PAVEMENT TECHNOLOGY ADVISORY
- PERFORMANCE GRADED BINDER MATERIALS FOR HOT MIX ASPHALT -
PTA-D4

INTRODUCTION

In 1999, the Illinois Department of Transportation (IDOT) began implementing the Superpave (Superior Performing Asphalt Pavements) mix design system, developed by the Strategic Highway Research Program. The Superpave method includes new terminology and procedures. The two most significant changes involve what used to be called asphalt cement. This is the material that holds hot mix asphalt (HMA) pavement together.

First, the term "binder" has been adopted to describe both modified and unmodified asphalt cement materials. One should note, however, that the intermediate paving course(s) of HMA pavements have traditionally been called "binders" or "binder courses," as well. Usually the context makes it apparent which is being referred to, but it can be a source of confusion. Eventually, a term such as "intermediate layer" should be adopted to replace the term "binder (course)" in the IDOT vocabulary.

Second, Superpave uses a performance graded (PG) system of classifying binder materials. The PG system has its own nomenclature that is much different than the previous asphalt cement (AC) grading system. The remainder of this document will focus on clarifying the differences between the AC and PG grading systems.

AC GRADING SYSTEM

Until Superpave introduced the PG grading system, asphalt cements were either "penetration" or "viscosity" graded. IDOT used the "penetration" system until the mid-1970's. From that time up to the conversion to Superpave, IDOT used a "viscosity" AC grading system.

One problem with the AC system is that it is based on empirical tests. Empirical specifications rely solely on practical experience and observations without regard for pavement performance theory. Therefore, the specification is based on the results from a given situation. Once the conditions change, the results may no longer be the same. The penetration test is a measure of asphalt stiffness, but the stiffness requirements were gained through experience. If the conditions change, the stiffness requirements may no longer be accurate. The accuracy will not be known until results are obtained under the new conditions.

Another drawback of the AC graded system is that long-term asphalt aging is not taken into consideration. The tests are performed on unaged or "tank" asphalt and on artificially short-term aged asphalt to simulate construction aging. No tests are performed to simulate in-service aging, which occurs when the asphalt reacts with the oxygen in the atmosphere by oxidation.

Oxidation increases the stiffness of the asphalt, making it more brittle or hard, causing premature cracking. Since oxidation occurs more rapidly at higher temperatures, warmer climates are more susceptible to greater amounts of in-service aging.

The AC system's tests do not cover the temperature extremes that a pavement endures. Binders that produce similar results at the temperatures used for penetration and viscosity testing may have very different results at other temperatures experienced by the pavement. For example, the three binders shown below (I, II, III) all meet the same AC grade specification; therefore, each may erroneously be expected to have the same characteristics during construction and the same performance during hot and cold weather conditions.

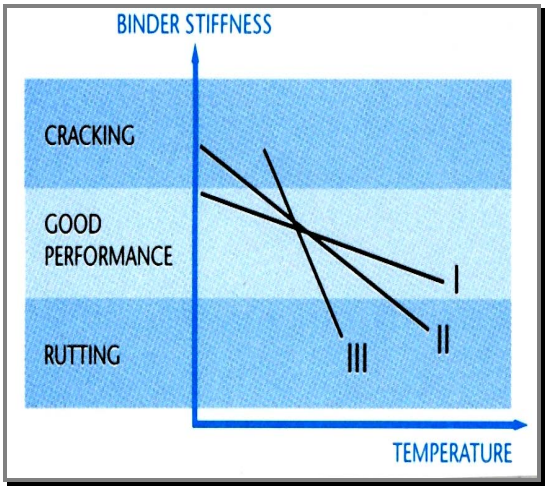

Figure 1: Temperature Responses of Different Binder Materials

CHANGING TIMES

Penetration and viscosity tests were developed in an era of significantly lower pavement loading. In the past, truck weights were around 72,000 lbs. with tires at 75 psi. Today, truck weights exceed 80,000 lbs. with 125 psi radial tires.

The 10% increase in truck weights yields a 40% increase in the stresses applied to the pavement, not to mention the increase in the number of trucks on the road. With such changes in road conditions, past experience is no longer sufficient to establish asphalt grading.

PERFORMANCE DRIVEN BINDERS

As part of the Superpave research, a new asphalt binder specification was devised. Grading based on viscosity and penetration has been replaced with a performance graded (PG) system. No longer are the tests empirical. The PG specification uses tests to measure physical properties that can be directly related to field performance by engineering principles.

PG binders are tested under conditions that are similar to the three critical stages of a binder's life. The binder is tested for the first stage of transport, storage, and handling. A rolling thin film oven is used to process the binder for the second stage, mix production and construction, by exposing binder films to heat and air that approximate exposure during mixing and laydown conditions. For the third stage, long term aging, the binder is aged using a pressure aging vessel. The pressure aging vessel exposes samples to heat and pressure to simulate years of in-service aging of a pavement.

WHAT DOES PG 64-22 MEAN?

PG means "performance graded" and may or may not contain polymers. The PG grade is selected largely based on the temperature where it is to be used. The nomenclature is illustrated in Figure 2. The first number (64 in the illustration) represents the maximum 7 day pavement design temperature in degrees Celsius (^{o}C) for which the binder is tested.

The higher the first number, the warmer the climate. The second number (-22 in the illustration) represents the minimum temperature in Celsius for which low temperature cracking should not occur. The low number is not relevant to PCC overlays, since low temperature contraction of an underlying concrete pavement cannot be restricted by the strength of the HMA overlay. Both numbers change in 6 °C (11 °F) increments in the Superpave system. Thus the grade in Figure 2 would be for a pavement with an operating temperature range between 64 °C and -22 °C (147 °F to -8 °F).

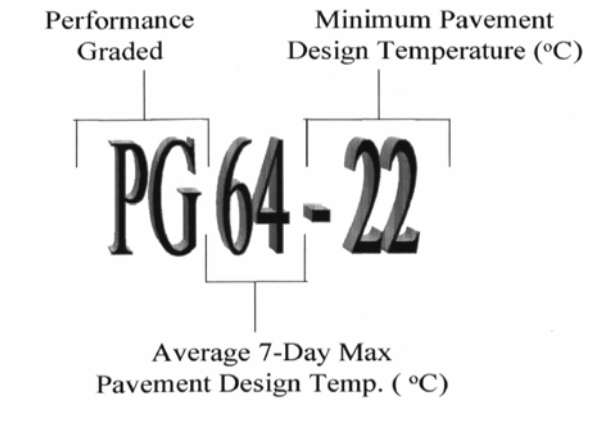

Figure 2: PG System Nomenclature

MODIFIED PG BINDERS

Some PG binders may require modifiers, such as polymers, to meet low and high temperature requirements (see *PTA-D5*). Although modifiers may affect many properties, the majority of modifiers attempt to decrease the temperature dependency and oxidation hardening of asphalt mixtures. A rule of thumb to determine whether a given grade will typically require some type of modifier is based on the working temperature range. For example, a PG 64-22 has a working range of 86 °C [64 + 22 = 86].

Higher quality crude oils can achieve a maximum working temperature of approximately 92 °C; whereas average crude oils have a maximum working temperature of approximately 90 °C.

IDOT allows any PG grade with a temperature differential of 86 °C or greater to be polymer-modified. Further, IDOT recommends polymer-modification for any PG grade with a temperature differential of 92 °C or greater. To assure that a polymer-modified PG binder is delivered by the supplier, the mix designer should specify a PG binder grade with the prefix "SBS" (e.g. SBS PG 64-28).

Unmodified PG binders should cost about the same as comparable AC grades (see the Grade Translation Chart on the following page), but modified binders can increase the cost of an HMA mixture by $2 to $5 per ton. As such, modified binders should not be prescribed without careful consideration of the benefits and costs associated with their use. Appropriate binder selection can be confirmed with the District Materials Engineer.

CERTIFICATION PROGRAM

PG binder materials and suppliers must be certified by the Bureau of Materials and Physical Research (BMPR) to be allowed on IDOT projects. A list of Certified Sources for Performance-Graded Asphalt Binder is available on the IDOT internet site.

If you have any questions about PG binder materials for hot mix asphalt, please contact:

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Physical Research
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GRADE TRANSLATION CHART

GUIDELINES FOR USE			
PG GRADE	**EQUIVALENT**	**USE**	**WHERE**
PG 64-22	AC 20	Overlays	Statewide
		Full Depth Pavements	Dist. 1-9
SBS PG 70-22	AC 20 MOD	Overlays	Statewide
		Full Depth Pavements	Dist. 7-9
SBS PG 76-22	AC 20 HD	Overlays	Statewide
		Full Depth Pavements	Dist. 7-9
SBS PG 64-28	AC 10 MOD	Full Depth Pavements	Dist. 1-6
SBS PG 70-28	AC 10 HD	Full Depth Pavements	Dist. 1-6
SBS PG 76-28	AC 10 HD+	Full Depth Pavements	Dist. 1-6
PG 58-22	AC 10	Local Agencies	
PG 58-28	AC 7.5	RAP mixes	
PG 52-28	AC 5	Local Agencies	
		RAP mixes	
PG 46-28	AC 2.5	Local Agencies	

Note: This chart is intended as a guideline only and does not constitute an IDOT policy. Binder grades other than those listed do exist, and new grades continue to be developed. Contact the District Materials Engineer for help in determining the most appropriate binder grade for a given application.