Material Selection Guide

Bituminous Materials

TxDOT, Materials and Tests Division

Introduction

This document provides guidance and information regarding selection of hot-mix asphalt (HMA) mixture types. This document is a tool to be used with sound engineering judgment and local experience in the development of plans, specifications, and estimates for future lettings. This document includes three sections as follows:

1. Surface Aggregate Selection Guide,
2. Performance Grade (PG) Binder Selection Guide, and
3. Hot-Mix Asphalt Mixture Selection Guide.

The first section is a surface aggregate selection guide for flexible pavements. It provides guidance on how to properly select aggregate for surface mixtures based on the pavement's demand for friction. This section takes the following design considerations into account; annual rainfall, traffic demands, geometric design, intersecting roadways, the percentage of wet surface crashes, and the surface design life.

The second section is a performance graded (PG) binder selection guide for flexible pavements. It provides guidance on how to properly select a PG binder based on both climate and traffic characteristics. Based on local weather stations surrounding each county throughout the state, Figure 2.1 was compiled to represent the minimum binder grade to withstand environmental conditions. After a base binder is determined, this section then outlines how traffic loading and speed affect the final binder grade for the HMA layers.

The third section is a mixture selection guide for flexible pavements. The mixture selection guide provides designers with recommendations for selecting hot-mix asphalt (HMA) mixture types based on factors such as traffic volume, loading characteristics, design speed, and desired performance characteristics. Recommendations regarding mixture selection are provided in the two tables contained within this section of the guide. Table 3.1 and Table 3.2 contain a listing of Relative Hot-Mix Rankings characterized by Level of Resistance and Level of Functionality respectively, designated by shades of color. These are subjective ratings, and it is important to read the notes following the table for more information and guidance. Table 3.3 contains a summary of Mixture Types, Sizes, and Typical Uses. District Standard Operating Procedures (SOP) should be used in conjunction with these tables. This guide provides information for the seven major HMA mixture types available for use by the Department. The seven mixture types are as follows:

- Dense-graded Mixtures,
- Permeable Friction Course (PFC),
- Superpave Mixtures,
- Stone Matrix Asphalt (SMA),
- Thin Overlay Mixtures (TOM),
- Thin Bonded Friction Courses, and
- Crack Attenuating Mixture (CAM).

Several 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), and
- selected performance grade (PG) binder.

It is important that the designer selects the proper mixture for the intended applications. It is also very important the designer selects the appropriate PG binder and aggregate properties for the intended application. These topics will not be covered in this guide since most Department 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 Materials and Tests Division.

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1. SURFACE AGGREGATE SELECTION GUIDE

Flexible pavement design considerations will also need to include aggregate and binder selection. Aggregate selection is a process which includes the pavement's surface mix demand for friction, and the friction that the aggregate will provide. To determine the frictional demand of a roadway, the following will need to be considered: annual rainfall, traffic (ADT), traffic speed, percentage of trucks, vertical grade of the roadway, horizontal curve of the roadway, number of driveways per mile, intersecting roadways traffic (ADT), and the percentage of wet surface crashes. To determine the available amount of friction able to be provided by an aggregate, the following will need to be considered:

- cross slope of the roadway,
- surface design life,
- the macro texture of the proposed surface,
- and the aggregate micro texture.

To aid in this selection process, the Materials and Tests Division maintains the Surface Aggregate Selection Form (form 2088). This form is required for all flexible pavement designs and the information from this form will determine the appropriate Surface Aggregate Classification (SAC) of the aggregate used for the final hot-mix asphalt (HMA) riding surface.

2. PERFORMANCE GRADE (PG) BINDER SELECTION GUIDE

2.1 Introduction

Superpave criteria for choosing a binder is a process which includes project location (climate), confidence levels for both high and low temperatures, and possible up-grades for traffic speed (fast, slow, or standing) and traffic volume. Specifications for HMA products (Items 341 and 344) require selection of a performance graded (PG) binder. Item 342, “Permeable Friction Course (PFC),” Item 346, “Stone-Matrix Asphalt (SMA),” and Item 348, “Thin Bonded Friction Courses (TBFC),” require the use of either PG 76 or Asphalt Rubber. Item 347, “Thin Overlay Mixture (TOM),” requires the use of PG 76 binder.

2.2 Phase I – Base Binder Grade

To specify a performance graded asphalt binder, one needs to determine the temperature extremes under which the pavement must perform. A grade is determined by indicating the high and low temperatures for performance. As an example, we expect PG 64-22 to perform at a high temperature of 64 ° C and a low temperature of -22 °C. The grading system uses increments of 6 ° C for the high and low temperature designation. The Performance-Graded Binder specification in Item 300 uses high temperatures of 58, 64, 70, 76, and 82 and low temperatures of -16, -22, -28, and -34. The high temperature designation represents the 7-day average high pavement temperature. The low temperature designation represents a single occurrence low pavement temperature. As a result, the high temperature will be used to design for rutting resistance, while the low temperature will be used to design for cracking resistance.

Select the beginning binder based on the location (climate) and confidence levels (the chance that normal variations in temperature will not exceed the binder's grade range). The selection algorithm uses this information and heat transfer calculations to determine a binder grade based on the pavement temperatures expected in the surface layer, 20 mm below the surface. In practice, this involves using a computer program for individual locations or maps developed for larger data sets showing climate grades in geographic areas.

Computer Program—The computer program (LTPP Bind) through the FHWA uses input of longitude, latitude, and high and low temperature confidence levels to calculate the binder grade required. The program allows individual entry of the high and low temperature confidence levels from 50% to 99.99%. These confidence limits are the percent chance that local climatic temperature variations will not exceed the design temperatures. The program output is the PG binder that meets the defined minimum confidence limits for the closest three weather database stations. These are the standard climate grades for the three locations and represent the binder required for fast moving traffic. The Department also maintains PG Binder Grade Selection software that will assist in the selection of both PG and SPG binder grades based on climate. More information on this process can be found within the Department document, "Superpave Binder Materials Selection Procedures."

Determining the base binder grade should include studying the effect of the confidence limit on the high and low temperature portions of the grade. In general, the high temperature part of the grade will not change unless one reduces the confidence significantly. This will probably result in unacceptable confidence levels. The low temperature part of the grade might change with modest decreases in confidence levels. The District should choose confidence levels it can support.

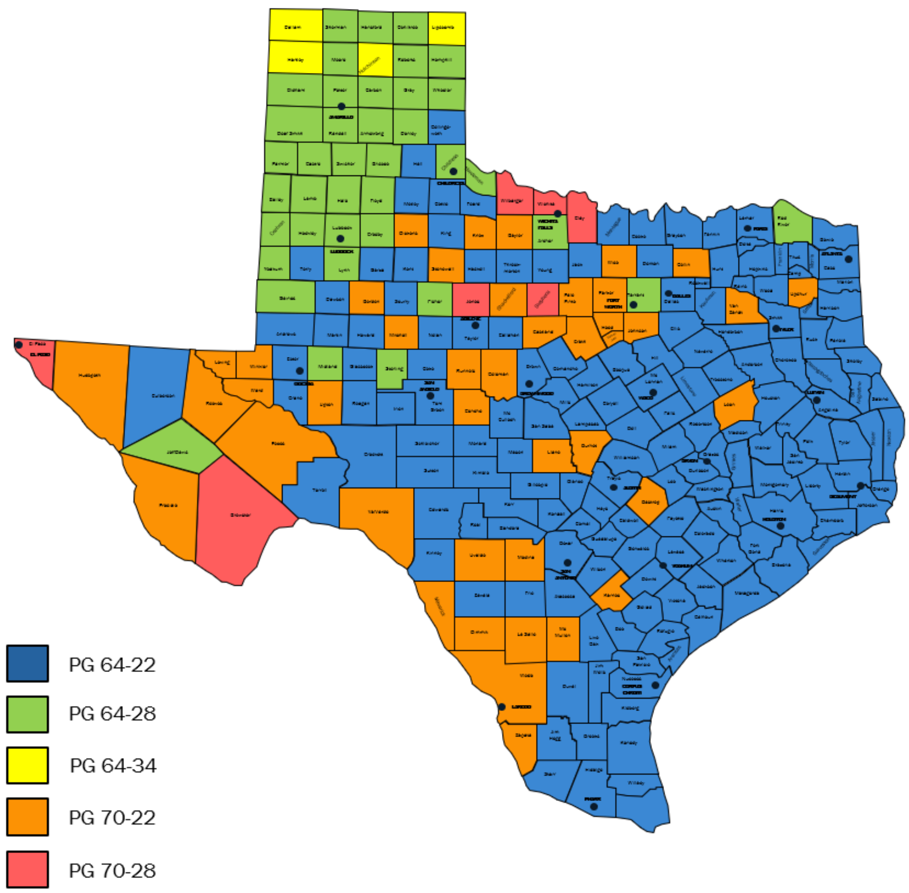


Figure 2.1
Recommended Climate-Based PG Binder Grade – 98% Confidence

Maps—The Materials and Tests Division supplies maps at 95% and 98% confidence levels that were generated using the computer program. These maps are color-coded according to PG binder grade by county.

2.3 Phase II – Possible High Temperature Designation Increases

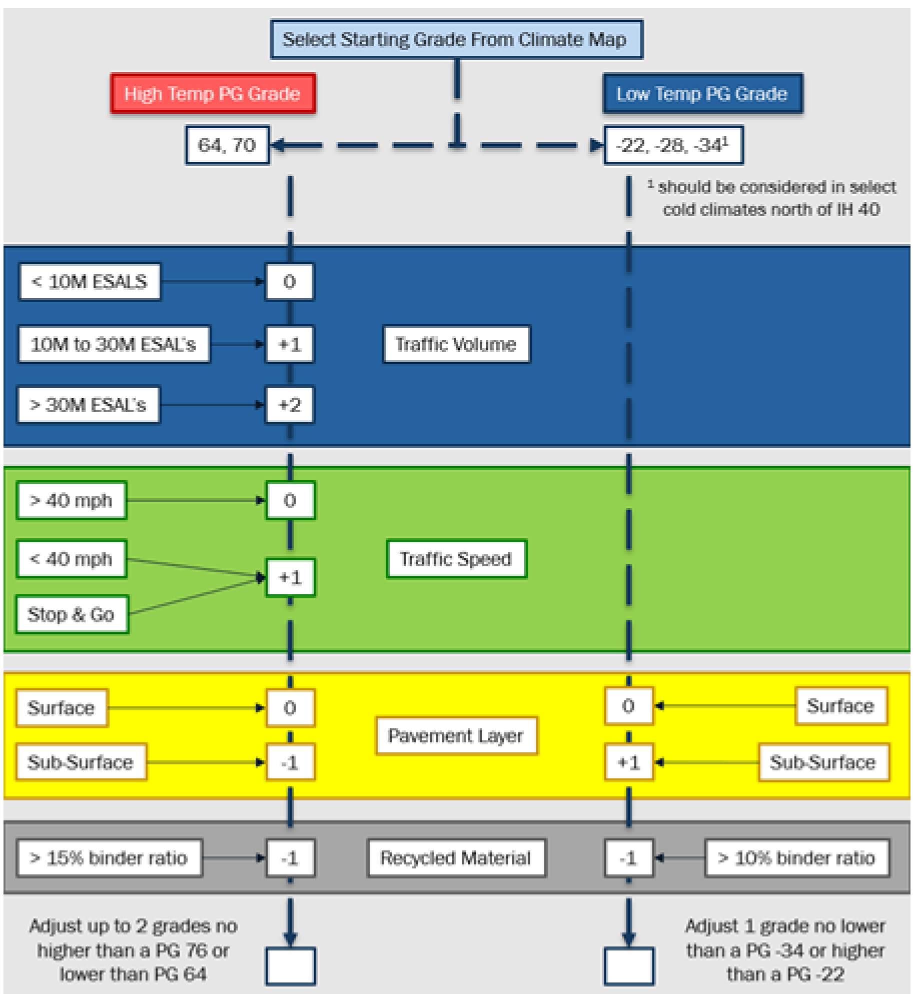
In theory, only the low temperature, and not traffic levels or mixture type, affects low temperature binder performance (resistance to thermal cracking). The high temperature designation can be influenced by factors other than climate, as described below.

Speed and Volume—The high temperature performance, resistance to rutting, is affected by several traffic related factors. The Superpave system allows one to increase the high temperature grade for traffic speed and volume.
The designation of the initial climate-based binder grade assumes a fast-loading rate, or fast-moving traffic. Slow moving traffic (longer loading times) may warrant an increase of one temperature grade on the high side.

With proper conditions, standing traffic (higher loading times) may warrant increasing the high temperature grade by two increments over the base climate grade.

There are also recommendations for increasing the high temperature designation to account for traffic volumes. Traffic volumes are described by the number of 18,000 lb. equivalent single axle loads (ESALs) expected over the design life of the pavement structure (typically 20 or 30 years). This accounts for the higher pavement load from trucks, and not by traffic counts, which treat all vehicles the same. The recommendations are: 1) If the design life of the pavement will see between 10 million and 30 million ESALs, consider increasing the high temperature designation by one grade, and 2) If the design life of the pavement will see more than 30 million ESALs, the high temperature designation is required to be increased by one grade. However, a two-grade increase should be considered. For a more detailed description on PG binder grade adjustments, see Table 2.1 below.

Table 2.1
PG Binder Grade Adjustment



Engineering Judgment—When determining the appropriate base binder grade and considering possible increases to the high temperature grade, there are some economic considerations as well.

The Department Specification for PG binders includes a test called Elastic Recovery (ER) for any binder with a temperature grade span of 92 or more. A binder span is defined as the difference between the higher temperature grade and the low temperature grade. For example, a PG 64-22 would have a span of 86. This ER requirement gets higher for increasing grade span. This requirement effectively requires the use of an elastic polymer additive in the manufacture of the binder. Polymers add cost (materials and processing) to the base binder and result in increased price. The higher the grade span, the more polymer, and generally a higher price.

Use judgment in the number of high-temperature “grade bumps.” One could come up with a scenario in which a base climate grade of PG 64-22 is bumped three or four times resulting in a PG 82-22 to be specified for a project. This would probably be overkill and would result in a very expensive binder, which also may be difficult to place. A maximum two-grade increase to no higher than a PG 76 is usually enough in all but the most extreme conditions.

The selection process, using weather data, assumes you are selecting the binder for a surface layer,20 mm below the surface. Deeper in the pavement structure, the binder is not exposed to the same temperature extremes as the surface; therefore, multi-layer paving projects can use less demanding binder grades in lower layers. Lower layers generally do not need grade bumps for the high temperature grade. Layers that are further from the surface can typically use lower high temperature grade binders than the climate-based selection process indicates. For example: If you were building three layers and PG 64-22 is indicated as the standard climate grade and you were on high volume facility, you might use PG 76-22 for the surface, PG 64-22 for the middle layer, and PG 64-22 for the lowest layer.

Another consideration is the number of binder grades specified in a project. Requiring the use of multiple binder grades may influence a Contractor’s ability to store binder and produce HMA. Using two binder grades in the same time frame is considered reasonable.

In the Department Specification, a specific binder grade meets all the requirements for that grade and all lesser performing grades. This means that a PG 64-22 meets the requirements for PG 58-22, PG 58-16, and PG 64-16. These grades usually will not require polymer additives in their manufacture and consequently will not have much, if any, price difference between them. Therefore, in the multiple layer example above, you might use a PG 76-22 for the surface and a PG 64-22 for all underlying layers to both meet your design and economic considerations without requiring too many grades for the Contractor to store. For a single layer project, if the climate showed you need PG 64-16, you may specify a PG 64-22 (theoretically a better performing grade) and expect little to no added binder cost.

3. HOT-MIX ASPHALT MIXTURE SELECTION GUIDE

3.1 General Description of Hot Mix Asphalt (HMA) Mixtures

3.1.1. Item 341: Dense-Graded Mixtures

Description: Quality control/quality assurance (QC/QA) specification for conventional dense-graded mixtures.

Typical Use: Dense-graded mixtures in this QC/QA specification 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 moderate volume (or moderate 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 70 years and have performed well when used in the correct applications.

The mixtures listed in the QC/QA specification can also be used on small or miscellaneous projects. When the material is designated as exempt the QC/QA specification calls for reduced QCQA measures to be taken by both the Contractor and the Department. The 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 make them more susceptible to cracking and more permeable. 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 specifications require the use of a Superpave Gyratory Compactor (SGC) to design dense-graded mixtures. It is possible to increase or decrease the amount of asphalt in the mixture by adjusting the number of gyrations from the standard 50 when using the SGC. Generally, the number of gyrations is reduced or increased in increments of 5. A lower number of gyrations will produce a mixture with more asphalt and vice versa. 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 will reduce the risk of cracking and less asphalt will reduce the risk of rutting. These practices are acceptable and are 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 the QC/QA specification, 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.

3.1.2. Item 342: Permeable Friction Course (PFC)

Description: 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 with a posted speed limit of 45 mph or higher. Existing pavement cracks must first be sealed to prevent moisture from infiltrating into the underlying layers. This can be achieved by requiring an underseal before placing PFC layers. PFC is not typically used as a structural overlay, however, it is excellent at draining water and reducing noise.

Advantages: As opposed to all other types of hot mix, PFC is designed to let water freely drain both vertically and horizontally. For this reason, it is imperative that the underlying material be impermeable and properly cross-sloped so that vertical water flow is restricted to the depth of the PFC and water is forced laterally off the roadway. PFC mixtures significantly reduce the risk of hydroplaning, reduce water spray, improve wet weather visibility and visibility of pavement markings, significantly reduce tire noise, and restore ride quality. More recently, PFC mixes have also been shown to improve the quality of storm water runoff. 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 at 1.5 inches thick, therefore the yield per ton of mix is relatively high. The PFC-F mixture can be placed as thin as 3/4 in. PFC unit weight is 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.) compared to conventional mixtures. The asphalt used in PFC mixtures contain high amounts of polymers. In addition to the polymers, PFC mixtures require the use of fibers and may require the use of lime. 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 before placing the PFC. A proper cross slope must exist on the underlying layer to ensure free water is directed laterally off the roadway. 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 (like 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, controlled intersections, etc. PFC is not recommended for mill and inlay operations. Furthermore, one of the disadvantages of PFC mixes is the lack of options for rehabilitation at the end of life for this mix.

It is not a good practice 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.

3.1.3. Item 344: Superpave Mixtures

Description: Superpave mixtures are produced and placed according to a quality control quality assurance (QC/QA) specification.

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

Advantages: An advantage is that most Contractors and HMA producers are generally familiar with the production and placement of Superpave mixtures. As compared to the QC/QA specification used for dense-graded mixtures, one of the primary advantages of Superpave mixtures is that 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. The rutting resistance is provided by the aggregate structure and is less dependent on the binder properties. This coarse aggregate structure also creates ample space to accommodate higher binder contents. This increase in overall binder content helps to create a mixture that is more cracking resistant. Superpave mixtures designed in this manner tend to have an overall coarse surface texture that can be beneficial in terms of wet weather traction.

An additional advantage is that the binder content within the mixture can be adjusted by modifying the Ndes level or by modifying the gradation. Balancing Ndes and the gradation allows designers to use different material across the state, while still achieving adequate asphalt contents and design volumetrics. For example: a mix with a low Ndes level, will yield a mixture that is higher in asphalt. The higher asphalt will help mitigate cracking and provided for greater durability. Conversely, a mix can be designed with a higher Ndes level for intermediate and base layers, which will yield a mixture that is lower in asphalt, thus minimizing the potential for flushing and fat spots. This decrease in asphalt content will also help to save money on subsurface layers.

Disadvantages: Compared to regular dense mixtures, Superpave mixtures can be more difficult to compact due to the stone-on-stone structure and aggregate quality requirements. Failing to achieve proper in-place density can potentially cause permeability problems and shorten the performance life of the pavement.

Compared to SMA mixtures, Superpave mixtures have a gradation that is not as “gap graded” as an SMA mixture. As a result, Superpave mixtures typically contain less asphalt than SMA mixtures and may therefore be more susceptible to cracking and water infiltration as compared to SMA.

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).

3.1.4. Item 346: Stone-Matrix Asphalt (SMA)

Description: Stone-Matrix Asphalt (SMA) mixtures are produced and placed according to a quality control quality assurance (QC/QA) specification.

Typical use: SMA mixtures are used as a surface layer in the pavement structure on high volume (or high demand) roadways. Thus, it is a good candidate to replace Dense Graded and Superpave mixtures when planning rehabilitation in high demand areas. When a PFC mixture is used as the final riding surface, SMA mixtures are often used directly beneath the PFC to provide a tough, durable, impermeable 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. SMAR is generally more expensive than the standard SMA; however, its unique properties warrant its use in certain applications. SMAR is generally recommended 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 and shoving. SMA mixtures are relatively impermeable, particularly when compared to Superpave 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 high amounts 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 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.

It is not a good practice 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.

3.1.5. Item 347: Thin Overlay Mixtures

Description: Thin Overlay Mixtures (TOM) are produced and placed according to a quality control quality assurance (QC/QA) specification.

Typical Use: TOM mixtures are used as a surface course usually in a pavement preservation capacity and to optimize the safety and comfort characteristics of the roadway. TOM mixtures are placed in thin lifts between 1/2 to 1-1/4 in. thick. High quality aggregates are specified, unless otherwise shown on plans. Polymer-modified binders using a high temperature grade of 76 and a minimum binder content of 6.0% is specified. No recycled products (RAP and RAS) are allowed in the mixture. These criteria make TOM mixtures expensive on a tonnage basis, but because they are placed in thin lifts, their yield is greater than standard dense-graded mixtures and are less expensive than a conventional 2 in. overlay on a square yard basis.

Advantages: TOM mixtures provide both excellent rut resistance and crack resistance. Quality aggregates ensure high skid resistance. A high asphalt content makes this a very durable mixture with excellent performance characteristics when placed on a sound substructure that may have minor cracking and rutting. When compared to a surface treatment, TOM mixtures are quieter, are not prone to vehicle-thrown rock chips, and provide better shear force resistance to turning and acceleration/deceleration movements. TOM mixtures can be an ideal solution to refreshing the pavement surface where fixed grade lines in curb and gutter sections or bridge clearances must be maintained. TOM mixtures can be considered for use over standard dense-graded mixes to provide a more durable (better moisture, oxidation, crack resistant) riding surface in new or rehabilitated pavement sections.

Disadvantages: The need to ensure performance through use of 100% quality virgin materials makes the mix expensive on a tonnage basis, but this is mitigated by thin-lift nature that increases the yield. Like surface-treatments, this type of treatment is not considered a structural overlay. Repair of all moderate or more severe isolated distressed locations must be addressed before placing a TOM mix. Where milling is used to correct ride or cross slope issues, micro-milling should be used to create a finer finish that will allow uniform compaction.

It is not a good practice to place any type of hot mix in cool or cold weather. TOM mixtures can be particularly difficult to place in cool weather because they are placed in very thin lifts, and they contain a high amount of polymer modified binder. The use of dual steel wheeled rollers working in tandem is highly recommended. They also do not lend themselves well to applications that require a significant amount of hand work.

3.1.6. Item 348: Thin Bonded Friction Courses

Description: Thin Bonded Friction Courses are produced and placed according to a quality control quality assurance (QC/QA) specification. There are two types of mixtures that fall under this specification: permeable friction courses and thin bonded wearing courses. Both types of mixtures require polymer-modified asphalt binder with a high-temperature grade of PG 76. Thin Bonded Friction Courses are placed by a spray-paver that applies a polymer modified emulsion membrane, followed immediately with a thin lift of the friction course. The membrane application rate is dictated by the design lift thickness and is designed to provide surface sealing capability for pavements with light distress, milled surfaces, or leaky joints. Thin Bonded Permeable Friction Course mixtures are placed in thin lifts between 3/4 to 1-1/2 in. thick; Thin Bonded Wearing Course mixtures are placed in thin lifts between 1/2 and 3/4 in. thick.

Typical Use: Thin Bonded Friction Courses are used to restore functional properties of the pavement structure as part of a pavement preservation program. The thin bonded PFC mixtures are used as a 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 with a posted speed limit of 45 mph or higher. The materials and mixture requirements for the PFC placed on the membrane are the same as those specified in Item 342. The thin bonded PFC is recommended instead of PFC as specified in Item 342 when placed as an overlay on existing flexible or concrete pavements, or when placed as an overlay on a pavement that has open texture/joints or minor-to-moderate cracking. The thin bonded wearing courses provide an alternative to Item 347 TOM mixtures. Unlike the TOM mixture, the thin bonded wearing course is more permeable (maximum design density is 92%), thus potentially offering better splash/spray and surface drainage characteristics.

Advantages: Thin Bonded Friction Courses use an all-in-one tack and paving process that eliminates the danger of tracking the tack coat from the prepared surface by construction and other traffic. The tack-membrane is of enough volume to seal the existing pavement surface, eliminating the need for an under seal. The result is an expedited process with potentially fewer delays for the traveling public as compared to conventional operations of placing a surface treatment followed by an overlay. Advantages mentioned previously for the standard PFC (Item 342) apply. Thin Bonded Wearing Courses have a gap-to-open-graded aggregate structure to improve surface drainage and reduce splash and spray over denser surfacing; a minimum required asphalt cement film thickness ensures durability. Compared to a traditional surface treatment, these mixtures will provide better resistance to shearing by traffic, noise reduction, and elimination of thrown rock chips. These mixtures allow renewal of surface texture quality while maintaining overhead clearances and pavement profiles.

Disadvantages: Thin Bonded Friction Courses typically have a higher initial cost compared to conventional dense-graded mixtures, but because they are placed in thin lifts, their yield is greater than standard dense-graded mixtures making these mixtures cost competitive. The process to place Thin Bonded Friction Courses requires a specialized piece of equipment that may not be as readily available as conventional equipment.

Thin Bonded Friction Courses contain more asphalt (6% min., minimum 9 micro-film thickness for wearing courses) compared to conventional mixtures. The asphalt used in Thin Bonded mixtures contain high amounts of polymers. In addition to the polymers, PFC mixtures require the use of fibers and may require the use of lime. All these additives not only add to the initial cost, but they sometimes require that the producer make modifications to their typical HMA production processes. Thin Bonded mixtures must be placed on top of a pavement that is structurally sound. Thin Bonded PFC is not recommended for low speed roadways, as they can clog up more quickly thus negating the beneficial drainage characteristics. Thin Bonded PFC mixtures tend to freeze faster and thaw slower (similar to a bridge) compared to conventional mixtures. Thin Bonded 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. Thin Bonded Friction Courses are not recommended for mill and inlay operations.

It is not a good practice to place any type of hot mix in cool or cold weather. Thin Bonded Friction Courses can be particularly difficult to place in cool weather because they are placed in thin lifts, have high void structure, and they contain a high amount of polymer modified binder. Also, during cool or cold weather, the polymer emulsion membrane may not break in a reasonable amount of time and the mixture may be placed on emulsion that has not broken. This may create an inadequate bond between the existing surface and the Thin Bonded mixture which could lead to cracking and premature failure. These mixtures also do not lend themselves well to applications that require a significant amount of hand work.

3.1.7. SS 3000: Crack Attenuating Mixture (CAM)

Description: Crack Attenuating Mixture (CAM) mixtures are produced and placed according to a quality control quality assurance (QC/QA) special specification.

Typical use: CAM mixtures are fine-graded and recommended for use as an intermediate layer in the pavement structure, placed in relatively thin lifts from 1 to 2 in. CAM is designed to reduce reflective cracking in hot mix overlays and is less susceptible to rutting than typical stress absorbing membrane interlayer (SAMI) products. It is recommended to place this mixture on the existing pavement followed with an overlay of hot mix asphalt with a minimum thickness of 2 in. It is not recommended to use this mixture as the final riding surface because the mixture is fine graded and lacks macro-texture. Vehicles may become more susceptible to hydroplaning, especially for high-speed roadways with posted speed limits > 45 mph and undivided highways with numerous vertical and horizontal curves. Recommended use for CAM mixtures are as an intermediate layer. CAM works well for placement on existing concrete pavements and pavements that have a moderately high amount of (ideally, non-load related) cracking. However, in high surface stress environments (heavy truck traffic with slow/accelerating/decelerating/stopping/turning movements), PG 70 or higher polymer modified binders should be used to prevent rutting under thin HMA surfacing.

Advantages: CAM mixtures can be designed to provide both resistance to cracking and rutting if the mixture is to be placed within 4 in. of the surface, or can be designed simply as a crack-resistant layer if placed deeper within the structure. CAM is designed and produced with an optimum asphalt content greater than 7%, and up to 10% fine material passing the #200 sieve. This combination produces a durable mixture. The PG binder grade selection range (PG 64 or higher) allows for flexibility in placement within the pavement structure. The special specification requires additional laboratory performance testing to evaluate the mixture. The mixture design and trial batch mixtures are tested and evaluated with the Hamburg Wheel-tracking Test and Overlay Tester. These laboratory tests provide an indication of the susceptibility to rutting and cracking. CAM can potentially be used to fill rutted wheel paths due to its fine gradation. CAM may be placed in relatively thin lifts, which may help maintain overhead clearances and pavement profiles. Special Specification 3000 requires payment for asphalt and aggregate separately.

Disadvantages: CAM mixtures typically have a higher initial cost compared to conventional dense-graded mixtures. This is attributed to several factors. CAM mixtures contain more asphalt with a minimum of 7%. If a PG binder grade of 70-XX or higher is selected, the higher polymer concentration will also add to the cost. The mixture design and trial batch require more testing with the overlay tester criterion in the special specification.

Blistering (a phenomenon that occurs when moisture is trapped deeper within the pavement structure) is more prevalent with the placement of CAM mixtures. CAM mixtures are generally placed and compacted to 2.0% to 6.0% air voids, thus, are less permeable than conventional mixtures. Blisters, approximately 1 inch in height and 1 to 2 feet in diameter may form when the ambient temperature increases above normal temperatures. Blisters may not be detrimental to the pavement structure as traffic may compact and level them. They may not be an issue after an overlay is placed on the CAM mixture. The overlay may provide insulation not allowing the temperature within the pavement structure to increase to the point where moisture vaporizes to form the blisters.

CAM mixtures are not recommended as the final riding surface because of safety concerns. These mixtures are finely graded and may lack the macro-texture to provide optimal skid resistance. CAM mixtures may also produce a glare off the pavement surface due to the rich liquid asphalt content, which may disturb the traveling public.

CAM mixtures are recommended as an underlayer with a minimum of approximately 2 to 4 inches of coverage of HMA. A pavement structure with less than 2 inches of HMA on top of the CAM may be prone to premature rutting or cracking. It is imperative that the correct asphalt binder be selected for the specific application of this mix. Premature failures have occurred throughout Texas and have been investigated by the Materials and Tests Division. The causes of these premature failures were due to multiple factors but primarily attributed to the lack of coverage of HMA on top of the CAM. The other factors included a high percentage of heavily loaded trucks and placement location, such as at intersections.

It is not a good practice to place any type of hot mix in cool or cold weather. CAM mixtures can be particularly difficult to place in cool weather because they are placed in thin lifts and may 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.

Tables 3.1 thru 3.3 provide guidance for the selection of hot mix asphalt (HMA) mixture types. These guidelines should be used in addition to good engineering judgment to determine the appropriate HMA selection.

Table 3.1

Relative Hot Mix Rankings Characterized by Level of Resistance

Surface Mix Type[1, 2]		Mixture Characteristics / Functionality: Impermeability	Long Term Durability	Wet Weather Traction	Wet Weather Visibility	Noise Reduction	Ease of Compaction	Ability to "Hand Work"	$/Ton[9]	Qualified Alternate[4]
Dense-Graded	TY-C	1	1	2	1	2	2	3	4	TY-D
	TY-D	2	2	2	1	2	2	3	4	TY-F
	TY-F	3	2	2	1	3	3	3	4	TOM
PFC[5]	PFC-F	*N/A*	3	4	4	4	4	1	2	TBPFC
	PFC-C		3	4	4	4	4	1	2	
Superpave	SP-C	3	3	3	1	2	2	3	4	TY-C, SP-D
	SP-D	3	3	3	1	3	3	3	3	TY-D
SMA[6,7]	SMA-C	4	4	3	2	2	1	1	3	SMA-D
	SMA-D	4	4	3	2	2	2	2	2	SMA-F, SMAR-F
	SMA-F	4	4	3	2	2	3	2	2	SMAR-F
	SMAR-F[8]	4	4	3	2	3	3	2	1	SMA-D, SMA-F
Thin Overlay Mixtures[5]	TOM-F	4	4	3	2	3	4	2	3	Micro Surface or Thin Bonded Friction Course
	TOM-C	4	4	3	2	3	4	2	3	
Thin Bonded Friction Courses[5]	TBPFC-F	*N/A*	3	4	4	4	4	1	1	PFC with an Underseal
	TBPFC-C		3	4	4	4	4	1	1	
	TBWC TY-A	*N/A*	3	4	3	3	4	1	1	PFC or TOM with an Underseal or Thin Bonded PFC
	TBWC TY-B		3	4	3	3	4	1	1	
	TBWC TY-C		3	4	3	3	4	1	1	

Level of Functionality	*Applicability*
High	4
Moderately High	3
Moderately Low	2
Low	1

Table 3.2
Relative Hot Mix Rankings Characterized as Level of Functionality

Surface Mix Type[1, 2]		Mixture Characteristics: Resistance to[3] Rutting	Cracking	Segregation	Ravelling	High Shear Forces (Braking, Acceleration, Hard Turning)	Moisture Damage	Qualified Alternate[4]
Dense-Graded	TY-C	2	1	1	1	3	1	TY-D
	TY-D	2	2	2	2	2	2	TY-F, TOM
	TY-F	2	3	3	3	1	3	TOM
PFC[5]	PFC-F	4	4	4	2	1	3	TBPFC
	PFC-C	4	4	4	2	1	3	
Superpave	SP-C	3	3	3	3	3	3	TY-C, SP-D
	SP-D	3	3	3	3	3	3	TY-D
SMA[6,7]	SMA-C	4	4	3	4	4	4	SMA-D
	SMA-D	4	4	4	4	4	4	SMA-F, SMAR-F
	SMA-F	4	4	4	4	4	4	SMAR-F
	SMAR-F[8]	4	4	4	4	4	4	SMA-D, SMA-F
Thin Overlay Mixtures[5]	TOM-F	3	3	4	4	4	4	Micro Surface or Thin Bonded Friction Course
	TOM-C	3	3	4	4	4	4	
Thin Bonded Friction Courses[5]	TBPFC-F	4	3	4	2	2	3	PFC with an Underseal
	TBPFC-C	4	3	4	2	2	3	
	TBWC TY-A	4	3	4	2	2	3	PFC or TOM with an Underseal or Thin Bonded PFC
	TBWC TY-B	4	3	4	3	3	3	
	TBWC TY-C	4	3	4	3	3	3	

Level of Resistance	*Applicability*
High	4
Moderately High	3
Moderately Low	2
Low	1

Notes for Tables 3.1 and 3.2:

Note 1—Surface treatments instead of HMA may be appropriate for use on pavements with ADT < 10,000 provided the existing pavement has no significant issues with structural capacity, rutting (transverse profile), ride quality (longitudinal profile), or noise mitigation. All surface mixtures should be used in conjunction with the Department's Wet Surface Crash Reduction Program (WSCRP)

Note 2—Increasing or decreasing the high temperature grade of the PG Binder may impact the expected performance and initial cost of the chosen mixture type.

Note 3—Mixture type may offer more resistance to rutting and high shear forces by increasing or "bumping" the high temperature grade by one or two grades. The mixture type may offer more resistance to cracking and freeze/thaw damage by decreasing the low temperature grade by one or two grades.

Note 4—Qualified alternates may not necessarily offer equal performance or structural capacity. Cost comparisons should be performed on a price per square yards basis.

Note 5—Does not provide or significantly add structural capacity to the pavement. Mixture type provides improved safety and other functional benefits, such as reducing risk of hydroplaning, improving visibility, skid resistance, and ride quality, and reducing noise.

Note 6—SMA is generally only recommended for high volume roadways, such as Interstate and US highways with a minimum of 5 million ESAL's. However, SMA offers significantly improved resistance to reflective cracking and therefore, it may be more appropriate for use instead of dense-graded and Superpave mixtures for pavements where reflective cracking is a significant issue.

Note 7—These mixtures are considered highly impermeable and generally can be used without an underseal provided that the underlying pavement has not been exposed to moisture intrusion for extended periods of time.

Note 8—The use of A-R modified asphalt binder is generally only recommended to mitigate reflective cracking & noise and when superior bonding is necessary such as when overlaying concrete pavements.

Note 9—Cost per ton represents the initial purchase price of the material. This price can fluctuate throughout the state and is highly dependent on the binder grade, aggregate availability, total project tonnage, and the availability of specialized equipment. Other variables should be considered such as: life expectancy of the pavement, layer thickness, locally available materials, and the intended purpose of the layer.

Table 3.3
Summary of Mixture Types, Sizes, and Typical Use

HMA Mixture Type		Nominal Maximum Aggregate Size	Minimum Lift Thickness (inches)	Maximum Lift Thickness (inches)	Typical Location of Pavement Layer
Dense-Graded (Item 341)	TY-B	1”	2-1/2”	5”	Base/Intermediate
	TY-C	3/4”	2”	4”	Intermediate/Surface
	TY-D	1/2”	1-1/2”	3”	Surface/Level-Up
	TY-F	3/8”	1-1/4”	2-1/2”	Surface/Level-Up
PFC (Item 342)	PFC-F PG 76	1/2”	3/4”	1-1/2”	Surface
	PFC-C PG 76	3/4"	1”	2”	Surface
Superpave Mixtures (Item 344)	SP-B	3/4”	2-1/2”	4”	Base/Intermediate
	SP-C	1/2”	2”	3”	Intermediate/Surface
	SP-D	3/8”	1-1/4”	2-1/2”	Surface/Level-Up
SMA (Item 346)	SMA-C	3/4”	2-1/4”	4”	Surface
	SMA-D	1/2”	1-1/2”	3”	Surface
	SMA-F	3/8”	1-1/4”	2”	Surface
	SMAR-F	3/8”	1-1/2”	3”	Surface
CAM (SS 3000)	CAM	3/8”	1”	2”	Base/Intermediate
Thin Overlay Mixtures (Item 347)	TOM-F TOM-C	1/2" 1/2”	1/2" 3/4”	1” 1-1/4”	Surface Surface
Thin Bonded Friction Courses (Item 348)	TBPFC-F PG 76	1/2”	3/4”	1-1/2”	Surface
	TBPFC-C PG 76	3/4”	1”	2”	Surface
	TBWC TY-A	3/8”	1/2”	3/4”	Surface
	TBWC TY-B	1/2”	5/8”	1”	Surface
	TBWC TY-C	3/4”	3/4”	1-1/4”	Surface