AGGREGATE BLENDING, ABSORPTION, & SPECIFIC GRAVITY

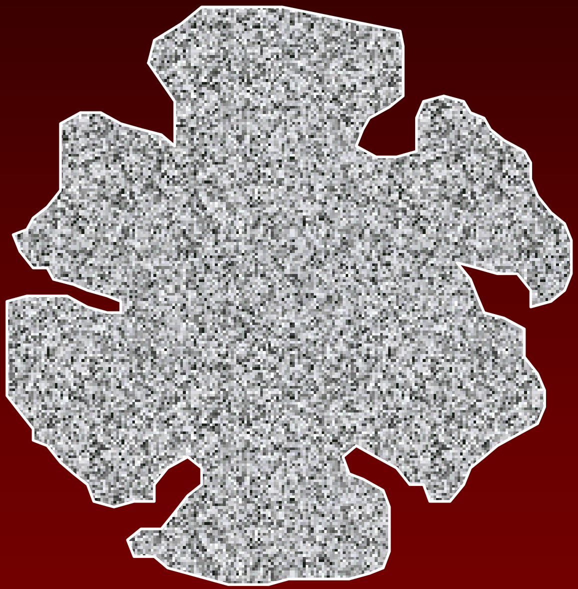
Topics to be Covered

- Aggregate Specific Gravities
- Gradations
- Blending Stockpiles
- Batching
- Combined Specific Gravities

Specific Gravity Tests for Aggregates

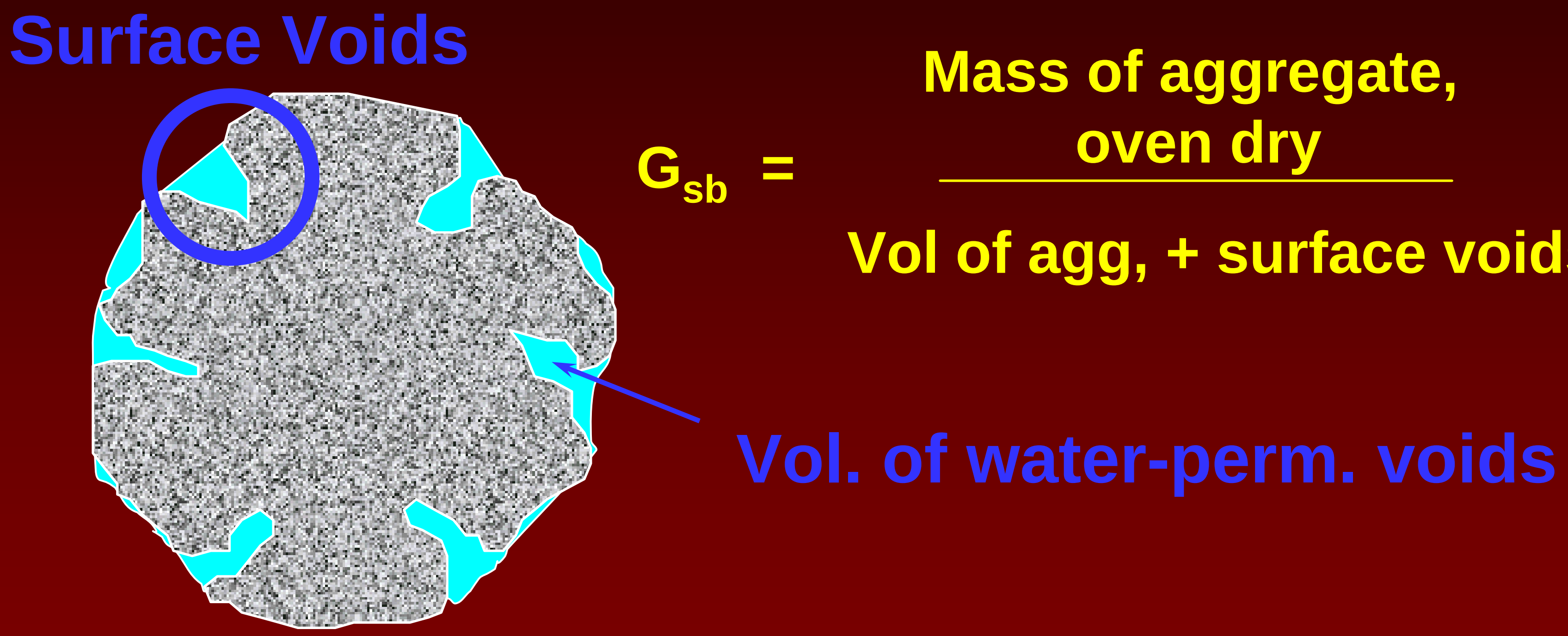
- Two tests are needed
  - Coarse aggregate (retained on the 4.75 mm sieve)
  - Fine aggregate (passing the 4.75 mm sieve)

Apparent Specific Gravity, G_{sa}



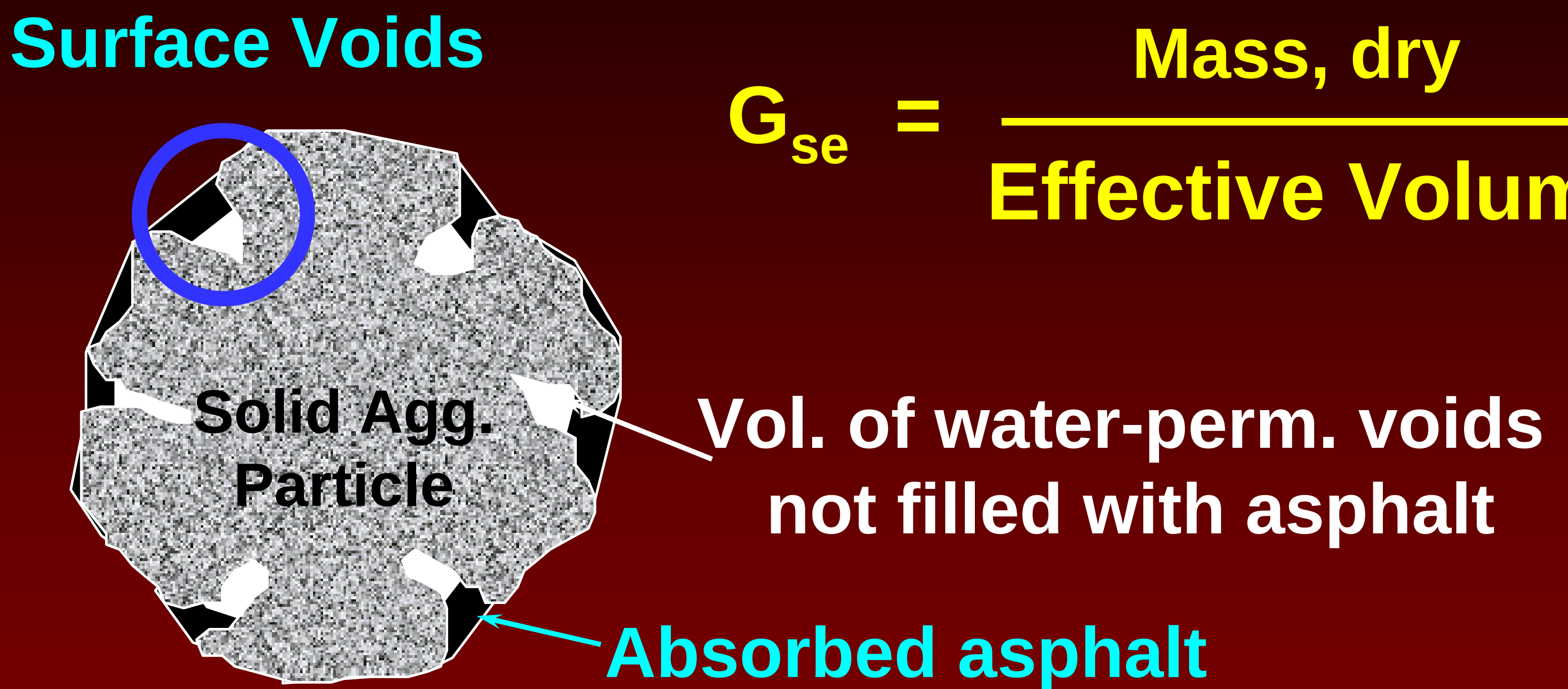
$$G_{sa} = \frac{\text{Mass of Aggregate, oven dry}}{\text{Volume of aggregate}}$$

Bulk Specific Gravity, G_{sb}



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

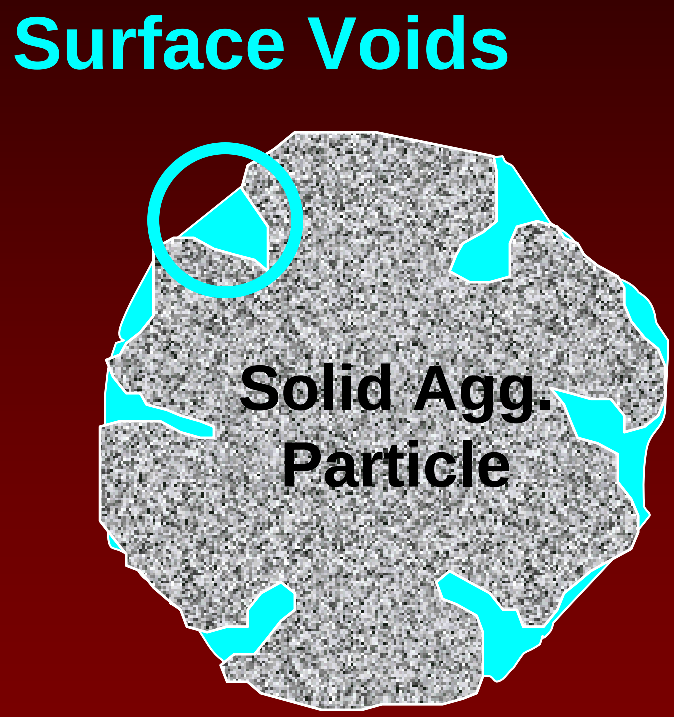
Effective Specific Gravity, G_{se}



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

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

Water Absorption



$$\frac{\text{SSD weight - Oven dry weight}}{\text{Oven dry weight}}$$

Coarse Aggregate Specific Gravity

- ASTM C127
  - Dry aggregate
  - Soak in water for 24 hours
  - Decant water
  - Use pre-dampened towel to get SSD condition
  - Determine mass of SSD aggregate in air
  - Determine mass of SSD aggregate in water
  - Dry to constant mass
  - Determine oven dry mass

Coarse Aggregate Specific Gravity

Coarse Aggregate Specific Gravity

Coarse Aggregate Specific Gravity

Calculations

- $G_{sb} = A / (B - C)$
  - **A = mass oven dry**
  - **B = mass SSD**
  - **C = mass under water**
- $G_{s,SSD} = B / (B - C)$
- $G_{sa} = A / (A - C)$
- Water absorption capacity, %
  - **Absorption % = [(B - A) / A] * 100**

Coarse Aggregate Specific Gravity

Calculations - Example Problem

- Given:
  - –Mass oven dry - 3625.5 (A)
  - –Mass SSD - 3650.3 (B)
  - –Mass under Water - 2293.0 (C)

Coarse Aggregate Specific Gravity

Calculations - Example Problem

- Apparent Specific Gravity - G_{sa}

  $A / (A - C)$

- Bulk Specific Gravity - G_{sb}

  $A / (B - C)$

- Absorption, %

  $(B - A) / A$

Coarse Aggregate Specific Gravity

Calculations - Example Problem

- Apparent Specific Gravity - G_{sa}

  3625.5/ (3625.5-2293.0) = 2.721

- Bulk Specific Gravity - G_{sb}

  3625.5 / (3650.3 - 2293.0) = 2.671

- Absorption, %

  (3650.3 - 3625.5) / 2293.0 = 0.68 %

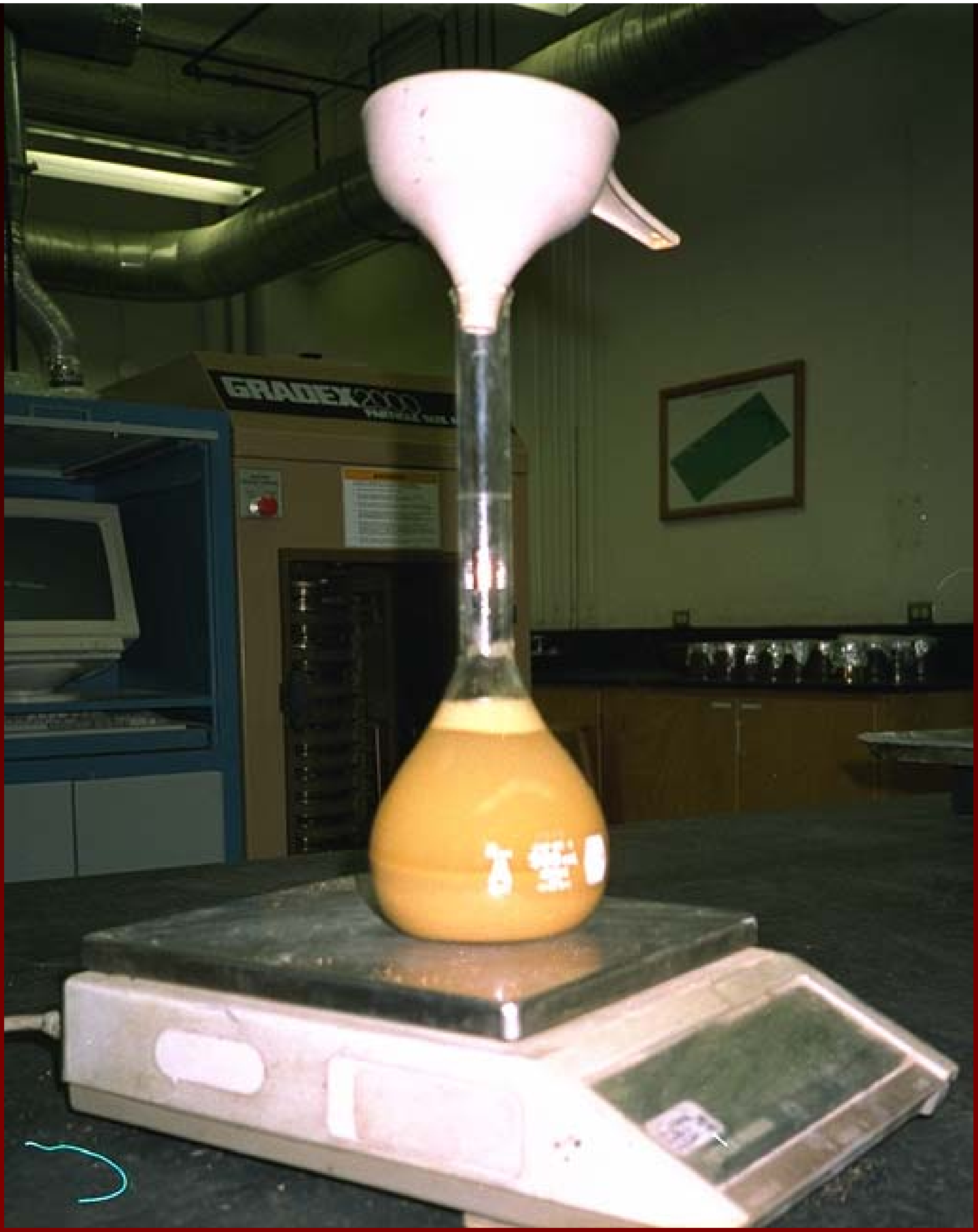
Fine Aggregate Specific Gravity

- ASTM C128
  - Dry aggregate
  - Soak in water for 24 hours
  - Spread out and dry to SSD
  - Add 500 g of SSD aggregate to pycnometer of known volume
    - Pre-filled with some water
  - Add more water and agitate until air bubbles have been removed
  - Fill to calibration line and determine the mass of the pycnometer, aggregate and water
  - Empty aggregate into pan and dry to constant mass
  - Determine oven dry mass

Fine Aggregate Specific Gravity

Fine Aggregate Specific Gravity

Fine Aggregate Specific Gravity



Fine Aggregate Specific Gravity *Calculations*

- $G_{sb} = A / (B + S - C)$
  - A = mass oven dry
  - B = mass of pycnometer filled with water
  - C = mass pycnometer, SSD aggregate and water
  - S = mass SSD aggregate
- $G_{sb,SSD} = S / (B + S - C)$
- $G_{sa} = A / (B + A - C)$
- Water absorption capacity, %
  - Absorption % = [(S - A) / A] * 100

Fine Aggregate Specific Gravity

Calculations - Example Problem

Given

A = mass oven dry =489.3

B = mass of pycnometer filled with water = 666.5

C = mass pycnometer, SSD aggregate and water = 982.3

S = mass SSD aggregate = 500.1

Fine Aggregate Specific Gravity

Calculations - Example Problem

- **G_{sb} = A / (B + S - C) = 498.9/(666.5+500.1-982.3)**
  = 2.707
- **$G_{sb,SSD}$ = S / (B + S - C) = 500.1/(666.5+500.1-982.3)**
  = 2.714
- **G_{sa} = A / (B + A - C) = 498.9/(666.5+498.9-982.3)**
  = 2.725
- **Water absorption = [(S - A) / A] * 100 =**
  (500.1-498.9)/498.9 = 0.24 %

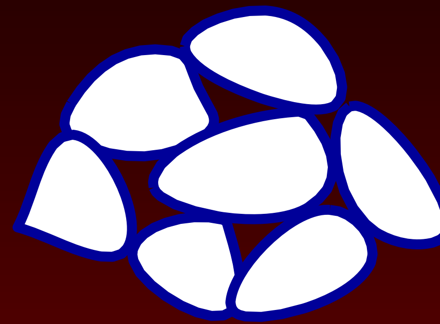
Aggregate Gradation

- Distribution of particle sizes expressed as percent of total weight
- Determined by sieve analysis

Types Of Gradations

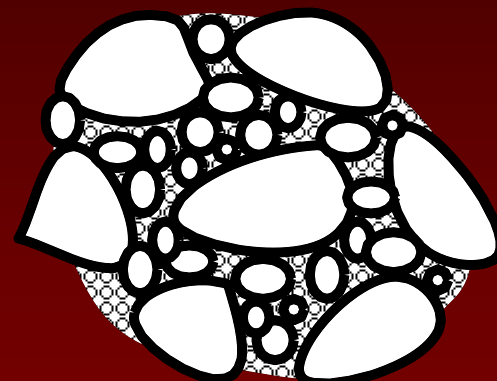
*** Open graded**

- **Few points of contact**
- **Stone on Stone contact**
- **High permeability**



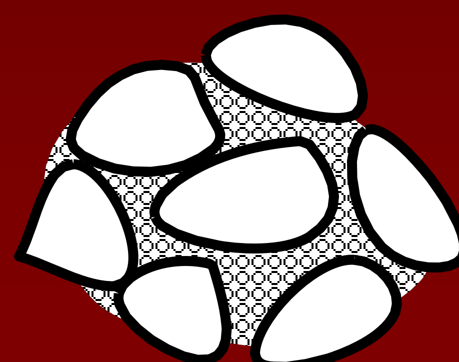
*** Well graded**

- **Good interlock**
- **Low permeability**

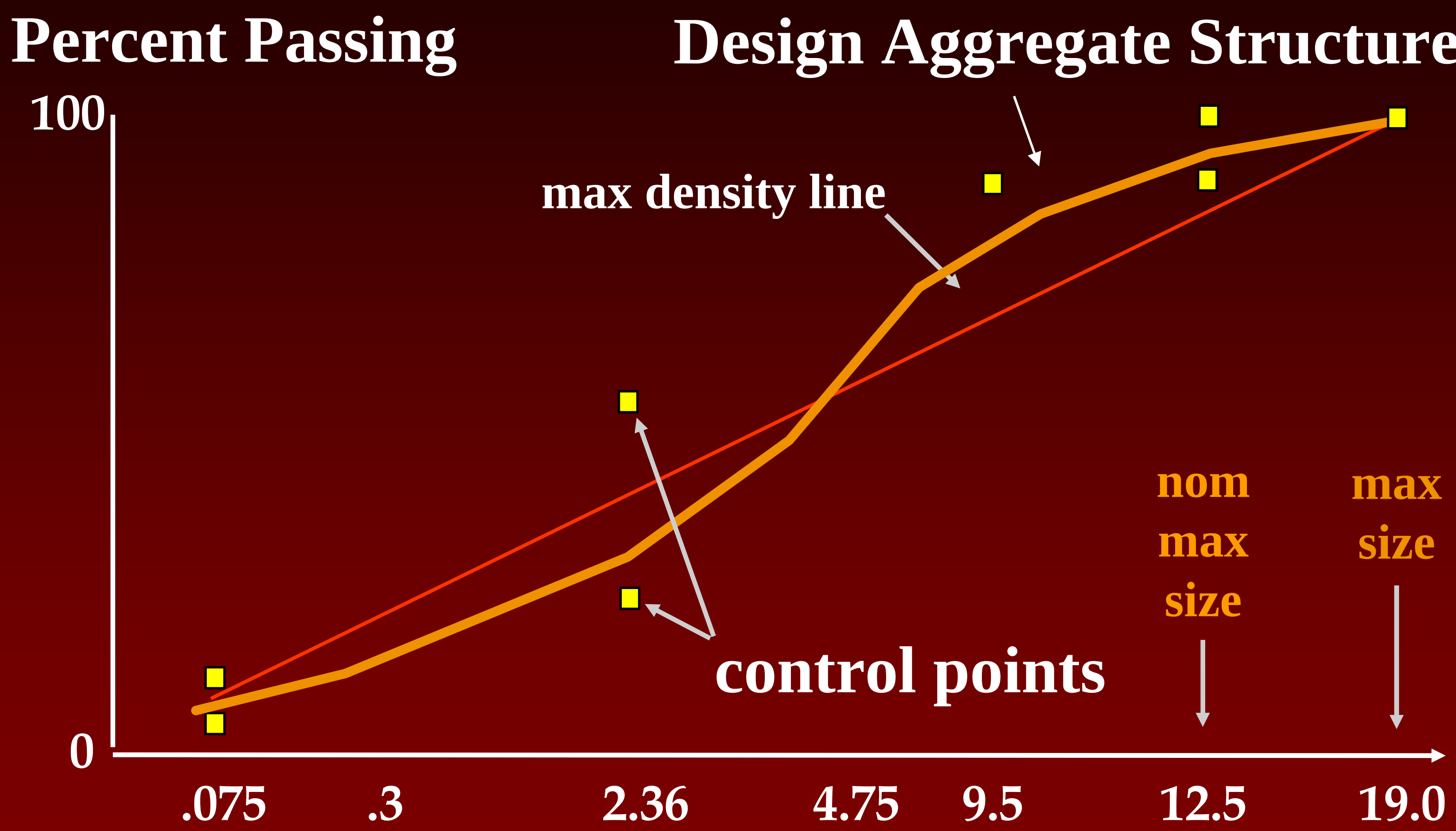


*** Gap graded**

- **Lacks intermediate sizes**
- **Good interlock**
- **Low permeability**



Superpave Aggregate Gradation



Sieve Size (mm) Raised to 0.45 Power

Definitions

100
100
90
72
65
48
36
22
15
9
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

100
99
89
72
65
48
36
22
15
9
4

Superpave Mix Size Designations

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

9.5 mm

12.5 mm

19.0 mm

Blending of Aggregates

- Reasons for blending
  - Obtain desirable gradation
  - Single natural or quarried material not enough
  - Economical to combine natural and process materials

Blending of Aggregates

- Numerical method
  - Trial and error
  - Basic formula

Blending of Aggregates

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

Blending of Aggregates

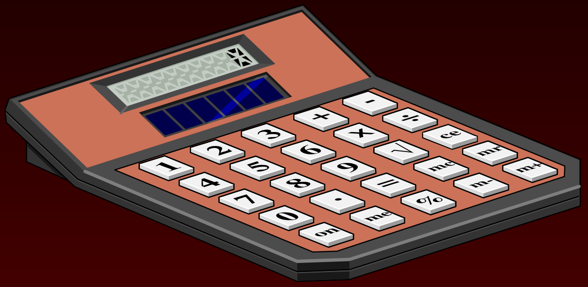
$$P = Aa + Bb + \ldots$$

Material	Aggregate No. 1		Aggregate No. 2		Blend	Target
% Used		a 30.0%		b 70.0%		
Sieve	% Passing	% Batch	% Passing	% Batch		
3/8	A 100	30.0%	B 100	70.0%	100.0%	100
No. 4	90	27.0%	100	70.0%	97.0%	90 to 100
No. 8	30	9.0%	100	70.0%	79.0%	36 to 76
No. 16	7	2.1%	88	61.6%	63.7%	
No. 30	3	0.9%	47	32.9%	33.8%	
No. 50	1	0.3%	32	22.4%	22.7%	
No. 100	0	0.0%	24	16.8%	16.8%	
No. 200	0	0.0%	10	7.0%	7.0%	2 to 10

Blending of Aggregates

$$P = Aa + Bb + \ldots$$

Material	Aggregate No. 1		Aggregate No. 2		Blend	Target
% Used		a 50.0%		b 50.0%		
Sieve	% Passing	% Batch	% Passing	% Batch		
3/8	A 100	50.0%	B 100	50.0%	100.0%	100
No. 4	90	45.0%	100	50.0%	95.0%	90 to 100
No. 8	30	15.0%	100	50.0%	65.0%	36 to 76
No. 16	7	3.5%	88	44.0%	47.5%	
No. 30	3	1.5%	47	23.5%	25.0%	
No. 50	1	0.5%	32	16.0%	16.5%	
No. 100	0	0.0%	24	12.0%	12.0%	
No. 200	0	0.0%	10	5.0%	5.0%	2 to 10



Classroom Problem

Blending of Aggregates

	Aggregate 1		Aggregate 2		Aggregate 3			
% Agg Used:								
Sieve Size	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch	Blend	Specification
3/8	100		100		100			
No. 4	87		100		100			90 to 100
No. 8	63		100		100			36 to 76
No. 16	19		93		100			
No. 30	8		88		100			
No. 50	5		55		100			
No. 100	3		36		97			
No. 200	2		3		88			2 to 10

Batching of Aggregate Blends

- Why Batch?
  - We Want To Reproduce the Desired Gradation for Mix Design

Batching

- Things We Need To Know To Batch
  - % of Each Stockpile in Blend
  - % Retained For Each Sieve of Each Stockpile

Batching

$$M_{per\ sieve} = \%Ret * \%Agg * M_{batch}$$

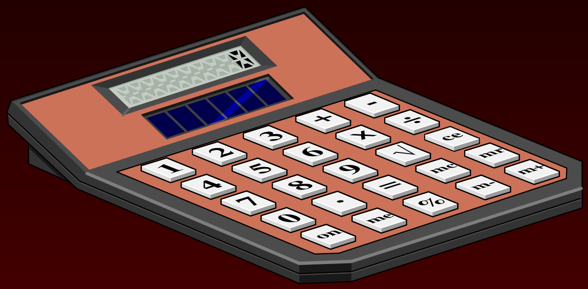
$M_{per\ sieve}$ = Mass of one aggregate in the blend for one sieve size
%Ret = Percent retained on the sieve expressed in *decimal* form
%Agg = The percent of the stock pile to being used in the blend in *decimal* form

EXAMPLE:

How much 1.18 mm material do I need from Aggregate #1 for a 4,000 gram batch given the following:

% Retained on 1.18 mm sieve = 23.0 %
% Agg. #1 Used in Blend = 30.0 %
Total Batch wt. = 4000 grams

Mass of 1.18 mm material = 0.230 * 0.300 * 4000 = 276.0 grams

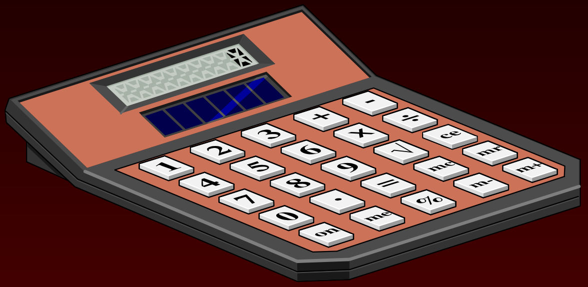


Example Problem

Batching of Aggregates

Total Batch Size: 4600.0 grams

Material	Aggregate No. 1		Aggregate No. 2		Mass of Agg # 1	Mass of Agg # 2
% Used	50.0%		50.0%			
Sieve	% Passing	% Retained	% Passing	% Retained		
3/8	100.0	0.0	100.0	0.0	0.0	0.0
No. 4	90.0	10.0	100.0	0.0	230.0	0.0
No. 8	30.0	60.0	100.0	0.0	1380.0	0.0
No. 16	7.0	23.0	88.0	12.0	529.0	276.0
No. 30	3.0	4.0	47.0	41.0	92.0	943.0
No. 50	1.0	2.0	32.0	15.0	46.0	345.0
No. 100	0.0	1.0	24.0	8.0	23.0	184.0
No. 200	0.0	0.0	10.0	14.0	0.0	322.0
Passing 200	0.0	0.0	0.0	10.0	0.0	230.0
Total Mass					2300.0	2300.0



Classroom Problem

Batching of Aggregates

Total Batch Size: 4600.0 grams

Material	Aggregate No. 1		Aggregate No. 2		Mass of Agg # 1	Mass of Agg # 2
% Used	30.0%		70.0%			
Sieve	% Passing	% Retained	% Passing	% Retained		
3/8	100.0		100.0			
No. 4	90.0		100.0			
No. 8	30.0		100.0			
No. 16	7.0		88.0			
No. 30	3.0		47.0			
No. 50	1.0		32.0			
No. 100	0.0		24.0			
No. 200	0.0		10.0			
Passing 200	0.0		0.0			
Total Mass						

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

- Example Problem -

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

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

Based on the information given:

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

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

Questions – does it all make sense?