Mixture Selection Guide for Flexible Pavements

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Introduction

This mixture selection guide for flexible pavements provides designers with recommendations for selecting hot mix asphalt (HMA) types based on factors such as traffic volume, loading characteristics, design speed and desired performance characteristics. Recommendations regarding mixture selection are provided in the 3 tables contained within this guide. Table 1 contains a listing of Relative Hot Mix Rankings. Table 2 contains a Summary of Mixture Types, Sizes, and Uses. Table 3 contains a listing of Recommended Choices for Surface Mixtures. This guide covers the 4 major HMA types listed in the Department's 2004 Standard Specification book. The 4 mixture types are:

- Item 340 and 341 – Dense Graded Mixtures
- Item 342 - Permeable Friction Course (PFC)
- Item 344 - Performance Design Mixtures
- Item 346 - Stone Matrix Asphalt (SMA)

This guide is intended to provide general recommendations based on the experiences of the engineering staff in the Flexible Pavements Branch of TxDOT's Construction Division. This guide is <u>not intended to be used as Department policy</u>. Districts are encouraged to make mixture selection choices based on engineering judgment along with the recommendations provided in this guidance document. A number of factors should be considered when selecting which HMA mixture is most appropriate for the intended application. Some of the factors that should be considered are listed below:

- previous experience with similar mixture types
- volume of truck traffic, traffic flow characteristics
- pavement geometric considerations
- lift thickness of paving layers
- condition of underlying pavement
- availability of local materials
- climatic and environmental conditions
- cost (initial as well as life cycle)
- selected performance grade (P.G.) binder

It is important that the designer select the proper mixture for the intended applications. It is also very important the designer select the appropriate PG binder and aggregate properties for the intended application. These topics will not be covered in this guide since most TxDOT districts have guidelines or policies currently in place that address binder and aggregate property selection. Those needing additional assistance should contact their district pavement engineer, district construction engineer, laboratory personnel or the Construction Division.

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General Description of Hot Mix Asphalt (HMA) Mixtures

Item 340

Description: Item 340 is a method specification for conventional dense graded mixtures.

Typical Use: Item 340 is typically used for projects with small quantities of hot mix asphalt (HMA). Item 340 is generally not recommended for projects with more than 5,000 tons of HMA. Conventional dense graded mixtures can be used for a wide variety of applications; however, under Item 340 it is recommended that the use of dense graded mixtures be limited to miscellaneous applications such as routine maintenance work, backfilling utility cuts, driveways, and other similar applications.

Advantages: The primary advantage of dense graded mixtures compared to other mixtures is lower initial cost. Another advantage is that most contractors and HMA producers are generally familiar with the production and placement of dense graded mixtures. Dense graded mixtures have been used in Texas for over 50 years and have performed well in most applications.

The mixtures listed in Item 340 are identical to those listed in Item 341. In contrast to Item 341, which is a quality control quality assurance (QCQA) specification, Item 340 does not prescribe QCQA measures. This may be an advantage in miscellaneous applications where QCQA measures are not warranted.

Disadvantages: Dense graded mixtures cannot accommodate high asphalt contents without becoming unstable and susceptible to rutting. Relatively low amounts of asphalt are typically used in dense graded mixtures, which in turn makes them more susceptible to cracking and more permeable. Generally speaking, dense graded mixtures can be designed to be either highly rut resistant or highly crack resistant but not both. Dense graded mixtures are not designed to have stone on stone contact. Their strength/stability characteristics are derived primarily from the quality of the intermediate and fine aggregate. Attempting to "coarsen" the mix to allow for more asphalt or to make the mix more rut resistant often has an adverse effect. Coarsening the mix often leads to a dryer mix and one that is more difficult to compact, more permeable and more susceptible to segregation. The texture of dense graded surface mixtures (Type C, D, and F) is relatively low. This can affect wet weather traction depending on the aggregate type, size and mineralogy.

Dense graded mixtures are currently designed with a Texas Gyratory Compactor (TGC). The TGC has a relatively high compactive effort and unlike the Superpave Gyratory Compactor (SGC), the TGC compactive effort can not be varied to match the intended application. Therefore, the TGC tends to produce a dry lean mix regardless of the application. Ideally, one would want to design a richer mix for a low volume/low demand roadway and a leaner mix for a high volume/high demand roadway. More asphalt in the mix reduces the risk of cracking and less asphalt reduces the risk of rutting. It is possible to increase or decrease the amount of asphalt in the mixture by adjusting the target laboratory molded density down or up from the standard value of 96.0%. Seldom is the target lab density adjusted down from the standard of 96.0%; however, it is common practice to adjust the target laboratory molded density up to 97.0% or higher in order to get more asphalt into the mixture. This practice is acceptable and actually encouraged where warranted; however, it should be noted that some mixtures may become susceptible to rutting if they contain too much asphalt especially if the asphalt is relatively soft such a PG 64 -22, etc.

Under Item 340, most of the responsibilities are on the Department rather than the contractor. On projects that warrant QCQA measures be taken, it could be risky to use Item 340 unless the department representatives are familiar with the roles and responsibilities required under method specifications.

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Item 341

Description: Item 341 is a quality control quality assurance (QC/QA) specification for conventional dense graded mixtures.

Typical Use: Dense graded mixtures in Item 341 can be used for a wide variety of applications ranging from new construction to overlays. Dense graded mixtures may be appropriate for applications ranging from high volume (or high demand) roadways to low volume (or low demand) roadways depending on the specified binder grade, aggregate properties, etc. Dense graded mixtures can be used as base, intermediate or surface layers.

Advantages: The primary advantage of dense graded mixtures compared to other mixtures is lower initial cost. Another advantage is that most contractors and HMA producers are generally familiar with the production and placement of dense graded mixtures. Dense graded mixtures have been used in Texas for over 50 years and have performed well in most applications.

The mixtures listed in Item 341 are identical to those listed in Item 340. In contrast to Item 340, which is a method specification, Item 341 prescribes numerous QCQA measures to be taken by both the contractor and the Department. The vast majority of the QCQA measures are the responsibility of the contractor.

Disadvantages: Dense graded mixtures cannot accommodate high asphalt contents without becoming unstable and susceptible to rutting. Relatively low amounts of asphalt are typically used in dense graded mixtures, which in turn makes them more susceptible to cracking and more permeable. Generally speaking, dense graded mixtures can be designed to be either highly rut resistant or highly crack resistant but not both.

Dense graded mixtures are not designed to have stone on stone contact. Their strength/stability characteristics are derived primarily from the quality of the intermediate and fine aggregate. Attempting to “coarsen” the mix to allow for more asphalt or to make the mix more rut resistant often has an adverse effect. Coarsening the mix often leads to a dryer mix and one that is more difficult to compact, more permeable and more susceptible to segregation.

Dense graded mixtures are currently designed with a Texas Gyratory Compactor (TGC). The TGC has a relatively high compactive effort and unlike the Superpave Gyratory Compactor (SGC), the TGC compactive effort can not be varied to match the intended application. Therefore, the TGC tends to produce a dry lean mix regardless of the application. Ideally, one would want to design a richer mix for a low volume/low demand roadway and a leaner mix for a high volume/high demand roadway. More asphalt in the mix reduces the risk of cracking and less asphalt reduces the risk of rutting. It is possible to increase or decrease the amount of asphalt in the mixture by adjusting the target laboratory molded density down or up from the standard value of 96.0%. Seldom is the target lab density adjusted down from the standard of 96.0%; however, it is common practice to adjust the target laboratory molded density up to 97.0% or higher in order to get more asphalt into the mixture. This practice is acceptable and actually encouraged where warranted; however, it should be noted that some mixtures may become susceptible to rutting if they contain too much asphalt especially if the asphalt is relatively soft such a PG 64 -22, etc.

The texture of dense graded surface mixtures (Type C, D, and F) is relatively low. This can affect wet weather traction depending on the aggregate type, size and mineralogy.

Under Item 341, there are numerous responsibilities that both the contractor and the Department have in terms of QCQA measures. This degree of control may not be warranted on extremely small projects or miscellaneous type projects.

Item 342

Description: Item 342 is a method specification for Permeable Friction Courses (PFC).

Typical Use: PFC mixtures are used as the surface course on high-speed roadways to optimize the safety and comfort characteristics of the roadway. For this guide, a high-speed roadway is defined as one having a posted speed limit of 45 mph or higher. The standard PFC mixture contains PG 76-22 and fibers and is recommended for the vast majority applications where PFC is used. Asphalt Rubber (A-R) PFC can be used as an alternate to the standard PFC. A-R PFC is generally more expensive than the standard PFC; however, it's unique properties warrant it's use in certain applications. As a general rule A-R PFC is recommend over the standard PFC when placed as an overlay on an existing concrete pavement, when a high degree of noise reduction is desired and when placed as an overlay on a pavement that has a high amount of cracking. Although both types are excellent at draining water and reducing noise, standard PFC tends to drain water better than the A-R PFC but is generally not considered to be as quiet as the A-R PFC.

Advantages: As opposed to all other types of hot mix, PFC is designed to let water drain through the mixture into the underlying layer. PFC mixtures significantly reduce water spray, improve wet weather visibility and visibility of pavement markings, significantly reduce tire noise, and restore ride quality. PFC mixtures have stone on stone contact and relatively high amounts of asphalt binder. As a result, they offer good resistance to rutting and cracking. PFC mixtures are relatively easy to design and place. PFC mixtures require only a minimal amount of compaction with a static roller. This helps facilitate a smooth riding surface. PFC mixtures provide for a roadway that has a uniform yet coarse surface texture. The coarse texture and permeable mix characteristics improve wet weather traction.

PFC mixtures contain approximately 20% air voids and they are typically placed only 1.5 inches thick therefore, the yield per ton of mix is relatively high. PFC weighs approximately 90 to 95 lbs./sy. per inch. as opposed to the standard weight for most hot mix, which is approximately 110 lbs./sy. per inch of depth.

Disadvantages: PFC mixtures typically have a higher initial cost compared to conventional dense graded mixtures. PFC mixtures contain more asphalt (6% min., 8% for min. A-R PFC) compared to conventional mixtures. The asphalt used in PFC mixtures contains a high amount of polymers (or asphalt rubber as an option). In addition to the polymers, PFC mixtures require the use of fibers (not required with asphalt rubber) and may require the use of lime. All of these additives not only add to the initial cost but they sometimes require that the producer make modifications to their typical HMA production processes.

PFC mixtures must be placed on top of a pavement that is structurally sound and relatively impermeable. A surface treatment (under seal) or level-up layer may be needed prior to placing the PFC. When used on low speed roadways, PFC mixtures can clog up more quickly thus negating the beneficial drainage characteristics. PFC mixtures tend to freeze faster and thaw slower (similar to a bridge) compared to conventional mixtures. PFC mixtures are not as resistant to high shearing forces therefore, they should be avoided on pavements where there are hard turning motions combined with braking such as short radius exit ramps, turnouts, etc. PFC is not recommended for mill and inlay operations.

Generally speaking, it is not good to place any type of hot mix in cool or cold weather. PFC mixtures can be particularly difficult to place in cool weather because they are placed in thin lifts and they contain a high amount of polymer modified binder. They also do not lend themselves well to applications that require a significant amount of hand work.

Item 344

Description: Item 344 is a quality control quality assurance (QC/QA) specification for performance design mixtures which includes traditional Superpave mixtures as well as coarse matrix high binder (CMHB) mixtures.

Typical Use: Although they are typically used on medium to high volume roadways, performance design mixtures may be appropriate for applications ranging from high volume (or high demand) roadways to low volume (or low demand) roadways depending on the specified design number of gyrations (Ndes), binder grade, aggregate properties, etc. Performance design mixtures can be used as base, intermediate or surface layers. Performance design mixtures can be used for a wide variety of applications ranging from new construction to overlays.

Advantages: As compared to Item 341, one of the primary advantages of performance design mixtures is that the mixture design procedures allows one to adjust the binder content (by adjusting the Ndes level) depending on the intended application. For example: a mix for a low volume roadway can be designed with a low Ndes level, which will yield a mixture that is higher in asphalt. The higher asphalt will help mitigate cracking and provided for greater durability. Conversely, a mix for a high volume roadway can be designed with a high Ndes level, which will yield a mixture that is lower in asphalt, thus minimizing rutting.

Another advantage is that performance design mixtures can be designed coarse enough to have stone on stone contact. Achieving stone on stone contact can yield a mix that is highly resistant to rutting and have a coarse surface texture. The coarse surface texture can be beneficial in terms of wet weather traction.

Disadvantages: Compared to regular dense mixtures, performance design mixtures can be more difficult to compact. Failing to achieve proper in-place density can cause potential permeability problems and shorten the performance life of the pavement. In some cases, performance design mixtures can be "too dry" in terms of asphalt content. This can result in a mixture that is susceptible to cracking.

Compared to SMA mixtures, performance design mixtures have a gradation that is not as "gap graded" as an SMA mixture. As a result, performance design mixtures typically contain less asphalt than SMA mixtures and may therefore be more susceptible to cracking and water infiltration. CMHB mixtures are not recommended for mill & inlay projects.

During compaction, a significant number of Superpave mixtures have experienced a phenomenon known as intermediate temperature tenderness. The mixtures may experience tenderness (or pushing) during compaction. The tenderness does not typically show up until several roller passes have been made and the mat begins to cool (usually in the 240F range). Contractors can overcome this phenomenon by ceasing compaction once the tenderness is observed and then resuming compaction once the mat cools to approximately 180F).

Item 346

Description: Item 346 is a quality control quality assurance (QC/QA) specification for Stone Matrix Asphalt (SMA) mixtures.

Typical use: SMA mixtures are typically used as a surface mix or intermediate layer in the pavement structure on high volume (or high demand) roadways. SMA mixtures are often used as the intermediate layer when PFC mix is used as the surface layer. The standard SMA mixture contains PG 76-22 and fibers and is recommended for the vast majority applications where SMA is used. Asphalt Rubber (A-R) SMA can be used as an alternate to the standard SMA. A-R SMA is generally more expensive than the standard SMA; however, it's unique properties warrant it's use in certain applications. As a general rule A-R SMA is recommend over the standard SMA when placed as an overlay on an existing concrete pavement, when a high degree of noise reduction is desired and when placed as an overlay on a pavement that has a high amount of cracking.

Advantages: SMA mixtures provide both excellent rut resistance and crack resistance. SMA mixtures have a high concentration of coarse aggregate, which facilitates stone on stone contact. The voids in the coarse aggregate skeleton are filled with fibers, mineral filler, and a relatively high amount (6% minimum) of polymer modified asphalt. This combination of materials allows for a "rich" mixture that is resistant to cracking while at the same time being highly resistant to rutting. SMA mixtures are considered to be relatively impermeable particularly when compared to performance design mixtures. SMA mixtures result in a pavement layer that has a high degree of surface texture which is beneficial in terms of wet weather traction.

Disadvantages: SMA mixtures typically have a higher initial cost compared to other mixtures. SMA mixtures contain more asphalt (6% minimum) compared to conventional mixtures. The asphalt used in SMA mixtures contains a high amount of polymers (or asphalt rubber as an option). In addition to the polymers, SMA mixtures require the use of fibers (not required with asphalt rubber), mineral filler and may require the use of lime. All of these additives not only add to the initial cost but they often require that the producer make modifications to their typical HMA production processes. SMA mixtures may also require higher quality aggregates than conventional mixtures. SMA mixtures usually require a significant compactive effort; however, they also produce a pavement layer with a higher density compared to conventional mixtures.

Generally speaking, it is not good to place any type of hot mix in cool or cold weather. SMA mixtures can be particularly difficult to place in cool weather because they are placed in thin lifts and they contain a high amount of polymer modified binder. They also do not lend themselves well to applications that require a significant amount of hand work.

Table 1. Relative Hot Mix Rankings (Subjective)
(0 to 5 scale with 5 being the "best")

Mixture Characteristic	Dense Graded (Item 340/341)	PFC (Item 342)	Performance Design Mixes (Item 344)	SMA (Item 346)	Determining Factors
Resistance to Rutting	2-5	4-5	3-5	4-5	Stone on stone contact & binder stiffness
Resistance to Cracking	1-4	3-5	2-4	4-5	Total volume of asphalt in mix, binder film thickness
Resistance to Segregation	1-4	5	3-4	4-5	Gradation, uniformity & aggregate size
Resistance to Raveling	2-4	2-4	3-4	4-5	Toughness of mastic & resistance to segregation
Ability to resist high shear forces (hard turning motions)	2-4	2-4	3-4	4-5	Toughness of mastic & resistance to raveling
Resistance to Moisture Damage	2-4	3-5	3-4	4-5	Binder film thickness & potential adverse permeability
Resistance to Freeze/Thaw Damage	3-4	2-4	3-4	4-5	Binder film thickness & potential permeability
Potential Permeability	3-4	N/A	2-4	4-5	Ability to compact to a relatively high in place density
Long Term Durability	2-3	3-4	3-4	4-5	Binder film thickness & toughness
Wet Weather Traction	2-4	4-5	3-4	3-4	Texture, permeability, & resistance to hydroplaning
Wet Weather Visibility	2-3	4-5	2-4	2-4	Texture & ability to quickly drain surface water
Noise Reduction (comfort)	3-4	4-5	3-4	3-4	Ability to buffer noise & surface texture
Aesthetically Pleasing	3-4	4-5	3-4	3-5	Texture, uniformity & resistance to segregation
Ease of Compaction	2-4	4-5	2-3	3-4	Volume of mastic, VMA, & toughness
Ability to "hand work"	3-5	2-3	2-4	2-3	Aggregate gradation & binder stiffness
Affordability (Initial Cost)	4-5	2-4	3-4	2-3	Aggregates, additives & production rates

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Table 2. Summary of Mixture Types, Sizes and Uses

Mixture Type/ Size	Nominal Aggregate Size	Minimum Lift Thickness (inches)	Maximum Lift Thickness (inches)	Typical location of pavement layer
Item 340/341				
Type A mix	1 ½”	3.0”	6.0”	Base
Type B mix	1”	2.5”	5.0”	Base/Intermediate
Type C mix	3/4”	2.0”	4.0”	Intermediate/Surface
Type D mix	1/2”	1.5”	3.0”	Surface layer
Type F mix	3/8”	1.25”	2.5”	Surface layer
Item 342				
PFC (PG 76 mixture)	1/2”	3/4”	1.5”	Surface
PFC (AR mixture)	½”	3/4”	1.5”	Surface
Item 344				
SP A	1 ”	3.0”	5.0”	Base
SP B	3/4”	2.25”	4.0”	Base/Intermediate
SP C	1/2”	1.5”	3.0”	Intermediate/Surface
SP D	3/8”	1.25”	2.0”	Surface
CMHB-C	3/4”	2.0”	4.0”	Intermediate/Surface
CMHB-F	3/8’	1.5”	3.0”	Surface
Item 346				
SMA-C	3/4”	2.25”	4.0”	Intermediate/Surface
SMA-D	1/2”	1.5”	3.0”	Intermediate/Surface
SMA-F	3/8”	1.25”	2.5”	Surface
SMAR-C	3/4”	2.0”	4.0”	Intermediate/Surface
SMAR-F	3/8”	1.5”	3.0”	Surface

Table 3. Recommended Choices for Surface Mixtures

Posted Speed	Traffic Volume / Load Demand		
	Low	Medium	High
< 45 mph	1. Dense graded mix 2. Performance design mix	1. Performance design mix 2. Dense graded mix	1. SMA 2. Performance design mix 3. Dense graded mix
45 mph or higher	1. Dense graded mix 2. Performance design mix 3. PFC	1. PFC 2. Performance design mix 3. Dense graded mix	1. PFC 2. SMA 3. Performance design mix 4. Dense graded mix

Note: A high load demand can be defined as having a high amount of cumulative axle loads, a high shear environment caused by decelerating/turning movements, slow moving or standing traffic with heavy axle loads.