Superpave Binder Materials Selection Procedures

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Asphalt Binder Branch, Materials and Tests Division

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 all hot mix asphalt (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)," 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 Mixtures (TOM)" requires the use of PG 76. This also applies to all Special Provision or Special Specifications for these materials. PG binders for these items must be still designated the low temperature portion of the PG grade on the plans.

This document provides guidance and information regarding the selection of PG binders for flexible pavements. It provides guidance on how to properly select a PG binder based on both climate, and traffic and other characteristics. It is presented in two phases; Phase 1- Selecting the base binder grade (climate), and Phase 2 - Modifications to the base binder grade (based on traffic and other factors).

Phase I—Base Binder Grade

To specify a PG binder grade, 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 PG 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 (i.e., 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 (PG Binder Grade Selection) uses input of longitude, latitude, and high and low temperature confidence levels to select both PG and Surface Performance Grade (SPG for seal coats) binder grades. 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.

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.

- *Maps*—Based on local weather stations in each county throughout the state, Figure 1 was compiled to represent the minimum binder grade required to withstand the environmental conditions at 98% confidence level for both high and low temperatures. The map includes information from the computer program, with modifications allowing for uniformity between local areas (each county is labelled and color-coded using the highest performing, most conservative, PG binder of all weather stations in the county) and historical binder supplier production data (most suppliers produce standard materials that meet the low temperature designation of -22). For this reason, some specific location inputs in the computer program may not match the designation shown on the map.

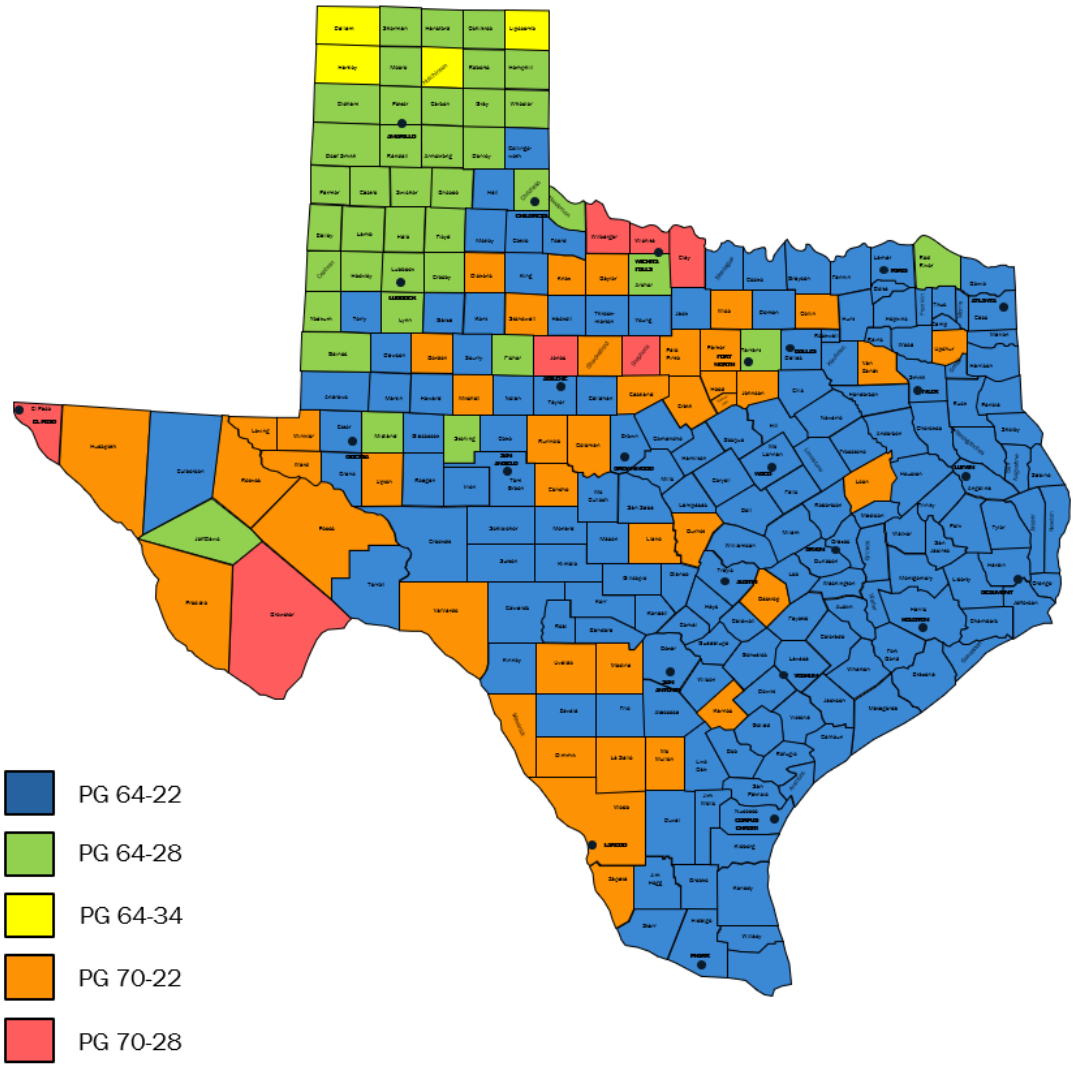


Figure 1. Recommended Climate-Based PG Binder Grade – 98% Confidence

Phase II—Possible High Temperature Designation Increases

In theory, only the temperature (how cold it gets), 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.

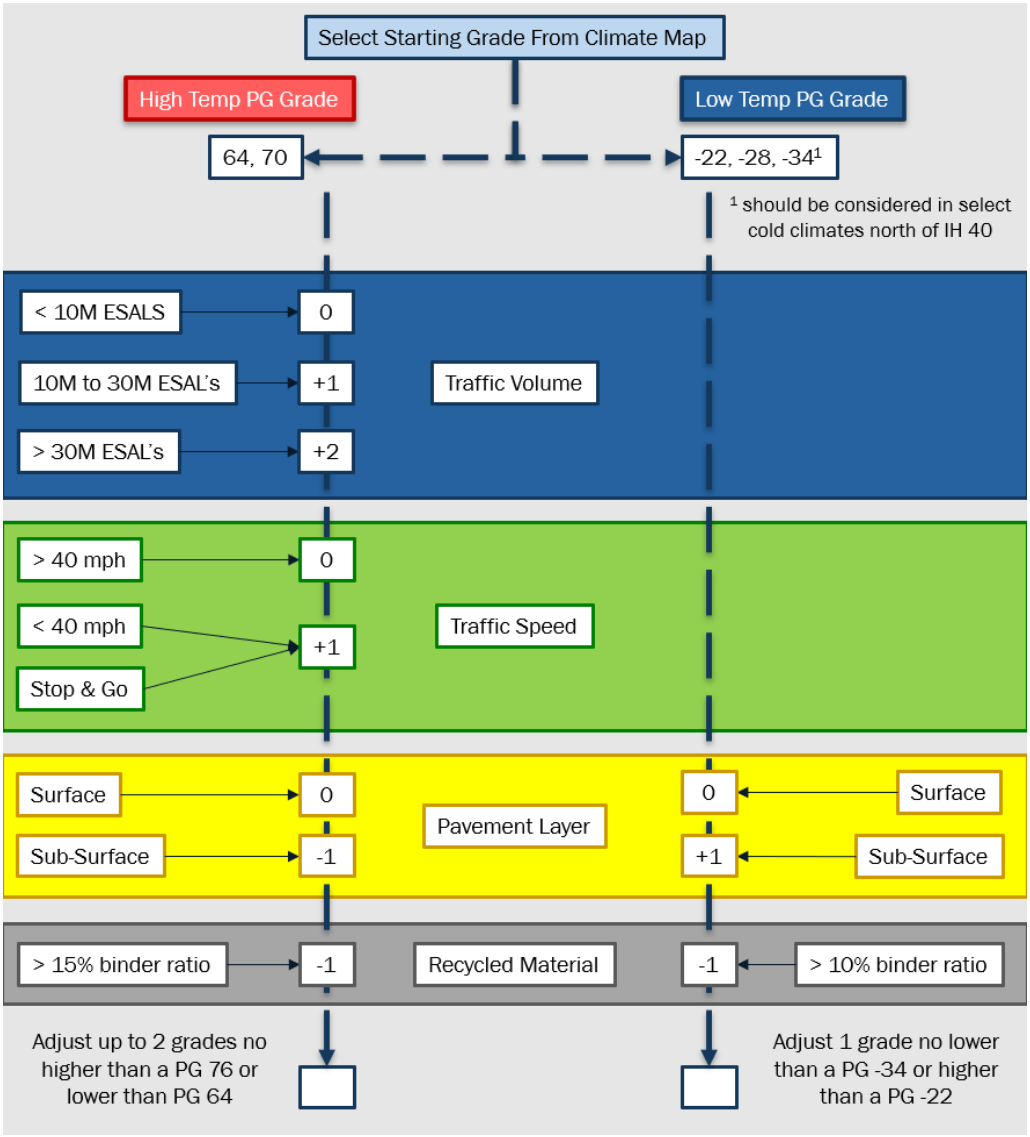
- *Speed and Volume*—The high temperature performance, resistance to rutting, is affected by several traffic related factors. The Superpave system allows one to increase the high temperature grade for traffic speed and volume.

  The designation of the initial climate-based binder grade assumed 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. 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 for traffic volumes. Traffic volumes are described by number of 18,000 lb. equivalent single axle loads (ESALs) expected over the design life of the pavement structure (typically 20 or 30 years) to account for the higher pavement loads 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, increase the high temperature designation by minimum one grade. However, you may consider a two-grade increase in such cases. In summary, the guidance is: above 10 million ESALs consider an increase, and above 30 million ESALs, increase the grade one increment.

  For a more detailed description on PG binder grade adjustments, see Table 1 below.

Table 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 TxDOT specification for PG binders includes two tests – the Elastic Recovery (ER) and the Multiple Stress Creep Recovery (MSCR) %Recovery tests – that determine the elasticity of any binder with a Useful Temperature Interval (UTI) of 92 or more. A binder's UTI is defined as the difference between the higher temperature grade and the low temperature grade. For example, a PG 64-22 would have a UTI of 64-(-22) = 86 while a PG 76-28 would have a UTI of 76-(-28) = 104. The ER test measures a binder's ability to rebound after elongation. The MSCR test is an elastic recovery-type test conducted using the Dynamic Shear Rheometer (DSR) used in PG binder testing. A binder that passes the MSCR test does not need to pass the ER, but a binder that does not pass the MSCR must meet the ER. The ER and MSCR requirements get higher with increasing UTI, thereby requiring 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 UTI, the more polymer, and generally a higher price.

Use judgment in the number of high-temperature grade "bump-ups." 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 sufficient in all but the most extreme conditions.

The selection process, using weather data, assumes you are selecting the binder for a surface layer (i.e., 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 bump-ups for the high temperature grade and the further from the surface they are, they can use lower high temperature grade binders than the standard selection process indicates. For example: If you were building three layers and PG 64-22 is indicated as the standard climate grade and you are on high volume facility, one might use PG 76-22 for the surface, PG 64-22 for the middle and the lowest layers.

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 TxDOT 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. Most producers make standard binders with a -22 low temperature designation, so asking for a less performing binder, say with a -16 designation may not be warranted.

One last consideration is the support for the pavement. Less pavement support means more deflection under traffic. One possibility to address this is to "bump" the low temperature grade down, for instance from a -22 to -28. This gives more cracking protection from temperature extremes but also makes the binder more fatigue resistant.

Remember that any binder with a UTI of 92 and higher is required to have elastic properties and will cost more. Above 92, the higher the UTI, the higher the cost.

Binder Selection Support

The Asphalt Binder Branch of the Flexible Pavements is available to answer questions about the use, suitability, or selection of PG binders. You may contact the Asphalt Binder Branch Manager at 512-506-5242.