Thi_ Qar University
College of Engineering/Civil Engineering Department

Highway Lectures

Fourth Class

Part #2: - Highway Aggregate

Lectures #4, #5 and #6

Aggregate Proprieties

Prepared By

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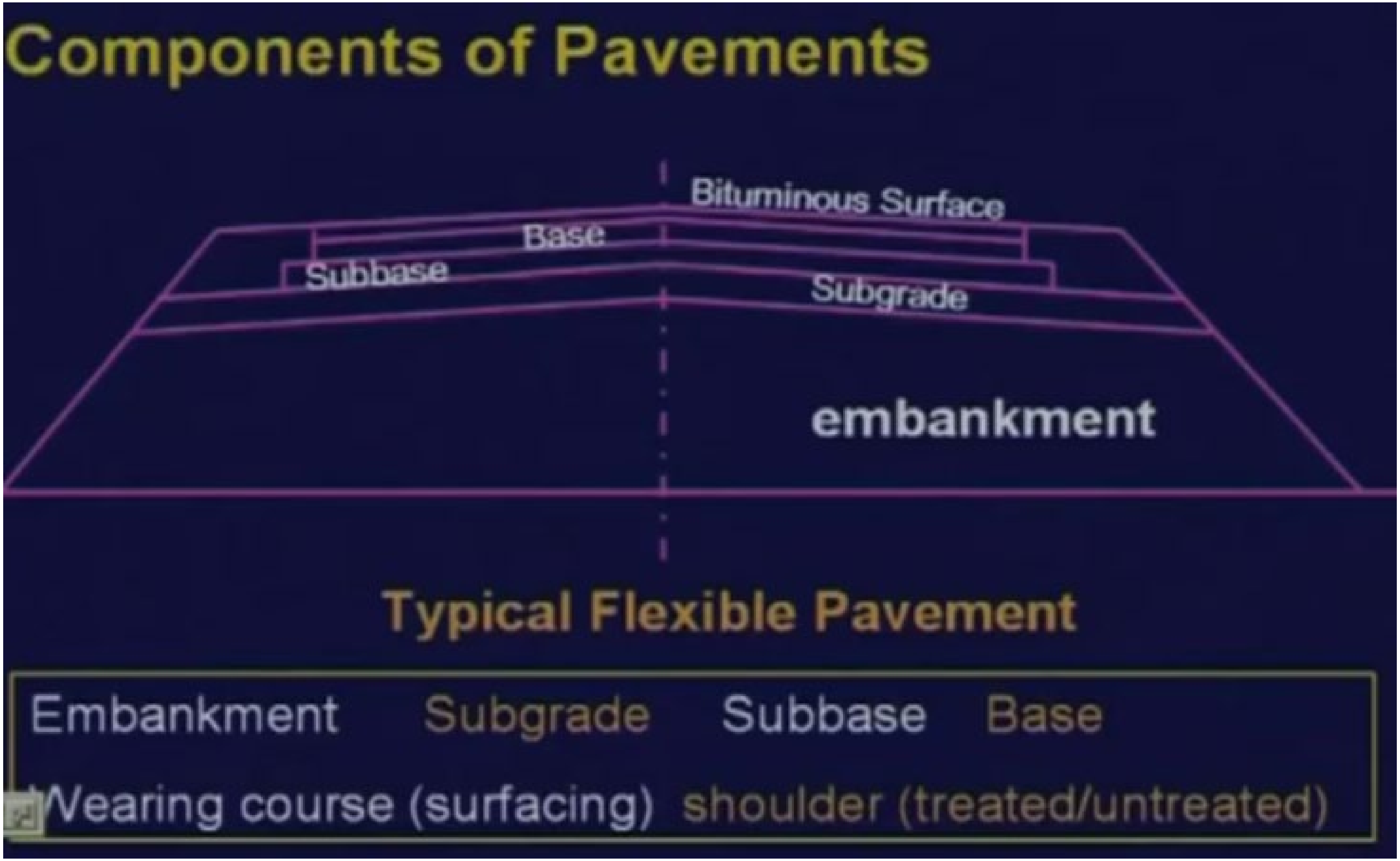
Objectives Learning Outcomes (OLC)

➢After completing this chapter (Aggregate) the students are expected to have:-

i. Learnt about the relevance of different properties of aggregate for pavement performance and their determination.
ii. Aggregate types and sources.
iii. Aggregate gradation types.
iv. Iraqi standard and specifications for aggregate that required for pavement design and construction.
v. Aggregate tests that required and important in pavement design.
vi. Aggregate blinding principles

Introduction



Ref. #2

Introduction

- The behavior of aggregate depend on the properties.
- The aggregate occupies 95% by weight or ~80-85% by volume of the asphalt mixture, so its important to see how aggregate properties affects the performance of bituminous mixes
- It is the basic and major component of material used in highway pavement constriction they not only support the main stress but also resist the wear due to abrasion by traffic as well as the effect of weathering.

Aggregate Types

According to Source

1. **Natural Aggregate:-** Native deposits with no change in their natural state other than washing, crushing & grading. (sand, gravel, crush stone)

   - Igneous: such Basalt and Granite.
   - Sedimentary: such Limestone
   - Metamorphic: such Quartz and marble

2. **Artificial Aggregate:-** They are obtained either as a by-product or by a special manufacturing process such as heating. (blast furnace slag, expanded perlite), which produced from processing of steel, tin and copper

Aggregate Types

Natural Aggregate

Aggregate Types

Artificial Aggregate

Aggregate Uses

- Under foundations and pavements
  - Stability
  - Drainage
- As fillers
  - Portland Cement Concrete
    - 60-75% of volume
    - 80-85% of weight
  - Hot Mix Asphalt
    - 80%-90% of volume
    - 90-96% of weight

Aggregate Uses in Highway

1) Asphalt – wearing course, base course
   - high fracture resistance
   - good interlocking
   - hardness
   - surface friction
   - light reflective
2) Base Material
   - good fracture resistance
   - good interlocking
   - drainage
3) Sub-Base Material
   - medium fracture resistance
   - good interlocking
   - drainage

Aggregate Properties in Highway

Coarse Aggregate and their Sieve Sizes

Sieve Designation	Opening (in)	Openeing (mm)
3 in	3.00	75.0
2 in	2.00	50.0
1½ in	1.50	37.5
1 in	1.00	25.0
3/4 in	0.75	19.0
½ in	0.50	12.5
3/8 in	0.375	9.50

- Retained on 4.75 mm (No.4) ASTM D692
- Retained on 2.36 mm (No.8) Asphalt Institute
- Retained on 2.00 mm (No.10) HMA Book

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Aggregate Properties in Highway

Fine Aggregate and their Sieve Sizes

Sieve Designation	Opening (in)	Opening (mm)
No. 4	0.187	4.75
No. 8	0.0937	2.36
No. 16	0.0469	1.18
No. 30	0.0234	0.60
No. 50	0.0117	0.30
No. 100	0.0059	0.15
No. 200	0.0030	0.075

Passing 4.75 mm (No.4) ASTM D1073

Retained on 2.36 mm (No.8) Asphalt Institute

- **Mineral filler**
  - At least 70% pass 0.075 mm ASTM D242

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Aggregate Properties in Highway

1) Cleanness
2) Shape and texture
3) Soundness
4) Toughness
5) Affinity for asphalt (Stripping)
6) Specific gravity and Absorption
7) Gradation

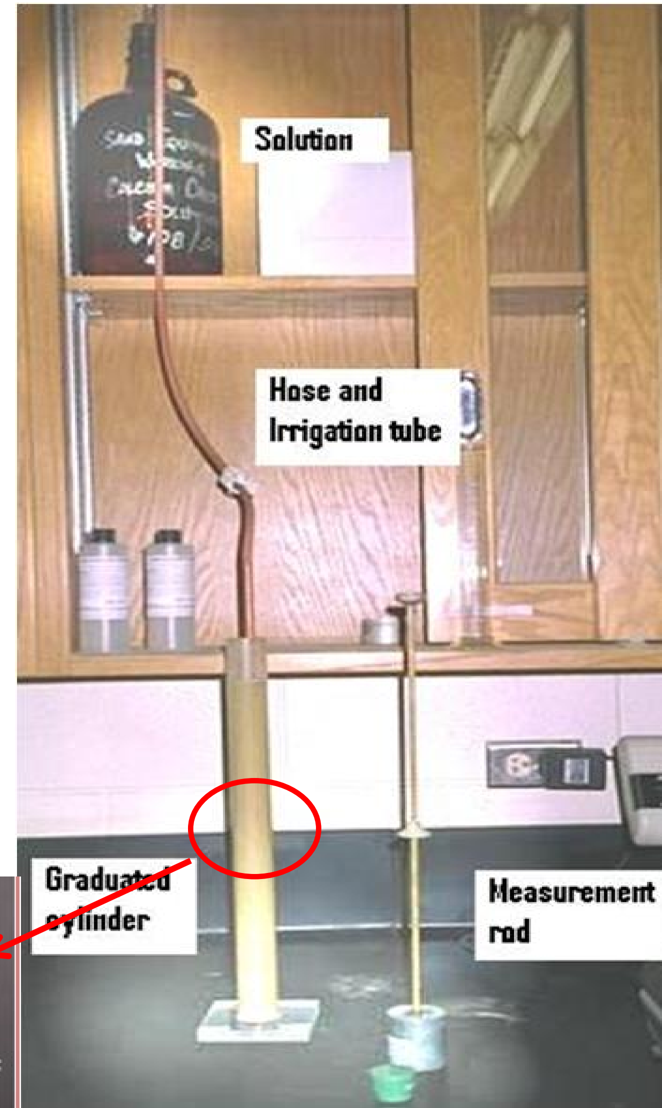
Aggregate Properties in Highway

1) Cleanness

- ✓ Dirty aggregate can reduce adhesion of the binder.
- ✓ Clay in the aggregate can causes stripping problem.
- ✓ Max. percent of clay in coarse aggregate is 2%.

➢ **Sand Equivalency Test**

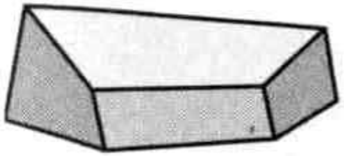
$SE = h_{sand} / h_{clay} \times 100 \geq 45\%$



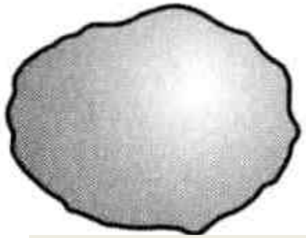
Aggregate Properties in Highway

2) Shape and texture

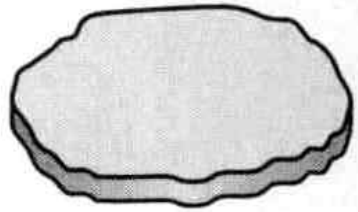
The aggregate may either be **(Rounded & Cubical &Angular &Flaky &elongated)** . **Cubical** similar to a cube, **Angular** posses edges, **Flaky** have smaller thickness as compared to the side. **Flaky &elongated** have less strength and durability. Therefore, avoided used in pavement construction. **Rounded** particle have better workability. In case of flexibility pavement where stability is mainly due to interlock angular are the best choice



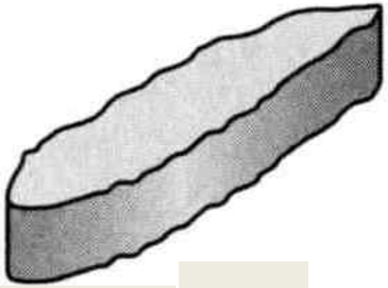
Angular



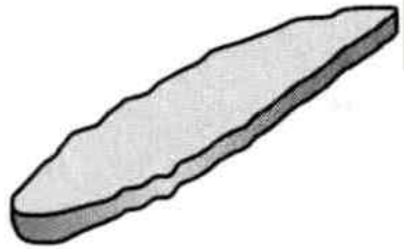
Rounded



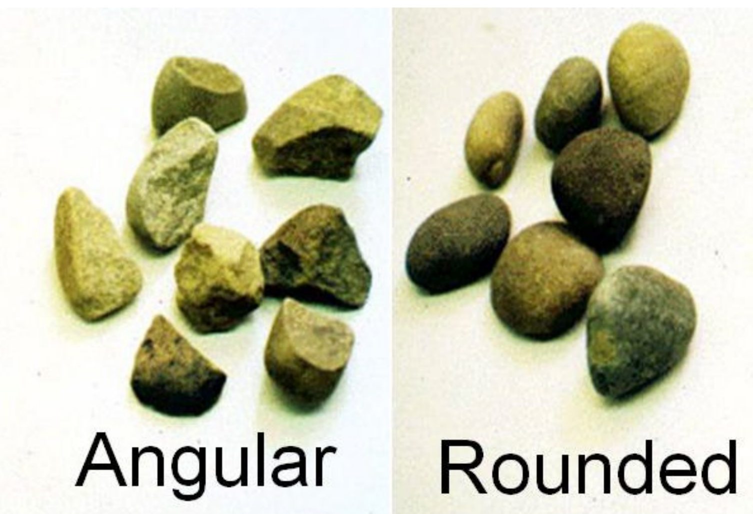
Flaky

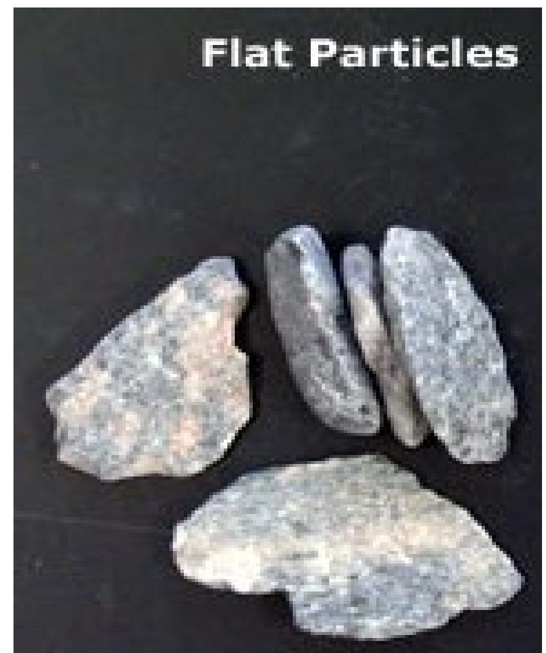


Elongated



Flaky & Elongated





Aggregate Properties in Highway

3) Soundness and Durability.

Resist weathering

- water freezing in voids fractures & disintegrates aggregates
- Test method uses "salt solution" to simulate freezing

•Prepare sample
minimum mass
specified gradation

Soak 16 hrs – dry 4 hrs
Repeat cycle 5 times

Measure gradation

$$Loss = \left(\frac{M_B - M_A}{M_B}\right)100$$

Aggregate Properties in Highway

4) Roughness.

Loss Angelus abrasion test

– Resist load damage
  - During construction
  - Traffic loads

$$Loss = \left(\frac{M_{original} - M_{final}}{M_{original}} \right) \times 100$$

- Prepare sample
- Minimum mass original
- Specified gradation

- Charge drum w/ sample
- Steel spheres
- 500 revolutions

- Sieve

Aggregate Properties in Highway

4) Roughness.

Loss Angelus abrasion test

The maximum allowable values of Los Angeles abrasion test according to Iraqi standard specification for roads and bridges are 45% for coarse aggregate which are used in granular materials (base and subbase layer) and 30%, 35% and 40% for coarse aggregates which are used in surface course, binder course and base course respectively in hot mix asphaltic concrete pavement.

Aggregate Properties in Highway

5) Affinity for asphalt (Stripping).

- ➢ Affects the bond between asphalt binder and aggregate
- ➢ Asphalt Stripping (moisture induced damage)
  - ✓ water causes asphalt film to separate from agg.
    - ❖reduces durability of Asphalt Concrete (A.C.)
  - ✓ Hydrophilic (water-loving)
    - ❖silicates – acidic, negative surface charge
    - ❖more susceptible to stripping
  - ✓ Hydrophobic (water-hating)
    - ❖limestone – basic, positive surface charge
    - ❖less susceptible to stripping.

Aggregate Properties in Highway

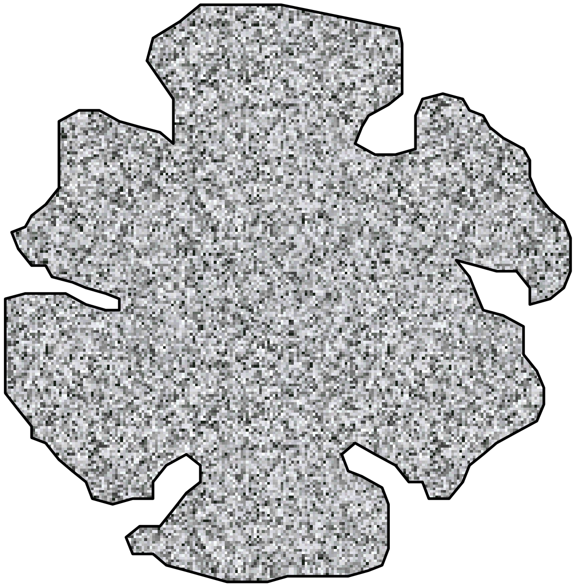
5) Affinity for asphalt (Stripping).

- stripping is also affected by porosity, absorption, coatings, etc.
- Testing
  i. ASTM D1664 & D3625 - submerge AC in tepid or boiling water
  ii. ASTM D1075 – freeze-thaw cycles

Aggregate Properties in Highway

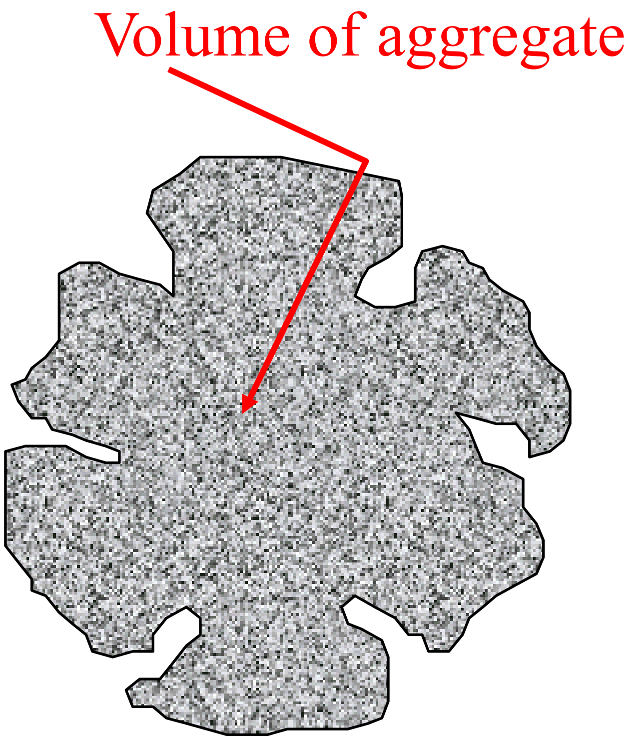
6) Specific gravity and Absorption

- Voids on the surface of aggregates create multiple definitions of specific gravity
  - Apparent
  - Bulk, Dry
  - Bulk, SSD



Aggregate Properties in Highway

6) Specific gravity and Absorption (Apparent Sp. Gr.)



Functional definition

$$G_{sa} = \frac{\text{Mass, oven dry agg.}}{\text{Vol. of agg.}}$$

Apparent

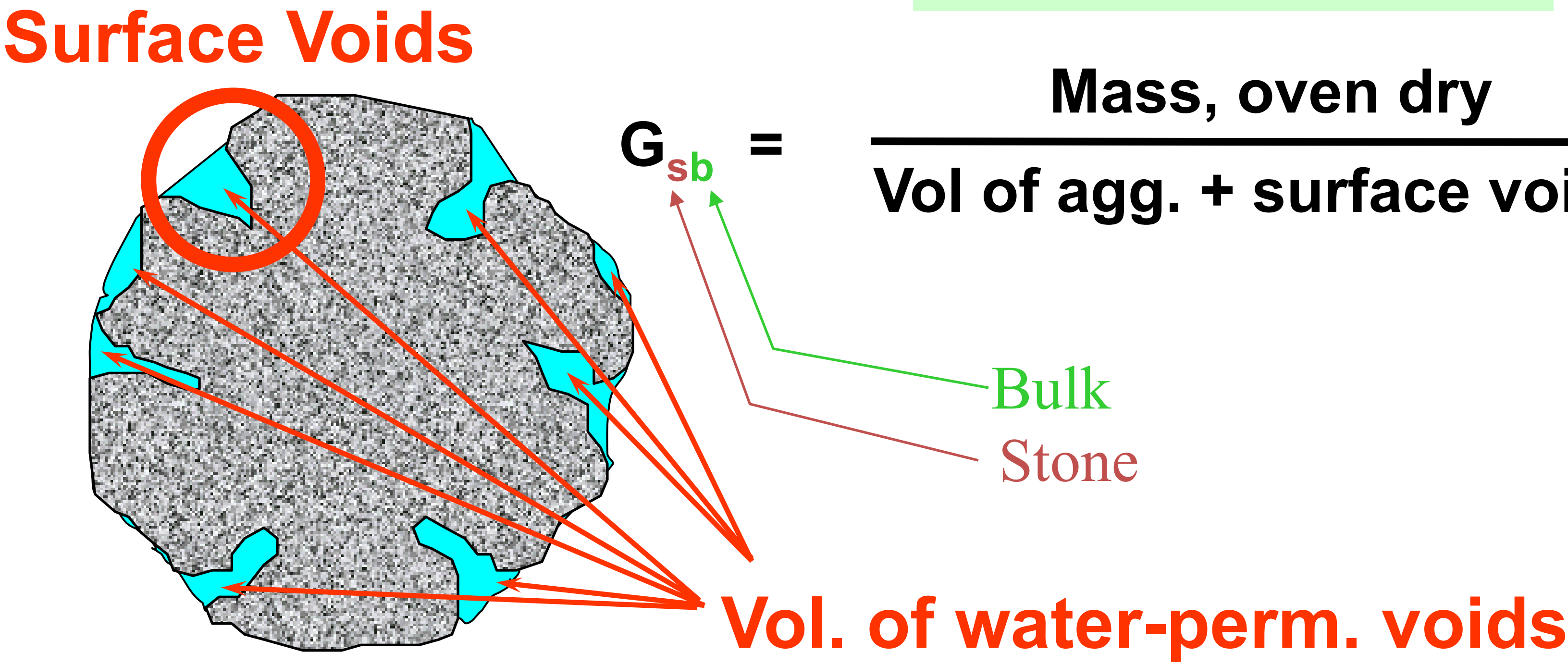
Stone

➢This ratio of the weight in air of a unit volume of the *impermeable* portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas-free distilled water at a stated temperature

Aggregate Properties in Highway

6) Specific gravity and Absorption (Bulk (dry)Sp. Gr.)

Functional definition



$$G_{sb} = \frac{\text{Mass, oven dry}}{\text{Vol of agg. + surface voids}}$$

s: Stone

b: Bulk

Aggregate Properties in Highway

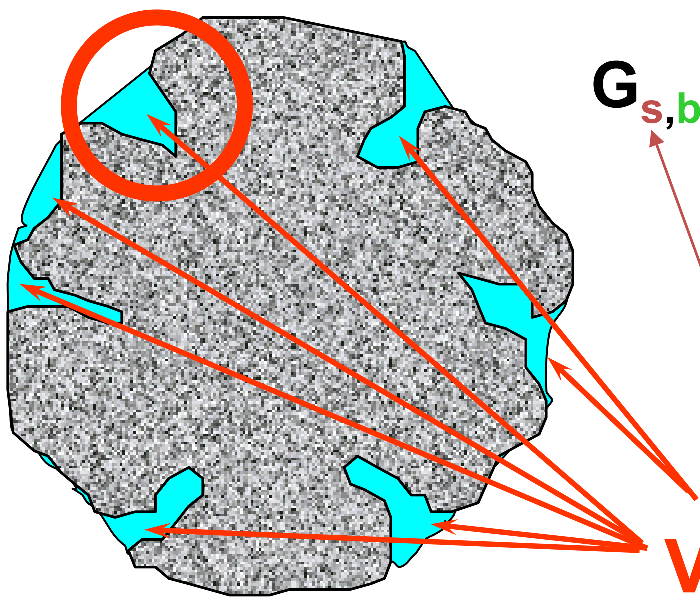
6) Specific gravity and Absorption (Bulk (dry)Sp. Gr.)

- The mass of oven-dry aggregate particles per unit volume of aggregate particles, including the volume of permeable and impermeable pores within particles, but not including the voids between the particles

$$\text{Bulk Dry Sp. Gr.} = \frac{\text{Dry Weight}}{(\text{Total Particle Volume})\gamma_w} = \frac{W_s}{(V_s + V_i + V_p)\gamma_w}$$

Aggregate Properties in Highway

6) Specific gravity and Absorption (Bulk (SSD)Sp. Gr.)



Functional definition

$$G_{s,b_{ssd}} = \frac{\text{Mass, SSD (oven agg.+water}}{\text{Vol of agg. + surface voids}}$$

s: Stone

b ssd: Bulk, saturated surface dry

$$\text{Bulk SSD Sp. Gr.} = \frac{\text{SSD Weight}}{(\text{Total Particle Volume})\gamma_w} = \frac{W_s + W_p}{(V_s + V_i + V_p)\gamma_w}$$

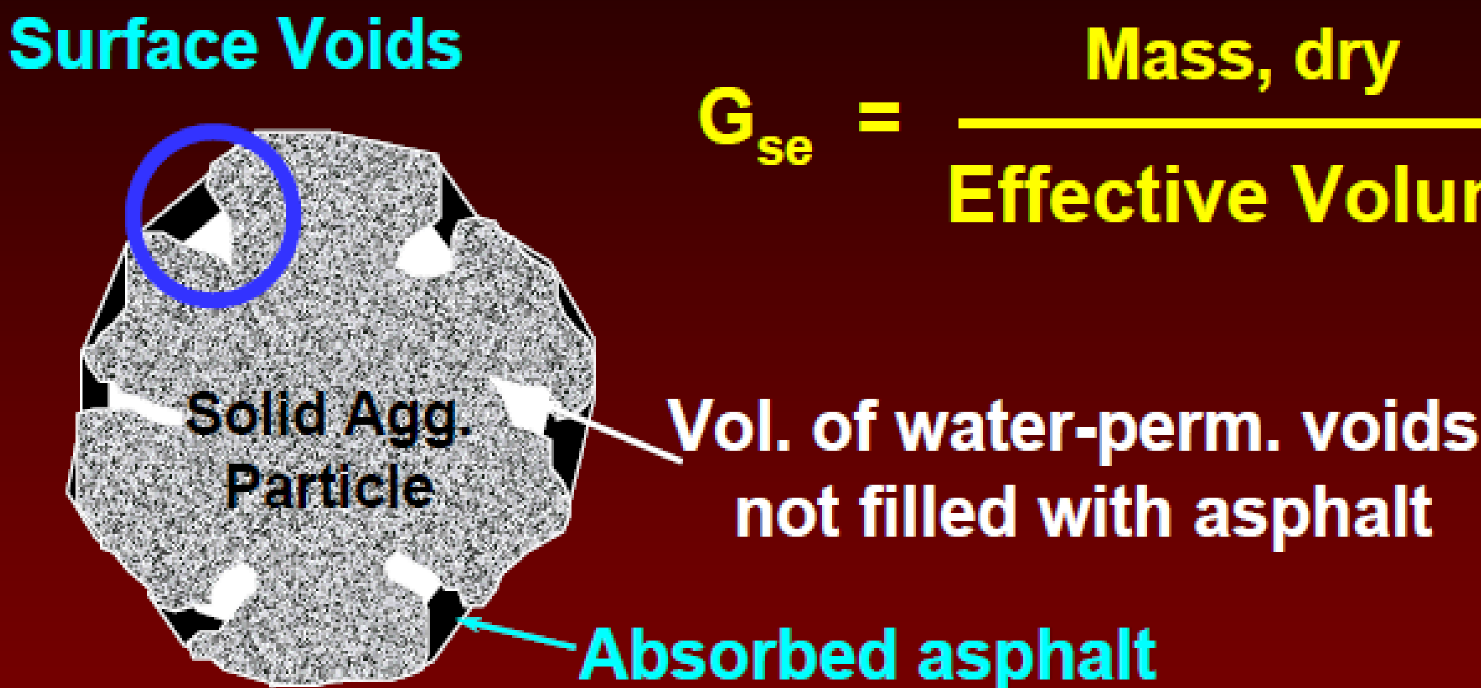
Aggregate Properties in Highway

6) Specific gravity and Absorption (Bulk (SSD)Sp. Gr.)

- The mass of saturated-surface-dry aggregate per unit volume of the aggregate particles, including the volume of impermeable pores and permeable, water-filled pores within the particles, but not including the voids between the particles.

6) Specific gravity and Absorption (Effective Sp. Gr.)

$$G_{se} = \frac{\text{Mass, dry}}{\text{Effective Volume}}$$



Effective volume = volume of solid aggregate particle + volume of surface voids not filled with asphalt

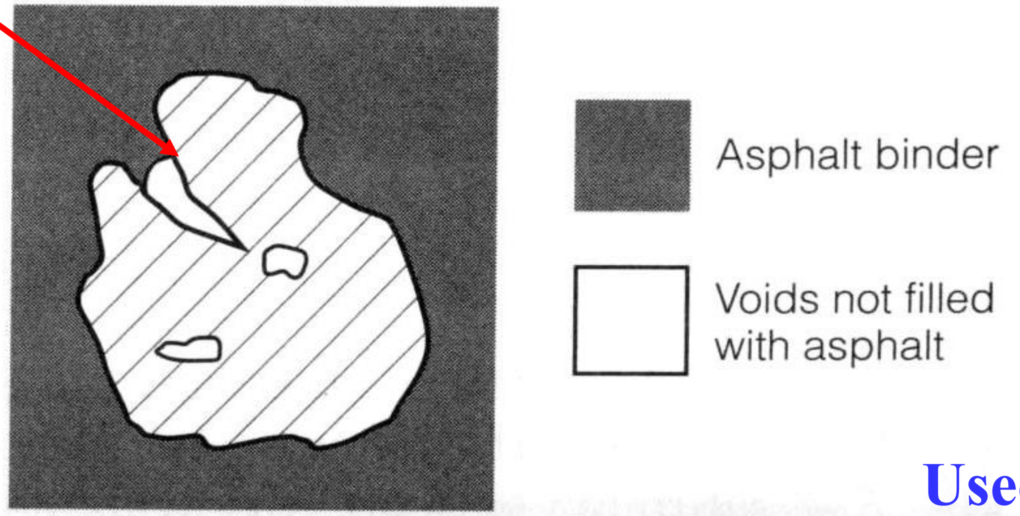
Aggregate Properties in Highway

6) Specific gravity and Absorption (Effective Sp. Gr.)

$$G_{se} = \frac{\text{Dry weight}}{(\text{Volume not accessible to asphalt})\gamma_w} = \frac{W_s}{(V_s + V_c)\gamma_w}$$

where V_c is volume of voids not filled with asphalt cement.

permeable



Used for hot mix asphalt design

Coarse Aggregate Specific Gravity by the Book

(ASTM C127)

$$\text{Bulk Dry Sp. Gr.} = \frac{A}{B - C}$$

$$\text{Bulk SSD Sp. Gr.} = \frac{B}{B - C}$$

$$\text{Apparent Sp. Gr.} = \frac{A}{A - C}$$

$$\text{Absorption (\%)} = \frac{B - A}{A}(100)$$

where

A = dry weight
B = SSD weight
C = submerged weight

Dry then saturate the aggregates

Dry to SSD condition and weigh

Measure submerged weight

Fine Aggregate Specific Gravity by the Book

(ASTM C128)

$$\text{Bulk Dry Sp. Gr.} = \frac{A}{B + S - C}$$

$$\text{Bulk SSD Sp. Gr.} = \frac{S}{B + S - C}$$

$$\text{Apparent Sp. Gr.} = \frac{A}{B + A - C}$$

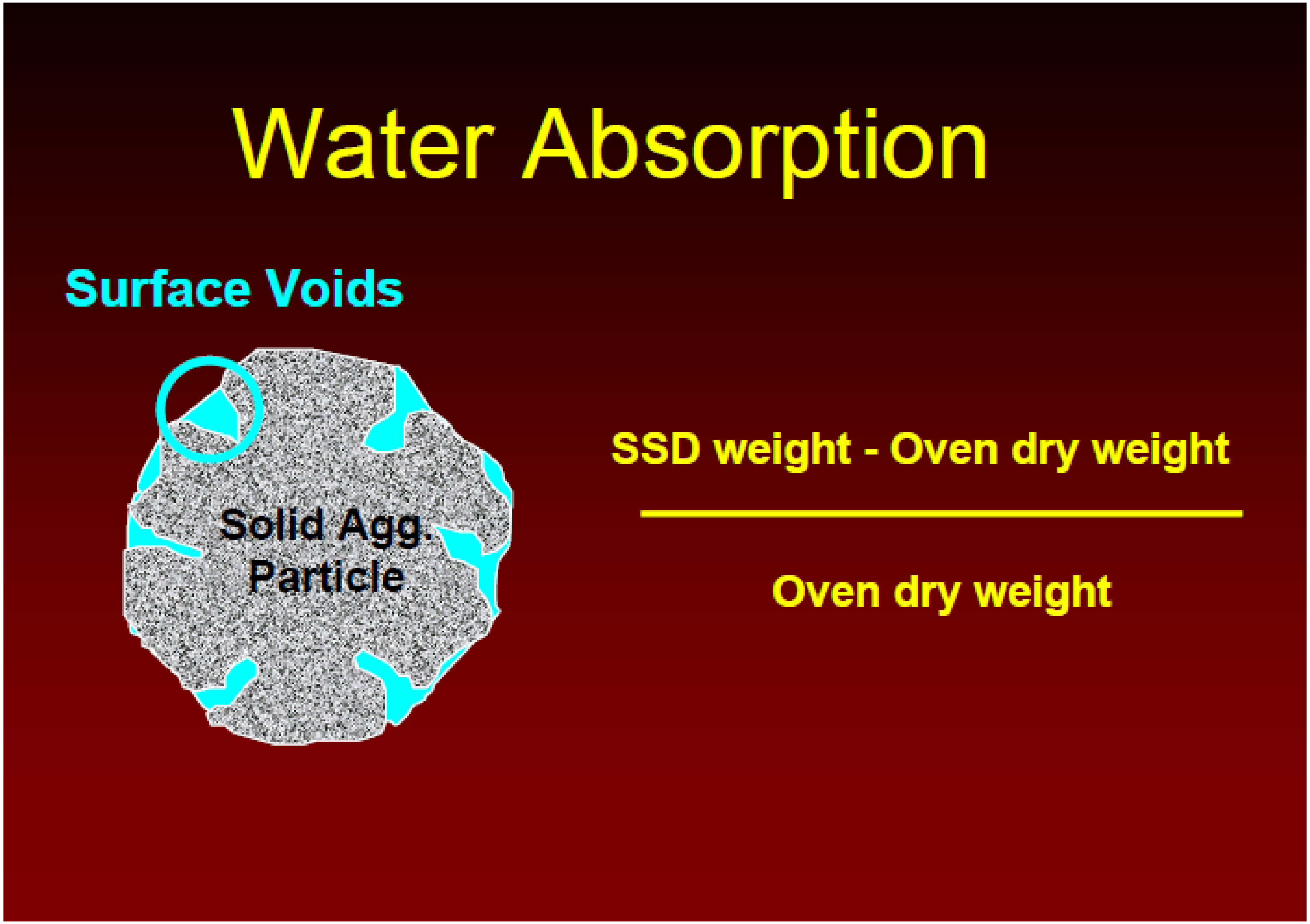
$$\text{Absorption (\%)} = \frac{S - A}{A}(100)$$

where

A = dry weight
B = weight of the pycnometer filled with water
C = weight of the pycnometer filled with aggregate and water
S = saturated surface—dry weight of the sample

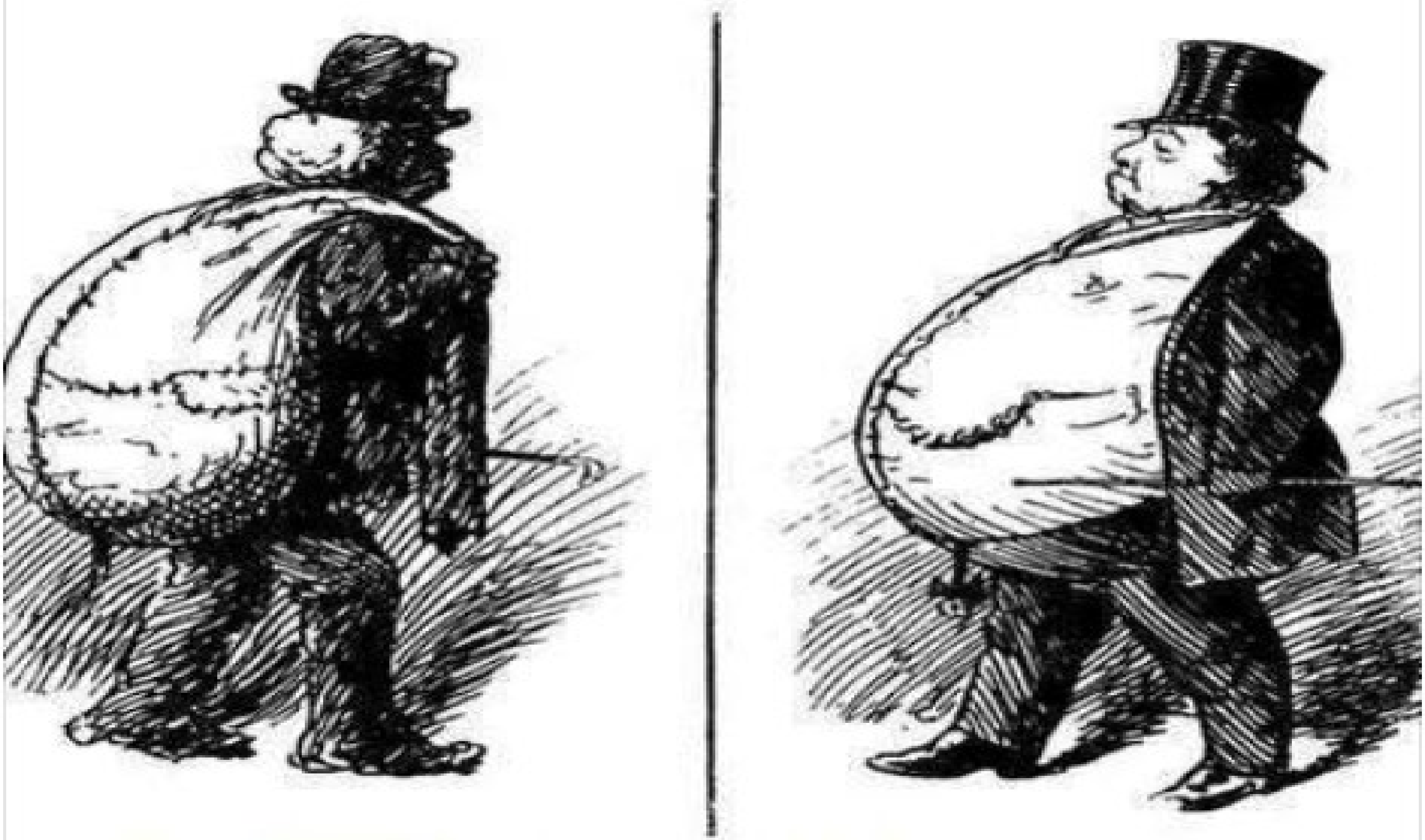
Aggregate Properties in Highway

6) Specific gravity and Absorption (Bulk (SSD)Sp. Gr.)



Desirable Aggregate Properties in Highway

- Clean and free of clay and organic matter
- Be angular and not excessively flaky
- Be strong enough to resist to crushing during mixing, laying, compaction, consolidation and in service
- Be resistant to abrasion and polishing when exposed to traffic
- Be non- absorptive
- Have good affinity to bitumen in case of bituminous pavements

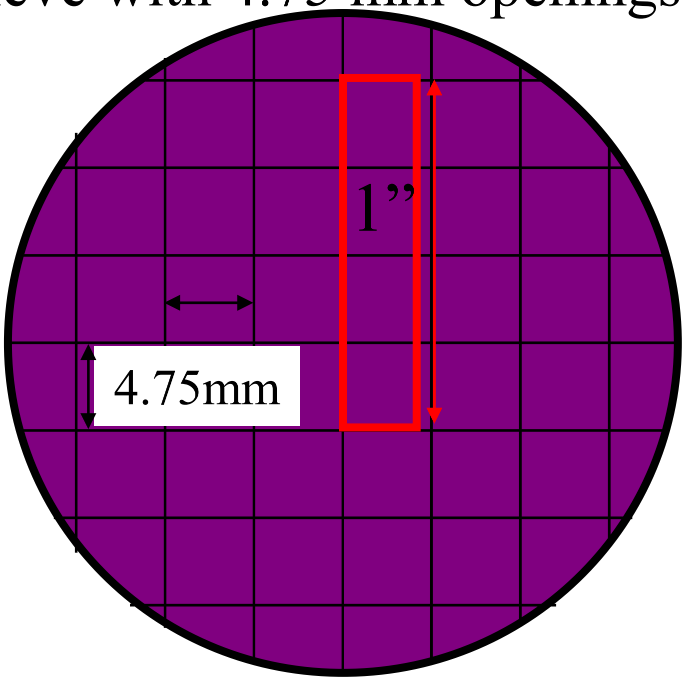


الفرق بين الطبقة الكادحة و الطبقة الثرية

Aggregate Properties in Highway

7) Aggregate Gradations

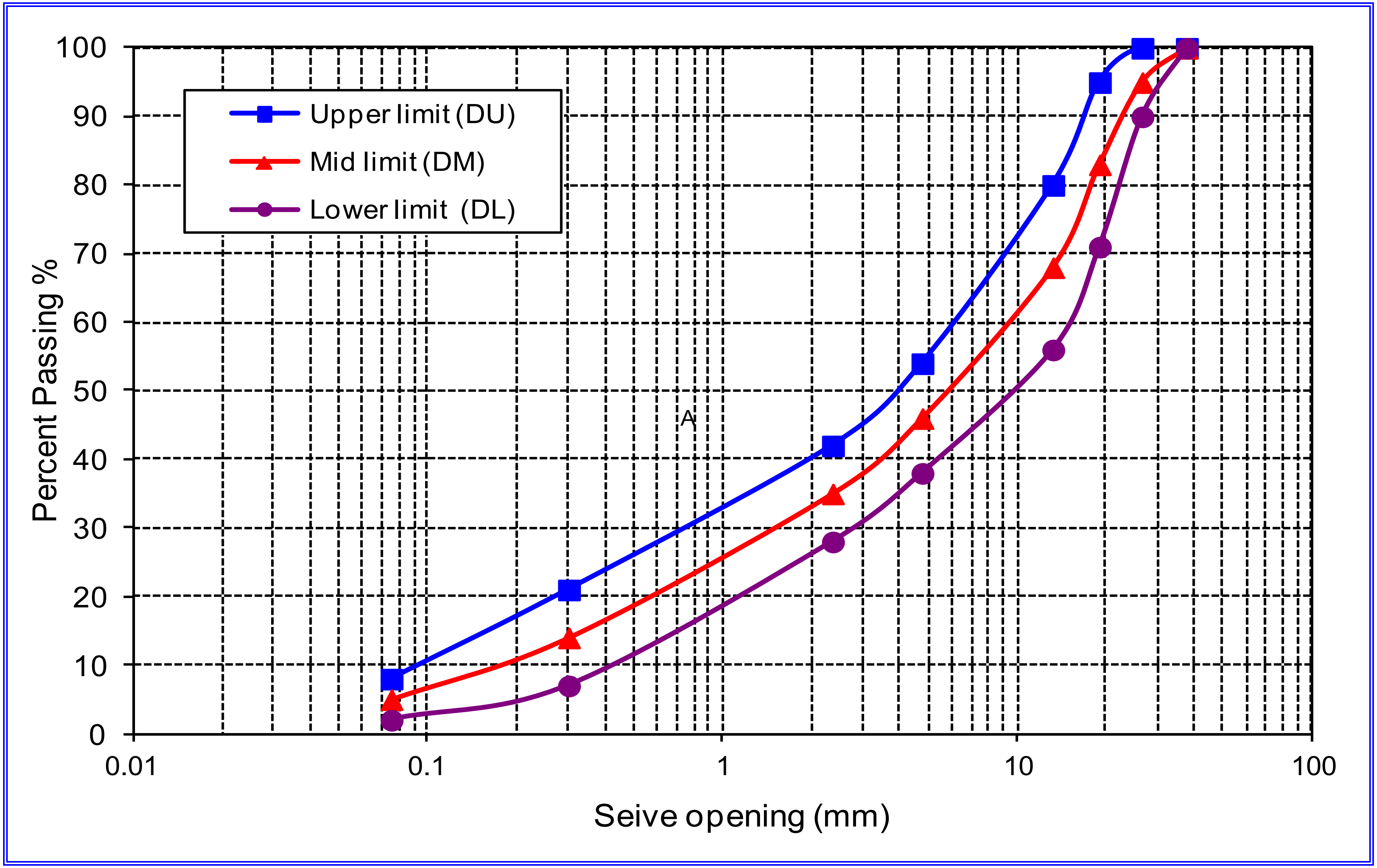
- **Coarse** aggregate material retained on a sieve with 4.75 mm openings
- **Fine** aggregate material passing a sieve with 4.75 mm openings



#4 sieve = Four openings/linear inch

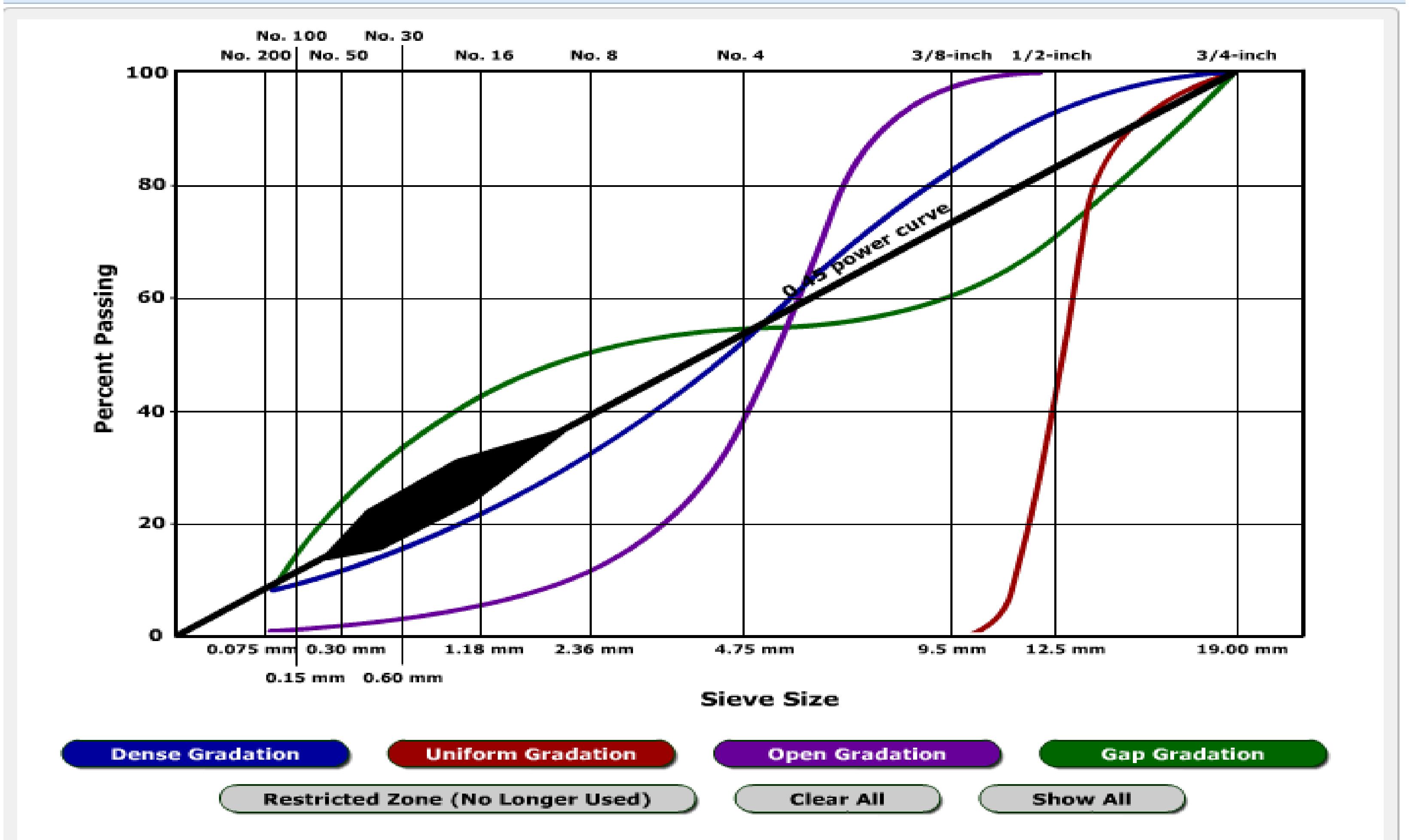
- Traditional
  - Maximum aggregate size – the largest sieve size that allows all the aggregates to pass.
  - Nominal maximum aggregate size – the first sieve to retain some aggregate, generally ***less*** than 10%.
- Superpave
  - Maximum aggregate size – one sieve size larger than the nominal maximum aggregate size
  - Nominal maximum aggregate size – one sieve larger that the first sieve to retain ***more*** than 10% of the aggregate

Semi Log Graph



Aggregate Properties in Highway

7) Aggregate Gradations- 0.45 power



http://www.pavementinteractive.org/article/gradation-and-size/#sthash.mYmjKudf.dpuf

Aggregate Properties in Highway

Types of Aggregate Gradation

•Dense or Well-Graded

Typical gradations are near the 0.45 power curve but not right on it. Generally, a true maximum density gradation (exactly on the 0.45 power curve) would result in unacceptably low VMA.

•Gap Graded

Refers to a gradation that contains only a small percentage of aggregate particles in the mid-size range. The curve is flat in the mid-size range. Some PCC mix designs use gap graded aggregate to provide a more economical mix since less sand can be used for a given workability. HMA gap graded mixes can be prone to segregation during placement.

•Open Graded

Refers to a gradation that contains only a small percentage of aggregate particles in the small range. This results in more air voids because there are not enough small particles to fill in the voids between the larger particles. The curve is near vertical in the mid-size range, and flat and near-zero in the small-size range.

•Uniformly Graded

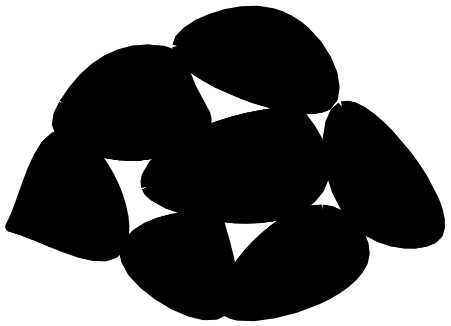
Refers to a gradation that contains most of the particles in a very narrow size range. In essence, all the particles are the same size. The curve is steep and only occupies the narrow size range specified.

Aggregate Properties in Highway

7) Aggregate Gradations

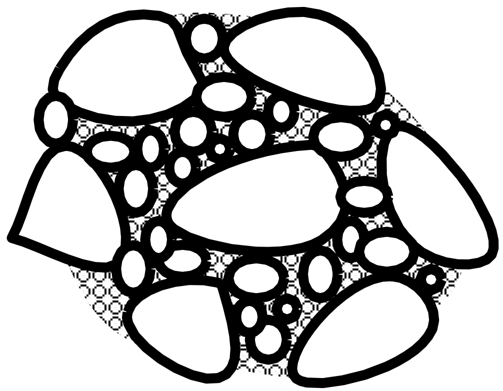
i. Uniformly graded

- Few points of contact
- Poor interlock (shape dependent)
- High permeability
- nearly vertical curve



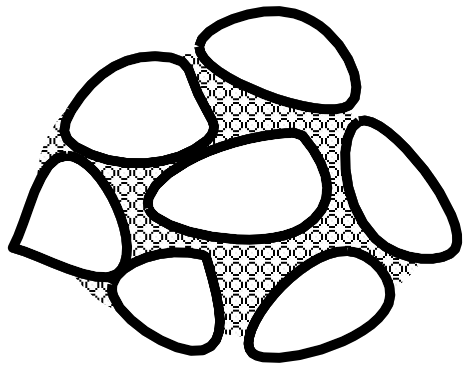
ii. Well graded

- Good interlock
- Low permeability



iii. Gap graded

- Only limited sizes
- Good interlock
- Low permeability

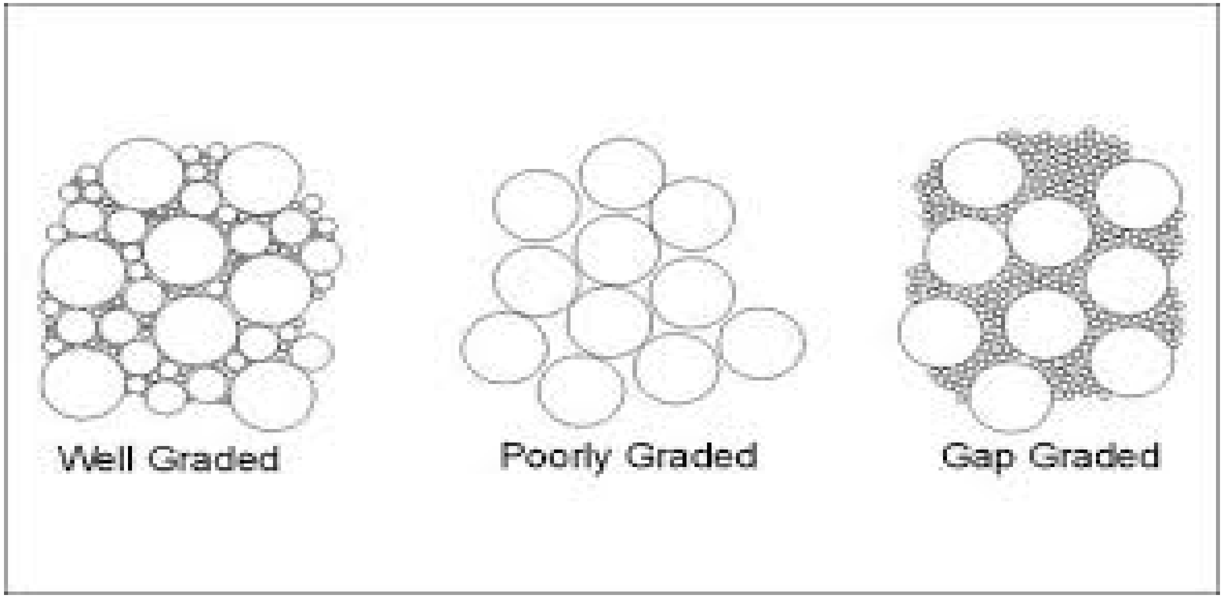


Aggregate Properties in Highway

7) Aggregate Gradations

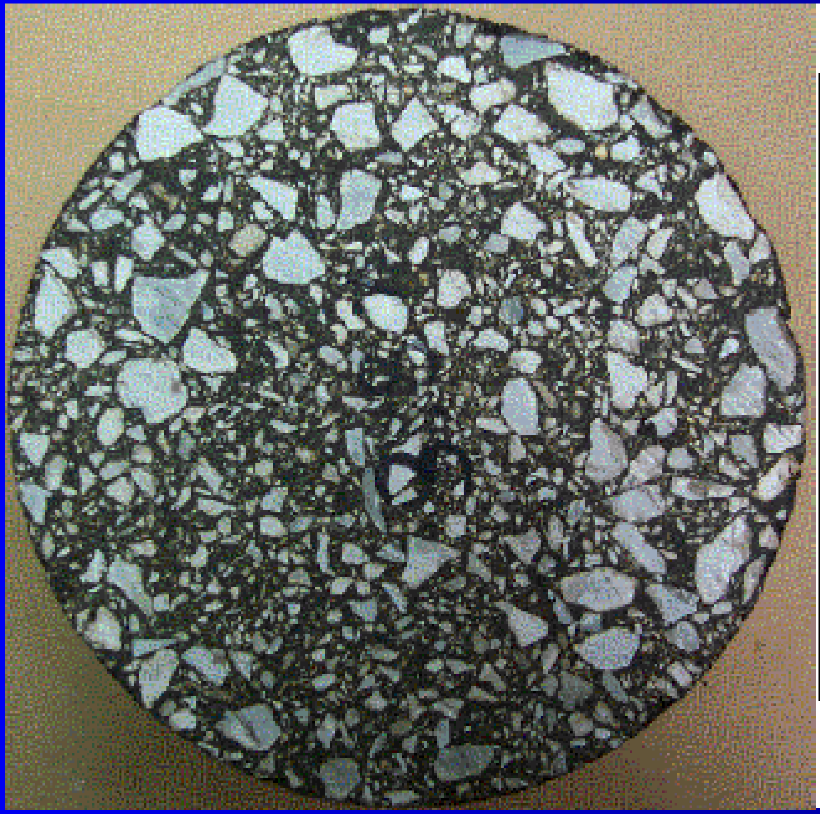
iv. Open graded

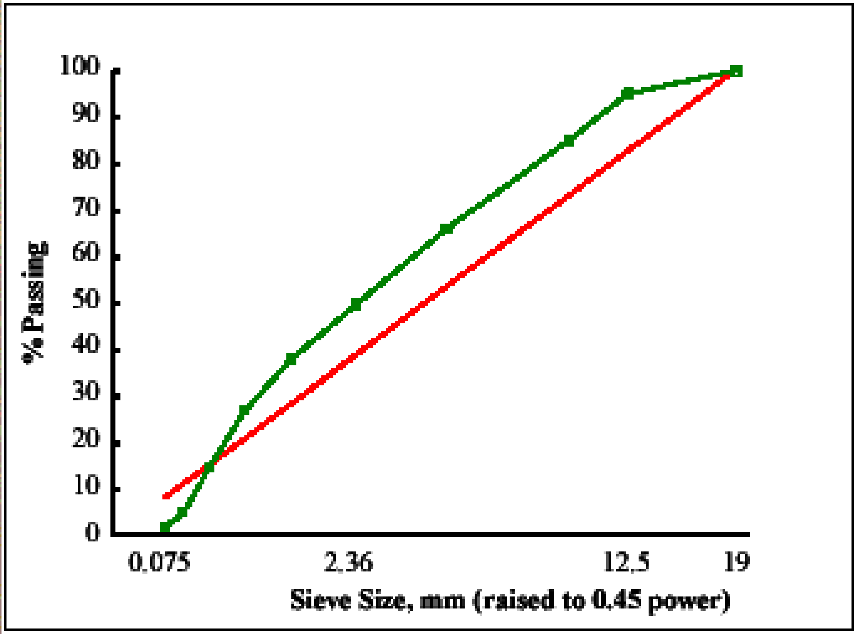
- missing small aggregates which fill in holes between larger ones
- lower part of curve is skewed toward large sizes



Dense Graded Mixes

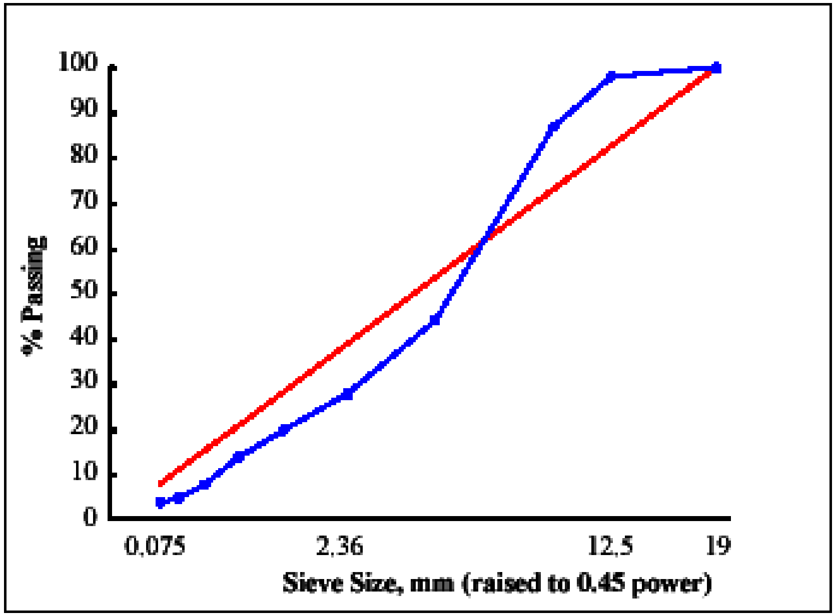
Dense Graded Fine Superpave





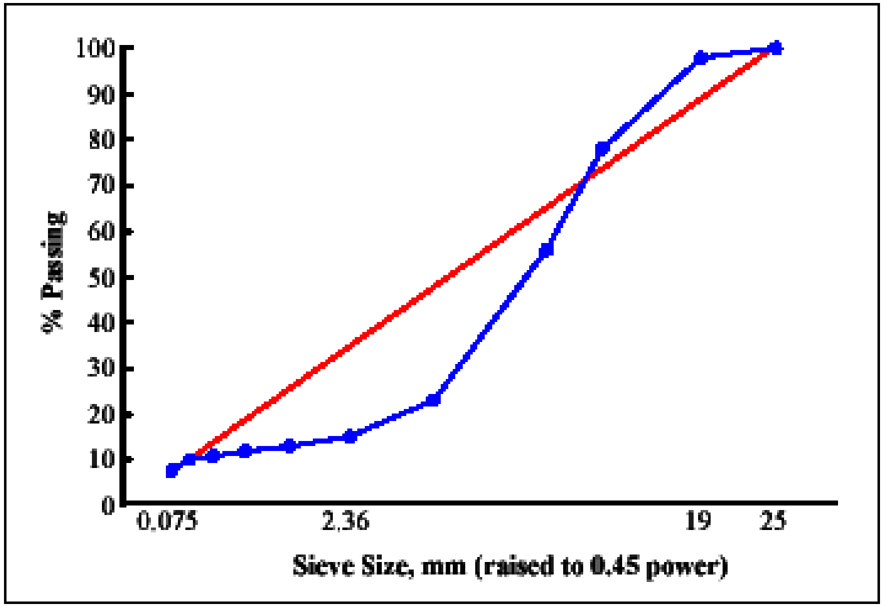
Course Graded Mixes

Dense Graded Course Superpave

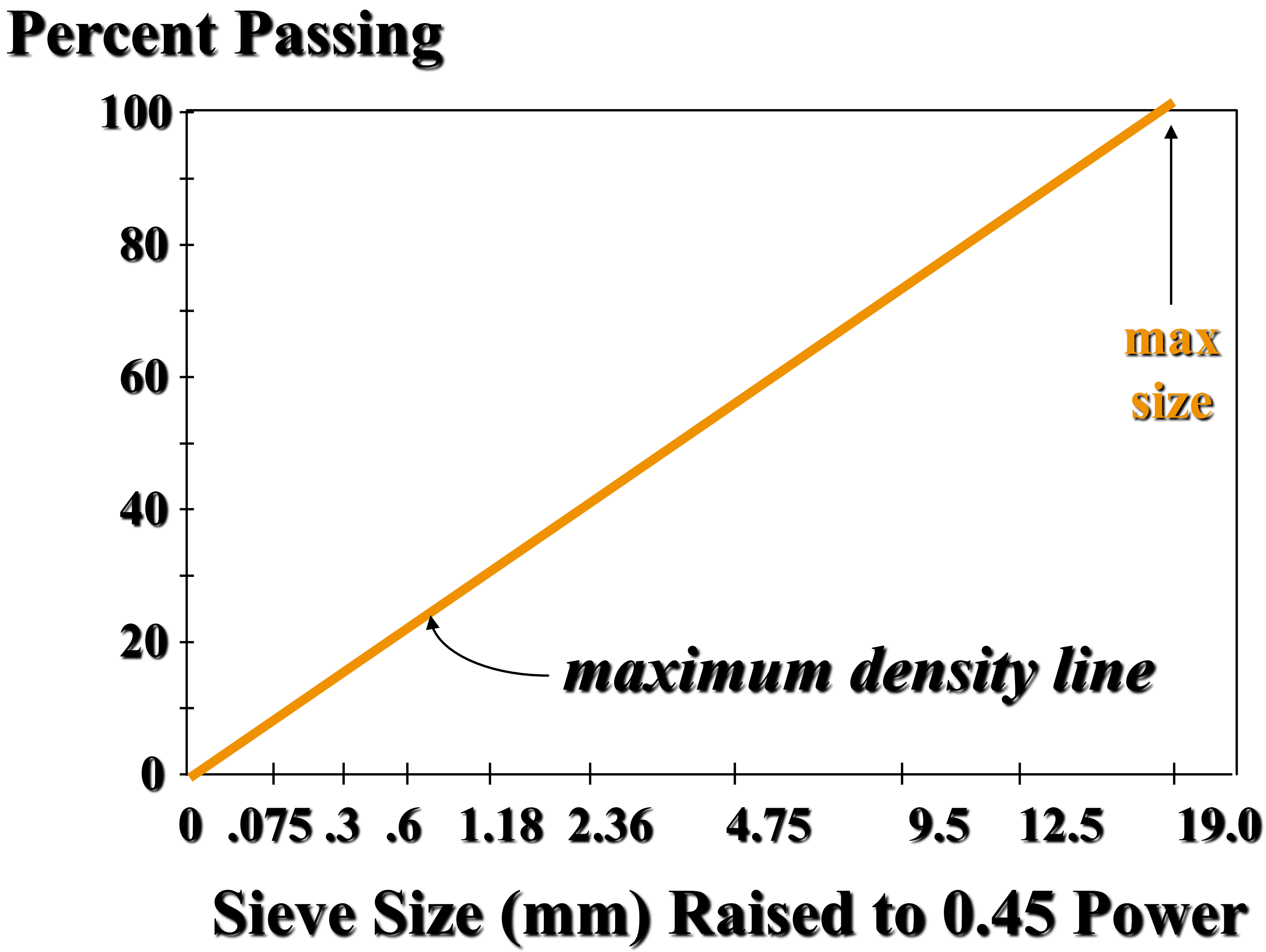


Gap Graded Mixes

SMA's



0.45 Power Grading Chart



0.45 Power Grading Chart

100	100
100	99
90	89
72	72
65	65
48	48
36	36
22	22
15	15
9	9
4	4

- *Nominal Maximum* Aggregate Size
  - one size larger than the first sieve to retain more than 10%
- *Maximum* Aggregate Size
  - one size larger than nominal maximum size

0.45 Power Grading Chart

Maximum and Nominal Aggregate Sizes

%P	%R
100	0
100	0
92	8
72	20
65	7
48	17
36	12
22	14
15	7
9	6
4	5
0	4

Nominal maximum size

One size larger than the first sieve to retain more than 10 %

Maximum size

One size larger than nominal maximum size

%P	%R
100	0
99	1
88	11
72	16
65	7
48	17
36	12
22	14
15	7
9	6
4	5
0	4

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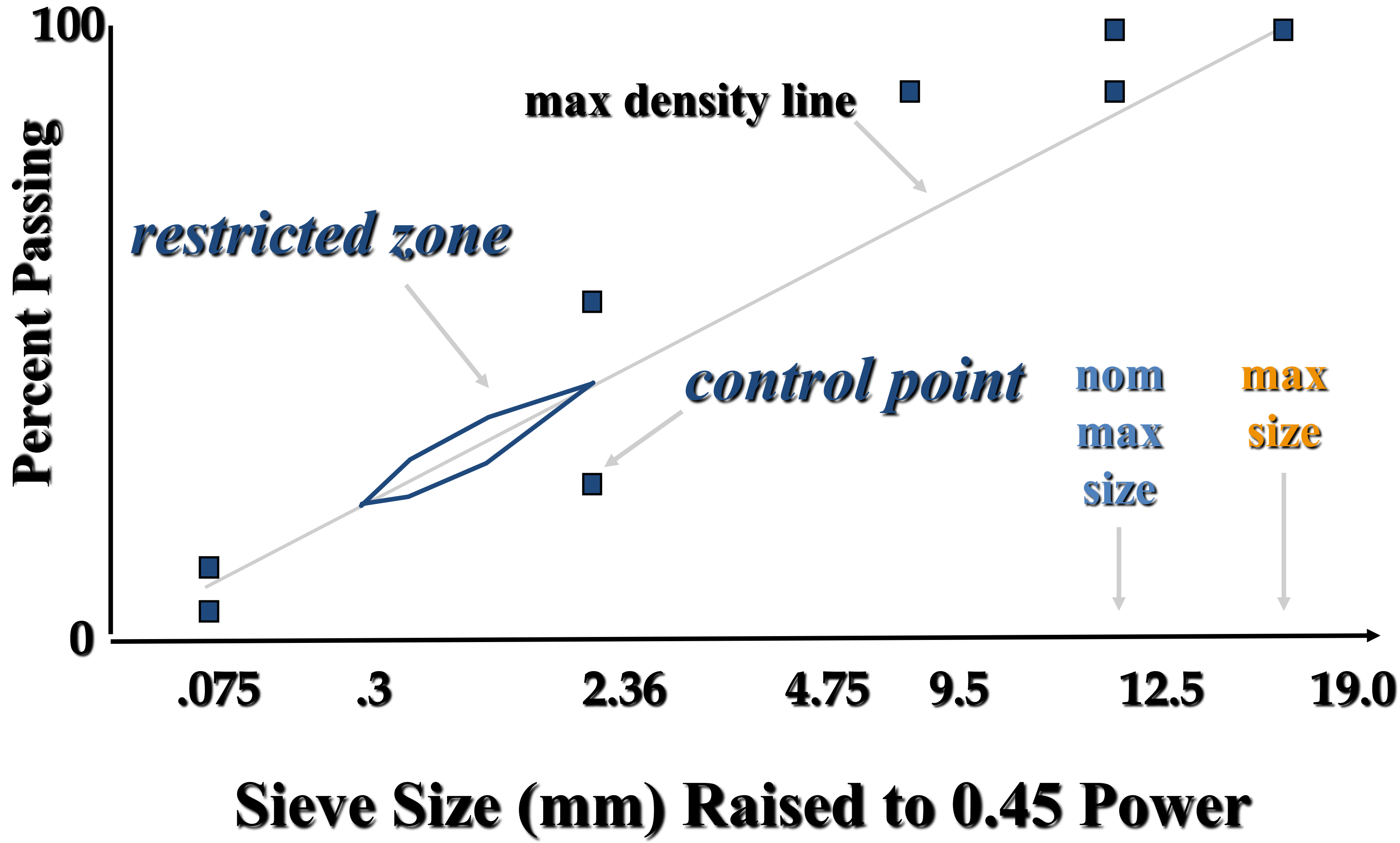
0.45 Power Grading Chart



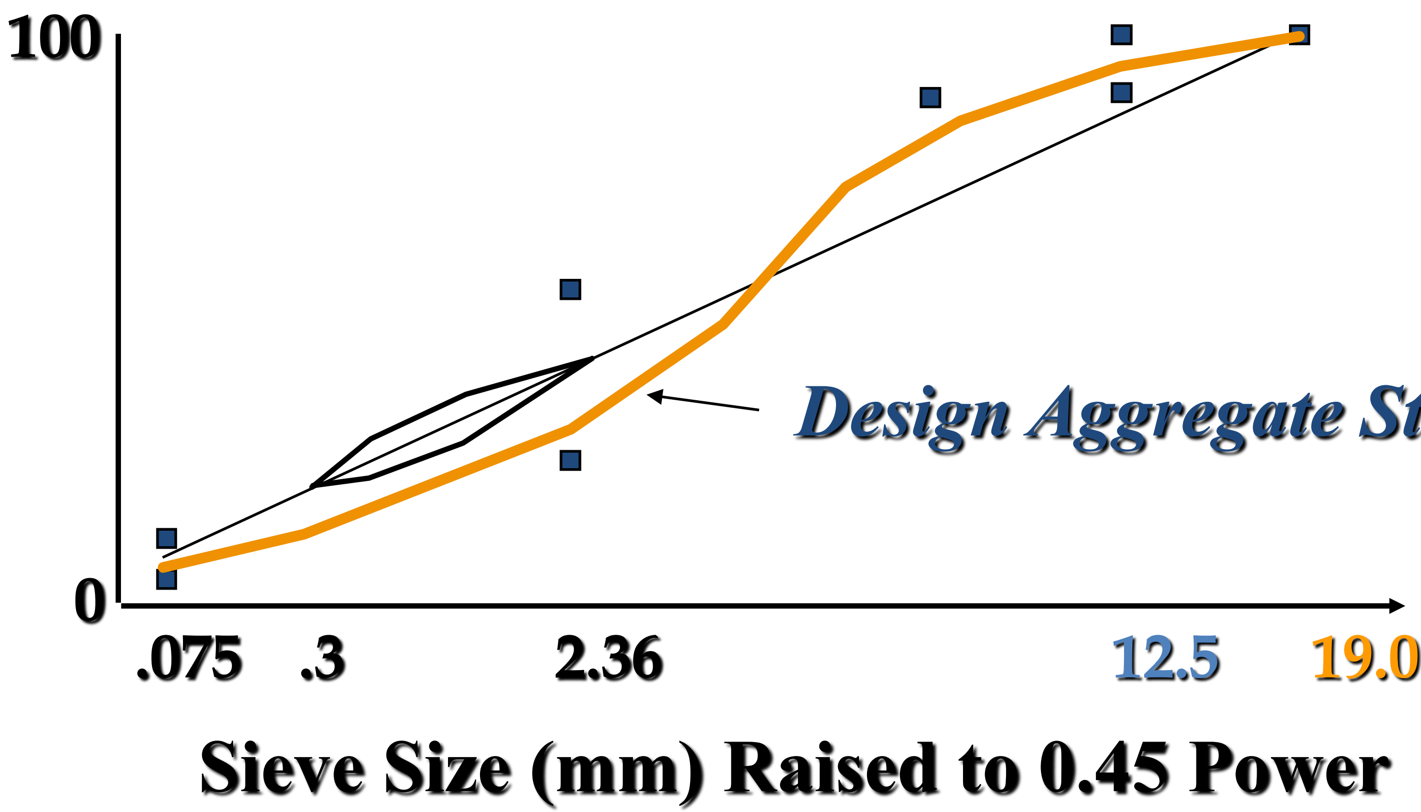
0.45 Power Grading Chart

Sieve	$P_i = 100(d_i/D)^{0.45}$
25 mm (1 in.)	100
19 mm (3/4 in.)	88
12.5 mm (1/2 in.)	73
9.5 mm (3/8 in.)	64
4.75 mm (No. 4)	47
2.36 mm (No. 8)	34
0.60 mm (No. 30)	19
0.30 mm (No. 50)	14
0.075 mm (No. 200)	7.3

This blend of aggregates results in the maximum weight of aggregates that can be placed in a container.

0.45 Power Grading Chart

- A design aggregate structure that lies between the control points and avoids the restricted zone meets the requirements of Superpave with respect to gradation.



0.45 Power Grading Chart

Control Points and Restricted Zone

- The restricted zone resides along the maximum density gradation between the intermediate size (either 4.75 or 2.36 mm) and the 0.3 mm size. Through which gradation should not pass.
- Gradations that pass through the restricted zone have often been called "humped gradations" because of the characteristic hump in the grading curve that passes through the restricted zone.
- Control points function as master ranges through which gradations must pass. They are placed on the nominal maximum size, an intermediate size and the dust size.

0.45 Power Grading Chart

Superpave Designation	Nom Max Size (mm)	Max Size (mm)
37.5 mm	37.5	50
25 mm	25	37.5
19 mm	19	25
12.5 mm	12.5	19
9.5 mm	9.5	12.5

0.45 Power Grading Chart

Control Points and Restricted Zone

Table 1. 37.5 mm (1.5 inch) Nominal Size

Sieve Size		Control Points		Restricted Zone	
(mm)	(U.S.)	Lower	Upper	Lower	Upper
50	2 inch	100	-	-	-
37.5	1.5 inch	90	100	-	-
25	1 inch	-	90	-	-
19	3/4 inch	-	-	-	-
12.5	1/2 inch	-	-	-	-
9.5	3/8 inch	-	-	-	-
4.75	No. 4	-	-	34.7	34.7
2.36	No. 8	15	41	23.3	27.3
1.18	No. 16	-	-	15.5	21.5
0.60	No. 30	-	-	11.7	15.7
0.30	No. 50	-	-	10.0	10.0
0.15	No. 100	-	-	-	-
0.075	No. 200	0	6	-	-

Table 2. 25 mm (1 inch) Nominal Size

Sieve Size		Control Points		Restricted Zone	
(mm)	(U.S.)	Lower	Upper	Lower	Upper
37.5	1.5 inch	100	-	-	-
25	1 inch	90	100	-	-
19	3/4 inch	-	90	-	-
12.5	1/2 inch	-	-	-	-
9.5	3/8 inch	-	-	-	-
4.75	No. 4	-	-	39.5	39.5
2.36	No. 8	19	45	26.8	30.8
1.18	No. 16	-	-	18.1	24.1
0.60	No. 30	-	-	13.6	17.6
0.30	No. 50	-	-	11.4	11.4
0.15	No. 100	-	-	-	-
0.075	No. 200	1	7	-	-

0.45 Power Grading Chart

Control Points and Restricted Zone

Table 3. 19 mm (3/4 inch) Nominal Size

Sieve Size		Control Points		Restricted Zone	
(mm)	(U.S.)	Lower	Upper	Lower	Upper
25	1 inch	100	-	-	-
19	3/4 inch	90	100	-	-
12.5	1/2 inch	-	90	-	-
9.5	3/8 inch	-	-	-	-
4.75	No. 4	-	-	-	-
2.36	No. 8	23	49	34.6	34.6
1.18	No. 16	-	-	22.3	28.3
0.60	No. 30	-	-	16.7	20.7
0.30	No. 50	-	-	13.7	13.7
0.15	No. 100	-	-	-	-
0.075	No. 200	2	8	-	-

Table 4. 12.5 mm (1/2 inch) Nominal Size

Sieve Size		Control Points		Restricted Zone	
(mm)	(U.S.)	Lower	Upper	Lower	Upper
19	3/4 inch	100	-	-	-
12.5	1/2 inch	90	100	-	-
9.5	3/8 inch	-	90	-	-
4.75	No. 4	-	-	-	-
2.36	No. 8	28	58	39.1	39.1
1.18	No. 16	-	-	25.6	31.6
0.60	No. 30	-	-	19.1	23.1
0.30	No. 50	-	-	15.5	15.5
0.15	No. 100	-	-	-	-
0.075	No. 200	2	10	-	-

0.45 Power Grading Chart

Control Points and Restricted Zone

Table 5. 9.5 mm (3/8 inch) Nominal Size

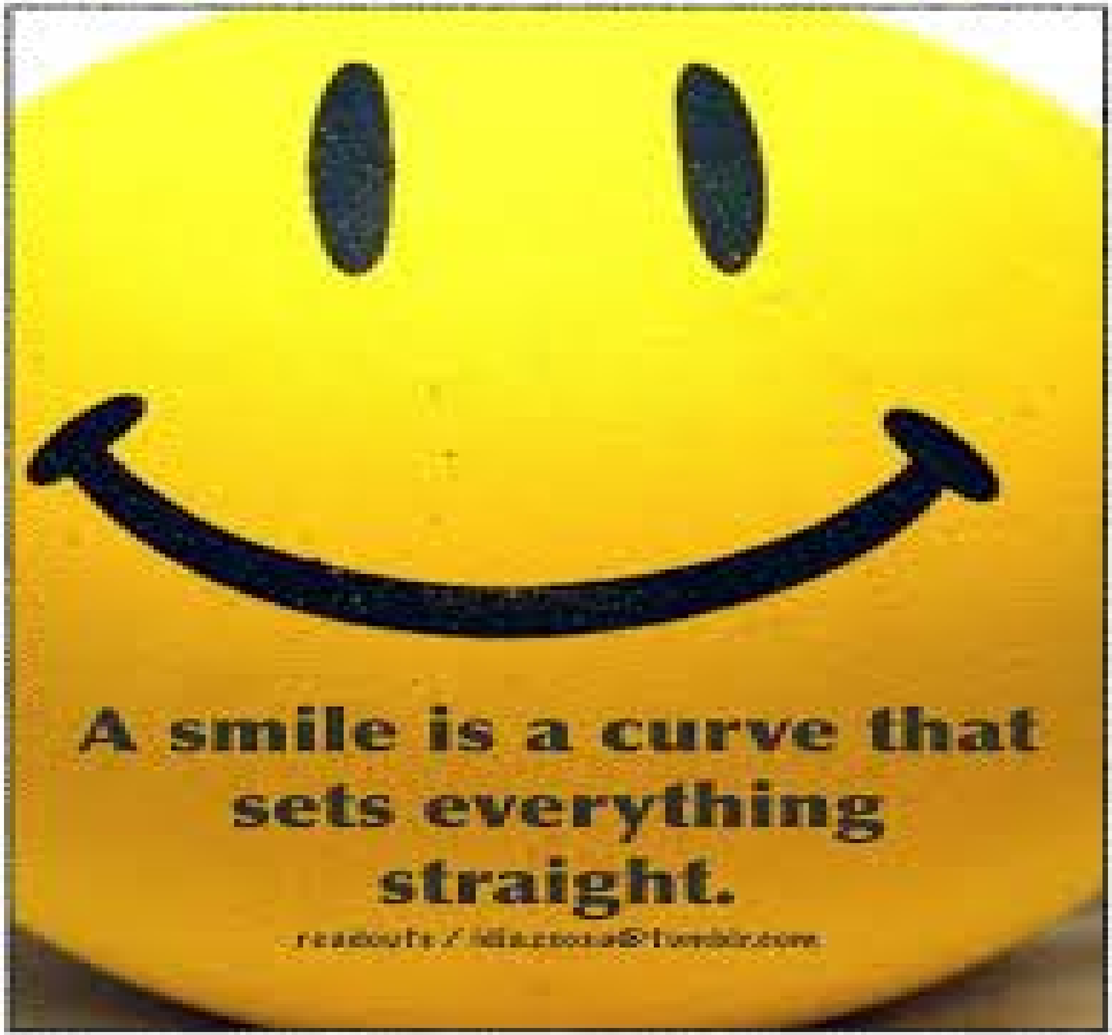
Sieve Size		Control Points		Restricted Zone	
(mm)	(U.S.)	Lower	Upper	Lower	Upper
12.5	1/2 inch	100		-	-
9.5	3/8 inch	90	100	-	-
4.75	No. 4	-	90	-	-
2.36	No. 8	32	67	47.2	47.2
1.18	No. 16	-	-	31.6	37.6
0.60	No. 30	-	-	23.5	27.5
0.30	No. 50	-	-	18.7	18.7
0.15	No. 100	-	-	-	-
0.075	No. 200	2	10	-	-

Effect of gradation in Bituminous Mixes

- Workability.
- Layer Thickness.
- Stability.
- Stiffness.
- Resistance to deformation (Rutting resistance).
- Fatigue strength.
- Durability.
- Permeability.
- Surface Texture and frictional resistance (Safety).

Effect of gradation in Concrete Mixes

- Workability.
- Strength
- Layer Thickness.
- Stability.
- Fatigue strength.
- Durability.
- Shrinkage.


A smile is a curve that
sets everything
straight.

Blending of Aggregates

- Numerical Method
  - Trial and Error
  - Basic Formula

Blending of Aggregates

Trial and Error Steps

- Select critical sieves in blend
- Determine initial proportions which will meet critical sieves
- Check calc. blend against specification
- Adjust if necessary and repeat above steps

Blending of Aggregates

Trial and Error Steps

- $P = A\,a + Bb + Cc + \ldots.$
  - Where:
    - P = % of material passing a given sieve for the blended aggregates A, B, C, …
    - A, B, C, … = % material passing a given sieve for each aggregate A, B, C, …..
    - a, b, c, …. = Proportions (decimal fractions) of aggregates A, B, C, … to be used in Blend

Blending of Aggregates

Material	Agg. #1		Agg. #2		Blend	specification
% Used						
U.S. Sieve	% Passing	% Batch	% Passing	% Batch		
3/8 “	100		100			100
No. 4	90		100			80 - 100
No. 8	30		100			65 - 100
No. 16	7		88			40 - 80
No. 30	3		47			20 - 65
No. 50	1		32			7 - 40
No. 100	0		24			3 - 20
No. 200	0		10			2 - 10

Blending of Aggregates

Material	Agg. #1		Agg. #2		Blend	specification
% Used	50 %		50 %			
U.S. Sieve	% Passing	% Batch	% Passing	% Batch		
3/8 "	100	50	100			100
No. 4	90	45	100			80 - 100
No. 8	30	15	100			65 - 100
No. 16	7	3.5	88			40 - 80
No. 30	3	1.5	47			20 - 65
No. 50	1	0.5	32			7 - 40
No. 100	0	0	2			3 - 20
No. 200	0	0	1			2 - 10

First Try
(remember trial & error)

100 * 0.5 = 50
90 * 0.5 = 45
30 * 0.5 = 15
7 * 0.5 = 3.5
3 * 0.5 = 1.5
1 * 0.5 = 0.5
0 * 0.5 = 50
0 * 0.5 = 0

NCAT

Blending of Aggregates

Material	Agg. #1		Agg. #2		Blend	specification
% Used	50 %		50 %			
U.S. Sieve	% Passing	% Batch	% Passing	% Batch		
3/8 "	100	50	100	50	100	100
No. 4	90	45	100	50	95	80 - 100
No. 8	30	15	100	50	65	65 - 100
No. 16	7	3.5	88	44	47.5	40 - 80
No. 30	3	1.5	47	23.5	25	20 - 65
No. 50	1	0.5	32	16	16.5	7 - 40
No. 100	0	0	24	12	12	3 - 20
No. 200	0	0	10	5	5	2 - 10

Blending of Aggregates

Material	Agg. #1		Agg. #2		Blend	specification
% Used	50 %		50 %			
U.S. Sieve	% Passing	% Batch	% Passing	% Batch		
3/8 "	100	50			100	100
No. 4	90	45			95	80 - 100
No. 8	30	15			65	65 - 100
No. 16	7	3.5			47.5	40 - 80
No. 30	3	1.5			25	20 - 65
No. 50	1	0.5	32	16	16.5	7 - 40
No. 100	0	0	24	12	12	3 - 20
No. 200	0	0	10	5	5	2 - 10

Let's Try
and get
a little closer
to the middle of
the target values.

Blending of Aggregates

Material	Agg. #1		Agg. #2		Blend	specification
% Used	30 %		70 %			
U.S. Sieve	% Passing	% Batch	% Passing	% Batch		
3/8 "	100	30	100	70	100	100
No. 4	90	27	100	70	97	80 - 100
No. 8	30	9	100	70	79	65 - 100
No. 16	7	2.1	88	61.6	63.7	40 - 80
No. 30	3	0.9	47	32.9	33.8	20 - 65
No. 50	1	0.3	32	22.4	22.7	7 - 40
No. 100	0	0	24	16.8	16.8	3 - 20
No. 200	0	0	10	7	7	2 - 10

Blending of Aggregates

Combined Specific Gravity

$$G_{sb} = \frac{(P_A + P_B + P_C)}{\left[\frac{P_A}{G_A} + \frac{P_B}{G_B} + \frac{P_C}{G_C}\right]}$$

Where: P_A, P_B & P_C = percent by mass of each aggregate in blend

G_A, G_B & G_C = Bulk Specific Gravity of each aggregate

Blending of Aggregates

- Example Problem -

$$G_{sb} = \frac{(P_A + P_B + P_C)}{\left[\dfrac{P_A}{G_A} + \dfrac{P_B}{G_B} + \dfrac{P_C}{G_C}\right]}$$

Where: P_A, P_B & P_C = percent by mass of each aggregate in blend
G_A, G_B & G_C = Bulk Specific Gravity of each aggregate

Based on the information given:

$P_A = 50\%$ $\quad G_A = 2.695$
$P_B = 25\%$ $\quad G_B = 2.711$
$P_C = 25\%$ $\quad G_C = 2.721$

$$G_{sb} = \frac{(50 + 25 + 25)}{\left[\dfrac{50}{2.695} + \dfrac{25}{2.711} + \dfrac{25}{2.721}\right]} = 2.705$$

Questions - ?

References

1) NCAT, *National Center for Asphalt Technology* “Traning course in SUPERPAVE Design method”.

2) K. Sudhaker Reddy, “Highway Materials Lecture” IIT Kharagpur, India.

Note

i. (إِنَّ الَّـذِينَ قَـالُوا رَبُّنَـا اللَّهُ ثُـمَّ اسْـتَقَامُوا تَتَنَـزَّلُ عَلَـيْهِمُ الْمَلَائِكَـةُ أَلَّا تَخَـافُوا وَلَا تَحْزَنُـوا وَأَبْشِرُوا بِالْجَنَّةِ الَّتِي كُنْتُمْ تُوعَدُونَ ﴿٣٠﴾. فصلت.

ii. (إِنَّ الَّذِينَ قَالُوا رَبُّنَا اللَّهُ ثُمَّ اسْتَقَامُوا فَلا خَوْفٌ عَلَيْهِمْ وَلا هُمْ يَحْزَنُونَ أُوْلَئِكَ أَصْحَابُ الْجَنَّةِ خَالِدِينَ فِيهَا جَزَاءً بِمَا كَانُوا يَعْمَلُونَ)الأحقاف.