



Superpave: How it Works and How it Can Work for Local Agencies

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The Superpave system

One of the principal results from the Strategic Highway Research Program (SHRP) is the mixed-design method known as Superior Performing Asphalt Pavements, or Superpave. This volumetric mix design method is intended to replace the Hveem and Marshall methods, and was designed to make the best use of asphalt paving technology and to enhance asphalt pavement's ability to balance the high-temperature rutting and low-temperature cracking characteristics of asphalt concrete. The method's major elements are an asphalt binder specification geared to pavement loading and local climate, a volumetric mix design and analysis system, and a performance prediction system that includes software, a weather database, and environmental considerations.

Superpave uses a performance-based specification system in which tests and analyses have direct relationships to field performance. Tests are performed at temperatures and aging conditions that realistically represent conditions encountered by in-service pavement, which combats the old design method's weakness of eventual rutting. Additionally, the Hveem and Marshall compaction devices have been replaced by a gyrator compactor, and the compaction effort in mix design is tied to expected traffic.

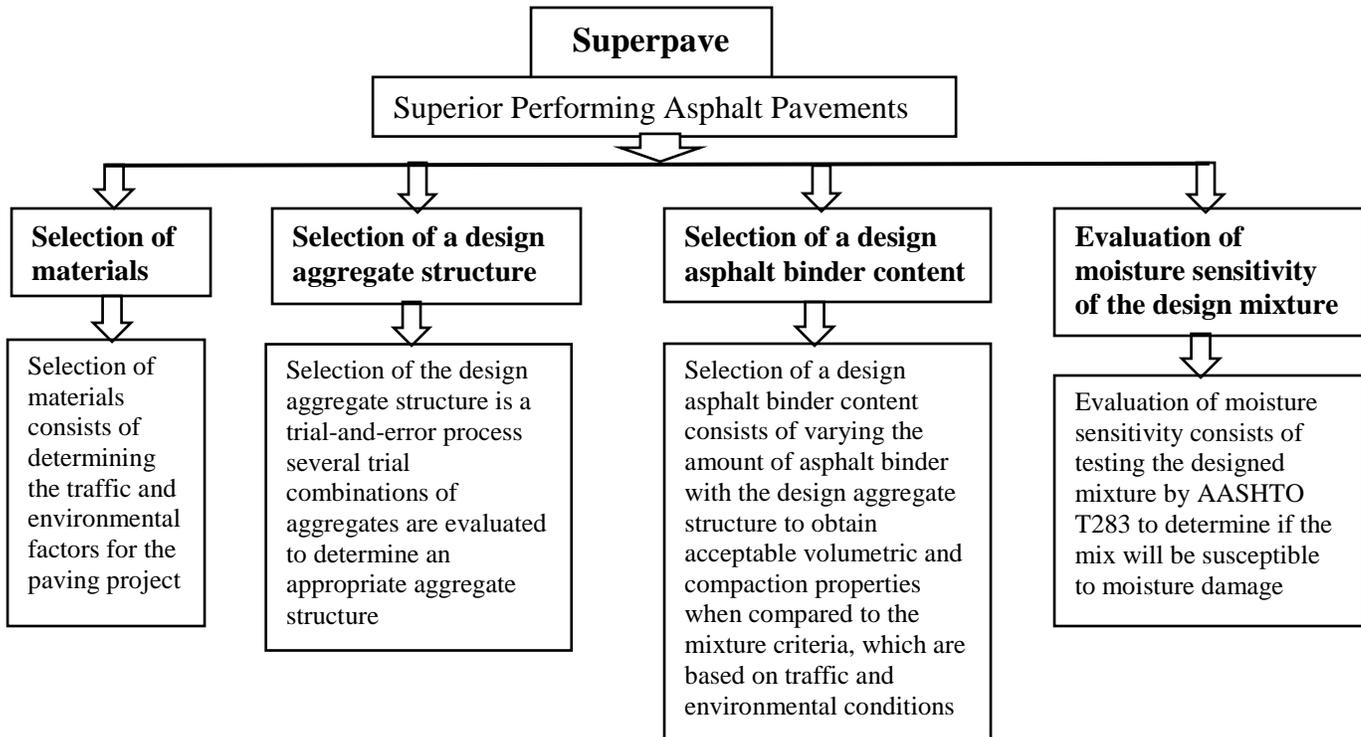
How Superpave works

Asphalt pavement has two basic components: 1) aggregates to carry the load, and 2) asphalt cement to bind the aggregates together. Superpave provides pavement engineers with a method for selecting materials and designing the asphalt concrete mix, and establishes how to select the right type of binder and aggregate. The system also establishes how to integrate material selection and mix design into procedures so that the aggregate and binder work together optimally for better performance and greater durability in all types of traffic and climate conditions. Testing procedures and performance-based models are used to estimate the performance life of hot mix asphalt (HMA) in terms of equivalent single-axle loads (ESALs).

Advantages of Superpave

One shortcoming of the old methods of grading asphalt is that under the penetration and viscosity grading systems, two asphalts may have the same properties at the tested temperature but different properties at another temperature. Superpave addresses this problem by using performance-graded (PG) asphalt binder, which uses a two-number designation such as PG 58-34. The numbers represent the high and low pavement temperature in Celsius at which the

pavement must perform, meaning that PG binders are selected based on the climate in which the



pavement will serve.

Additionally, a key point underlying Superpave mix designs is the idea that the aggregate provides a structure or skeleton that bears most of the load in a pavement, and the asphalt binder holds the aggregates together. In order to provide this structure, the mix of aggregate sizes and shapes must result in a significant amount of point-to-point contact. There must also be a sufficient number of smaller particles to fill in any large gaps in the matrix, but not so many that there is no room for asphalt binder. Superpave addresses both concerns.

Who is responsible for quality?

Construction of cost-effective, quality pavements has always been a central goal of highway agencies. Among the Transportation Research Board (TRB) specifications is determining who is responsible for the quality of construction. Materials-and-methods specifications, end-result specifications, and quality control/quality assurance (QC/QA)—these are some of the specifications that help determine who is responsible.

Materials-and-methods specifications place all responsibility for achieving a quality pavement on the road agency as long as the contractor fulfilled the requirements of the specification. This means that, in terms of responsibility for the quality of construction, materials-and-methods specifications allocate zero percent responsibility to the contractor and 100 percent to the highway agency. These specifications require the full-time presence of experienced field personnel to direct each step, and also obligate the road agencies to accept the completed work regardless of quality. Moreover, if a project fails the parties involved may face an inability to resolve differences and even legal challenges.

On the other hand, end-result specifications are based on properties indicative of potential pavement performance, which place the responsibility for the quality of construction *on the*

contractor. Acceptance or rejection of the final product, as well as applying a penalty system that accounts for the degree of noncompliance with the specifications, is the responsibility of the roadway agency.

A QC/QA specification is a combination of end-result specifications and materials-and-methods specifications that shifts some of the responsibility for quality control from the roadway agency to the contractor. The contractor is fully responsible for controlling the quality of the work, and the state is responsible for ensuring that the quality achieved is adequate to meet the specification bid. The advantage of using a QC/QA specification is that a less variable HMA will be produced with constant control throughout production and placement operations. This reduction in variability creates better performance and longer pavement life, which result in a decreased pavement cost over time.

However, implementing a QC/QA specification may increase costs because of the additional testing required by the contractor. Fully integrating QC/QA specifications into the construction operations allows the contractor to quickly detect and respond to problems. Continuous sampling, testing, and monitoring throughout production and placement of the HMA allows production of a high-quality pavement. QC/QA specifications, therefore, improve contractor/state relations, stimulate contractor innovation and competition, and improve the quality of pavements.

KDOT quality control and acceptance for Superpave QC/QA mix

All state highway agencies require a unique specification that will fit their situation at a given time. The Kansas Department of Transportation (KDOT) has a definition of QC/QA specifications similar to that found in the TRB glossary of terms: a combination of materials-and-methods specifications and end-result specifications. Based on KDOT QC/QA specifications, the contractor is responsible for QC (process control), and KDOT is responsible for verification. The contractor and KDOT use random sampling and lot-by-lot testing that tell the contractor if the operations are creating an acceptable product.

KDOT requires contractors to “provide a quality control organization or private testing firm having personnel certified according to the Policy and Procedures Manual for the Certified Inspection and Testing (CIT) Training Program.” Contractors will need “personnel certified in Aggregate Field Tester (AGF), Aggregate Lab Technician (ALT), Superpave Field (SF), Profilograph (PO) and Nuclear Moisture Density Gauge Tester (NUC) classifications.” Further, contractors must provide “a minimum of one employee on the project certified in the QC/QA Asphalt Specs (QCA) classification.”

KDOT requires the certified individual to be on the project site whenever HMA is being produced and placed at the project site. The person must perform and use quality control tests and other quality control practices to ensure that delivered materials and proportioning meet the requirements of the mix designs. That person should also periodically inspect all equipment used in transporting, proportioning, mixing, placing, and compacting to guarantee it is operating properly so that placement and compaction comply with the contract requirements. Consequently, one person working for KDOT and one person working for the contractor on a Superpave project must be certified. These certifications are necessary for all KDOT Superpave projects.

KDOT sampling process

Pavement samples from behind the paver must be obtained before compaction using a three-sided shovel pushed into the mat. A squire shovel without sides is then used to extract all asphalt mixtures from the selected locations. The sample is obtained by KDOT personnel from a minimum of three locations randomly selected throughout one truckload of placed material. The sample is collected into a cooler with a steel lining and is then transferred to the field lab for testing.

During the production, the contractor must take four quality control samples per lot of 3,000 tons. If two lots meet all the requirements, the lot size will be increased from 3,000 to 4,000 tons. If two more lots meet all the requirements, the lot size will be increased from 4,000 to 5,000 tons. For QA, KDOT takes one independent sample per lot.

KDOT commercial-grade mix and QC/QA mix

KDOT uses both commercial-grade and QC/QA Superpave mix. Commercial-grade Class A mix has roughly the same requirements as the method for SR-12.5A QC/QA mix, with properties for a 20-year design traffic range of 300,000 to < 3,000,000 ESALs. The central difference between the two is how they are tested in the field and how KDOT accepts these mixes. KDOT accepts commercial-grade based on cold-feed (virgin aggregate) gradation tests by KDOT. The samples are collected at the plant, and gradation tests are performed by KDOT for acceptance purposes. KDOT checks to see if the gradation in the field matches the gradation of the approved mix design; if it does not, a deduct may be applied if prescribed by specification.

On QC/QA projects, HMA samples are collected from behind the paver by the contractor and by KDOT, and volumetric and other tests are performed by both parties. The contractor's results will be used for acceptance purposes if the test results are verified by KDOT. In-place compaction on commercial grade is controlled using an approved rolling procedure while in-place density testing is performed on QC/QA mixes with a plan thickness of 1.5" or greater. Bonuses or deducts may be prescribed by specification for air voids and in-place compaction on QC/QA projects. KDOT uses statistical methods to compare contractor and KDOT test results, and more than two lots of production are needed to get sufficient data to perform the tests.

Tests required by KDOT for QC/QA mixes

There are multiple tests to be performed during the production and placement of HMA. These tests are used to compare the characteristics of the HMA being produced and placed to characteristics that are known to represent a good product. Density, asphalt content, and aggregate gradation are three of the most commonly controlled characteristics.

Mixture and Mat Characteristics Controlled in QC/QA

Characteristics	Tests
Aggregate Gradation, (extracted)	QC/QA
Aggregate Gradation	QC/QA
Asphalt Content (extract)	QC/QA
VTM	QC/QA
VMA	QC/QA
Voidless Unit Weight	QC/QA
Dust to Asphalt Ratio	QC/QA

TSR	QC/QA
Mix Temp.	QC/QA
Mat Density	QC/QA
Clay Content	QA
Smoothness	QC

Superpave for local (low-volume) roads

Low-volume roads may have different requirements in terms of mix design performance, aggregate and availability, and project budget levels. The requirements of mix design are performance-related and can be less restrictive for low-volume roads than for higher volume roads. Aggregate requirements (mostly consensus properties) can also be less restrictive. However, if Superpave requirements for crushed aggregate under higher traffic loads hold for lower traffic levels, it could lead to increased costs.

The Iowa Highway Research Board conducted a research project to determine if the Superpave mix design strategy for low-volume roads is practical and economical. Eight projects were selected in five counties, and performance evaluation data were collected annually. In these projects, the use of performance-graded binders resulted in much less thermal transverse cracking than typical for that area. In addition, no significant construction problems or increases in costs related to the use of Superpave were observed.

Superpave case study in Kansas: Douglas County Route 458 improvements

This Douglas County project aimed to improve 4.5 miles of Route 458 from the N 950 Road/E 800 Road to just north of the E 1000 Road/N 1156 Road intersection southeast of Clinton Lake. The purpose of the project was to improve safety by reconstructing three 40-mph curves to meet 55-mph design speed, constructing 6.5'-wide paved shoulders throughout the project length, and flattening roadside slopes. Replacing existing culverts and rehabilitating the existing pavement in tangent sections was also included in the scope of this project, which is currently underway.

Route 458 is a medium-high volume, Principal Arterial road in Douglas County, with average annual daily traffic of 1,950 vehicles per day, 17 percent of which are trucks. The road's original grading dates to 1955, and was subsequently surfaced by county forces with crushed rock base and double chip seal surface treatment. The road has been patched, overlaid with asphalt pavement, and chip-sealed as needed in the decades since construction. Borings revealed an average of 6.5" crushed aggregate base with 8.5" asphalt pavement, which was in fair condition with some cracking, rutting, and shoving.

The project specified SM 12.5A (PG 64-22) HMA base course and SM 12.5A (PG 70-28) surface course. In the full-depth pavement in the curve relocations, the Superpave mix base course was placed in three lifts with a total (nominal) thickness of 7 inches on 6" aggregate base. In the tangent sections, the existing pavement is being milled 1" with a 2" HMA base course. A 2" surface course will be laid over the entire project length. Since use of QC/QA is required for Superpave mixes, Douglas County hired Kaw Valley to do the testing. Douglas County is using a Superpave mix in this project with the expectation of longer service life and reduced contracted maintenance costs over the life of the pavement. Douglas County Public Works Director Keith Browning says that it will be "a few years into the future" when Superpave benefits are realized, and that the section of 458 with Superpave "will require less maintenance in future years."



N950 and E850, placing the first lift of asphalt on 3,700 feet of road



N1000 and E1000, placing and compacting the second lift of asphalt

Conclusions

Superpave was developed to address the rutting and transverse cracks that occurred using the Marshall and Hveem methods and produce higher quality asphalt pavement.

KDOT uses two types of asphalt pavement mixes: commercial-grade and Superpave QC/QA. The main difference between the two mixes is how they are tested in the field. KDOT does not require counties to use Superpave. Commercial-grade mix is a type of material-and-method specification, in which KDOT or the roadway agency specifies both the materials and the construction process to be used by the contractor. This system neither rewards the contractor nor encourages the contractor to be creative during the construction process. The roadway agency assumes most of the risk, but receives the benefit of only requiring a simple test for acceptance.

However, a more successful asphalt pavement is one that is constructed according to unique specifications, and this can be achieved by applying QC/QA specifications. These specifications divide the responsibility of producing a quality asphalt pavement into QC conducted by the contractor and QA performed by the roadway agency. Using QC/QA Superpave mixes, then, can control and improve the quality of producing, placing, and constructing asphalt pavement. This may result in an increased service life and reduced maintenance costs over the life of the pavement. Research has shown this to be true in Iowa and Douglas County is hoping for the same results on their recent project.

Sources:

- Email Correspondence: Blair Heptig on 10/10/2017 and 10/28 /2017; Keith Browning on 10/13/2017, 11/1/2017, and 2/21/18; and Tod Salfrank on 10/23/2017.
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- Mogawer, W and Malik, R.B. *Design of Superpave HMA for Low Volume Roads, 2004*, a research project conducted by University of Massachusetts—Dartmouth, North Dartmouth, MA. The research presents determination of the optimum value of a key volumetric property and an optimum number of design gyrations for producing compacted HMA mixes with adequate resistance against aging/high stiffness related durability problems: http://www.cti.uconn.edu/pdfs/netcr51_01-03.pdf
- Edward J. Engle, Low Volume Road. Iowa Highway Research Board, October 2004, a research project that describes the practicality of Superpave for low volume roads: http://publications.iowa.gov/17197/1/IADOT_tr414construction_Superpave_Mix_Design_Low_Vol_Rds_2001.pdf

Suggested Resources on This Topic:

- KDOT Commercial grade mix requirements: <http://www.ksdot.org/Assets/wwwksdotorg/bureaus/burConsMain/specprov/2015/611.pdf>
- KDOT QC/QA mix requirements: <https://www.ksdot.org/Assets/wwwksdotorg/bureaus/burConsMain/specprov/2015/602.pdf>
- Superpave mix designs approved by KDOT: <https://kdotapp.ksdot.org/HMA/HMA.aspx>
- KDOT's Superpave Manual. The manual includes Superpave mixture design and analysis, Laboratory Manual, KDOT Standard Test Methods and Special Provisions for Superpave: https://conferences.k-state.edu/superpave/files/2016/02/Superpave2017_Final_11.22-27c8u7t.pdf.
- FHWA Superpave Fundamentals Reference Manual. The Manual includes the objective of Superpave, drawbacks of old methods, how Superpave improved HMA, Superpave asphalt binder specifications and requirements, how to select Superpave asphalt binder, asphalt mixture volumetric and mix design procedure, and impact of Superpave on HMA Construction: <https://idot.illinois.gov/Assets/uploads/files/Transportation-System/Manuals-Guides-&-Handbooks/T2/P028.pdf>
- QC-QA Certified Hot Mix Asphalt Technician Manual, developed by the Indiana Department of Transportation. It includes HMA materials and production characteristics

with focus on QC/QA procedures:

<http://www.in.gov/indot/div/mt/manuals/CertifiedHotMixAsphaltTechnicianManual.pdf>

- North Dakota QC/QA Introduction to Asphalt, a presentation prepared by the North Dakota Department of Transportation to explain asphalt and QC/QA procedures:

<http://www.dot.nd.gov/divisions/materials/ttqp/intro2016.pdf>

- Asphalt Pavement Design Guidelines for Low-Volume Roads and Parking Lots:

http://www.pavprod.com/sc_asphalt_pavement_guide.pdf