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ONTARIO ASPHALT PAVEMENT COUNCIL

The ABCs of
Superpave

The Road to Success for Asphalt Pavements

SUPERPAVE – SUPERIOR PERFORMING ASPHALT PAVEMENTS

Superpave is a system that was developed by Federal Highways Authority (FHWA) to improve the performance of hot mix asphalt (HMA) pavements. The system provides pavement engineers and contractors with a rational method for selecting materials and designing an asphalt mix. It establishes how to select the right type of aggregate, the right type of asphalt cement and how to design the mix so that the aggregate and asphalt cement work together optimally for better performance and greater durability under all types of traffic and climatic conditions.

The Ontario Ministry of Transportation (MTO) started implementation of Superpave in the late 1990s and the mix design technology has been standard on all MTO projects since 2006.

The objective of any HMA mix design is to determine the combination of aggregates and asphalt cement that will provide a durable pavement that is resistant to permanent deformation (rutting), fatigue cracking, and low temperature cracking. Superpave mix design system includes detailed aggregate requirements, and procedures for selecting the appropriate asphalt cement based on the environmental conditions and anticipated traffic loadings. Correct use of the Superpave system provides a HMA mix that strikes a balance between a stable aggregate structure with the appropriate type and amount of asphalt cement, for a stable and durable HMA within a pavement structure.

DEFINING TRAFFIC

Superpave accommodates a wide variety of traffic conditions by identifying different design requirements based on traffic categories. Knowing the traffic category, pavement engineers can design a mix using differing aggregate and mix performance characteristics to tailor the mix to suit specific traffic loading.

In most cases, the owner agency establishes the traffic category at the contract design stage and states it in the contract tender documents.

Traffic counts are the best way to establish a traffic category and confirm the number and weight distribution of trucks using the road. Typical traffic counts for provincial highways from 1989 to 2004 are available on the MTO web site and designers can use Table 1 from OPSS.MUNI 1151, as a simple guide.

Choosing the correct traffic category for the road will ensure that the chosen mixes have sufficient stability to withstand the stresses from the anticipated traffic, to resist rutting in the mixture.

HOW SUPERPAVE WORKS

An asphalt pavement has two interrelated components: aggregates to carry the load, and asphalt cement to bind the aggregates together. The properties of the individual components are important, equally as important is the behavior of the combined mixture. A properly designed Superpave mixture will have an aggregate structure that is strong to resist compressive and shear stresses from the traffic loading, and flexible to resist tensile stresses from repeated loading that otherwise cause fatigue cracking.

ASPHALT CEMENT – Asphalt cement is the glue that binds the pavement together. Using a classification system called Performance Graded Asphalt Cements (or PGACs), asphalt cements are graded and selected based on their performance under climatic conditions and traffic loading. Like traffic category, the grade of PGAC is typically determined by the owner and is stated in the contract tender documents. According to the 1999 Ontario Ministry of Transportation life cycle costing study, PGACs can extend the life of an asphalt pavement by at least two years.

A more detailed explanation of PGACs and how they should be specified in Ontario is found in the ABCs of PGAC posted on the OAPC web site www.onasphalt.org.

AGGREGATES – Aggregates, produced from gravel pits or quarries, are the backbone of a pavement. Superpave defines the key aggregate properties

TABLE 1 (OPSS 1151 – NOV 2006) · SUPERPAVE DESIGN TRAFFIC CATEGORIES BY ESALS

ONTARIO TRAFFIC CATEGORY	20 YEAR DESIGN ESALS	TYPICAL APPLICATIONS
A	Less than 0.3 million	Low volume roads, parking lots, driveways, and residential roads.
B	0.3 to 3 million	Minor collector roads.
C	3 to 10 million	Major collector and minor arterial roads.
D	10 to 30 million	Major arterial roads and transit routes.
E	Greater than 30 million	Freeways, major arterial roads with heavy truck traffic, and special applications such as truck and bus climbing lanes or stopping areas.

Note: Equivalent Single Axle Load (ESAL) for the projected traffic level expected in the design lane over a 20-year period, regardless of the actual design life of the pavement.

such as size, shape and angularity that give the pavement the strength and durability to meet a variety of traffic conditions. The aggregate combination used in hot mix pavement is a blend of aggregates from various sources which ranges in size from small grains of sand up to stones of about 50 mm in diameter, depending upon the application. The final selection of the specific aggregates used for a mix depends on the traffic loading of the pavement. OPSS 1003 outlines the aggregate quality required for different traffic levels.

For high volume traffic conditions, more "stone on stone" contact is desirable for strength and durability. As the traffic level goes up (from Category A to E), so to does the required quality of both coarse and fine aggregates, with the Superpave system. In addition, the HMA near the surface (the upper 100 mm of the pavement structure) requires higher quality aggregates to meet higher pavement stresses than those deeper in the pavement structure.

For the lowest traffic category, Traffic Category A, local aggregates used in the past to make Marshall mixes can still be used. Traffic Category B mixes have some additional stipulations on aggregate properties but almost all aggregates used in the past for Marshall mixes should meet these criteria.

The additional coarse and fine aggregate quality requirements for Traffic Category C may result in a reduction in the amount of certain natural sands and rounded pit

source stone and an increased use of manufactured sand or washed screenings together with quarried stone. (This will not apply to all parts of the province but may have some significance for aggregate from parts of southwestern Ontario). However, these additional requirements only apply to the top 100 mm of the pavement. Superpave does allow local aggregates to be blended to meet specifications requirements.

Mixes for Traffic Category D and E are similar to the heavy-duty mixes specified on higher volume roads in the past. Surface course mixes requiring superior skid resistance are specially designated as 12.5 mm FC1 and 12.5 mm FC2 mixes (FC stands for Friction Course) and they are similar to the HL 1 and DFC mixes. Since the aggregates for these mixes come from designated sources as they have in the past, there is little change in the system.

The mix design, which takes all these technical requirements into account, ensures an optimum blend of the correct aggregates.

MIX SELECTION – Superpave uses a volumetric approach to mix design. A gyratory compactor simulates traffic conditions in the laboratory. Using Superpave mix designs, contractors can produce asphalt mixes to meet specific traffic loads and climates.

Superpave is about selecting the proper mix to suit the traffic and climatic conditions. This includes specifying that the lift thickness is at least 3 times (preferably 4 times) the thickness of the Nominal Maximum

Aggregate Size of the blended aggregate to ensure adequate compaction and thus adequate long-term performance.

The mix design process also addresses durability by determining the moisture sensitively of the mix. *(See below)*

SPECIFICATIONS
MTO, Municipalities and consultants use the Ontario Provincial Standards (a set of standard specifications and drawings) for the tendering of contracts in Ontario. The latest edition of the following OPS Specifications should be referred to when preparing tenders.

OPSS 1003
Material Specification for Aggregates - Hot Mix Asphalt

OPSS 1101
Material Specification for Performance Graded Asphalt Cement

OPSS 1151
Material Specification for Superpave and Stone Mastic Asphalt Mixtures

Training

The Ontario Asphalt Pavement Council, in conjunction with the Asphalt Institute, provides Superpave mix design training courses for contractors, consultants, and municipal and provincial engineers from across Ontario. Private consultants have also developed training courses. The Canadian Council of Independent Laboratories has a certification program for Superpave mix testing to meet Provincial qualification requirements. Lunch & Learn seminars and/or webinars are also offered by the OAPC.

MOISTURE SENSITIVITY

Moisture damage in hot mix asphalt pavements, better known as stripping, is a primary requirement of Superpave. Stripping can be a cause of distresses in the asphalt pavement layers. The water induced damage in HMA layers is typically associated with the loss of adhesion and/or loss of cohesion. This occurs when water gets between the asphalt and aggregate typically because the aggregate

has a greater affinity for water than the asphalt. This essentially strips the asphalt film away resulting in poor mix durability. To help prevent stripping, aggregate treatments such as Hydrated Lime, or approved chemical alternates can be used, or liquid anti-stripping additives can be added to the asphalt cement if required.

The most widely used method for determining HMA moisture resistance is the AASHTO Standard Method of Test T 283, "Resistance of Compacted Bituminous Mixture to Moisture Induced Damage". A set of six compacted specimens are fabricated to 7 percent ±0.5 percent air voids, the specimens are grouped in two subsets: one subset is conditioned and the other is dry. The tensile strength of "conditioned" sample S_2(Conditioned) – which is the measurement of the tensile strength resulting from water saturation, and accelerated water conditioning including a freeze-thaw cycle – is compared to the tensile strength of "unconditioned" sample S_1(Dry) to determine Tensile Strength Ratio (TSR) as follows:

$$\text{TENSILE STRENGTH RATIO (TSR)} = \frac{S_2}{S_1}$$

S_1 = average tensile strength of the dry subset, psi (kPa)
S_2 = average tensile strength of the conditioned subset, psi (kPa)

The requirement in Ontario is a minimum value of TSR = 80% in the moisture sensitivity test for Superpave HMA mixtures in Ontario. A visual (subjective) estimation of the magnitude of stripping of the conditioned sample is also required as part of the test procedure.

The T 283 test method and other published stripping tests all have inherent weaknesses that result in an ongoing search for a better moisture susceptibility test. These weaknesses tend to be issues with repeatability and reproducibility of test results and questionable link to performance.

PERFORMANCE TESTING

The Superpave System is evolving to provide an even higher level of confidence in the mix design process through development of performance tests. The performance-based mix design concept involves using performance predicting tests in conjunction with the standard mix design procedure to choose the gradation and asphalt cement content.

The procedure would incorporate a test for rutting and one or more tests for cracking according to the mix type and the project. The rutting test will control the upper limit for the asphalt cement content of the mix while the cracking test will control the lower limit for the asphalt cement content of the mix.

There are many contenders for the cracking prediction test. The leading contenders are some version of the Semi-Circular Beam Test (SCB) and the Disk Shaped Compact Tension Test (DCT). Both tests use samples initially prepared in the Superpave Gyratory Compactor. The SCB uses a semi-circle sample with a crack inducing axial saw cut tested in three-point loading to produce tension on the lower surface and across the cut. There are several different procedures and alternate calculation methodologies. The DCT uses a circular sample with an axial crack inducing saw cut tested in tension across the cut. Both tests give a value for the stress needed to initiate failure and a stress necessary to propagate continuing failure.

The Asphalt Mixture Performance Tester (AMPT) and the Hamburg Wheel Tracking Test (HWTT) are the two leading contenders for the rutting prediction test in North America. Both tests use samples initially prepared in the Superpave Gyratory Compactor. The AMPT tests the sample in cyclical axial loading at lower than failure stress and provides a Flow Number (the point at which the sample starts to change at a faster rate) which has been shown to correlate well with rutting in the field. The HWTT exposes the sample to repeated loading from a weighted steel wheel and identifies the point at which the sample starts to change at a faster rate. Two values are obtained, the rut depth at a number of wheel passes and the stripping inflection point (the point at which the sample starts to change at a faster rate). Some agencies use this test to evaluate moisture sensitivity.

The issue with these tests is that we don't have enough experience with them in Ontario. A concentrated and collaborate effort is needed between owner agencies and industry to develop confidence and the acceptance criteria for mixes produced in Ontario.

Sources:

1. http://www.raqsb.mto.gov.on.ca/techpubs/TrafficVolumes.nsf/tvweb
2. Refer to Appendix A of OPSS 1151 for an explanation of the NMAS and lift thickness.