gradation, three levels of asphalt binder content and three levels of initial in-place air voids were placed. Five replicated test sections were also placed. During rehabilitation of the track, a second aggregate and asphalt binder source were used to place eight sections of another coarse-graded mixture.

Monitoring and sampling are a key part of the project, as is information on rutting and fatigue performance. The greatest amount of rutting has been associated with mixes with higher asphalt content. In general, the high air void content mixtures have also experienced somewhat higher rutting. The test sections containing coarse-graded mixtures had higher rut depths than the fine-plus graded and the fine-graded hot mix asphalt mixtures.

The largest amount of fatigue cracking was associated with those mixtures placed at initial high in-place air void contents. Mixtures at low asphalt binder contents have also experienced more fatigue cracking than mixtures at higher asphalt binder contents. The test sections containing coarse-graded mixtures had higher amounts of fatigue cracking than the fine-plus and fine-graded mixtures. Performance prediction models and pavement-related specification will be developed from result from the test track.

According to the present schedule, traffic will be placed on the facility through the mid-summer of 1998 (approximately 7 million ESALs). Performance monitoring and sampling will continue during this period. Laboratory testing, analysis and report preparation will continue to April 1999.

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