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Superpave System Calculation

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Abstract

A superpave system is a way to specify the components in asphalt pavements that perform better than average.A new approach has been created for specifying the asphalt ingredients in asphalt concrete as part of the Strategic Highway Research Program (SHRP). The shorthand name for this technology is superpave, which stands for high performance asphalt pavements.The research that resulted in the creation of this new system was started because, prior to the invention of superpave, it was challenging to connect the dots between the performance of the pavement and the findings from laboratory analysis in the previous systems.

Index terms— superpave system, binder, asphalt mixture, asphalt mix design, superpave calculation.

1 Introduction

he Superpave mix design approach primarily uses performance-based and performance-related features as the selection criteria for the mix design, which is a significant distinction from other design methods like the Marshal and Hveem methods.

Here, we'll take a smooth and accurate look at how to use superpave method to create an asphalt mix and compare it to the minimum criteria using procedures including employing equations, displaying the results, modifying, and comparing.

The objective of this mix design is to obtain a mixture of asphalt and aggregates that has the following characteristics:

1. Sufficient asphalt binder. 2. Sufficient voids in the mineral aggregates (VMA) and air voids. The first number 64, is often called the "high temperature grade". This means that the binder would possess adequate physical properties at least up to 64C.

This would be the high pavement temperature corresponding to the climate in which the binder is actually expected to serve.

The second number -22, is often called the "low temperature grade" and means that the binder would possess adequate physical properties in pavements at least down to -22C.

The selection can be made in one of three ways:

2 Performance grade (PG) evaluation

The Superpave system didn't consider the air temperature should be used as the design temperature; the system therefore uses this equation to convert the maximum air temperature to the maximum design pavement temperature.

The low-pavement design temperature can be selected using this equation:?? ???????? = (?? ?????? -0.00618?????? ?? + 0.2289Lat + 42.2)(0.9545) -17.78

Where:

?? 20???? = high-pavement design temperature at a depth of 20 mm ?? ?????? = seven day average high air temperature (C) Lat= the geographical latitude of the project location (degrees)

The low-pavement design temperature can be selected using this equation:?? ?????? = 1.56 + 0.72?? ?????? -0.004?????? ?? + 6.26?????? ???? (H+25) -Z(??. ?? + ??. ð ??"ð ??"???? ?????? ??) ??.ð ??"ð ??"

Where: Determine a suitable binder that could be used for the pavement of this highway if the depth of the pavement surface is 155 mm and the expected ESAL is 9 ×10 6 .?? ?????? =

3 Determine the high-pavement temperature at a depth of 20 mm

4 Determine low-AC-pavement temperature

Tests on Binder Asphalt (Physical Properties) Physical properties are also measured on binders that have been aged in 1. Rolling thin film oven (RTFO) (Long Term Aging) to simulate oxidative hardening that occurs during hot mixing and placing.

5 Pressure aging vessel (PAV) (Short Term Aging)

to simulate the severe aging that occurs after the binder has served many years in a pavement. Binder physical properties are measured using four devices 1. Dynamic Shear Rheometer (DSR) is used to measures the complex shear modulus and phase rotational angle. * to control asphalt stiffness * prevent Fatigue cracking 2. The Rotational Viscometer (RV) to characterizes the stiffness of the asphalt at 135 C , where it acts entirely as a viscous fluid. * To know that asphalt have a viscosity of less than 3 Pa-s. This ensures that the asphalt can be pumped and otherwise handled during HMA manufacturing.

6 b) Selection of Mineral Aggregate

The aggregate characteristics that generally were accepted by the experts for good performance of the hot mix asphalt include: 1. Coarse Aggregates Angularity (CAA) 2. Fine Aggregates Angularity (FAA) Table **??**8.17: Clay Content Criteria

7 The Clay Content

Maximum dimension five times greater than its minimum dimension.

8 Summary

? Seeking to achieve HMA with a high degree of internal friction and thus, high shear strength for rutting resistance. ? Limiting elongated pieces ensures that the HMA will not be as susceptible to aggregate breakage during handling and construction and under traffic. ? Limiting the amount of clay in aggregate, the adhesive bond between asphalt binder and aggregate. Table **??**8.16: Thin and Elongated Particles Criteria

9 A Flat and Elongated Particle

The distribution particle sizes for a given blend of aggregate mixture is known as the design aggregate structure.

10 1-The nominal maximum size

Is one sieve larger than the first sieve that retains more than 10 percent of the aggregate.

11 2-Maximum size

Is defined as one sieve larger than the nominal maximum size. Step 1

Compute the bulk and apparent specific gravities of the total aggregates in the trial aggregate mix using

Step 2 Compute the effective specific gravity the total aggregate in the trialgradation

12 Step 3

The amount of asphalt binder absorbed by the aggregates The table below shows properties of three trial aggregate blends that to be evaluated so as to determine their suitability for use in a Superpave mix. If the nominal maximum sieve of each aggregate blend is 19 mm, determine the initial trial asphalt content for each of the blends.

13 Property

Trial blend 1 Trial blend 2 Trial blend 3 Criteria to compare»> Given ?? ???? at ?? ?????? < 89% ?? ?? = 4% VMA ? 13% 65% <VFA <75% 0.6%<Dust<1.2% 1-All Blend ?? ?? = 4% 2-Blend 1 VMA = 12.72% < 13% × Blend 2 VMA = 12.94% < 13% × Blend 3 VMA = 13.34% > 13% â??" 3-All Blend VFA between 65-75% 4-All Blend ?? ???? less than 89% [1] [2]

Traffic, Million ESALs	Depth from Surface	
	< 100 mm	> 100 mm
< 0.3	55/–	–/–
< 1	65/–	–/–
< 3	75/–	50/–
< 10	85/80	60/–
< 30	95/90	80/75
< 100	100/100	95/90
> 100	100/100	100/100

Note: "85/80" indicates that 85% of the coarse aggregate has one or more fractured faces and 80% two or more fractured faces.

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Figure 1: 3 .

Traffic, Million ESALs	Percent Air Voids in Loosely Compacted Fine Aggregates Smaller than 2.36 mm — Depth from Surface	
	< 100 mm	> 100 mm
< 0.3	–	–
< 1	40	–
< 3	40	40
< 10	45	40
< 30	45	40
< 100	45	45
≥ 100	45	45

Figure 2:

Traffic, Million ESALs	Sand Equivalent Minimum, Percent
< 0.3	40
< 1	40
< 3	40
< 10	45
< 30	45
< 100	50
≥ 100	50

3

Figure 3: 3 .

Traffic, Million ESALs	Maximum, Percent
< 0.3	–
< 1	–
< 3	10
< 10	10
< 30	10
< 100	10
≥ 100	10

Figure 4:

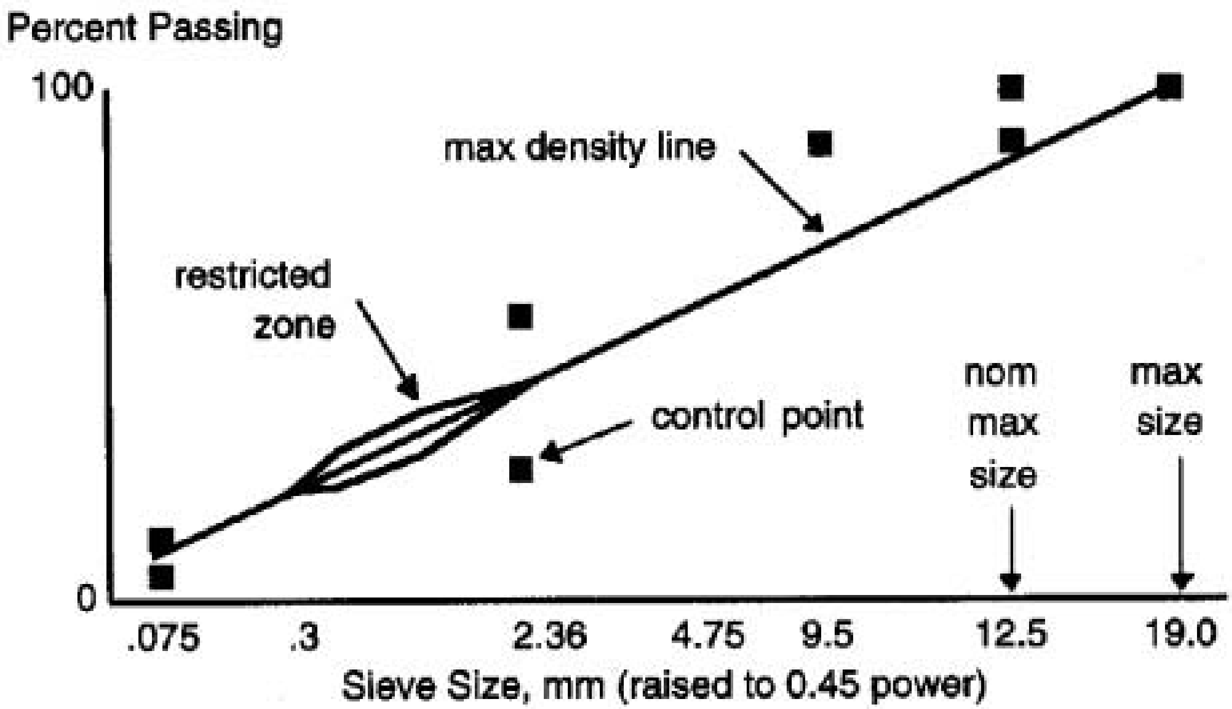

Figure 5:

$$G_{sb} = \frac{P_{ca} + P_{fa} + P_{mf}}{\frac{P_{ca}}{G_{bca}} + \frac{P_{fa}}{G_{bfa}} + \frac{P_{mf}}{G_{bmf}}}$$

Figure 6:

$$G_{\mathrm{asb}} = \frac{P_{\mathrm{ca}} + P_{\mathrm{fa}} + P_{\mathrm{mf}}}{\frac{P_{\mathrm{ca}}}{G_{\mathrm{aca}}} + \frac{P_{\mathrm{fa}}}{G_{\mathrm{afa}}} + \frac{P_{\mathrm{mf}}}{G_{\mathrm{amf}}}}$$

3

Figure 7: 3 -

$$G_{\mathrm{se}} = G_{\mathrm{sb}} + 0.8(G_{\mathrm{asb}} - G$$

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Figure 8: Blend 1 : 1 -Old 1 -

$$V_{\mathrm{ba}} = \frac{P_{\mathrm{s}}(1 - V_{\mathrm{a}})}{\frac{P_{\mathrm{b}}}{G_{\mathrm{b}}} + \frac{P_{\mathrm{s}}}{G_{\mathrm{se}}}}\left[\frac{1}{G_{\mathrm{sb}}} - \frac{1}{G_{\mathrm{se}}}\right]$$

Figure 9:

$$V_{\mathrm{be}} = 0.176 - (0.0675)\log(S_{\mathrm{n}})$$

Figure 10:

$$P_{bi} = \frac{G_b(V_{be} + V_{ba})}{(G_b(V_{be} + V_{ba})) + W_s} \times 100$$

Figure 11:

$$W_s = \frac{P_s(1 - V_a)}{\frac{P_b}{G_b} + \frac{P_s}{G_{se}}}$$

Figure 12:

Since G_{sb} and G_{se} are given, the trial percentage of asphalt binder can be found using Equations 18.17, 18.18, and 18.19 and the assumed values as indicated in the textbook:

$P_b = 0.05$
$P_s = 0.95$
$G_b = 1.02$
$V_a = 0.04$

For trial blend 1:

Use Equation 18.17,

$$V_{ba} = \frac{P_s(1-V_a)}{(\frac{P_b}{G_b}+\frac{P_s}{G_{se}})}[\frac{1}{G_{sb}}-\frac{1}{G_{se}}] = \frac{0.95(1-0.04)}{(\frac{0.05}{1.02}+\frac{0.95}{2.765})}[\frac{1}{2.698}-\frac{1}{2.765}] = 0.0209$$

Use Equation 18.18,

V_{be} = 0.176-0.0675 log S_n = 0.176-0.067 log (19) = 0.0903

Use Equation 18.20,

$$W_s = \frac{P_s(1-V_a)}{\frac{P_b}{G_b}+\frac{P_s}{G_{se}}} = \frac{0.95(1-0.04)}{(\frac{0.05}{1.02}+\frac{0.95}{2.765})} = 2.323$$

Use Equation 18.19,

$$P_{bi} = 100\frac{G_b(V_{be}+V_{ba})}{(G_b(V_{be}+V_{ba}))+W_s} = 100\frac{1.02(0.090+0.021)}{1.02(0.090+0.021)+2.323} = 0.0466$$

Figure 13:

For trial blend 2:

Use Equation 18.17,

$$V_{ba} = \frac{P_s(1-V_a)}{(\frac{P_b}{G_b}+\frac{P_s}{G_{se}})}[\frac{1}{G_{sb}}-\frac{1}{G_{se}}] = \frac{0.95(1-0.04)}{(\frac{0.05}{1.02}+\frac{0.95}{2.766})}[\frac{1}{2.696}-\frac{1}{2.766}] = 0.0218$$

Use Equation 18.18,

V_{be} = 0.176-0.0675 log S_n = 0.176-0.067 log (19) = 0.0903

Use Equation 18.20,

$$W_s = \frac{P_s(1-V_a)}{\frac{P_b}{G_b}+\frac{P_s}{G_{se}}} = \frac{0.95(1-0.04)}{(\frac{0.05}{1.02}+\frac{0.95}{2.766})} = 2.324$$

Use Equation 18.19,

$$P_{bi} = 100\frac{G_b(V_{be}+V_{ba})}{(G_b(V_{be}+V_{ba}))+W_s} = 100\frac{1.02(0.090+0.022)}{1.02(0.090+0.022)+2.324} = 0.0469$$

Figure 14:

low AC-pavement temperature below surface (C)
?? ?????? = low air temperature (C)
Lat= latitude of the project location (degrees)
H = depth of pavement surface mm
?? ?????? = standard deviation of the mean low air temperature (C)
Z = 2.055 for 98 percent reliability
Ex:
Determining a Suitable Binder Grade Using High and Low Air Temperatures.
The latitude at a location where a high-?? ???????? = (?? ?????? -0.00618??????
?? + 0.2289Lat + 42.2)(0.9545) -17.78
?? 20???? = (50 -0.00618*41 2 + 0.2289*41 + 42.2)(0.9545) -17.78
?? 20???? = 69.

Figure 15: speed rural road is to be located is 41 o . The seven-day average high air temperature is 50 o C and the low air temperature is -20 o C. The standard deviation for both the high and low temperatures is ±1 o C.

blend	1	2	3
Trial binder	4.4%	4.4%	4.4%
% ?? ???? at ?? ??????	96.2%	95.7%	95.2%
% ?? ???? at ?? ??????	87.1%	85.6%	86.3%
% Pa	3.8%	4.3%	4.8%
%VMA	12.7%	13%	13.5%
%VFA	68.5%	69.2%	70.1%
%Dust	0.9%	0.8%	0.9%

Figure 16:

Step 4

The percent of effective asphalt binder by volume Vbe : the volume of effective binder content Sn : the nominal maximum sieve size (mm)

Step 5 A trial percentage of asphalt binder

[Principles of Pavement Design 2 nd edition chapter 1] *Principles of Pavement Design 2 nd edition chapter 1*, Yoder Ej.

[Traffic and highway engineering 4 th edition chapter 19] *Traffic and highway engineering 4 th edition chapter 19*, Nicholas J. Garber. 2. National Asphalt Training Center By FHWA