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Superpave System Calculation

By Eng. Adeeb Khalil Adeeb Khalil
Al balqa Applied University

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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.

Keywords: superpave system, binder, asphalt mixture, asphalt mix design, superpave calculation.

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SUPERPAVESYSTEMCALCULATION

Strictly as per the compliance and regulations of:

Superpave System Calculation

Eng. Adeeb Khalil Adeeb Khalil

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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.

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Introduction

The 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.
3. Sufficient workability.
4. Performance characteristics over the service life of the pavement.

Enter:

Superpave system consists of the following parts:

- Selection of Materials
- Volumetric Trial Mixture Design
- Selection of Final Mixture Design

I. Selection of Materials

a) Selection of Asphalt Binder

The selection can be made in one of three ways:

1. The designer may select a binder based on the geographic location of the pavement.
2. The designer may determine the design pavement temperatures.
3. The designer may determine the design air temperatures which are then converted to design pavement temperatures.

∗ Superpave system specifies asphalt on the basis of the climate and pavement temperatures is expected to serve.

∗ Physical properties requirements remain the same, but the temperature of asphalt must attain the properties changes.

Performance grade (PG) binders are graded such as PG 64-22.

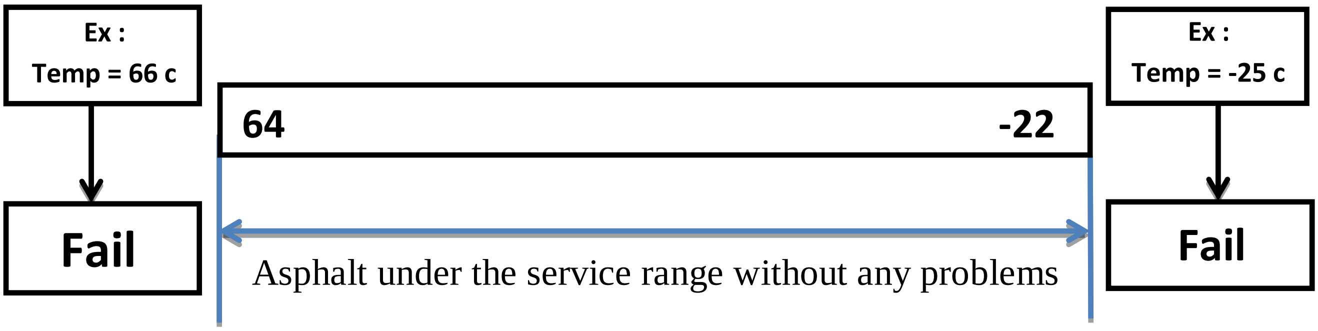
The first number 64, is often called the "*high temperature grade*".

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.

Author: Al balqa Applied University Faculty of Engineering Technology. e-mail: oobkhalil@gmail.com



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:

$$\boldsymbol{T_{20mm}} = (\boldsymbol{T_{air}} - 0.00618\boldsymbol{Lat^2} + 0.2289Lat + 42.2)(0.9545) - 17.78$$

Where:

T_{20mm} = high-pavement design temperature at a depth of 20 mm
T_{air} = 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:

$$\boldsymbol{T_{pav}} = 1.56 + 0.72\boldsymbol{T_{air}} - 0.004\boldsymbol{Lat^2} + 6.26\boldsymbol{log_{10}}(\text{H}+25) - \text{Z}(\boldsymbol{4.4} + \boldsymbol{0.52\sigma^2_{air}})^{0.5}$$

Where:

T_{pav} = low AC-pavement temperature below surface (C)
T_{air} = low air temperature (C)
Lat= latitude of the project location (degrees)
H = depth of pavement surface mm
σ_{air} = 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-speed rural road is to be located is 41^o. The seven-day average high air temperature is 50^oC and the low air temperature is -20^oC. The standard deviation for both the high and low temperatures is $\pm 1^o$C.

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 $\times 10^6$.

1. *Determine the high-pavement temperature at a depth of 20 mm*

$$\boldsymbol{T_{20mm}} = (\boldsymbol{T_{air}} - 0.00618\boldsymbol{Lat^2} + 0.2289Lat + 42.2)(0.9545) - 17.78$$

$$T_{20mm} = (50 - 0.00618*41^2 + 0.2289*41 + 42.2)(0.9545) - 17.78$$

$$T_{20mm} = 69.27^o \text{ C}$$

2. *Determine low-AC-pavement temperature*

$$\boldsymbol{T_{pav}} = 1.56 + 0.72\boldsymbol{T_{air}} - 0.004\boldsymbol{Lat^2} + 6.26\boldsymbol{log_{10}}(\text{H}+25) - \text{Z}(\boldsymbol{4.4} + \boldsymbol{0.52\sigma^2_{air}})^{0.5}$$

$$T_{pav} = 1.56 + 0.72(-20) - 0.004*41^2 + 6.26log_{10}(155+25) - 2.055(4.4 + 0.52 * 1^2)^{0.5}$$

$$T_{pav} = -10^o\text{C}$$

PG (–10, 69)

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.

2. 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.

3. The Bending Beam Rheometer (BBR)

to characterize the low temperature stiffness properties of binders.

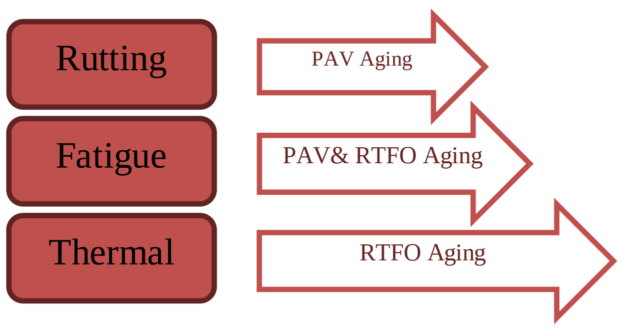
* To minimize low temperature cracking due to load.

4. Direct Tension Test (DTT)

to Know binders (Asphalt) are sufficiently ductile at low temperatures

* Resistance low temperature cracking due to Climate.

* *These are examples of problems and how they are tested to prevent them from occurring.*



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)
3. A flat and elongated particle
4. The clay content

1. *Coarse Aggregates Angularity (CAA)*

The percent of coarse aggregates larger than 4.75 mm with one or more fractured faces.

Table 18.14: Coarse Aggregate Angularity Criteria **Minimum Value** **Given**

Traffic, Million ESALs	Depth from Surface < 100 mm	Depth from Surface > 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.

When CAA Increase , Performance Increase

Ex : ESAL = 40*10^6 and depth from surface = 12 cm
are 82% acceptable ?

SOL: Depth from surface = 12 cm = 120 mm
ESAL = 40 < 100

82% < 95/90% → Not Acceptable

2. *Fine Aggregates Angularity (FAA)*
The percent of air voids in loosely compacted aggregates smaller than 2.36 mm.

Table 18.15: Fine Aggregate Angularity Criteria

Minimum Value **Given**

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

When FAA Increase , Performance Increase

Ex : ESAL = 20*10^6 and depth from surface = 7 cm
percent of air voids in fine aggregates = 40%
the FAA acceptable ?

SOL: Depth from surface = 7 cm = 70 mm
ESAL = 20 < 30

40% < 45% → Not Acceptable

3. *The Clay Content*

Is the percentage of clayey material in the portion of aggregate passing through the 4.75 mm sieve.

Table 18.17: Clay Content Criteria

Minimum Value **Given**

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

Blend which has lowest sand Equivalent , has a highest clay content

When sand Equivalent increase , performance increase
When clay content increase , performance decrease

Ex : ESAL = 18*10^6 , sand equivalent = 45%
is the caly content Acceptable ?

SOL:

ESAL = 18 < 30
45% = 45% → Acceptable

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4. *A Flat and Elongated Particle*

Maximum dimension five times greater than its minimum dimension.

Table 18.16: Thin and Elongated Particles Criteria

Maximum Value **Given**

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

When ElongatedIncrease , Performance Decrease

Ex : ESAL = 4*10^6 , elongated particles = 11%

Acceptable or Not ?

SOL:

ESAL = 4 < 10

11% > 10% Not Acceptable

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.

c) *Gradation*

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

The advantage of granular grading of aggregates is to obtain the highest density of aggregates and the lowest voids

1-The nominal maximum size

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

2- Maximum size

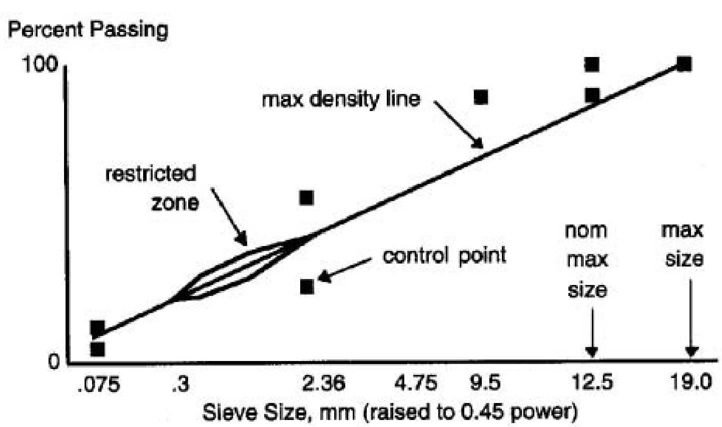
Is defined as one sieve larger than the nominal maximum size.

EX : Find Maximum nominal size & Maximum Size for These Sieve

Sieve (mm)	Passing (+)	Retain (-)
50	100%	0%
37.5	100%	0%
25	95%	5%
19	92%	8%
12.5	89%	11%
9.5	85%	15%
4.75	70%	30%

Maximum Nominal Size

Maximum Size



Control point : upper and lower limits where superpave gradation must pass through them

Restricted Zone : Control Fine Minerals

Max density Line : to Know density Of Mix

II. Volumetric Trial Mixture Design

a) Determining Trial Percentage of Asphalt Binder

Step 1

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

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

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

Step 2

Compute the **effective** specific gravity of the total aggregate in the trialgradation

$$G_{se} = G_{sb} + 0.8(G_{asb} - G_{sb})$$

Step 3

The amount of **asphalt binder absorbed** by the aggregates

$$V_{ba} = \frac{P_s(1 - V_a)}{\frac{P_b}{G_b} + \frac{P_s}{G_{se}}}\left[\frac{1}{G_{sb}} - \frac{1}{G_{se}}\right]$$

Where:
Vba : volume of absorbed binder of mix

Pb:percent of binder = 0.05
Ps: percent of aggregate = 0.95
Gb:specific gravity of binder =1.02
Va= **Pa** = volume of air voids = 0.04

Step 4

The percent of effective asphalt binder by volume

$$V_{be} = 0.176 - (0.0675)\log(S_n)$$

Where:

Vbe : the volume of effective binder content

Sn : the nominal maximum sieve size (mm)

Step 5

A trial percentage of asphalt binder

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

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

Where:

Pbi: initial trial percent of binder by mass of mix

Gb :specific gravity of binder assumed = 1.02

Ws:mass of aggregate

Ex:

The table below shows properties of three trial aggregate blends that are 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.

Property	Trial blend 1	Trial blend 2	Trial blend 3
G_{sb}	2.698	2.696	2.711
G_{se}	2.765	2.766	2.764

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,

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

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,

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

For trial blend 3:

Use Equation 18.17,

$$V_{ba} = \frac{P_s(1-V_a)}{(\frac{P_b}{G_b}+\frac{P_s}{G_{se}})}[\frac{1}{G_{sb}}-\frac{1}{G_{se}}] = \frac{0.95(1-0.04)}{(\frac{0.05}{1.02}+\frac{0.95}{2.764})}[\frac{1}{2.711}-\frac{1}{2.764}] = 0.0164$$

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,

$$W_s = \frac{P_s(1-V_a)}{\frac{P_b}{G_b}+\frac{P_s}{G_{se}}} = \frac{0.95(1-0.04)}{(\frac{0.05}{1.02}+\frac{0.95}{2.764})} = 2.322$$

Use Equation 18.19,

$$P_{bi} = 100\frac{G_b(V_{be}+V_{ba})}{(G_b(V_{be}+V_{ba}))+W_s} = 100\frac{1.02(0.090+0.016)}{1.02(0.090+0.016)+2.322} = 0.0634$$

b) Evaluating Trial Mix Design

To know if the percentage of asphalt that we got is suitable after the compaction

∗ By Using Superpave Gyratory Compactor (SGC)

1. Number of gyrations (N_{design}) to compute level of compaction.
   The N_{design} depends on the average design high air temperature and the design ESAL.
2. Maximum number of gyrations, N_{max}, is used to compact the test specimens.
3. Initial number of gyrations, N_{ini}, is used to estimate the compactibility of the mixture.

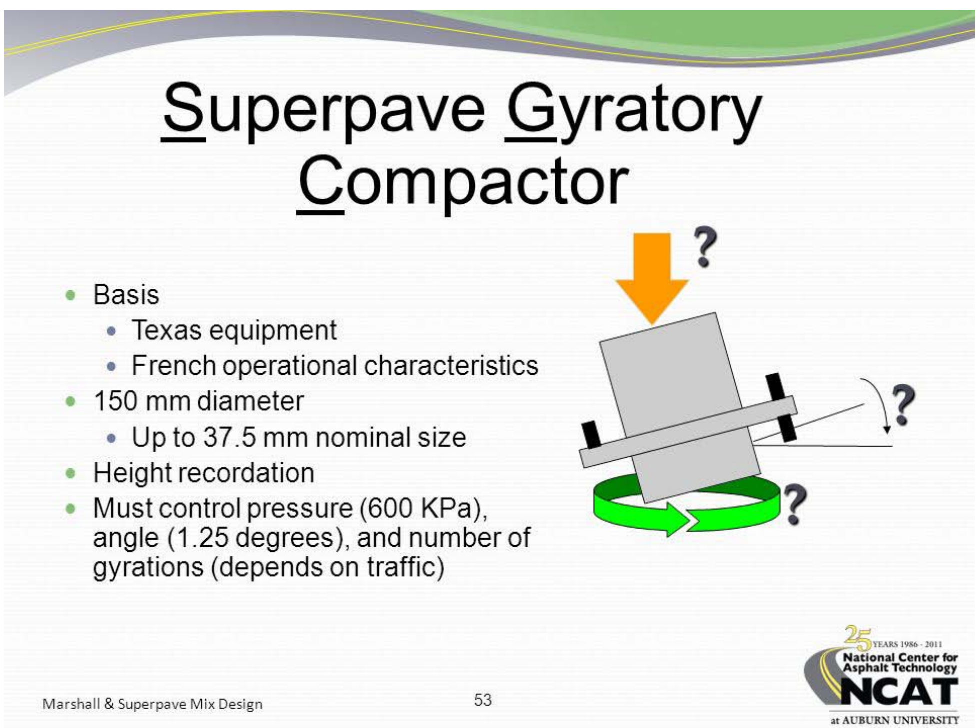
$$\text{Log } N_{\text{max}} = 1.10 \text{Log } N_{\text{des}}$$

$$\text{Log } N_{\text{ini}} = 0.45 \text{Log } N_{\text{des}}$$

Ndesign
To know compaction level

Nmax
To compact the specimen

Ninitial
To know specimen's bearing capacity



Ex : When Design ESALs = 10 – 30 (millions) and the Average design high air temperature = 41 to 42 C given N_{design}= 124

Find N_{max}&Compactibility ?

Log N_{max} = 1.1 Log N_{design} or N_{max} = (N_{design}) ^ 1.1
N_{max} = (128) ^ 1.1 = 208

$N_{initial}$ = (N_{design}) ^ 0.45
$N_{initial}$ = (128) ^ 0.45 = 9

- Volumetric Calculation at the N_{design}gyration

Know the characteristics of the sampleafter compaction.

1- percent air voids at N_{design} (Pa or Va)

$$P_a = 100\left(\frac{G_{mm} - G_{mb}}{G_{mm}}\right) = 100 - \%Gmm\ @\ N_{design}$$

Pa :air voids at Ndes percent of total volume
Gmm: maximum theoretical specific gravity at Ndes
Gmb : bulk specific gravity of the compacted mixture

2- voids in mineral aggregate (VMA)

$$VMA = 100 - \left(\frac{G_{mb} P_s}{G_{sb}}\right)$$

Gmb=%Gmm @ Ndes *Gmm

VMA : voids in mineral aggregate, percent in bulk volume
Gmb: bulk specific gravity of the compacted mixture
Ps : aggregate content cm3/cm3, by total mass of mixture
Gsb: bulk specific gravity of aggregates in the paving mixture

3- Void filled Asphalt (VFA)

$$VFA = 100\left(\frac{VMA - P_a}{VMA}\right)$$

VMA equation
in the past paper

4- %Gmm = (Gmb / Gmm) * 100%

$$5\text{-}P_{ba} = 100 * \frac{G_{se} - G_{sb}}{G_{se}\, G_{sb}} * G_b$$

$$6\text{-}\ P_{be} = P_b - \frac{P_{ba}}{100} *\ P_s$$

7- Dust % = P0.75 / Pbe

We use the previous three lawsto know
Pa & VMA & VFA

IF

Pa = 4%

Compare each of
VMA , VFA , Gmm , DP
that we obtained from the
previous equations with criteria
in 18.22 & 18.20 table

Pa >< 4%

Correcting all values through the
following equations, and after
correction, we compare them with
the same criteria

To Modify

Correction Equation

1) P_b,estimated= P_{bi} - 0.4 (4 – Pa)

Pb,estimated: estimated asphalt content.
Pbi: initial (trial) asphalt content, percent by mass of mixture.
Pa : percent air voids at Ndes (trial)**≠4%**

2) VMAestimated = VMAinitial + C (4 – Pa)

C = 0.1 if Pa < 4%
C = 0.2 if Pa > 4%

3)

$$VFA_{\text{estimated}} = 100\,\frac{VMA_{\text{estimated}} - 4.0}{VMA_{\text{estimated}}}$$

<u>4) The effective binder content after correction (P_{be})</u>

$$P_{ba} = 100 * \frac{G_{se} - G_{sb}}{G_{se}\,G_{sb}} * G_b$$

$$P_{be} = P_{b,estimated} - \frac{P_{ba}}{100} * P_s$$

<u>5) Dust Percetage</u>

$$DP = \frac{P_{0.75}}{P_{\text{be}}}$$

Percent of aggregate content passing the 0.075-mm sieve

6) Gmm,estimatedat Nmax= Gmm,trialat Nmax– (4 – Pa)

7) Gmm,estimatedat Nini = Gmm,trialat Nini – (4 – Pa)

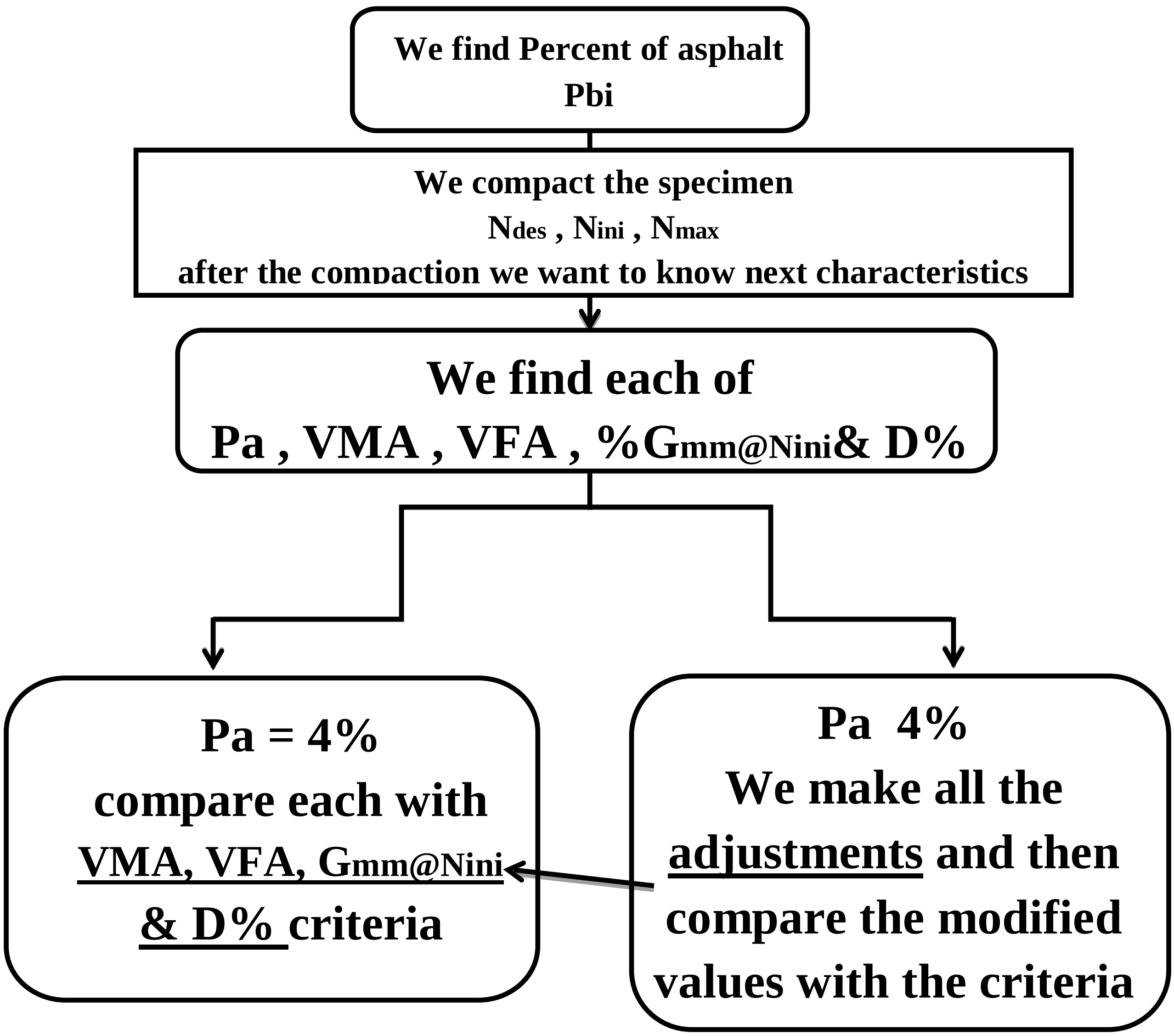


Table 18.20: Voids in Mineral Aggregate Criteria

Nominal Maximum Size (mm)	Minimum Voids in Mineral Aggregate (%)
9.5	15.0
12.5	14.0
19.0	13.0
25.0	12.0
37.5	11.0
50.0	10.5

Table 18.22: VFA Criteria

Traffic, Million ESALs	Design VFA, Percent
< 0.3	70–80
< 1	65–78
< 3	65–78
< 10	65–75
< 30	65–75
< 100	65–75

$$0.6\% < \text{Dust}\% < 1.2\%$$

$$\text{Gmm at } N_{initial} \leq 89\%$$

$$\text{Gmm at } N_{Max} \leq 98\%$$

Ex:

Find which blend satisfy to criteria for volumetric properties in trial mix, use result in this table to choose.

blend	1	2	3
Trial binder	4.4%	4.4%	4.4%
% G_{mm} at N_{des}	96.2%	95.7%	95.2%
% G_{mm} at N_{ini}	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%

First, we look at the percentage of air voids **Pa**for each mixture. We note that each mixture needs to adjustthe values to obtain percentage of air void 4%, after that we compare the specifications for each ratio.

Blend 1:

1- $P_{b,estimated} = P_{bi} - 0.4(4 - P_a) = 4.4 - 0.4(4 - 3.8) = 4.32\%$

Old Pa% not modified

2- $VMA_{estimated} = VMA_{ini} + C(4 - P_a) = 12.7 + 0.1(4 - 3.8) = 12.72\%$

3- $VFA_{estimated} = 100 * \frac{VMA_{estimated} - 4}{VMA_{estimated}} = \frac{12.72 - 4}{12.72} = 68.55\%$

4- $G_{mm,estimated}$ at $N_{ini} = G_{mm} - (4 - P_a) = 87.1 - (4 - 3.8) = 86.9$

C = 0.1 because $P_a < 4\%$

Blend 2:

1- $P_{b,estimated} = P_{bi} - 0.4(4 - P_a) = 4.4 - 0.4(4 - 4.8) = 4.72\%$

2- $VMA_{estimated} = VMA_{ini} + C(4 - P_a) = 13.5 + 0.2(4 - 4.8) = 13.34\%$

3- $VFA_{estimated} = 100 * \frac{VMA_{estimated} - 4}{VMA_{estimated}} = \frac{13.34 - 4}{13.34} = 70\%$

4- $G_{mm,estimated}$ at $N_{ini} = G_{mm} - (4 - P_a) = 86.4 - (4 - 4.8) = 87.2$

C = 0.2 because $P_a > 4\%$

Blend 3:

1- $P_{b,estimated} = P_{bi} - 0.4(4 - P_a) = 4.4 - 0.4(4 - 4.3) = 4.52\%$

2- $VMA_{estimated} = VMA_{ini} + C(4 - P_a) = 13 + 0.2(4 - 4.3) = 12.94\%$

3- $VFA_{estimated} = 100 * \frac{VMA_{estimated} - 4}{VMA_{estimated}} = \frac{12.94 - 4}{12.94} = 69.1\%$

4- $G_{mm,estimated}$ at $N_{ini} = G_{mm} - (4 - P_a) = 85.6 - (4 - 4.3) = 85.9$

Criteria to compare>>> Given				
G_{mm} at N_{ini} < 89%	P_a = 4%	VMA ≥ 13%	65% <VFA <75%	0.6%<Dust<1.2%

1- All Blend P_a = 4%

2-

Blend 1 VMA = 12.72% < 13% ×

Blend 2 VMA = 12.94% < 13% ×

Blend 3 VMA = 13.34% > 13% ✓

3- All Blend VFA between 65–75%

4- All Blend G_{mm} less than 89%

References Références Referencias

1. Traffic and highway engineering 4th edition chapter 19, Nicholas J. Garber.
2. National Asphalt Training Center By FHWA.
3. Principles of Pavement Design 2nd edition chapter 1, Yoder Ej.
4. Pavement Analysis and Design 2nd edition appendix D, Yang Huang.