

SECTION 605 – ASPHALT CONCRETE MIX SELECTION GUIDELINES

Sec. 605.01 Purpose of Guidelines

The guidelines provided herein are intended to aide the user in recommending mix types for asphalt overlays of flexible and rigid pavement, and new construction based on specific traffic and environmental conditions expected. These guidelines should be used as part of, or in conjunction with an engineering analysis of the pavement section. These guidelines are not intended to address pavement distress mechanisms, structural inadequacy of the pavement, existing pavement defects or other types of pavement deficiencies. It is the responsibility of the user to conduct an analysis/evaluation of the existing or expected pavement conditions prior to using this guide. Failure to do so could significantly affect the performance and service life of the materials and mixes selected.

These guidelines are applicable to VDOT projects. While the guidelines could be used for non-VDOT work with similar conditions, experience and engineering judgment should be exercised for such application.

These guidelines indicate the general highway conditions under which each mix should be used. Generally, a single mix type is used for all lanes in a single direction of a roadway. The asphalt binder type ESAL (Equivalent Single Axle load) range is based on an expected service life and is used in conjunction with the mix type's nominal maximum aggregate size in this guide. Traffic speed, vehicle types and volume should also be considered in the selection of a mix type. These considerations may warrant the use of a stiffer binder. Experience and judgment should be used in selecting the appropriate mixes to be used. Each District may implement a simple guide chart to eliminate those mixes that are not needed in their area.

Sec. 605.02 – Description of asphalt Concrete mixes

Numerous asphalt mixes are used in Virginia. These mixes are designed to perform different functions within the pavement structure. Mixes vary based on nominal maximum aggregate size, aggregate gradation, asphalt binder content and other variables just to name a few. The following sections describe common asphalt mixes used in Virginia.

(a) Dense Graded Mixes

Dense graded mixes, also known as SUPERPAVE™, are asphalt mixes with a uniform distribution of aggregate sizes along the maximum density line. These mixes can be “fine” or “coarse” graded depending on whether the aggregate gradations are above or below the maximum density line. Dense graded mixes are identified based on the nominal maximum aggregate size. The nominal maximum aggregate size is defined as one sieve size larger than the first sieve to retain more than 10 percent aggregate as shown in the design range specified in Section 211.03, Table II-13 of the Road and Bridge Specifications. [It is important to note that while Virginia uses US Customary units for constructing projects, asphalt mixes are identified based on the metric sieve equivalent (i.e. 9.5mm, 12.5mm, 19.0mm and 25.0mm).] Three different families of dense graded mixes are used in Virginia – surface, intermediate and base. A description of each family and the associated asphalt mix(s) are provided in the following section.

(1) Surface Mixes

Surface mixes serve as both functional and structural layers of the pavement structure. Surface mixes are directly exposed to traffic and the environment. They must provide a smooth, stable, safe (i.e. skid resistance) riding surface, and promote surface water drainage. In addition, they serve to prevent the entrance of excessive quantities of water into the underlying HMA layers, bases and subgrade. The surface layer normally contains the highest quality materials. In most instances, only one surface mix lift will be placed on a project. VDOT has three predominant dense graded surface mixes. Surface mixes are given the SM-XY.Z designation in contracts, specifications and special provisions where SM stands for surface mix and XY.Z denotes the nominal maximum aggregate size.

SM-9.0 This mix is a 'fine' (3/8 inch (9.5 mm) nominal maximum aggregate size) surface mix generally placed at 1 inch (25 mm) thickness. This mix is generally used in subdivisions and low volume pavements with little or no heavy vehicle traffic (trucks, buses) as a final riding surface. This mix should never be placed directly on aggregate base material; it is recommended to be placed on a minimum of 2 inches (50 mm) of a larger nominal maximum aggregate surface, intermediate or base mix.

SM-9.5 This mix is a 'fine' to 'medium' (3/8 inch (9.5 mm) nominal maximum aggregate size) surface mix generally placed at 1 1/2 inches (40 mm) thickness. SM-9.5 mixes usually result in low water permeability values. This mix tends to be less susceptible to segregation than the SM-12.5 mix type described below. **SM-9.5 surface mixes can be considered the desired surface mix and are recommended for most final surface applications.**

SM-12.5 This mix is a 'medium' to 'coarse' (1/2 inch (12.5 mm) nominal maximum aggregate size) surface mix generally placed at 2 inches (50 mm) thickness. Depending on the aggregate gradation, this mix is more suited for roadways that need additional structural capacity to handle traffic loads. This mix tends to have higher permeability values when compared to a SM-9.5.

(2) Intermediate Mix

The intermediate mix, sometimes called binder course, consists of one or more lifts of structural asphalt concrete placed below the surface layer. Its purpose is to distribute traffic loads so that stresses transmitted to the pavement foundation will not result in permanent deformation of that layer. Additionally, it facilitates the construction of the surface layer. Designed with larger aggregates, the intermediate layer is intended to provide resistance to rutting and to intercept top-down fatigue cracking. In most instances, only one intermediate mix lift will be used on a project. Intermediate mixes are given the IM-XY.Z designation in contracts, specifications and special provisions where IM stands for intermediate mix and XY.Z denote the nominal maximum aggregate size.

IM-19.0 This mix is a 'coarse' (3/4 inch (19.0 mm) nominal maximum aggregate size) mix generally placed at 2 inches (50 mm) thickness. This mix can handle public traffic during construction for an extended period of time and allows for later application of a surface mix to provide a final wearing surface. In certain cases where structure is of a prime concern or traffic loadings are extreme, this mixture may be designated as a **SM-19.0** mixture and used as a final surface course, which requires a non-polishing aggregate when used as the final surface.

(3) Base Mix

As the name implies, the base mix is the base asphalt layer for the pavement structure. Its major function is to provide the principal support of the pavement structure. The base mix uses the largest aggregate particles to provide resistance to rutting and to bottom-up fatigue cracking. Unlike surface mixes, more than one lift of base mix may be placed on a project to obtain the designed base layer thickness. Base mixes are given the BM-XY.Z designation in contracts, specifications and special provisions where BM stands for base mix and XY.Z denotes the nominal maximum aggregate size.

BM-25.0 This mix is a 1 inch (25.0 mm) nominal maximum aggregate size mix generally placed at 3 inches (75 mm) or greater thickness. Depending on the aggregate gradations and placement procedures, this base does not usually require placement of an intermediate course to provide a platform for placement of a smooth wearing surface. Public traffic should not be permitted on this material for extended periods of time without restrictions.

(b) Gap Graded Mixes

Gap graded mixes, are asphalt mixes with a non-uniform distribution of aggregate sizes. Stone Matrix Asphalt (SMA) is the only gap graded mix in Virginia. These mixes contain aggregates retained on the upper and lower sieves, but with little aggregate retained on the middle sieves. As with dense graded mixes, gap graded mixes (SMA) are identified based on the nominal maximum aggregate size. Two families of gap graded mixes are used in Virginia – surface and intermediate.

SMA is composed of a gap-graded aggregate that maximizes rutting resistance and durability with a stable stone-on-stone skeleton held together by a rich mixture of asphalt binder (specified PG grading), filler and stabilizing agents such as fibers. This mix is for use on heavy to extreme heavy traffic volume routes where the expected higher cost can be justified with improved performance over other mixes. SMAs are recommended for placements of a minimum of 5,000 tons and only in heavy traffic conditions due to their higher cost and special considerations in their design, production, and placement.

A description of each family and the associated asphalt mix(s) are provided in the following section. All gap graded mixes are given the designation SMA-XY.Z(binder type) in contracts, specifications and special provisions where SMA stands for stone matrix asphalt, XY.Z denotes the nominal maximum aggregate size, and (binder type) denotes the binder to be used.

(1) Surface Mixes

VDOT has two SMA surface mixes.

SMA-9.5 This mix is a ‘fine’ to ‘medium’ (3/8 inch (9.5 mm) nominal maximum aggregate size) surface mix generally placed at 1 ½ inches (40 mm) thickness. SMA 9.5 surface mix is recommended for final surface applications on high traffic volume and high truck volume routes.

SMA-12.5 This mix is a ‘medium’ (½ inch (12.5 mm) nominal maximum aggregate size) surface mix generally placed at 2 inches (50 mm) thickness. SMA 12.5 surface mix is recommended for final surface applications on high traffic volume and high truck volume routes.

(2) Intermediate Mix

In most instances, only one intermediate mix lift will be used on a project. When rigid pavement is overlaid, more than one intermediate mix lift may be used.

SMA-19.0 This mix is a 'medium' to 'coarse' (¾ inch (19.0 mm) nominal maximum aggregate size) mix generally placed at 2 inches (50 mm) thickness. SMA 19.0 mixes are recommended for intermediate applications on high traffic volume and high truck volume routes.

(3) Base Mix

VDOT does not have any SMA Base Mix designation. If a base mix is desired for use with SMA, use a dense graded Base mix.

(c) Specialty Mixes

While the vast majority of asphalt placed in Virginia is either dense graded or gap graded, VDOT does use some specialty mixes. These mixes are designed to provide specific functions in the pavement structure. Below is a description of two mixes used in Virginia.

Thin Hot Mix Asphalt Overlay (THMACO) This mix is a 'fine' to 'medium' (3/8 inch (9.5 mm) nominal maximum aggregate size) surface mix generally placed at 3/4 inch (19 mm) thickness. THMACO is a gap graded hot mix asphalt applied atop a polymer-modified emulsion membrane and it is used for final surface applications as a functional overlay on flexible and rigid pavements. THMACO is primarily used for pavement preservation.

Open Graded Drainage Layer (OGDL) is a 'medium' (¾ inch (19.0 mm) nominal maximum aggregate size) mix generally placed at 2 inches (50 mm) thickness. This mix has very little fine aggregate material to allow for the movement of water. It is used as part of a pavement drainage system. Guidelines on use of OGDL can be found in Section 604.

Sec. 605.03 VDOT Asphalt Binders

As with the asphalt mixes, VDOT typically uses letters to designate asphalt binders in contracts, specifications and special provisions. For dense graded mixes, asphalt binder designations A, D and E are used. Mix stiffness generally increases from 'A' to 'E', with 'A' being the softest. For gap graded asphalt concrete, no letter designation is used in contracts, specifications and special provisions. In the specifications and special provisions for specialty mixes, the asphalt binder is declared. The following sections defined each asphalt binder.

(a) Dense Graded Mix Binder Letter Designations

'A' - The 'A' designation corresponds with a Performance Graded (PG) asphalt binder of PG 64-22. Surface asphalt mix types using the 'A' binder designation are intended to experience 0 to 3 million cumulative equivalent single axle loads (ESALs); intermediate mix types up to 10 million ESALs; and base mix types up to 20 million cumulative ESALs over a specified service life. See Table 1 in Section 605.04 for service life per mix type and Section 604 for the procedure to determine cumulative ESALs. This designation should perform well in low to medium traffic loading situations.

‘D’ - The ‘D’ designation corresponds with a Performance Graded (PG) asphalt binder of PG 70-22. Surface asphalt mix types using the ‘D’ binder designation are intended to experience 3 to 10 million cumulative equivalent single axle loads (ESALs); intermediate mix types between 10 and 20 million ESALs; and base mix types exceeding 20 million cumulative ESALs over a specified service life. See Table 1 in Section 605.04 for service life per mix type and Section 604 for the procedure to determine cumulative ESALs. This designation should perform well in medium to high traffic loading situations.

‘E’ - The ‘E’ designation corresponds with a Performance Graded (PG) asphalt binder of PG 76-22 with polymer modification. Surface asphalt mix types using the ‘E’ binder designation are intended to experience in excess of 10 million cumulative equivalent single axle loads (ESALs) and intermediate mix types above 20 million ESALs over a specified design life. In general applications, the ‘E’ binder designation is not used in a base mix. See Table 1 in Section 605.04 for service life per mix type and Section 604 for the procedure to determine cumulative ESALs. Mixes with this binder designation should perform well in high to extremely high traffic loading situations. The stiffness of mixes using this binder should not be used as a substitute for deficient pavement structure (high deflections under traffic loadings will destroy any pavement structure).

(S) Stabilized - designation indicates the use of a PG 64-22 binder with an approved stabilizing additive from the Department’s approved list in the Materials Division Manual of Instructions. This designation can be used in extreme traffic loading situations. This designation does not provide resistance to reflective cracking. This designation should only be combined with ‘A’ mixes.

(b) Gap Graded and Specialty HMA Binders

PG 70-22 – Like the ‘D’ designation for dense graded mixes, this binder is the Performance Graded (PG) 70-22. Surface asphalt mix types using the PG 70-22 binder are intended to experience 3 to 10 million cumulative equivalent single axle loads (ESALs) and intermediate mix types between 10 and 20 million ESALs over a specified service life. See Table 1 in Section 605.04 for service life per mix type and Section 604 for the procedure to determine cumulative ESALs. This binder should perform well in medium to high traffic loading situations and over continuously reinforced concrete pavement.

PG 76-22 – Like the ‘E’ designation for dense graded mixes, this binder is the Performance Graded (PG) 76-22 with polymer modification. Surface asphalt mix types using the ‘E’ binder are intended to experience in excess of 10 million cumulative equivalent single axle loads (ESALs) and intermediate mix types above 20 million ESALs over a specified service life. In general applications, the PG 76-22 asphalt binders are not used in a base mix. See Table 1 in Section 605.04 for service life per mix type and Section 604 for the procedure to determine cumulative ESALs. These designations should perform well in high to extremely high traffic loading situations and over jointed concrete pavement. The stiffness of this mix should not be used as a substitute for deficient pavement structure (high deflections under traffic loadings will destroy any pavement structure).

PG 70-28 – This binder is a polymer modified Performance Graded (PG) 70-28. The purpose of this binder is to resist thermal cracking and minimize reflective cracking over jointed concrete pavement.

Sec. 605.04 Asphalt Binder and Mix selection – General Applications

When making a determination regarding which asphalt mix type to use, the cumulative ESALs must be calculated and the pavement type must be known (new construction, existing flexible pavement or existing rigid pavement). The expected service life of the asphalt layer is necessary to calculate cumulative ESALs for selecting the mix type to use. The service life of the layer is a function of the layer's position within the pavement's structure and the asphalt mix as described in Section 605.02. Table I provides the expected service life for each layer.

NOTE: Preliminary analysis and field experience indicate gap graded mixes generally outperform conventional mixes; therefore, justifying the additional cost for the gap graded mixes. Further investigation will be performed to quantify the actual service life of each mix and calibrate the pavement models.

Layer	Expected Life (yrs)		Comments
	New Const.	Overlay	
Surface	12	12	10 yrs for 2 Lane Roads for dense graded mixes
Intermediate	20	20	
Base	30	30	Generally an 'A' mix is used for most applications

Table 5 – Expected Service Life by Asphalt Layer

(a) Asphalt Binder Selection

Once the expected service life is selected, then the cumulative equivalent single axle loads (ESALs) must be calculated for selecting the appropriate binder. (Refer to Section 604 of the Manual of Instructions for the procedure in calculating cumulative ESALs.) Tables 2 through 6 summarize the binder selection process based on pavement layer, cumulative ESALs and pavement type. Note: the suggested binder is stiffer for overlay of rigid pavements than flexible pavements for equivalent ESAL levels.

(b) Asphalt Mix Selection

During the pavement evaluation and design process, a total asphalt thickness is determined. From this thickness, a series of asphalt lifts are used to construct the pavement structure. For the base layer, one or more lifts may be required. VDOT has one base mix, BM-25.0, for use in construction, reconstruction or major rehabilitation

VDOT has two intermediate and five surface mixes for use in construction, reconstruction or rehabilitation. Tables 2 through 6 summarize the mixes available for various layers based on cumulative ESALs and pavement type.

Cumulative ESALs	Mix Designation		
	Flexible Pavements	Rigid Pavement Overlays	
		Jointed	Continuously Reinforced
0 – 3 million	SM-9.0A or SM-9.5A	SM-9.5D or SM-12.5D	SM-9.5D or SM-12.5D
3 to 10 million	SM-9.5D or SM-12.5D	SM-9.5E or SM-12.5E	SM-9.5D or SM-12.5D
> 10 million	SM-9.5E or SM-12.5E	SM-9.5E or SM-12.5E	SM-9.5D or SM-12.5D

Table 6 – Dense Graded Surface Selection

Cumulative ESALs	Mix Designation		
	Flexible Pavements	Rigid Pavement Overlays	
		Jointed	Continuously Reinforced
0 – 3 million	IM-19.0A	IM-19.0D	IM-19.0D
3 to 10 million	IM-19.0A	IM-19.0E	IM-19.0D
> 10 million	IM-19.0D	IM-19.0E	IM-19.0D

Table 7 – Dense Graded Intermediate Selection

Cumulative ESALs	Mix Designation		
	Flexible Pavements	Rigid Pavement Overlays	
		Jointed	Continuously Reinforced
0 to 20 million	BM-25.0A	BM-25.0A	BM-25.0A
> 20 million	BM-25.0D	BM-25.0D	BM-25.0D

Table 8 – Dense Graded Base Selection

Cumulative ESALs	Mix Designation		
	Flexible Pavements	Rigid Pavement Overlays	
		Jointed	Continuously Reinforced
0 – 3 million	NR	NR	NR
3 to 10 million	SMA-9.5(70-22) or SMA-12.5(70-22)	SMA-9.5(76-22) or SMA-12.5(76-22)	SMA-9.5(70-22) or SMA-12.5(70-22)
> 10 million	SMA-9.5(70-22)* or SMA-12.5(70-22)*	SMA-9.5(76-22) or SMA-12.5(76-22)	SMA-9.5(70-22) or SMA-12.5(70-22)

NR – Gap graded mixes are not recommended

* Consideration to use of a PG 76-22 binder should be given when the Cumulative ESALS are greater than 20 million.

Table 9 – Gap Graded (SMA) Surface Selection

Cumulative ESALs	Mix Designation		
	Flexible Pavements	Rigid Pavement Overlays	
		Jointed	Continuously Reinforced
0 – 3 million	NR	NR	NR
3 to 10 million	SMA-9.5(70-22) or SMA-12.5(70-22)	SMA-9.5(76-22) or SMA-12.5(76-22)	SMA-9.5(70-22) or SMA-12.5(70-22)
> 10 million	SMA-9.5(70-22)* or SMA-12.5(70-22)*	SMA-9.5(76-22) or SMA-12.5(76-22)	SMA-9.5(70-22) or SMA-12.5(70-22)

NR – Gap graded mixes are not recommended

Table 10 – Gap Graded (SMA) Intermediate Layer Selection

Sec. 605.05 Asphalt Binder and Mix selection – Specialized locations

There will be times when a designer needs to select binder and mix types in areas with high truck percentages and slow speeds, excessive grades (>6%) and standing traffic which result in extreme pavement loadings. Some examples of these areas are truck climbing lanes, quarry roads, or truck parking areas. In these situations, the designer should select a binder with high stiffness to resist movement under load. To aide the designer, Table 7 lists the mixes that can be used in the extreme loading situations.

Mix Type	Surface	Intermediate	Base
Truck Climbing Lane and Roads with Excessive Grades (>6%)	SM-9.5E SM-12.5E SM-19.0D SMA-9.5 (76-22) SMA-12.5 (76-22)	IM-19.0D IM-19.0E SMA-19.0 (76-22)	BM-25.0D
Industrial Route, Quarry	SM-9.5D SM-9.5E SM-12.5D SM-12.5E	IM-19.0D IM-19.0E	BM-25.0A BM-25.0D
Truck Parking Area	SM-9.5E SM-12.5E	IM-19.0D IM-19.0E	BM-25.0D
Intersections with Heavy Truck Percentage	SM-9.5E SM-12.5E	IM-19.0D IM-19.0E	BM-25.0D
Heavy Urban Traffic with Buses	SM-9.5E SM-12.5E	IM-19.0D IM-19.0E	BM-25.0D

Table 11 – Specialized Pavement Locations

Sec. 605.06 Application Rates

The normal application rate for a single lift thickness for the various mixes is shown in Table 8. Deviations to the normal application rate should be done in accordance with Section 315.05 (c) of the Road and Bridge Specifications.

Asphalt Concrete Mixes	Nominal Maximum Aggregate Size	Normal Application Rate ^{Note 1}
Surface Mix		
SM-9.0	3/8 inch (9.5 mm)	1 inch – 110 lb/ yd ² (25.0 mm – 60 kg/m ²)
SM-9.5	3/8 inch (9.5 mm)	1.5 inch - 165 lb/ yd ² (40.0 mm – 90 kg/m ²)
SM-12.5	1/2 inch	1.5 inch - 165 lb/ yd ²

Asphalt Concrete Mixes	Nominal Maximum Aggregate Size	Normal Application Rate ^{Note 1}
Surface Mix		
	(12.5 mm)	(40.0 mm – 90 kg/m ²)
SM-19.0	3/4 inch (19.0 mm)	2 inch – 220 lb/yd ² (50.0 mm – 125 kg/m ²)
SMA-9.5	3/8 inch (9.5 mm)	1.5 inch - 165 lb/yd ² (40.0 mm – 90 kg/m ²)
SMA-12.5	1/2 inch (12.5 mm)	1.5 inch - 165 lb/yd ² (40.0 mm – 90 kg/m ²)
Intermediate Mix		
SMA 19.0 (intermediate)	1/2 to 1 inch (12.5 to 19.0mm) ^{Note 2}	2 inch – 220 lb/yd ² (50.0 mm – 125 kg/m ²)
IM-19.0	3/4 inch (19.0 mm)	2 inch – 220 lb/yd ² (50.0 mm – 125 kg/m ²)
Base Mix		
BM-25.0	1 inch (25.0 mm)	3.0 inch ^{Note 3} (75.0 mm)
Open Graded Drainage Layer		
OGDL	--	2.0 inch (50 mm)
Thin Hot Mix Asphalt Concrete		
THMACO	--	3/4 inch (19.0 mm)

Note 1 Application rate is based upon 110 pounds per square yard per inch (2.35 kilograms per square meter per millimeter) of thickness.

Note 2 SMA Intermediate design criterion allows the mixture to meet the definition of either nominal maximum aggregate size.

Note 3 Application rate for BM Type mixes should be determined from the actual specific gravity of the mixture as called for by the Materials Division or by region as indicated

in Table 9.

Table 12 – VDOT Mix Comparison Table

Sec. 605.07 Typical asphalt Base mix application rates

Table 9 should be used to determine the approximate quantity of base asphalt for construction and maintenance program projects. This table contains the average weight for the base mix based on the aggregate present in the District.

**VIRGINIA DEPARTMENT OF TRANSPORTATION
WEIGHT OF BASE ASPHALT MIXES FOR APPROXIMATE
QUANTITY CALCULATIONS**

DISTRICT	AREAS	Mass kg/m ² /mm	Lbs/S.Y./In
Bristol	Abingdon-Marion-Wytheville-Galax	2.46	115
	Bluefield-Big Stone Gap-Woodway-Bristol	2.39	112
Salem	Buchanan-Roanoke-Salem-Radford- Martinsville	2.43	114
Lynchburg	Lynchburg	2.41	113
	Danville	2.35	110
	South Boston	2.37	111
Richmond		2.35	110
Hampton Roads		2.35	110
Fredericksburg		2.35	110
Culpeper	Charlottesville	2.52	118
	Culpeper - Flint Hill	2.41	113
Staunton		2.39	112
NOVA	Arlington - Fairfax	2.61	122

Table 13 – Application Rates for Asphalt Base Mix