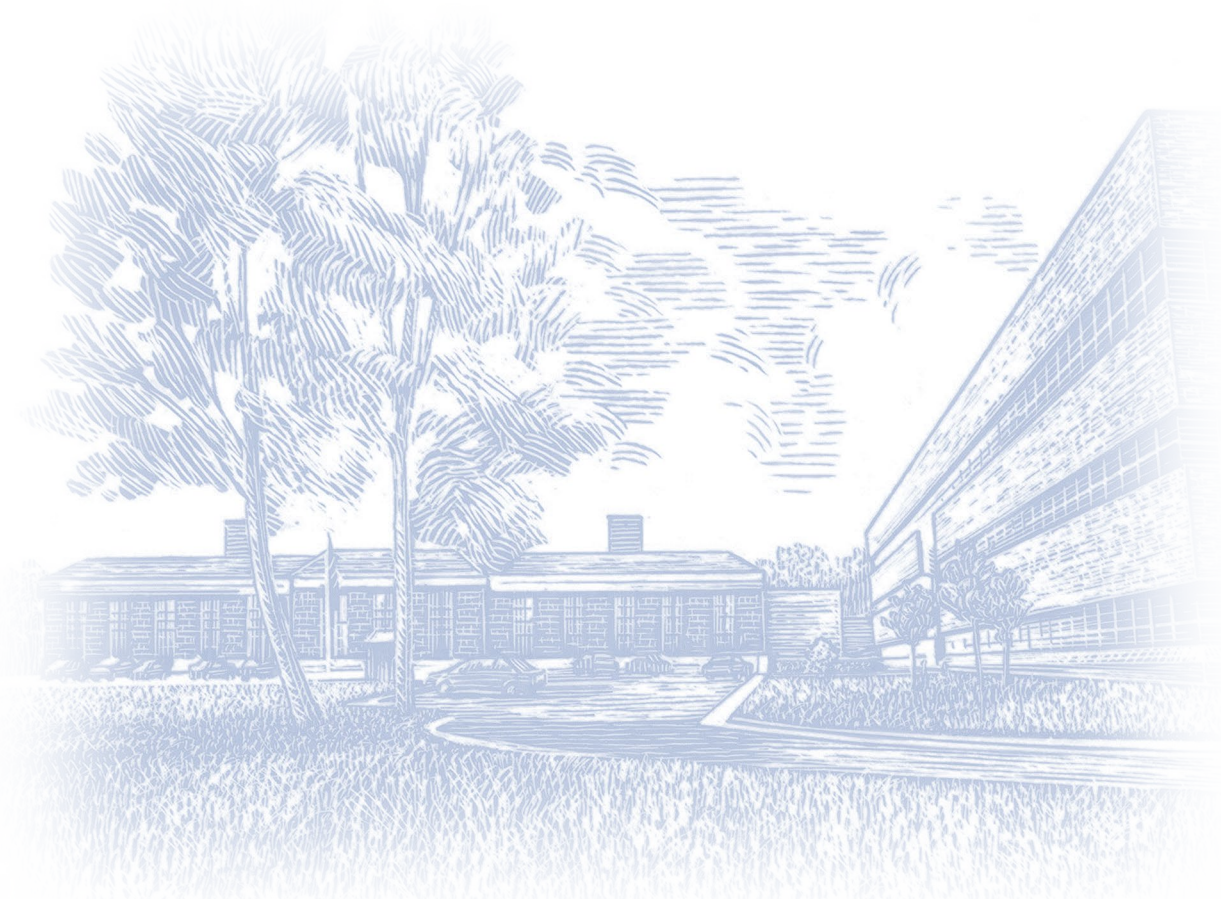


Application Note: Using LTPPbind V2.1 to Improve Crack Sealing in Asphalt Concrete Pavements

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Table of Contents

List of Tables	3
The Challenge	4
The Solution.....	5
Using LTPPBind To Select Crack-Sealing Materials.....	7
Low Temperature Properties.....	8
High Temperature Properties	8
Sealant Product Classification	8
Reservoir-Widening Guidelines.....	8
LTPPBind Application Benefits	9
For More Information	9

List of Tables

Table 1. Summary of 98-Percent Reliability Rates from LTPPBind Measured at the Fairbanks, AK, International Airport Weather Station.....	5
Table 2. Summary of 98 percent Reliability Rates from LTPPBind Measured at the Laredo, TX, International Airport Weather Station	6
Table 3. Grade Summary Based on 98-Percent Reliability Rates from LTPPBind, Temperatures for Various Climates.....	7
Table 4. Suggested Sealant Reservoir Configurations for Crack Sealing of Working Cracks for Various LTPPBind Temperature Ranges.....	9

The Challenge

Repairing cracks in asphalt concrete pavements is essential to insuring pavement performance and reducing life-cycle maintenance and replacement costs. One of the ways to extend pavement life is to include crack-sealing treatments as part of pavement preventive maintenance practice. The effectiveness of these treatments depends on many factors, including the properties of sealant materials, installation methods, temperature extremes, pavement conditions, traffic levels, and crack movements.

Sealants with different properties are needed in different climates. Warm climates require stiff sealants to resist hot summer temperatures. If the sealant is too soft, it may flow or be pulled from the crack by vehicle tires. Softer, more flexible sealants are more appropriate for cold climates in which pavements are prone to large crack movements, especially during the winter. In any given climate, sealant materials must function over the range of temperatures from summer to winter.

Installation methods also vary by climate. Correct installation ensures that the sealant can conform to crack movements in the pavement. The tendency of pavement cracks to widen or move in the winter increases as the distances between existing cracks and variations in winter and summer temperatures increase. If the installation is not correct, cracking or debonding may develop as cracks widen in the winter.

Pavements in good condition that demonstrate transverse thermal cracking, but otherwise have minimal cracking, are best treated with rout and seal procedures. These procedures use very flexible and extensible sealants in widened reservoirs with working cracks that move more than 3 millimeters (mm) throughout the year. For pavements with more extensive cracking, such as longitudinal, block, fatigue, and closely spaced transverse cracks in which crack movement is minimal (less than 3 mm a year), techniques such as crack filling, clean and seal, and overband are appropriate. These techniques use stiffer, more traffic-resistant sealant materials in cracks that generally are not widened.

In the past, highway agencies from across the United States have developed area-specific crack-sealing treatment procedures through a series of test sections, evaluating and investigating sealant types and installation methods by trial and error. Selecting sealant materials for specific climates has been based on approximate descriptions of temperature ranges in hot, moderate, or cold climates, and with some general air temperature highs and lows.

Table 1. Summary of 98-Percent Reliability Rates from LTPPBind Measured at the Fairbanks, AK, International Airport Weather Station

Latitude, degree	64.82	
Depth to surface of layer, mm	0	
Desired reliability, percent	98	
Traffic loading, million ESAL	0	
Traffic speed	Fast	
Method for adjusting for traffic	Strategic Highway Research Program	
Pavement temperature and pavement grade	High	Low
Design air temperature, °C	27.8	-45.0
Design air temperature standard deviation	1.8	3.6
Using HT/LT model: LTPP/LTPP	High	Low
Design pavement temperature,	47.3	-48.9
Adjustment for traffic loading	+0	
Adjustment for traffic speed	+0	
Adjustment pavement temperature, °C	47.3	-48.9
Selected binder grade	52	-52

Although these descriptions help with product selection, a more efficient method of identifying temperature ranges and climate applicability to select pavement crack-sealing materials is needed.

The Solution

The Federal Highway Administration's Long-Term Pavement Performance (LTPP) program originally developed the software program LTPPBind to help highway agencies select the most suitable and cost-effective Superpave® asphalt binder performance grade for a particular site. LTPPBind determines both high and low pavement temperatures for a given project location. Normally, temperatures from LTPPBind are used to determine the grade classification of asphalt cement used for asphalt concrete paving.

High and low temperature grades are determined in 6 °Celsius (C) increments, with highs ranging from 40 to 76 °C and lows ranging from -46 to -10 °C. Temperatures can be determined at the surface or at a depth in the pavement, and because temperatures are never the same from year to year, they can be selected by the designer to provide either a 50- or 98-percent reliability.

Sealant manufacturers quickly realized that crack-sealing materials in any given climate would be exposed to and would need to function within the same pavement temperatures that LTPPBind identifies. The temperature grade range (difference between temperature highs and lows) that LTPPBind determines also helps predict the amount of thermal-induced crack widening as the pavement cools from summer to winter. LTPPBind, therefore, can help highway agencies select the appropriate crack-sealing materials and procedures for different climates and conditions.

Table 2. Summary of 98 percent Reliability Rates from LTPPBind Measured at the Laredo, TX, International Airport Weather Station

Latitude, degree	27.53	
Depth to surface of layer, mm	0	
Desired reliability, percent	98	
Traffic loading, million ESAL	0	
Traffic speed	Fast	
Method for adjusting for traffic	Strategic Highway Research Program	
Pavement temperature and pavement grade	High	Low
Design air temperature, °C	39.8	-2.7
Design air temperature, standard deviation	.8	2.7
Using HT/LT Model: LTPP/LTPP	High	Low
Design pavement temperature, °C	64.7	-3.7
Adjustment for traffic loading	+0	
Adjustment for traffic loading	+0	
Adjusted pavement temperature, °C	64.7	-3.7
Selected binder grade	70	-10

Tables 1 and 2 show 98-percent reliability rates from LTPPBind for Fairbanks, AK (an extremely cold climate), and Laredo, TX (a hot climate). Table 3 summarizes high and low pavement temperatures and temperature ranges for these two climates as well as several other more moderate climates.

The information in table 3 shows that high pavement temperatures differ by as much as 18 °C, ranging from 47 °C in Fairbanks, AK, to 65 °C in Laredo, TX. Low temperatures, however, vary much more, from a low of -49 °C in Fairbanks, AK, to 0.4 °C in San Diego, CA—a difference of 50 °C.

Table 3. Grade Summary Based on 98-Percent Reliability Rates from LTPPBind, Temperatures for Various Climates

Climate Description	Location	High	Low	Range	Grade
Extreme Cold	Fairbanks, AK	47.3	-48.9	96.2	52-52
Very Cold	Mildred, ND	58.9	-34.8	93.7	64-40
Cold	Omaha, NE	58.3	-24.4	82.7	64-28
Moderate	Washington, DC	59.2	-13.0	72.2	64-16
Hot	Laredo, TX	64.7	-3.7	68.4	70-10
Coastal	San Diego, CA	56.3	0.4	55.9	58.10

98% Pavement Temperature, °C

The range of high-low pavement temperatures in a specific climate also varies, with as much as a 96 °C variation in temperature in Fairbanks, AK, to as little as a 56 °C temperature variation in San Diego, CA. In general, moderate coastal climates have the smallest differences between summer and winter temperatures, and therefore have the narrowest range of high and low pavement temperatures. The 56 °C range in San Diego, CA is typical of these areas.

This pavement temperature information helps determine crack-sealing procedures and materials. For example, crack-sealing products in Fairbanks, AK, will need to resist high temperatures of 47 °C and remain flexible down to -49 °C, and the material and installation configuration must accommodate the movement of cracks that results from a 96 °C drop in pavement temperature.

The extent to which cracks widen depends more on the differences in pavement temperature than the temperature itself. For example, temperatures in Mildred, ND, are 12 to 14 °C higher than in Fairbanks, AK, but the temperature range, at 94 °C, is very similar to the range in Fairbanks. Therefore, pavement cracks in Mildred should experience about as much movement as those in Fairbanks. In comparison, the temperature ranges in Omaha, NE, and Washington, DC, are 83 °C and 72 °C, respectively, so there will be less pavement crack expansion in Omaha than in Mildred or Fairbanks, and even less expansion in Washington, DC.

Laredo, TX, in contrast, has a high pavement temperature of 65 °C and a low pavement temperature of -4 °C- a 69 °C range. In this climate, crack sealants must tolerate hot pavement temperatures and must remain workable only to -4 °C, which is quite different than the requirements for sealants in Fairbanks, AK.

Using LTPPBind To Select Crack-Sealing Materials

Typical specifications for cracksealing materials include sealant property evaluations at high, moderate, and low temperatures. The evaluations provide some information on materials characteristics at those

temperatures. Using LTPPBind, sealant properties at anticipated high and low temperatures can be evaluated or compared.

Low Temperature Properties

Sealants that meet the American Society for Testing and Materials (ASTM) D6690-Type I (ASTM D1190) are evaluated for low temperature bond at -18 °C using 5 cycles of 50-percent extension. This -18 °C temperature exceeds the -16 °C LTPPBind temperature grade, which indicates that these materials can function at -16 °C. D6690 Type II (ASTM D3405) sealants are tested for bond using 3 cycles of 50-percent extension at -29 °C, which exceeds the -28 °C LTPPBind temperature grade, indicating functioning at -28 °C. ASTM D6690 Type IV (low modulus D3405) sealants are evaluated for bond at -29 °C, but with 200-percent extension. These materials typically will pass 50- or 100-percent bond tests at temperatures as low as -40 °C. These types of sealants are used most often in -34 °C or -40 °C LTPPBind-rated climates.

Flexibility or mandrel bend testing also is performed commonly on materials that are used to treat and fill nonworking cracks. Test procedures vary somewhat, but ASTM D3111 with a 25-mm diameter mandrel and a 10-second bend time is typical. Even though these crack types typically do not move as much as thermal transverse cracks, the selected materials should not become brittle at low temperatures for the climate. Common flexibility test temperatures are -7, -12, -18, -29, and -34 °C. These temperatures are similar to the LTPPBind grades of -10, -16, -28, and -34 °C. Passing results indicate that the material in question can be used successfully in nonworking cracks in climates with those low temperatures.

High Temperature Properties

Standard measurements of sealant properties at high temperatures do not correspond to LTPPBind temperatures as well as sealant properties at low temperatures. Tests that provide some indication of high temperature properties include ASTM D5329 cone penetration testing at 25 and 60 °C and ASTM D36 softening point testing. ASTM D6690 Type I and II products have penetration limits of 90 dmm maximum at 25 °C and typically are used in climates that do not exceed 64 °C. ASTM D6690 Type IV materials have penetration limits of 150 dmm maximum, and generally are used in climates with temperatures as high as 58 °C. In hot climates, (70 °C or higher), low penetration products, such as those less than 40 dmm are required. For filling in hot climates, softening points above 90 or 100 °C commonly are specified.

Sealant Product Classification

Based on testing evaluations and past experience in various climates, sealant materials can be classified or rated according to LTPPBind high and low temperature determinations. For example, materials that meet ASTM D6690 Type I (ASTM D1190) can be classified as 64-16 sealants, and ASTM D6690 Type II materials can be classified as 64-28 sealants. This means that they can be used in climates with temperatures as high as 64 °C and can function at -16 °C or -28 °C, respectively, in bond testing.

Similarly, the softer ASTM D6690 Type IV materials can be classified as 58-34 or 58-40 sealing materials, because they can pass bond tests at -34 or -40 °C, and typically are used successfully in -34 or -40 °C low temperature graded climates. Accordingly, sealant suppliers can develop and identify products that are appropriate for different climates by using the LTPPBind temperature guidelines.

Reservoir-Widening Guidelines

As discussed above, the extent of thermal crack movement depends on crack spacing and temperature range. The LTPPBind temperature range gives a general indication of expected crack movement, with

greater movements occurring in climates with more extreme temperature ranges. In general, wide reservoirs are required for successful sealant performance with thermal transverse cracks in cold climates. In very cold climates (-34 °C and below), wide, shallow reservoir configurations (40 x 12 mm) have yielded the best performance. In -22 to -28 °C climates, narrower, 19 x 19 mm reservoirs usually work well. Suggested reservoir configurations for crack sealing (working cracks) based on LTPPBind grade range determinations are shown in table 4.

Table 4. Suggested Sealant Reservoir Configurations for Crack Sealing of Working Cracks for Various LTPPBind Temperature Ranges

LTPPBind - 98% Grade Range	Minimum Reservoir Width (mm)	Reservoir Depth (mm)
80 °C	12	19
86 °C	19	19
92 °C	28	12
98 °C or greater	40	12

LTPPBind Application Benefits

Temperature grade guidelines from LTPPBind should be used to evaluate and develop sealant properties and specifications. The program's ability to determine high and low pavement temperatures can provide insight into the conditions that crack-sealing treatments will be subjected to in the field. Sealant material properties can be evaluated at different temperatures, and sealants can be classified according to their effectiveness at various LTPPBind temperature ranges.

An improved understanding of pavement temperatures and corresponding material properties helps highway agencies determine the sealant materials and installation methods that provide the best results. Using LTPPBind to design and select crack-sealing treatments will help improve pavement performance, ensure longer-lasting treatments, reduce repairs, and decrease life-cycle costs.

For More Information

For more details on applying LTPPBind to crack sealing, contact Antonio Nieves, 202-493-3074, antonio.nieves@dot.gov.