Asphalt
Aggregate Specifications

Aggregate Specifications

In order to make good asphalt concrete, you need to start with good aggregate. The aggregate …

1. must be dense-graded because the strength of the asphalt concrete comes from good interlocking between the aggregate particles;
2. must be hard because you don't want it to polish or break down under repeated tire loads;

Aggregate Specifications

3. must be durable to keep from breaking down with repeated cycles of heating and cooling, wetting and drying, or freezing and thawing;

4. must be rough-surfaced to provide good friction between the aggregate particles and lots of surface area for the asphalt cement to cling to;

5. must be “cubical” (angular and equidimensional) so the aggregate particles lock together to form a stable aggregate skeleton;

Aggregate Specifications

6. should be hydrophobic (water hating) so water will not work its way under the asphalt cement coating and strip it off the aggregate particles;

7. must be free of deleterious substances so the asphalt cement can achieve a good bond with the aggregate;

8. should have low porosity to reduce the amount of wasted asphalt cement absorbed into the pervious pores of the aggregate.

Right Type of Aggregate

Dense-graded
Hard
Durable
Rough-surfaced
Cubical (angular and equidimensional)
Hydrophobic
Free from deleterious substances
Low Porosity

Aggregate Specifications

TDOT's *Standard Specifications for Road and Bridge Construction* covers aggregate for asphalt concrete used in pavement surface courses in Section 903.11.

TDOT Specifications

SECTION 903-AGGREGATES

Source: Standard Specifications for Road and Bridge Construction (TDOT, 2006)

Aggregate Specifications

The coarse aggregate requirements include limits on the LA abrasion loss (hardness), sodium soundness loss (durability), absorption (porosity), fractured faces (cubical), and elongation (equidimensional).

TDOT Specifications

Asphalt Coarse Aggregate

LA Abrasion Loss < 40%

(Hard)

Absorption < 5%

(Low Porosity)

2+ Fractures Faces > 70%

(Angular)

5:1 Elongated < 20%

(Equidimensional)

Sodium Soundness Loss < 9%

(Durable)

Aggregate Specifications

The fine aggregate requirements include limits on the sodium soundness loss (durability), the amount of material passing the #200 sieve and the amount of clay, coal, lignite and other deleterious substances.

TDOT Specifications

Asphalt Fine Aggregate

Material Passing No. 200 Sieve < 4%

(Free of deleterious substances)

Clay Lumps < 0.5%

(Free of deleterious substances)

Coal and Lignite < 0.5%

(Free of deleterious substances)

Other Deleterious Substances < 3%

(Free of deleterious substances)

Sodium Soundness Loss < 12%

(Durable)

Aggregate Specifications

There are also two different gradation specifications (D and E) for dense-graded aggregate blends that are centered on the theoretical maximum density curve and differ only in the allowable amount passing the #100 and #200 sieves.

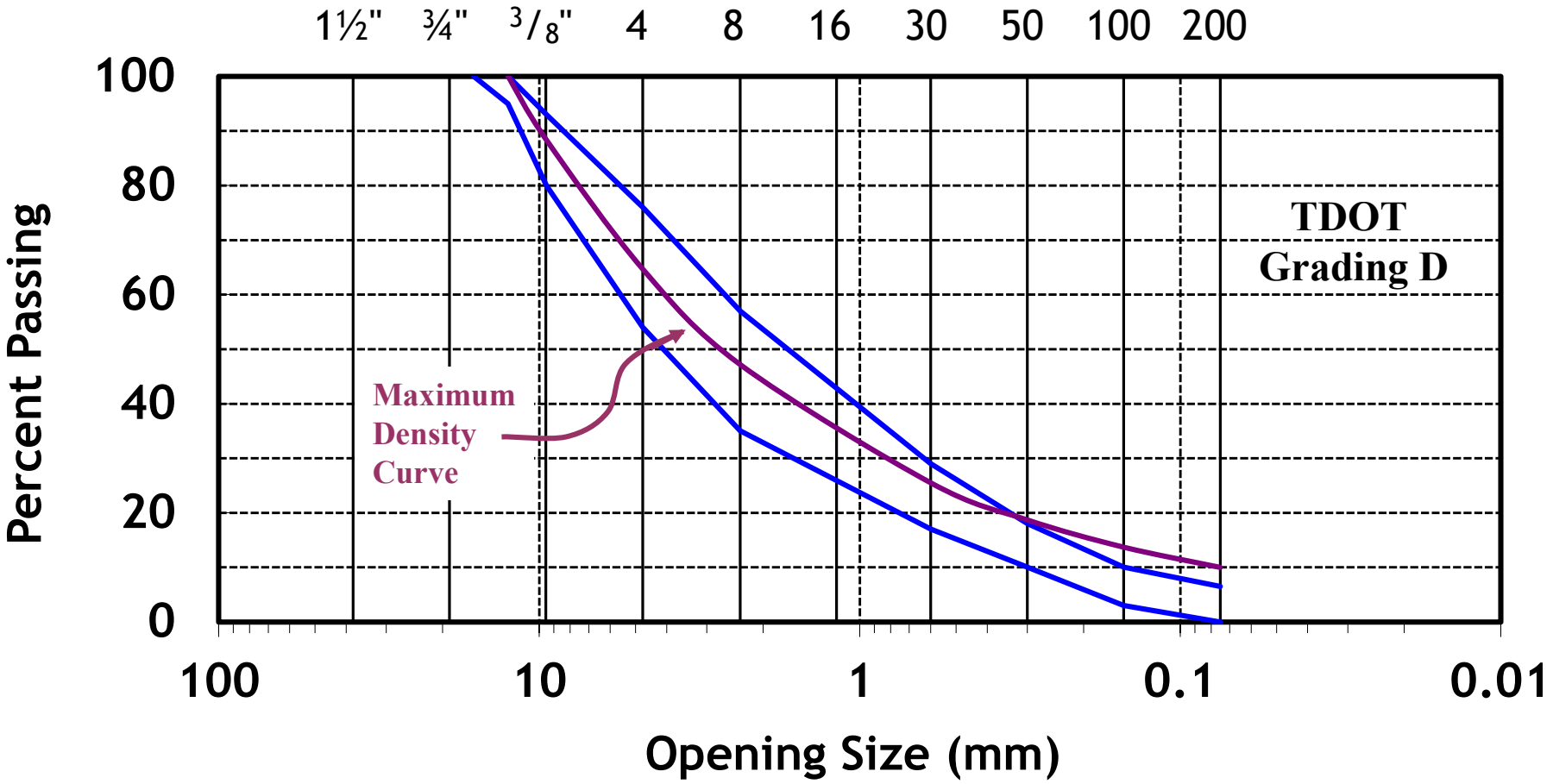
TDOT Specifications

ASPHALT CONCRETE SURFACE COURSE
MIXTURE DESIGNATION
DESIGN RANGE OF GRADATIONS

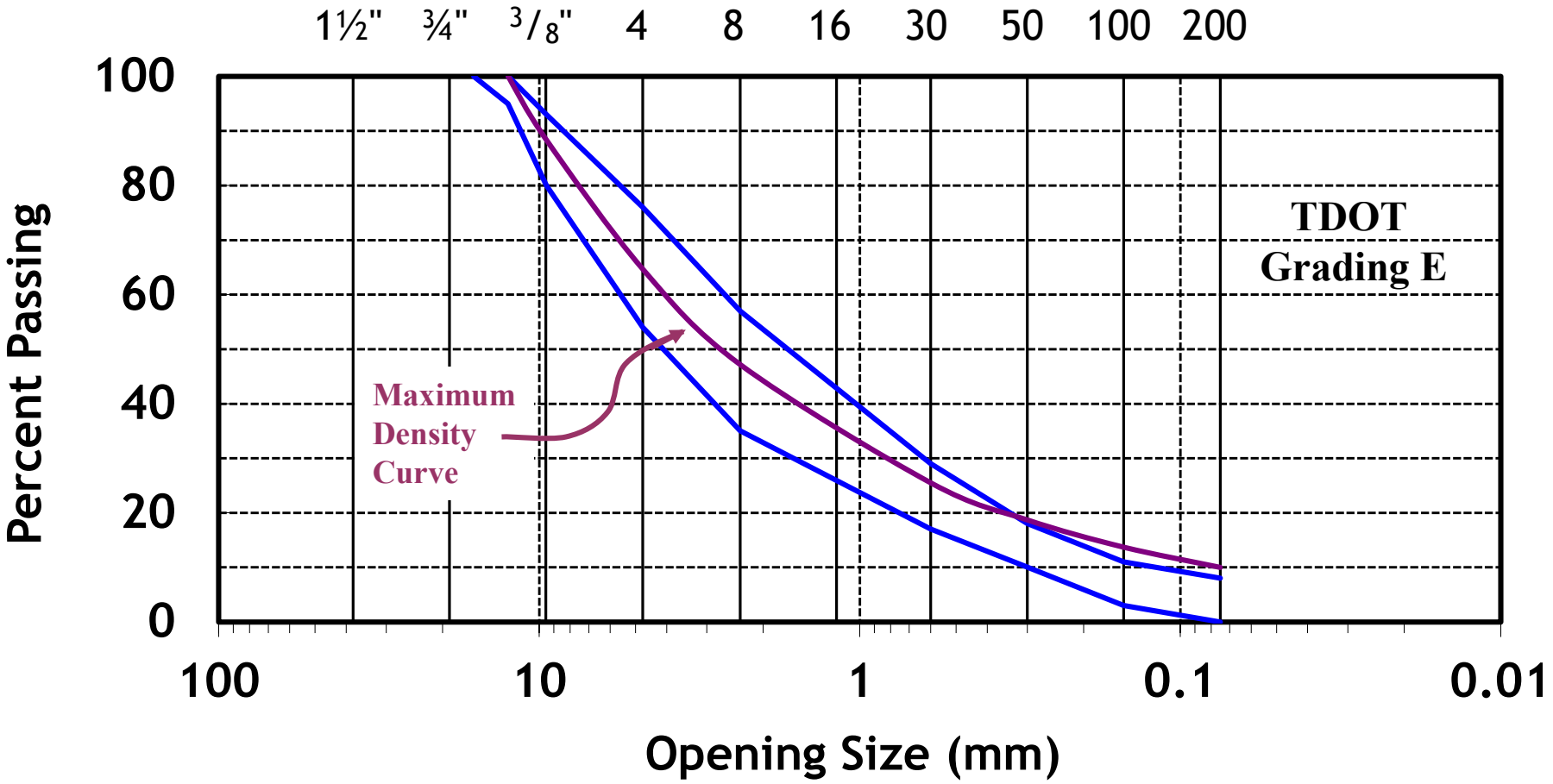
Total Percent Passing, by Weight

Sieve Size	Grading D	Grading E
19 mm (3/4")	-	-
16 mm (5/8")	100	100
12.5 mm (1/2")	95-100	95-100
9.5 mm (3/8")	80-93	80-93
4.75 mm (No. 4)	54-76	54-76
2.36 mm (No. 8)	35-57	35-57
600 µm (No. 30)	17-29	17-29
300 µm (No. 50)	10-18	10-18
150 µm (No. 100)	3-10	3-11
75 µm (No. 200)	0-6.5	0-8

TDOT Specifications



TDOT Specifications



Superpave Specifications

While researchers and engineers were developing the new Superpave asphalt cement grading system, they were also developing new specifications for asphalt concrete aggregate. This included specifications for the gradation of the aggregate blend as well as many specifications related to aggregate suitability.

Superpave Gradation Specs

The Superpave gradation specifications are all built around the theoretical maximum density gradation on the 0.45-power chart.

Rather than specify, sieve-by-sieve, a band in which the gradation must fit (as TDOT does), Superpave specifies several ***control points*** through which the gradation must pass. These are established at the NMAS, the No. 4 sieve, and the No. 100 sieve.

Superpave Gradation Specs

There are actually 5 gradation specifications, each corresponding to a different maximum aggregate size: 37.5 mm, 25 mm, 19 mm, 12.5 mm and 9.5 mm. The next slide shows the gradations at the control points for each of these.

Superpave Gradation Specs

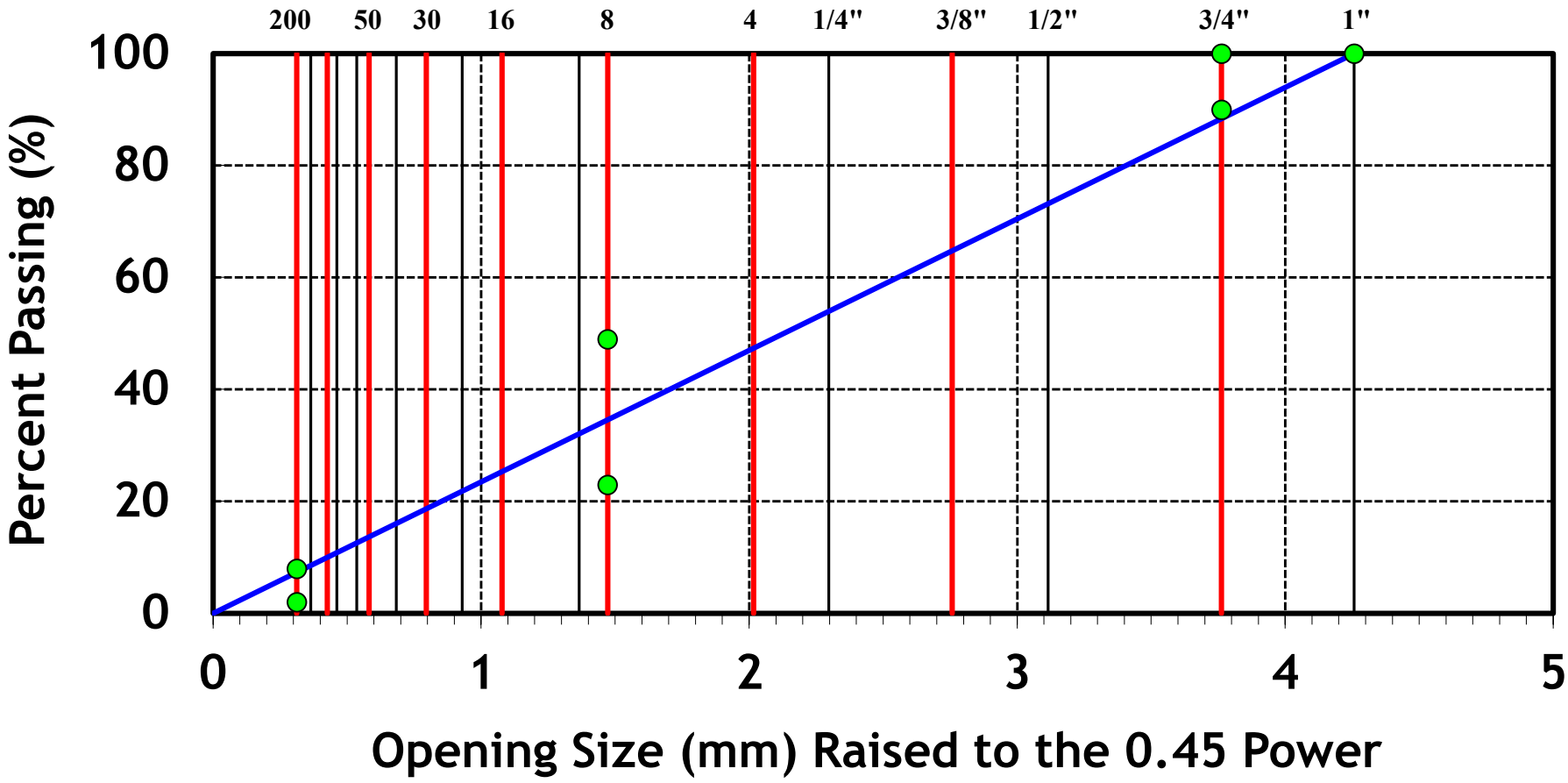
PERCENT PASSING CRITERIA (CONTROL POINTS)					
STANDARD SIEVE, mm	NOMINAL MAXIMUM SIEVE SIZE (mm)				
	9.5	12.5	19.0	25.0	37.5
50					100
37.5				100	90–100
25.0			100	90–100	
19.0		100	90–100		
12.5	100	90–100			
9.5	90–100				
2.36	32–67	28–58	23–49	19–45	15–41
0.075	2–10	2–10	2–8	1–7	0–6

Source: NCEES *FE Supplied Reference Handbook*

Superpave Gradation Specs

The next slide illustrates the concept of control points using the specification for a maximum aggregate size of 25 mm (which corresponds to a NMAS of 19 mm). Any gradation that passes through the green dots can be used as a starting point for your mix design.

19-mm Gradation Example

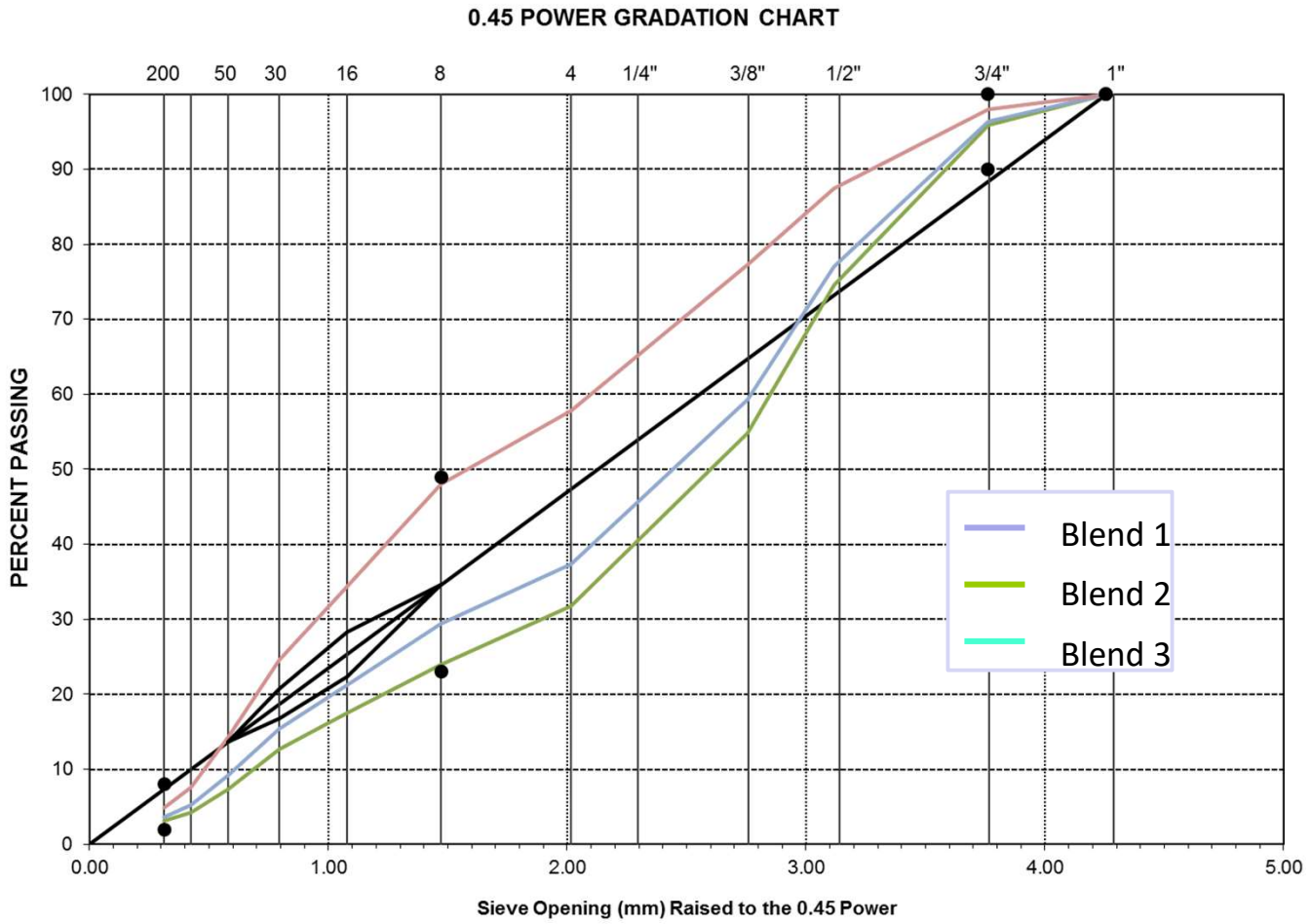


Superpave Gradation Specs

To develop a mix design you typically start with 3 trial blends with at least one of them falling mostly above the maximum density line and at least one falling below the maximum density line (while still passing through the control points).

Originally, there was a “restricted zone” between the No. 8 and No. 50 sieves through which none of the gradations could pass. This was later abandoned but it is still showing up in the next slide.

Superpave Specifications



Superpave Suitability Specs

The Superpave suitability specifications include flat and elongated particles, coarse aggregate angularity, fine aggregate angularity and clay content. Unlike previous specifications, the requirements depend on the traffic levels and, in some cases, the depth of the asphalt layer beneath the pavement surface. The idea is to tighten the requirements when the traffic levels are higher and to tighten them even more close to the pavement surface where the stresses are highest.

Superpave Suitability Specs

TRAFFIC, MILLION EQUIV. SINGLE AXLE LOADS (ESALs)	COARSE AGGREGATE ANGULARITY		FINE AGGREGATE ANGULARITY		FLAT AND ELONGATED PARTICLES	CLAY CONTENT
	DEPTH FROM SURFACE		DEPTH FROM SURFACE		MAXIMUM PERCENT	SAND EQUIVALENT MINIMUM
	≤ 100 mm	> 100 mm	≤100 mm	> 100 mm		
< 0.3	55 / –	– / –	–	–	–	40
< 1	65 / –	– / –	40	–	–	40
< 3	75 / –	50 / –	40	40	10	40
< 10	85 / 80	60 / –	45	40	10	45
< 30	95 / 90	80 / 75	45	40	10	45
< 100	100 / 100	95 / 90	45	45	10	50
≥ 100	100 / 100	100 / 100	45	45	10	50

Source: NCEES *FE Supplied Reference Handbook*

Coarse Aggregate Angularity

Coarse aggregate angularity ensures a high degree of aggregate internal friction and rutting resistance. It is defined as the percent by weight of aggregate particles larger than 4.75 mm having (a) one or more fractured faces and (b) two or more fractured faces.

The required minimum values are a function of the traffic level (ESALs) and there are slightly higher minimum values when the asphalt is within 4" of the pavement surface.

Coarse Aggregate Angularity

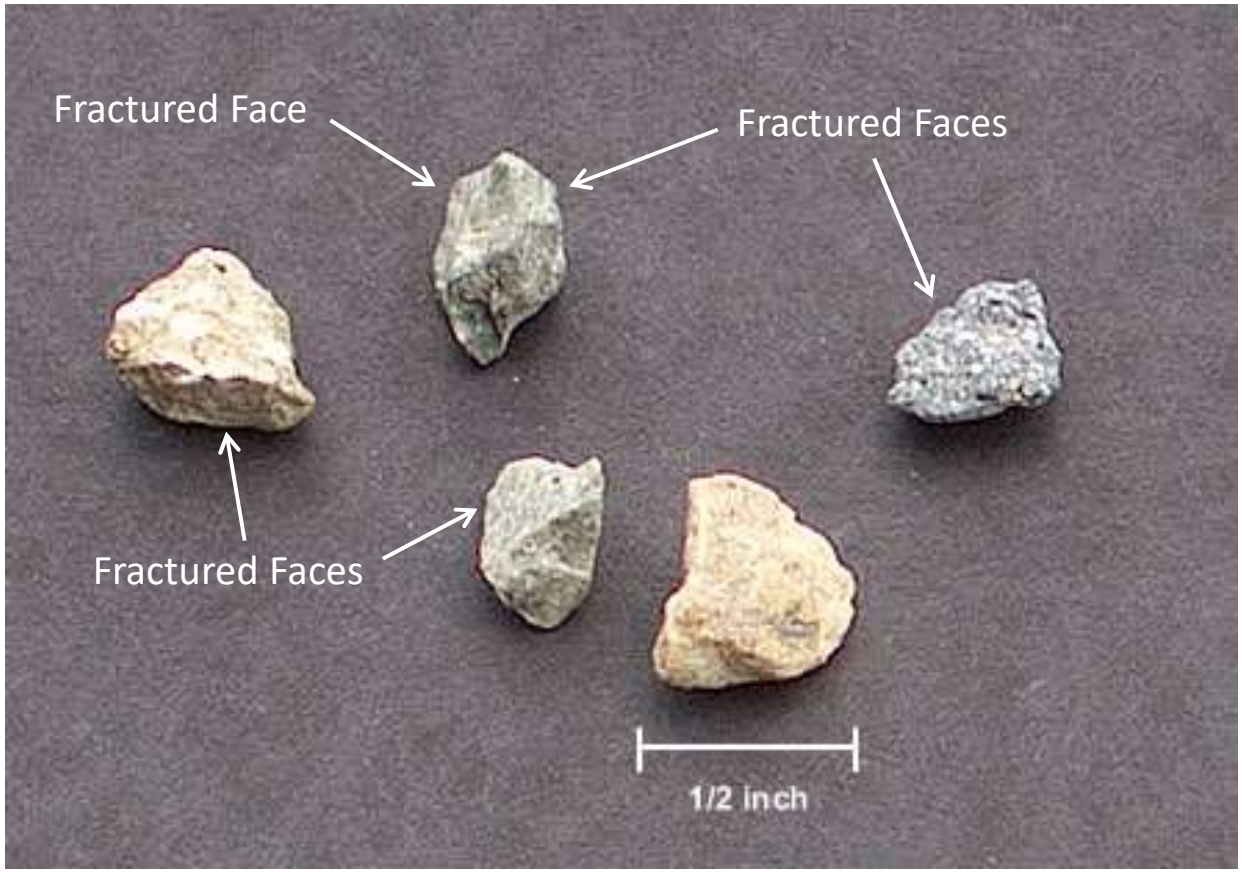
TRAFFIC, MILLION EQUIV. SINGLE AXLE LOADS (ESALs)	COARSE AGGREGATE ANGULARITY		FINE AGGREGATE ANGULARITY		FLAT AND ELONGATED PARTICLES	CLAY CONTENT
	DEPTH FROM SURFACE		DEPTH FROM SURFACE		MAXIMUM PERCENT	SAND EQUIVALENT MINIMUM
	≤ 100 mm	> 100 mm	≤100 mm	> 100 mm		
< 0.3	55 / –	– / –	–	–	–	40
< 1	65 / –	– / –	40	–	–	40
< 3	75 / –	50 / –	40	40	10	40
< 10	85 / 80	60 / –	45	40	10	45
< 30	95 / 90	80 / 75	45	40	10	45
< 100	100 / 100	95 / 90	45	45	10	50
≥ 100	100 / 100	100 / 100	45	45	10	50

Source: NCEES *FE Supplied Reference Handbook*

Percentage with two or more fractured faces

Percentage with one or more fractured faces

Coarse Aggregate Angularity



Source: http://pavementinteractive.org

Fine Aggregate Angularity

Fine aggregate angularity ensures a high degree of fine aggregate internal friction and rutting resistance. It is defined using the uncompacted void content of the aggregate. The more angular the fine aggregate, the higher the uncompacted void content.

The required minimum values are a function of the traffic level (ESALs) and there are slightly higher minimum values when the asphalt is within 4" of the pavement surface.

Fine Aggregate Angularity

TRAFFIC, MILLION EQUIV. SINGLE AXLE LOADS (ESALs)	COARSE AGGREGATE ANGULARITY		FINE AGGREGATE ANGULARITY		FLAT AND ELONGATED PARTICLES	CLAY CONTENT
	DEPTH FROM SURFACE		DEPTH FROM SURFACE		MAXIMUM PERCENT	SAND EQUIVALENT MINIMUM
	≤ 100 mm	> 100 mm	≤100 mm	> 100 mm		
< 0.3	55 / –	– / –	–	–	–	40
< 1	65 / –	– / –	40	–	–	40
< 3	75 / –	50 / –	40	40	10	40
< 10	85 / 80	60 / –	45	40	10	45
< 30	95 / 90	80 / 75	45	40	10	45
< 100	100 / 100	95 / 90	45	45	10	50
≥ 100	100 / 100	100 / 100	45	45	10	50

Source: NCEES *FE Supplied Reference Handbook*

Fine Aggregate Angularity

Source: http://pavementinteractive.org

$$V_{sand} = \frac{m_{sand}}{RD_{sand} \times \rho_w}$$

$$V_{voids} = V_{cyl} - V_{sand}$$

$$\% \text{ Voids} = \frac{V_{voids}}{V_{cyl}} \times 100\%$$

Flat and Elongated Particles

This is defined as the percentage by weight of coarse aggregate particles that have a length-to-width ratio greater than 5:1. Elongated particles are undesirable because they tend to break during construction and under traffic loads.

The maximum allowable is 10% regardless of the traffic levels or the position within the pavement.

Flat and Elongated Particles

TRAFFIC, MILLION EQUIV. SINGLE AXLE LOADS (ESALs)	COARSE AGGREGATE ANGULARITY		FINE AGGREGATE ANGULARITY		FLAT AND ELONGATED PARTICLES	CLAY CONTENT
	DEPTH FROM SURFACE		DEPTH FROM SURFACE		MAXIMUM PERCENT	SAND EQUIVALENT MINIMUM
	≤ 100 mm	> 100 mm	≤100 mm	> 100 mm		
< 0.3	55 / –	– / –	–	–	–	40
< 1	65 / –	– / –	40	–	–	40
< 3	75 / –	50 / –	40	40	10	40
< 10	85 / 80	60 / –	45	40	10	45
< 30	95 / 90	80 / 75	45	40	10	45
< 100	100 / 100	95 / 90	45	45	10	50
≥ 100	100 / 100	100 / 100	45	45	10	50

Source: NCEES *FE Supplied Reference Handbook*

Particle Shape

(Flat and Elongated Particles)

Source: http://pavementinteractive.org

Clay Content

This is defined as the amount of clay-sized material in the aggregate fraction smaller than 4.75 mm (i.e., a No. 4 sieve). It determined using the sand equivalent test.

The required clay content values for fine aggregate are expressed as a minimum sand equivalent and are a function of the traffic level.

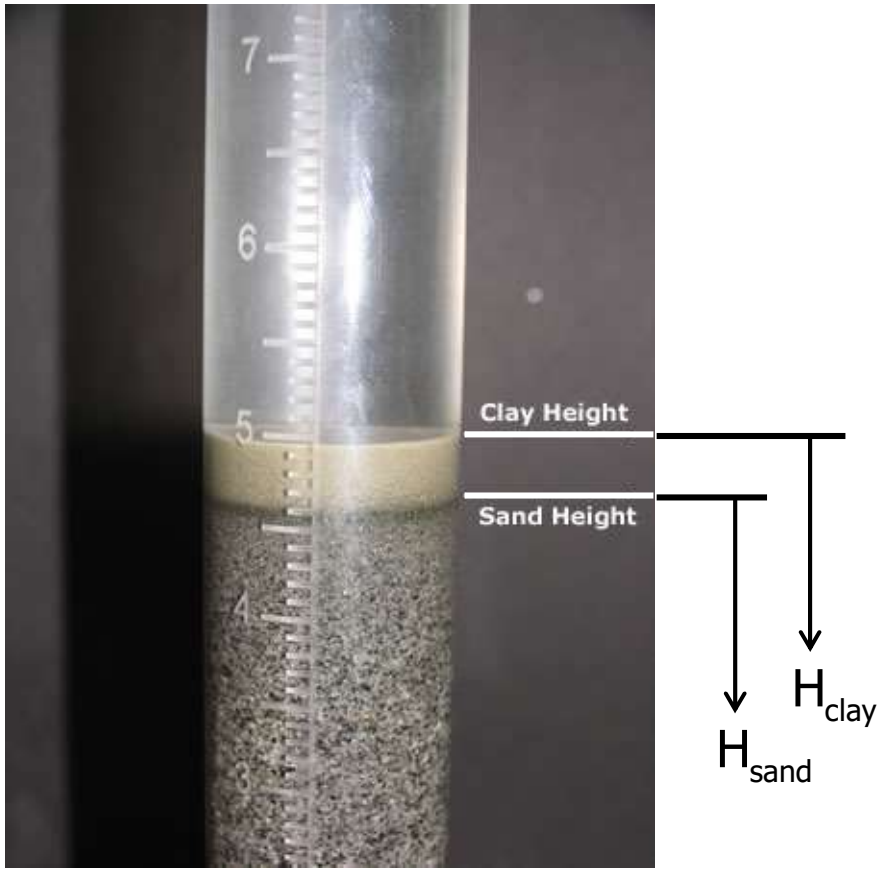
Clay Content

TRAFFIC, MILLION EQUIV. SINGLE AXLE LOADS (ESALs)	COARSE AGGREGATE ANGULARITY		FINE AGGREGATE ANGULARITY		FLAT AND ELONGATED PARTICLES	CLAY CONTENT
	DEPTH FROM SURFACE		DEPTH FROM SURFACE		MAXIMUM PERCENT	SAND EQUIVALENT MINIMUM
	≤ 100 mm	> 100 mm	≤100 mm	> 100 mm		
< 0.3	55 / –	– / –	–	–	–	40
< 1	65 / –	– / –	40	–	–	40
< 3	75 / –	50 / –	40	40	10	40
< 10	85 / 80	60 / –	45	40	10	45
< 30	95 / 90	80 / 75	45	40	10	45
< 100	100 / 100	95 / 90	45	45	10	50
≥ 100	100 / 100	100 / 100	45	45	10	50

Source: NCEES *FE Supplied Reference Handbook*

Clay Content

(Sand Equivalent Test)



$$SE = \frac{H_{sand}}{H_{clay}} \times 100\%$$

Source: http://pavementinteractive.org

Superpave Specifications

The suitability properties mentioned here are known as the ***consensus properties*** because the researchers and engineers who developed the specifications were able to reach a consensus as to what the requirements should be.

Other suitability properties, called ***source properties***, were recommended as being critical properties, but the researchers couldn't come to a consensus, so the right values are decided by each local agency.

Superpave Specifications

These ***source properties*** include toughness (the LA abrasion test), sodium or magnesium soundness (to assess durability) and deleterious materials.