Bailey Method for Achieving Volumetrics and HMA Compactability

Aggregate Blending

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- Trial and ***Error***?
  - Specification Bands
    - Coarse
    - Medium
    - Fine
  - Which blend is **best**?
  - How will a gradation change affect Volumetric Properties
- Is there a more ***systematical*** way to calculate changes?

The Bailey Method

- Originally developed by Robert D. Bailey
  - The **Bailey Method** was developed by Bob Bailey in the early 1980's.
  - He retired as a civil engineer, who worked with the **Illinois DOT**, District 5 Materials Bureau for over 35 years
  - Research and Development of the Method has been continued by the Heritage Research Group of Indianapolis

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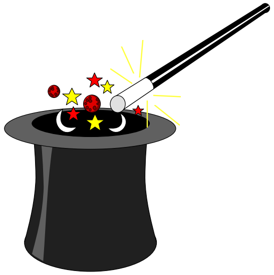
What is the Bailey Method?

The Bailey Method will

- Evaluate aggregate packing characteristics
- Determine what is “Coarse” and “Fine”
- Evaluate individual aggregates
- Combined blend by VOLUME and by weight
- **Estimate Air void and VMA changes due to gradation.**

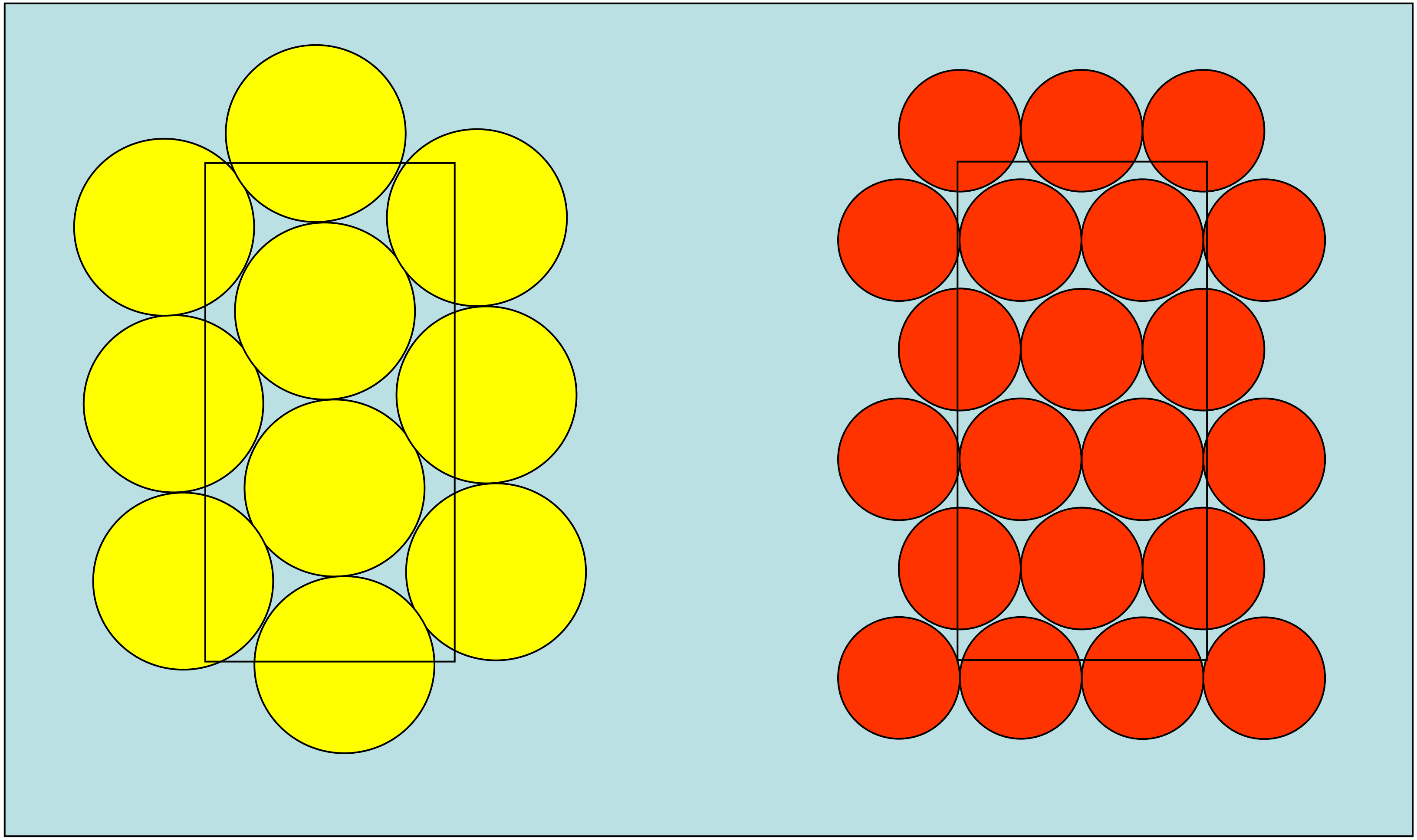


Aggregate Packing

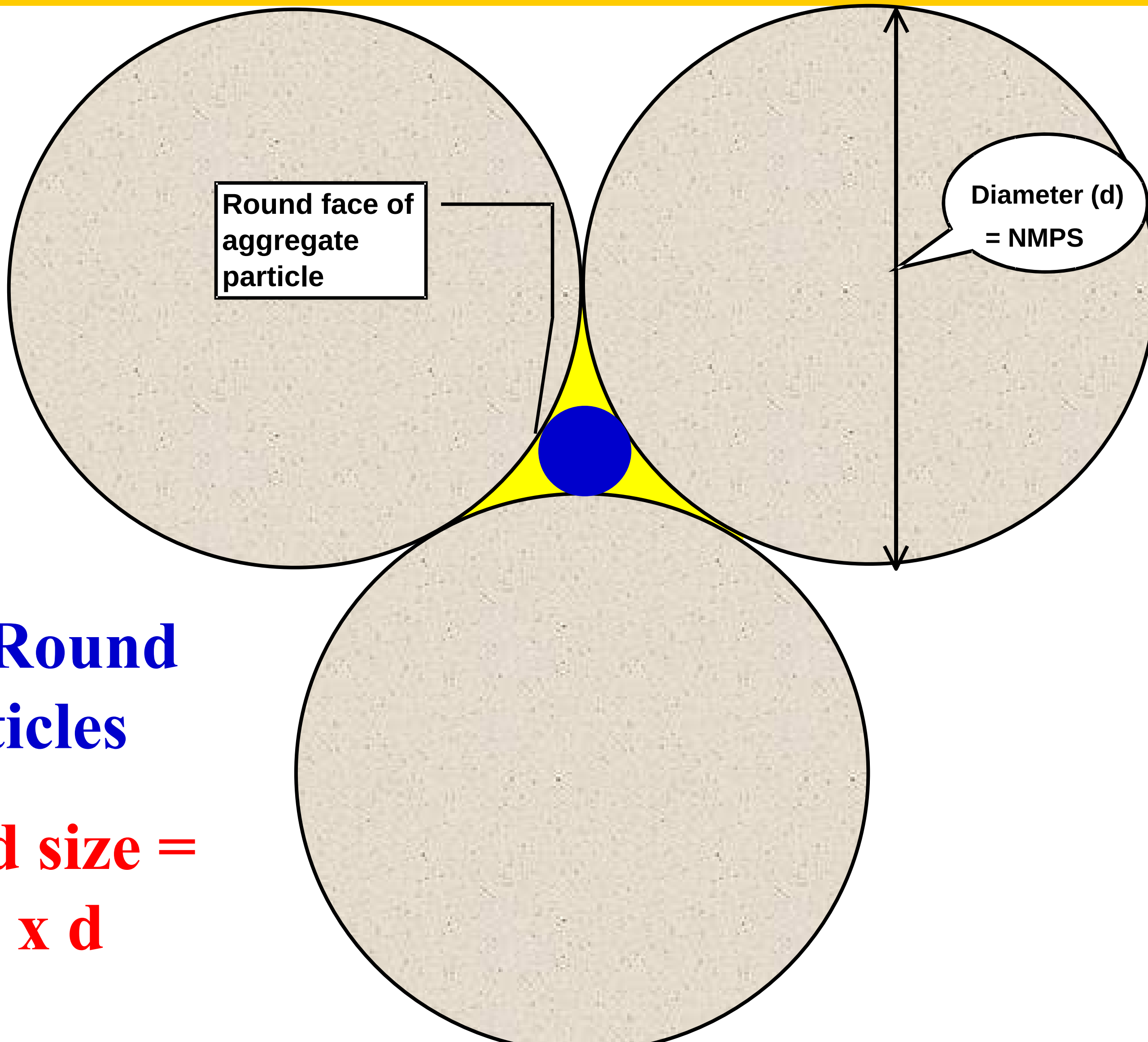
What Influences the Results?

- **Gradation**
  - continuously-graded, gap-graded, etc.
- **Shape**
  - flat & elongated, cubical, round
- **Surface Texture** (micro-texture)
  - smooth, rough
- **Type & Amount of Compactive Effort**
  - static pressure, impact or shearing
- **Strength**

What Happens to the Number & Size of Voids?



Principle #1 - P.C.S.



All Round particles

Void size = 0.15 x d

Principle #1 - P.C.S.

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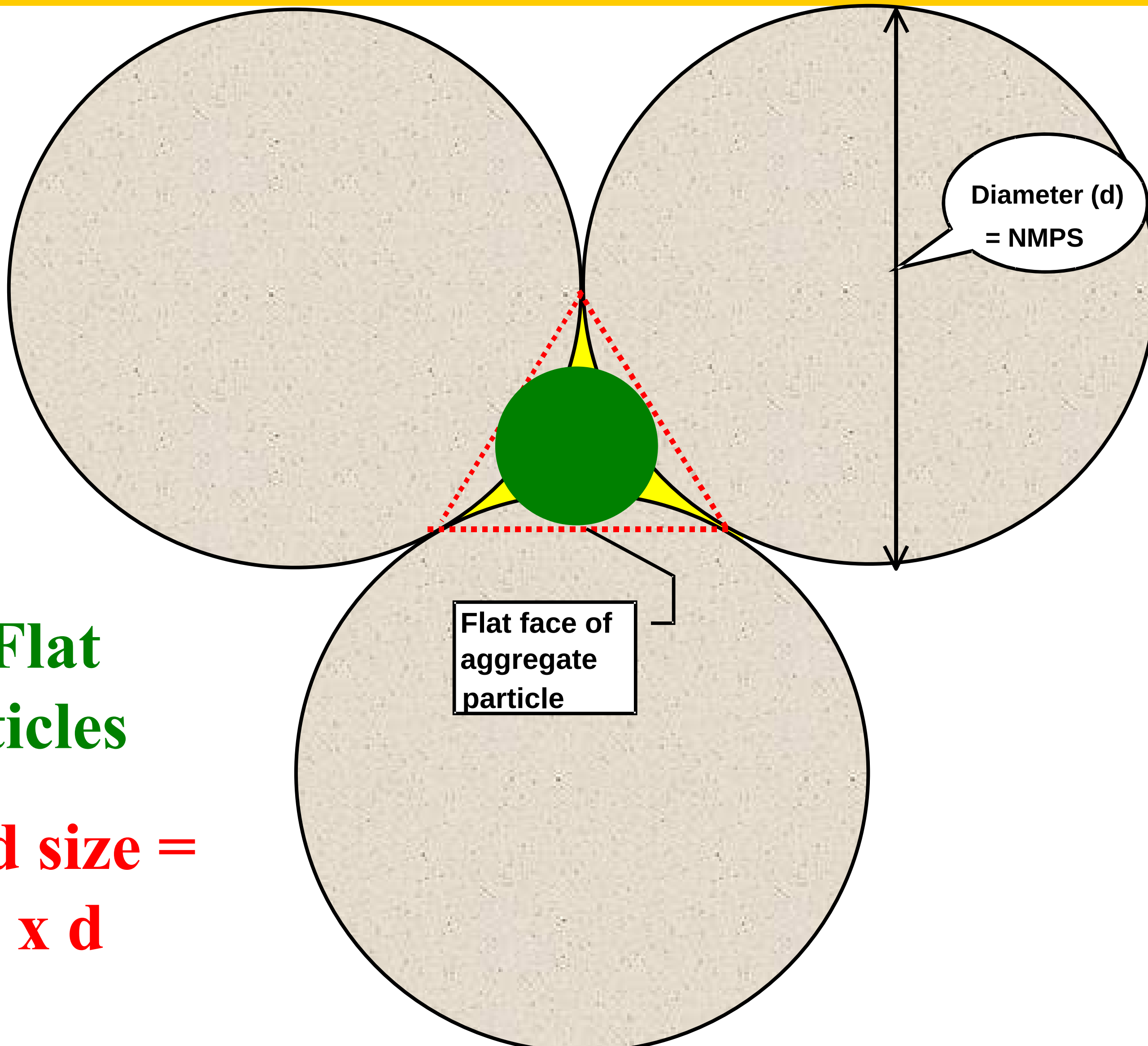
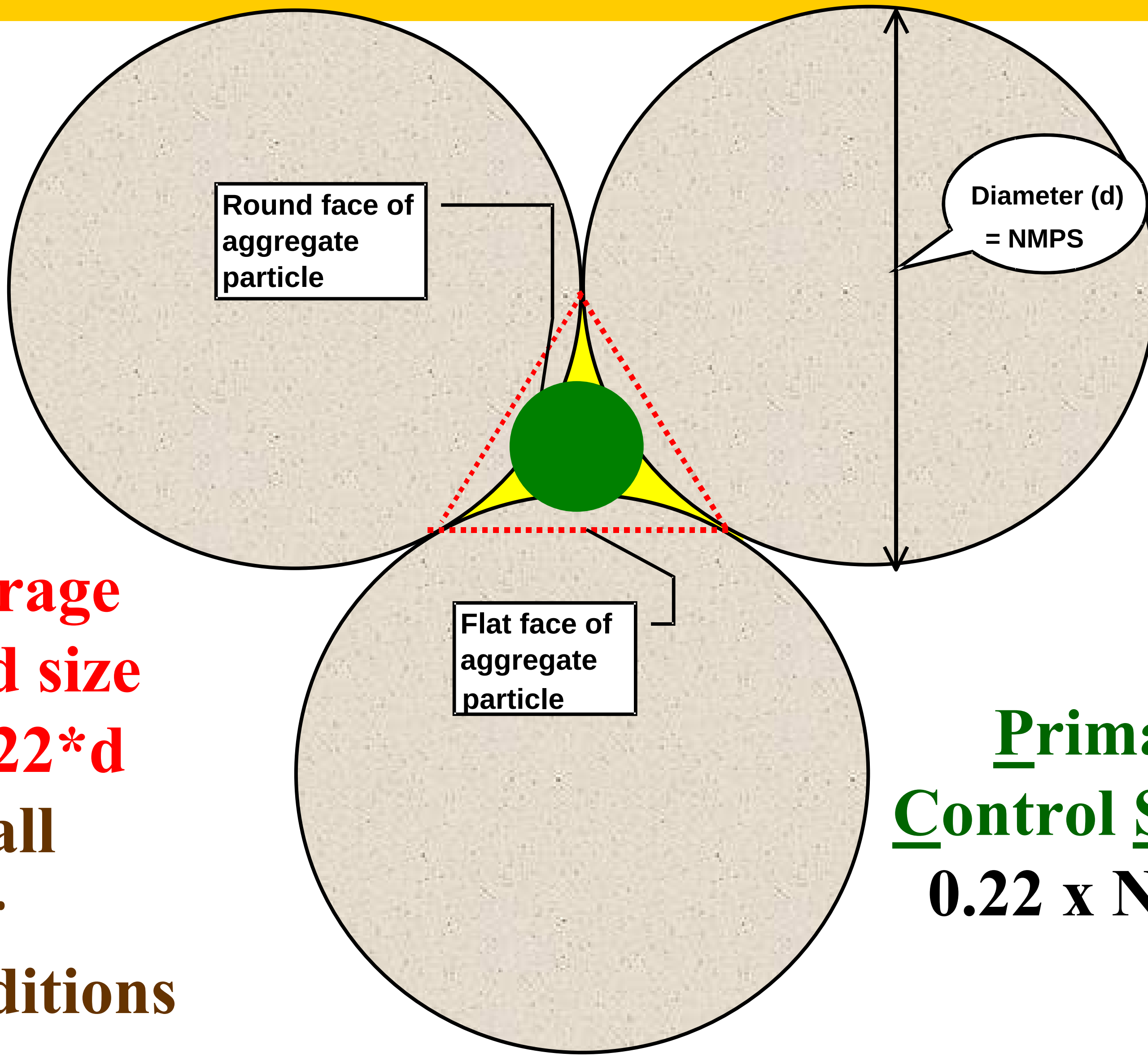


All Flat particles

Void size = 0.29 x d

Principle #1 - P.C.S.



Average Void size = 0.22*d for all four conditions

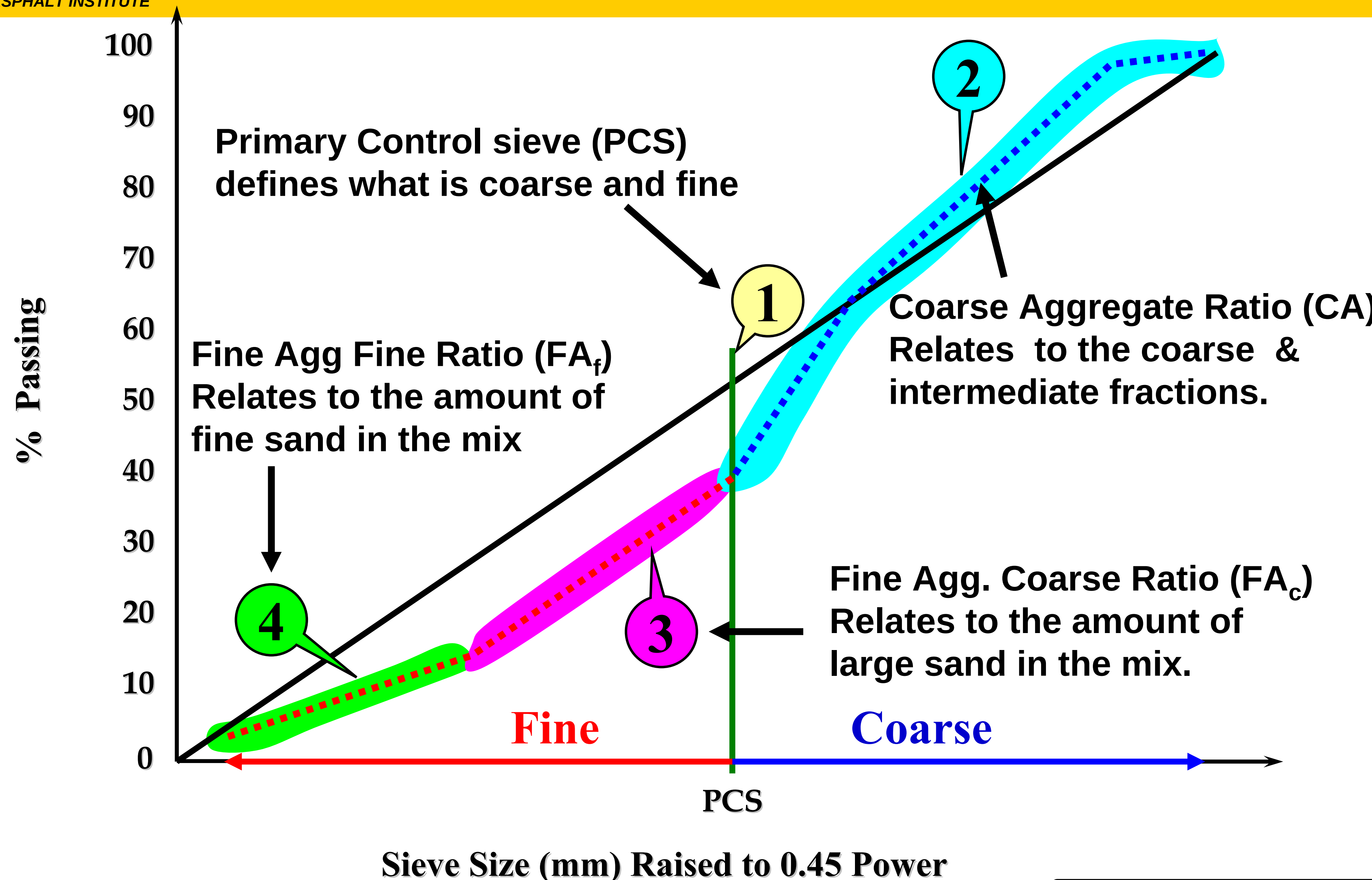
Primary Control Sieve = 0.22 x NMPS

Primary Control Sieve

Mixture NMPS	NMPS x 0.22	Primary Control Sieve
37.5mm	8.250mm	**9.5mm**
25.0mm	5.500mm	**4.75mm**
19.0mm	4.180mm	**4.75mm**
12.5mm	2.750mm	**2.36mm**
9.5mm	2.090mm	**2.36mm**
4.75mm	1.045mm	**1.18mm**

PCS determines the **break** between **Coarse** and **Fine** in the combined blend **and** if a **given** aggregate is a **CA** or **FA**

The Main Principles



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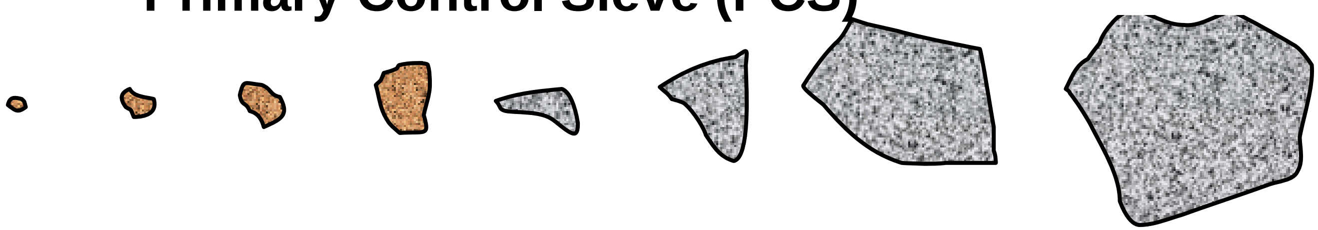
Principle #1 – P.C.S.

Defining "**Coarse**" and "**Fine**"

- "**Coarse**" fraction
  - Larger particles that **create** voids
- "**Fine**" fraction
  - Smaller particles that **fill** voids
- Estimate void **size**
  - Using **N**ominal **M**aximum **P**article **S**ize (**NMPS**)
- **Break** between "**Coarse**" and "**Fine**"
  - **Primary Control Sieve (PCS)**



Bailey Method Mix Types

The Bailey Method defines the mix type by volume of CA in the mix.

Loose Unit Weight - CA % FA

- **NO** compactive effort
- **Start** of particle-to-particle contact
- Determine **LUW**
  - Kg/m^3 or lbs./ft^3
- Determine **volume** of **voids**

Rodded Unit Weight - CA & FA

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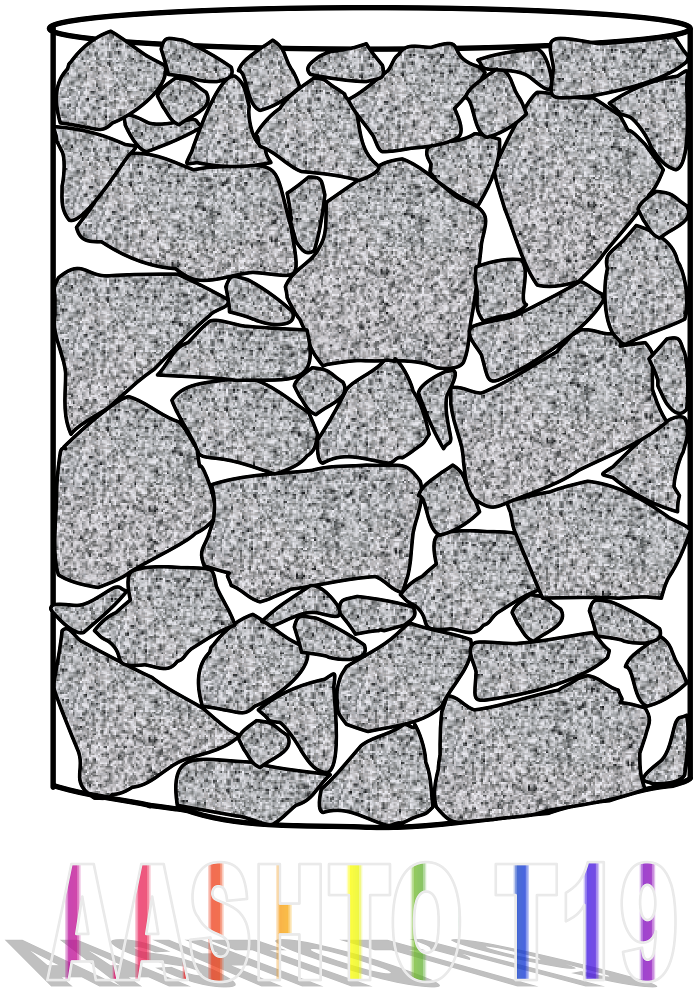

- **With** compactive effort
  - 3 layers
  - Rodded 25 times each
- **Increased** particle-to-particle contact
- Determine **RUW**
  - Kg/m^3 or $lbs./ft^3$
- Determine **volume** of **voids**

Fine-Graded Mixes

- **CA Volume < LUW**
- **Little to No** particle-to-particle contact of **CA**
- **Fine** fraction carries most of the load

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Coarse-Graded Mixes

- **CA Volume ≈ LUW**
- **Some** particle-to-particle contact of **CA**
- **Coarse** **and** **Fine** fractions carry load

Stone Matrix Asphalt Mixes

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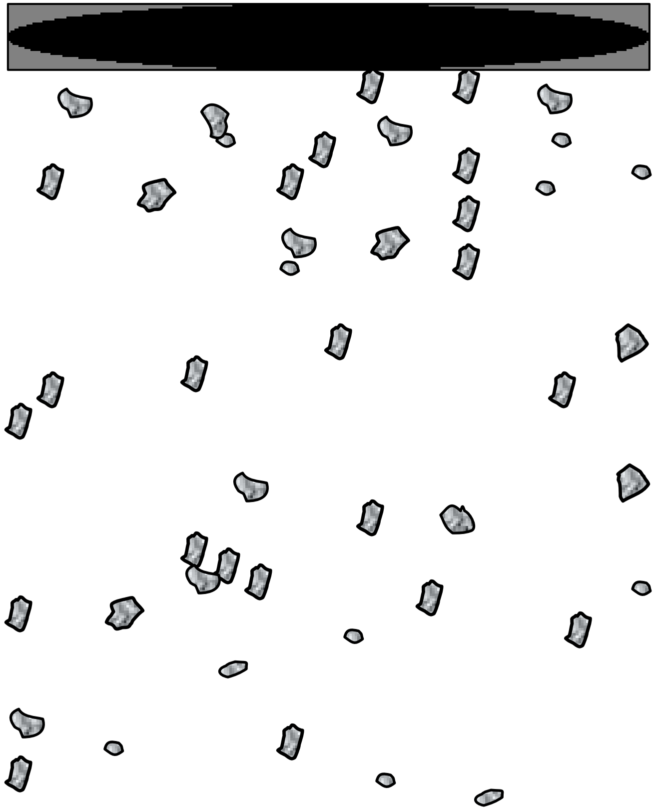

- **CA Volume > RUW**
- **Coarse** fraction carries the **load**
- Remaining voids filled with **mastic**
  - **FA**, mineral filler, fibers & asphalt cement

Evaluating Blended Aggregate

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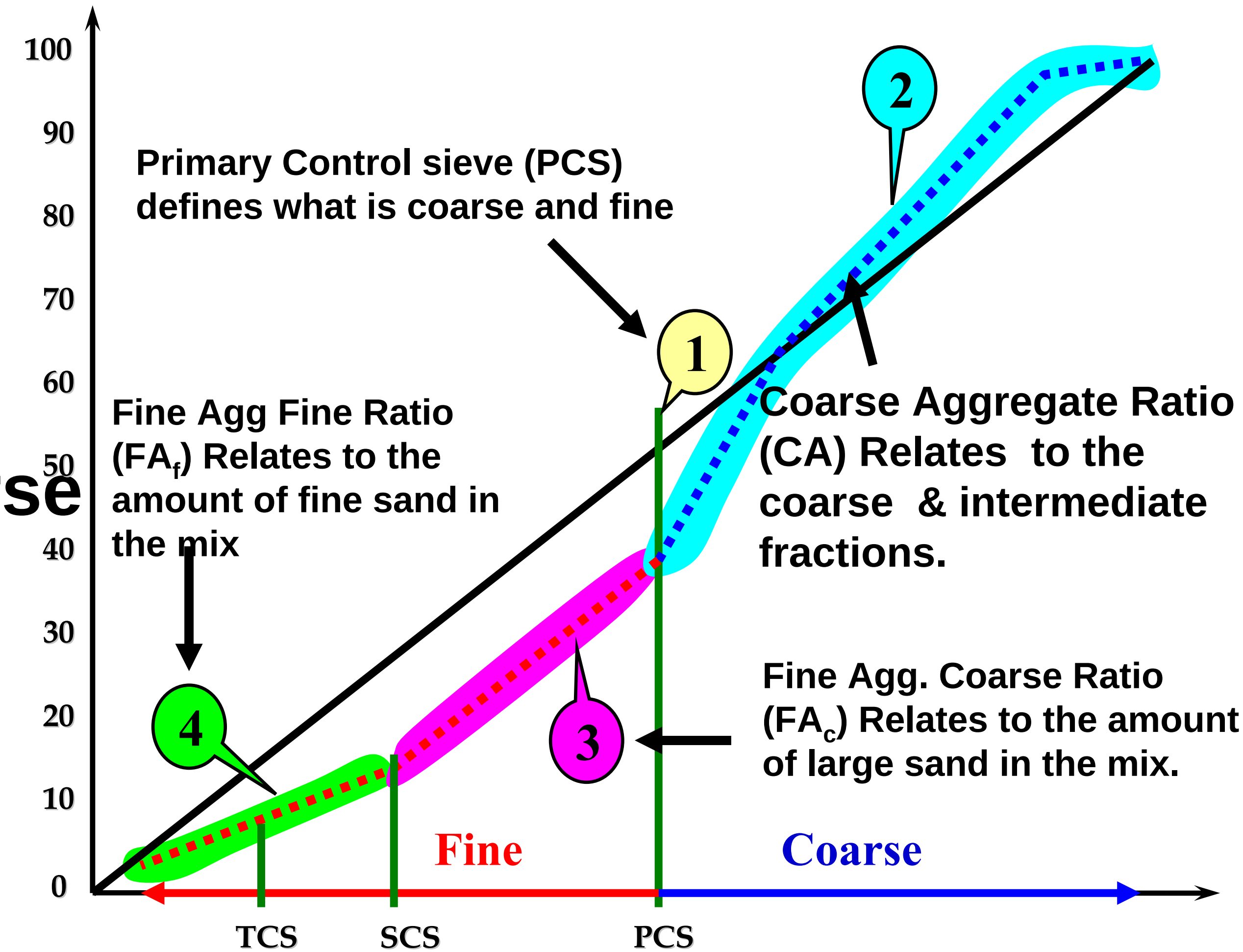
- Coarse Agg. Ratio (CA)
- Fine Agg. Coarse Ratio (FA_c)
- Fine Agg Fine Ratio (FA_f)



Combined Blend Evaluation Summary

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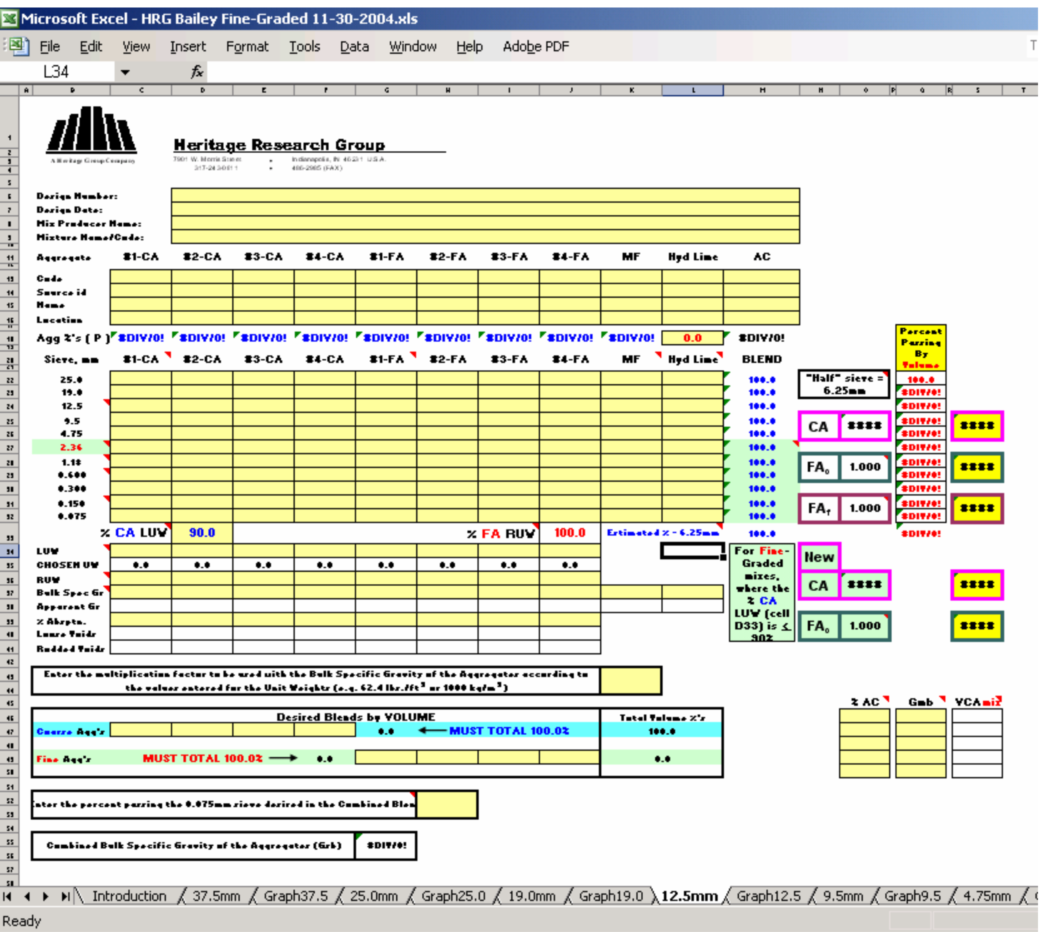
Coarse-Graded & Fine Graded Mixes
Rules-of-thumb or ratios

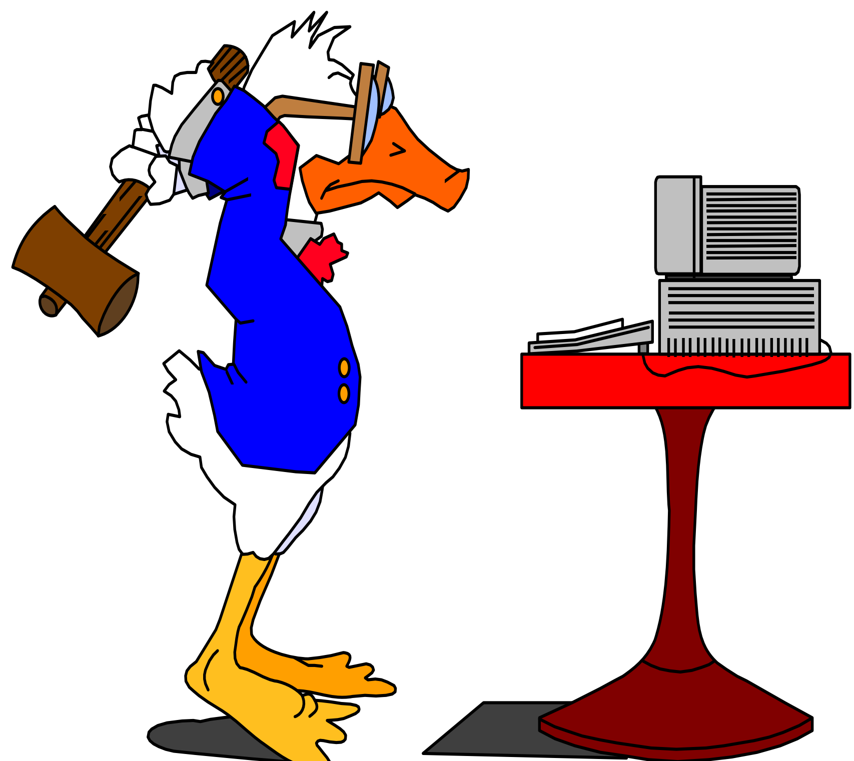
Amount and Direction for each 1% Change in VMA

1. **%PCS** = ± 1% VMA
2. **CA Ratio** = ± 1% VMA
3. **FA_c Ratio** = ± 1% VMA
4. **FA_f Ratio** = ± 1% VMA

Evaluating Mix Designs

HRG Blending Spreadsheets





HRG Basic Voids Estimating Sheets

12.5 F-G Basic Estimating VMA and Voids 11172006B

	Sample	Mix Design	1	2	3	4	5	6	7	8	9	10
	Date											
	Identification											
	19.0mm											
	12.5mm											
	9.5mm											
	6.25mm											
	4.75mm											
	2.36mm											
	1.18mm											
	0.600mm											
	0.300mm											
	0.150mm											
	0.075mm											
	% AC											
	% AC Absptn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Actual VMA											
	Actual Voids											
	CA											
	FAc											
	FAf											
	New CA											
	New FAc											
	Original PCS	Compares Each Sample to the Mix Design										
	New CA											
	New FAc											
	Total											
	Est VMA											
	Act VMA											
	Diff in VMA											
	Est Voids											
	Act Voids											
	Diff in Voids											
	Original PCS	Compares Each Sample to the Previous Sample										
	New CA											
	New FAc											
	Total											
	Est VMA											
	Act VMA											
	Diff in VMA											
	Est Voids											
	Act Voids											
	Diff in Voids											
Original	Est Pba											
Orig PCS	Gsb											
6.00	Gmb 1											
New CA	Gmb2											
0.350	Gmb3											
New FAc	Avg											
0.050	Gmm 1											
New FAc Dip	Gmm 2											
0.500	Avg											
~~New FAf~~	VMA											
	Voids											
~~New FAf Dip~~	Gse	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Pba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AC Volume	Eff AC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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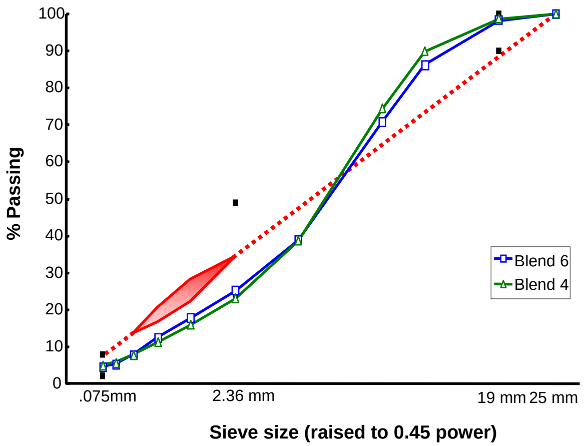
AI Blend 4 & 6

	Blend 4	Blend 6
25-mm	100%	100%
19-mm	98.7%	98.2%
12.5-mm	89.9%	86.4%
9.5-mm	74.4%	71.0%
4.75-mm	38.4%	38.8%
2.36-mm	23.0%	25.1%
1.18-mm	15.7%	17.7%
0.6-mm	11.2%	12.6%
0.3-mm	7.8%	7.8%
0.15-mm	5.9%	5.3%
0.075-mm	5.2%	4.6%



	Blend 4	Blend 6
%Binder	4.7%	4.7%
Air Voids	3.7%	5.7%
VMA	13.5%	15.3%
Est. Binder @4% Air Voids	4.6%	5.4%
Est. VMA	13.5%	15.0%

Scheduled Courses

- Introductory Course
  - 1 – Day
  - 6 of 8 Hosted by SAPA
- Main Course
  - 3 – Days
  - Lexington
  - IAPA
- Advance Course
  - 2 – Days
  - Lexington
  - Graduates with one year experience
- Bill Pine – Heritage Research

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The Bailey Method

- ***"To sum it all up in numbers, last year we lost around $250,000 in deducts for Voids, VMA, and Compaction. This year, using the Bailey Method, we are up $300,000 in incentives. To make this an even greater accomplishment, we achieved this on half of the incentive jobs we had last year."***
    - **Graduate of the 3-day Bailey Course**

Thanks !

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