GUIDELINES FOR SUPERPAVE BITUMINOUS CONCRETE MIXES

Superpave Traffic Level Rationale

For each nominal maximum aggregate size, the Superpave design method contemplates four traffic levels which are based on the accumulated traffic to which they will be subjected over their in-service life. The accumulated traffic in the Superpave design method is characterized by standardizing the axle loads into an equivalent number of repetitions of a single, 18-kip reference axle. These loads, called Equivalent Single Axle Loads (ESALs) are accumulated over the design life of the pavement and determine which Superpave traffic level is used. The higher the volume of traffic of the roadway, the higher the number of ESALs, and the higher the Superpave traffic level of the mix. Consequently, a substantial length of interstates and expressways would require a Superpave Traffic Level 4 mix, whereas many secondary roadways with low traffic loadings would be best served by Superpave Traffic Level 2 mixes.

(Note: The state of the art in traffic characterization for pavement design is to consider "load spectra" instead of ESALs to measure the cumulative effect of traffic loadings on a pavement structure. This is part of the upcoming AASHTO Mechanistic Pavement Design Guide.)

The Connecticut Department of Transportation has reduced the number of Superpave traffic levels needed for the state roadway system to two – Traffic Level 2 and Traffic Level 3. Traffic Level 1 and Traffic Level 4 mix design requirements were eliminated due to very low demand for these mixes on the state roadway system. However, Traffic Level 4 mix characteristics are still needed on a few select, high volume roadways. Traffic Level 4 design characteristics can be achieved by stiffening the high temperature end of the asphalt binder and applying that to a Traffic Level 3 aggregate structure. By altering the binder only, Traffic Level 4 performance characteristics can be achieved. This is typically accomplished by the addition of a polymer modifier. When a polymer is added, the bituminous concrete shall be designated as Polymer Modified Asphalt (PMA) and should be specified, measured, and paid for under the appropriate PMA item.

Modified Superpave Bituminous Concrete Mixes

The term "modified" in this context refers to any bituminous concrete that has been altered from its normal/original/neat state. Almost always it is the liquid asphalt binder that is modified or altered from its original state. During a typical refining process, the asphalt binder created or generated is most commonly PG 64S -22 – with PG referring to performance grade, S referring to standard, 64 referring to the upper temperature performance limit in degrees Celsius, and -22 ("negative 22") referring to the lower temperature performance limit (^{o}C). The upper limit is the average 7-day maximum design temperature and the lower limit is the 1-day minimum design temperature. Much like multi-grade motor oils, asphalt binders are manufactured and formulated to perform over various temperature ranges.

Various refining methods and strategies can produce varying grades of liquid asphalt binders, but there are limitations to the performance grades that can be achieved through the refining process alone. Using other modification technologies allows asphalt producers to extend the performance characteristics of commonly produced asphalts. There are different reasons for modifying liquid asphalt binders used in hot mix asphalts. The two primary forms of asphalt modification currently being used by the Department are 1) Polymer Modified Asphalt and 2) Warm Mix Asphalt.

1) Polymer Modified Hot Mix Asphalt (Polymer Modified Asphalt – PMA)

Polymer is a technical word for plastic. Plastics can be formulated to have certain strength and stiffness characteristics throughout all types of temperature ranges. When the right polymer, at the right amount, is added to asphalt it can greatly enhance the properties of the asphalt without any detrimental effect to any other performance characteristic.

Higher volume roadways see more trucks and other heavy vehicles and are susceptible to rutting during the hot summer months. Asphalt softens with increases in temperature. It is when temperatures are hottest and traffic is the heaviest that asphalt pavements are most vulnerable to deformation – (flushing, bleeding, rutting, and shoving). There are two ways to stiffen bituminous concrete – make the aggregate interlock stronger and/or stiffen the binder properties at higher temperatures. Substituting a more effective binder – one that is stiffer at high temperatures – is the easiest and most effective way to accomplish this. And it provides other additional benefits such as increased durability and increased resistance to cracking. Strengthening the aggregate matrix, while increasing the mix's ability to withstand high temperature loading, typically leads to a reduction in asphalt content to make room for more tightly packed aggregate. **Lower asphalt contents cause many detrimental effects to the durability of the bituminous concrete. This makes polymer modification of liquid asphalt the best choice.**

The standard Superpave binder (PG 64S -22) can be modified to create other PG grades, primarily ones that are stiffer on the high temperature end of their grade, while still maintaining the low temperature grade desired. For example, a relatively small amount of polymer can be added to generate a PG 64E -22, which essentially performs like a PG 76 -22. The E in this case stands for extreme. A PG 76 -22 binder has the same low temperature performance as a PG 64 -22, but better rut resistance and durability at higher temperatures approaching 76 degrees Celsius. A Traffic Level 3 mix design using PG 64E -22 will generally deliver the same rut resisting performance as a Traffic Level 4 Superpave mixture with PG 64S -22, without reducing the asphalt content. The Department has adopted the use of PMA for all interstate roadway resurfacing as well as for any rut prone section of roadway. For such roadway sections, specifying Traffic Level 3 Superpave Polymer Modified Asphalt is desired.

Adding polymer also increases the overall durability of bituminous concrete and can be added to help resist cracking and raveling/disintegration of any level and type of

Superpave mixture. Using polymer modification for enhanced durability and cracking resistance should be evaluated on a case by case (project by project) basis. Note that polymer can make the mix sticky and causes hand placement to be difficult. It is not appropriate for pothole patching or most trenches for this reason.

If polymer modification of bituminous concrete is required, it should be specified, measured, and paid for under the appropriate "PMA" item. All PMA specification requirements can be found in the most recent version of Section 4.06 - Bituminous Concrete.

2) Warm Mix Asphalt

Warm mix asphalt, best known as WMA, is a term/title describing a technology used to reduce the production and placement temperatures of bituminous concrete. This is generally accomplished by adding some type of additive to the liquid asphalt to change its viscosity or act as a "lubricant" at various temperature ranges. Like polymer modification, the natural temperature performance range of neat or normally refined asphalts can be manipulated or changed with an added ingredient. The difference is that warm mix modification aims at changing the viscosity characteristics of the binder or acting as a lubricant only in the production and placement range of temperatures, while not affecting the final ambient temperature performance characteristics of the in-place asphalt mixture.

Current warm mix technologies typically reduce the production and placement temperatures of bituminous concrete by 40 - 50^{o} F. In general, Superpave mixes are produced in the 300 - 325^{o} F range with compaction primarily achieved in the 300 - 250^{o} F range. Warm mix technology shifts these ranges to 250 - 275^{o} F and 250 - 200^{o} F, respectively.

A 40 - 50^{o} F reduction in temperature for both the production and placement phases has several positive effects on the entire bituminous concrete operation. Lower production costs, possible increase in the ability to achieve compaction, reduction in environmental impacts, and increased worker safety are some of the benefits. Because of these positive impacts, an increase in the use of WMA is expected. The use of WMA additives is an option for all Superpave mixtures. Both HMA and PMA can utilize a WMA additive. The decision to use WMA additives will be made by the Contractor at his discretion. There will be no separate item or payment made for the use of WMA. The cost (or savings) shall be included in the general cost of the HMA or PMA item. If a WMA additive is added to HMA or PMA it shall be included in the submissions required for the "Job Mix Formula" (JMF) and "Contractor Quality Control (QC) Requirements for Placement."

USAGE GUIDELINES FOR SUPERPAVE BITUMINOUS CONCRETE MIXES

HMA S0.25 – Ideal for leveling of deteriorated and raveled surfaces, milled surfaces, or repaired concrete surfaces prior to overlay. Also good for very short-term or temporary thin lift maintenance overlays of any roadway with posted speeds of 40 mph or less. Not to be used as a surface course on wet weather/skid sensitive roadways. Also good for a first lift overlay of many bridge membrane systems. Surface course of choice for walkways, bikeways, and sport courts.

HMA S0.375 – Can be used for leveling of deteriorated and raveled surfaces, milled surfaces, or repaired concrete surfaces. Ideal as a surface course for most local roads and many secondary roadways with speed limits less than 50 mph. It is the preferred mix for patching small areas that require a lot of handwork. Also good for short-term or temporary thin lift maintenance overlays of any roadway. May be acceptable for some limited access highways and interstates depending on surface texture and wet weather/skid sensitive pavement needs. Mix of choice for driveways and parking lots. Most versatile mix for wedge course applications.

HMA S0.5 – The most versatile and widely used bituminous concrete mix. Ideal as a surface course and intermediate course for all types of roadways. Primary surface for interstates, limited access, and other higher volume roadways. Can also be used for some wedge course applications.

HMA S1 – Used as the primary base/binder course mix. May not be suitable as a riding surface due to its larger aggregate size and therefore may be required to be covered with a Superpave mix of smaller maximum aggregate size, typically one or two lifts/courses of S0.375 or S0.5 mixes. Usually placed on bank run or crushed subbase/base. Can be used in thicker filling/wedging applications.

PMA Mixes – In general, polymer modified asphalt (PMA) mixes follow all of the same usage guidelines as their HMA counterparts. But because they're modified with polymer, they provide increased durability and rut resistance (see explanation in "Polymer Modified Hot Mix Asphalt…"). There are two main reasons to specify a PMA mix instead of the standard HMA mix item: 1) to increase mix stability and resistance to rutting and 2) to increase the overall durability (resistance to raveling and cracking). Adding polymer increases the bituminous concrete's stiffness at elevated temperatures and increases its elasticity at lower temperatures. Polymer modification generally increases the cost of the mix, but it can also increase the lifespan. The expected increase in relative surface life of PMA mix over conventional HMA is 3 to 4 years.

PMA S0.25 – May be used as a binder course on high volume or rut sensitive roadways to support a thin or ultra-thin surface treatment.

PMA S0.375 – Can be used as a surface lift for secondary and local roadways where increased durability or strength, and resistance to rutting or cracking are warranted. May be used as a binder course on high volume or rut sensitive roadways to support the placement of a thin or ultra-thin surface treatment.

PMA S0.5 – A mix primarily used for the surface lift of high volume limited-access roadways where increased durability and longer surface life is desired. Can also be used as a surface for roadways subjected to heavy loads (trucks, buses, or specialized vehicles) where increased mix stiffness to guard against rutting is warranted. Can also be used anywhere an increase in strength, durability, and resistance to cracking is needed. May be used as a binder course on high volume or rut sensitive roadways to support a thin or ultra-thin surface treatment.

PMA S1 – May be used as a high strength/high resiliency base course for high volume or heavily loaded roadways.

THICKNESS GUIDELINES FOR SUPERPAVE BITUMINOUS CONCRETE MIXES

Below are recommended compacted lift thicknesses for Superpave bituminous concrete mixes. These recommended lift thicknesses apply to both unmodified [Hot Mix Asphalt (HMA)] and modified [Polymer Modified Asphalt (PMA)] Superpave bituminous concrete mixes.

Traffic Level (See Notes 1, 2, 3, 4, 5)	Minimum Lift Thickness	Maximum Lift Thickness	Recommended Lift Thickness
HMA and PMA S0.25*			
Level 2	0.75”	1.25”	1.0”
Level 3**	0.75”	1.25”	1.0”
HMA and PMA S0.375***			
Level 2	1.25”	2.0”	1.5”
Level 3	1.25”	2.0”	1.5”
HMA and PMA S0.5****			
Level 2	2.0”	3.0”	2.0”
Level 3	2.0”	3.0”	2.0”
HMA and PMA S1*			
Level 2	3.0”	5.0”	4.0”
Level 3	3.0”	5.0”	4.0”

** This mix is not to be used for the surface lift*
*** HMA/PMA S0.25, Traffic Level 3 should only be specified when approved for use by the Pavement Management Unit. Use Level 2 in all cases unless otherwise specified.*
**** Surface lift <u>minimum</u> lift thickness on bridges for HMA/PMA S0.375 = 1.5 inches*
***** Surface lift <u>maximum</u> lift thickness on bridges for HMA/PMA S0.5= 2.5 inches; top lift of 1.5 inches for HMA/PMA S0.5 may be considered in certain extenuating circumstances (for friction- or texture-sensitive areas, i.e. steep grade, curve, posted speed limit >= 50 mph)*

Note 1: Mix designations are composed of three elements: the mix design method, the nominal maximum aggregate size in the mixture, and the design level based on the accumulated traffic loading to which the material will be subjected. Example: "HMA S1 – Traffic Level 3" represents a hot mix asphalt mix designed in the Superpave system (S), with a nominal maximum aggregate size of 1.0 inch, designed for Traffic Level 3 traffic.

Note 2: If a design level is not shown above, it is generally not approved for use on state roadways and facilities.

Note 3: Lower design level mixes can be used on higher level roadways as long as the mix is not being used as a permanent surface course. For example, an HMA S0.25 – Traffic Level 2 could be used on a Traffic Level 3 roadway as a thin lift maintenance overlay or as a leveling course that would be covered with a Traffic Level 3 mix permanent surface course.

Note 4: Placement of lifts outside these guidelines incurs a significantly greater risk of early in-service failure and is therefore not recommended. Lift thicknesses above and below the recommended ranges present compaction, workmanship, durability, and rideability challenges that may result in roughness, raveling, rutting, or delamination failures. These failures could occur within a short period of time. Surface or wearing courses should never be placed outside of the recommended thickness tolerances above.

Note 5: Only in non-surface placement applications, e.g. to develop the proper cross-slope and grade, should lift thicknesses be allowed to fall outside of the tolerances recommended above. Recommendations for such placement can be found below.

GUIDELINES FOR WEDGE COURSES

Wedge courses are defined as those that have a cross-section approximating a triangle (or have a distinct elevation difference from one side of the cross-section to the other, such as a "trapezoidal" cross-section), with one end approaching 0 inches and the other end being placed as thick as the particular mix allows in order to develop an elevation difference in the cross-section. The table below presents the wedging lift thickness practical limits.

Mix Designation	Maximum Lift Thickness in Wedging	Minimum Lift Thickness in Wedging
HMA/PMA S0.25	1.5"	0.0"
HMA/PMA S0.375	2.5"	0.5"
HMA/PMA S0.5	3.5"	1"
HMA/PMA S1	6.0"	2"

Note 1: End wedge at a minimum distance of:

- One (1) foot from the minimum-thickness edge (or thin edge of following wedging lift) for HMA S0.25 and HMA S0.375 wedges
- Two (2) feet from minimum-thickness edge (or thin edge of following wedging lift) for HMA S0.5 wedges
- Three (3) feet from minimum-thickness edge (or thin edge of following wedging lift) for HMA S1 wedges

Note 2: Wedge courses should be covered by a uniform 2” pavement thickness from curb-to-curb without exception.

Compacted Lift Thickness

The recommended lift thicknesses listed above refer to the thickness of the mix after placement and compaction. This is the value used by designers and pavement engineers to specify pavement lift thickness and for Construction engineers to measure as-built thicknesses. (Individuals who have to address the actual placement of the mix may make use of the “rule of thumb” that uncompacted mix placed by a paver is generally ¼” higher per inch of compacted thickness desired. For example, to achieve a 2” compacted lift thickness, the uncompacted thickness should be approximately 2-1/2”)

Please contact the Pavement Management Unit at 860-594-3280 if you have any questions.