DEVELOPMENT OF MIX DESIGN AND STRUCTURAL DESIGN PROCEDURES FOR COLD IN-PLACE RECYCLING

Pavement Engineering and Science Program
University of Nevada, Reno

Progress – Update

October 26, 2016

Experimental Program

RAP	Emulsion	Slurry Level	Mix Design					M-E Design			
			Superpave	Hveem	Moist.	Ravel.	Cohes.	E*	Fn	RC	FC
Graded	A	4.5	√	√	√	√	√	√	√	√	√
		6.0	√	√	√	√	√	√	√	√	√
	B	4.5	√	√	√	√	√	√	√	√	√
		6.0	√	√	√	√	√	√	√	√	√
	C	4.5	√	√	√	√	√	√	√	√	√
		6.0	√	√	√	√	√	√	√	√	√
	D	4.5	√	√	√	√	√	√	√	√	√
		6.0	√	√	√	√	√	√	√	√	√
Non-Graded	A	4.5	√	√	√	√	√	√	√	√	√
		6.0	√	√	√	√	√	√	√	√	√
	B	4.5	√	√	√	√	√	√	√	√	√
		6.0	√	√	√	√	√	√	√	√	√
	C	4.5	√	√	√	√	√	√	√	√	√
		6.0	√	√	√	√	√	√	√	√	√
	D	4.5	√	√	√	√	√	√	√	√	
		6.0	√	√	√	√	√	√	√	√	√

4.5 = 1.5%HL+ 3%W
6.0 = 2%HL + 4%W

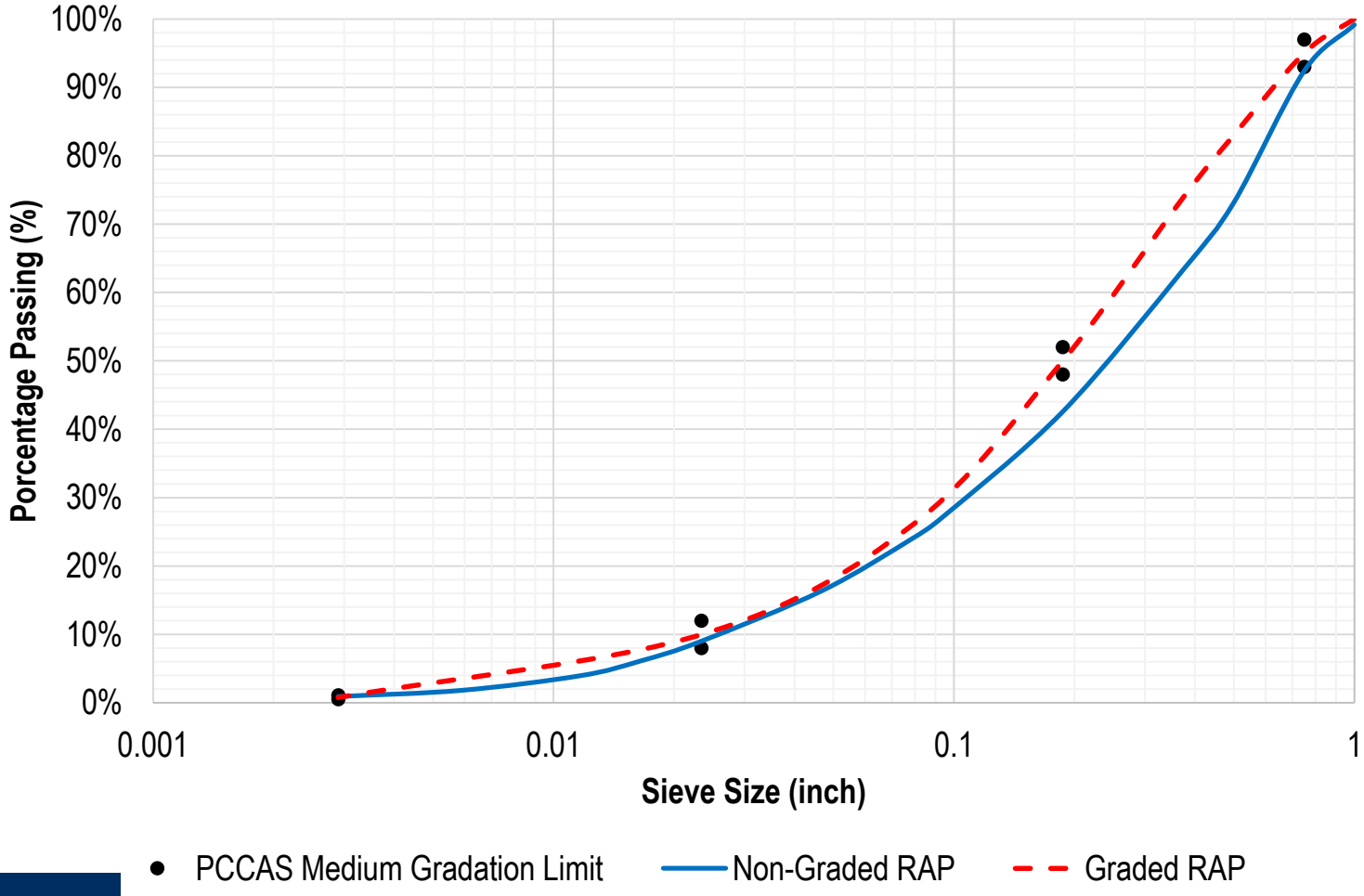
E* = Dynamic Modulus
RC = Reflective Cracking

Fn = Flow Number
FC = Fatigue Cracking

Superpave Mix Design

- Air voids: 13±1%
- Identify N_{design}
- Identify OEC
- Check:
  - Moisture Sensitivity
  - Raveling
  - Cohesion

RAP Gradation



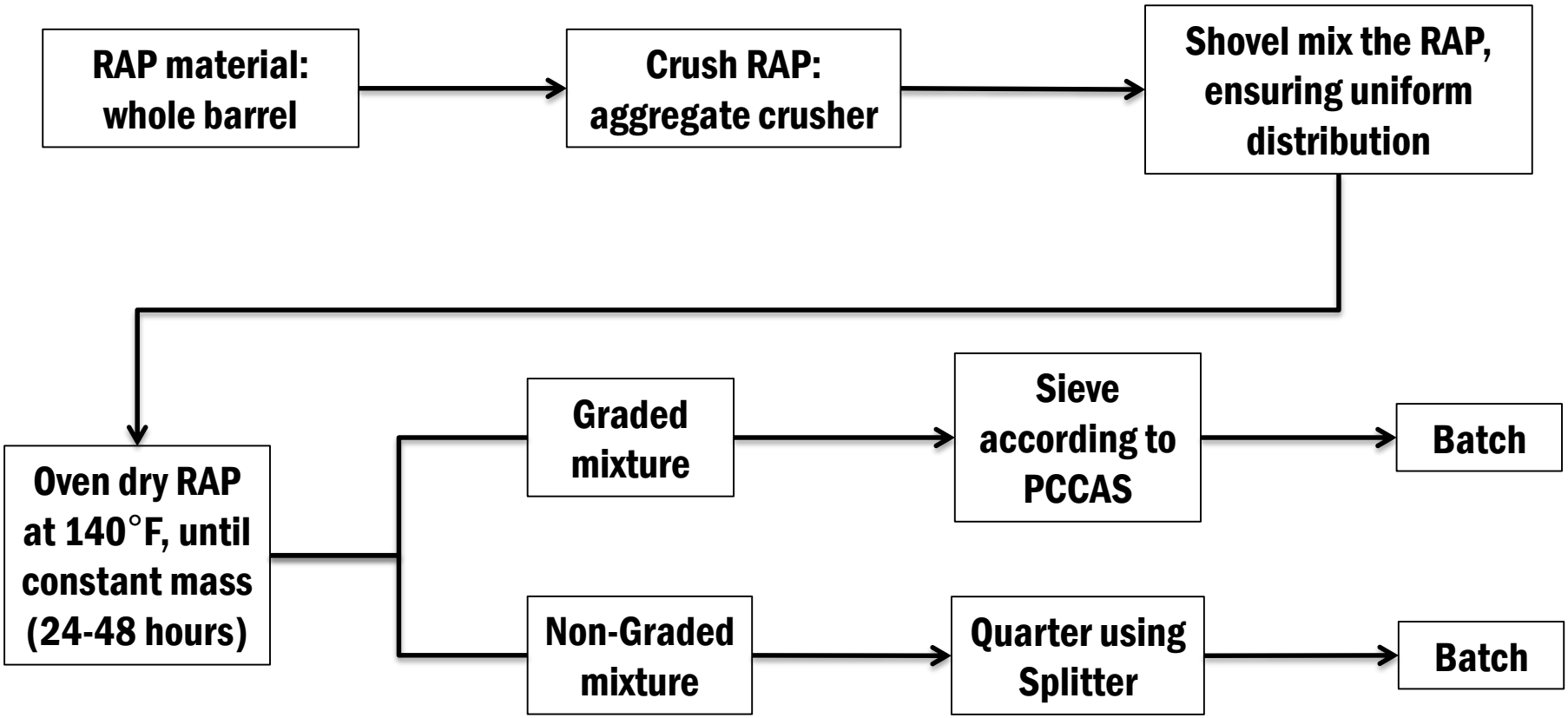
Graded RAP:

- PCCAS medium gradation

Non-Graded RAP:

- 100% passing 1.5” (NDOT)

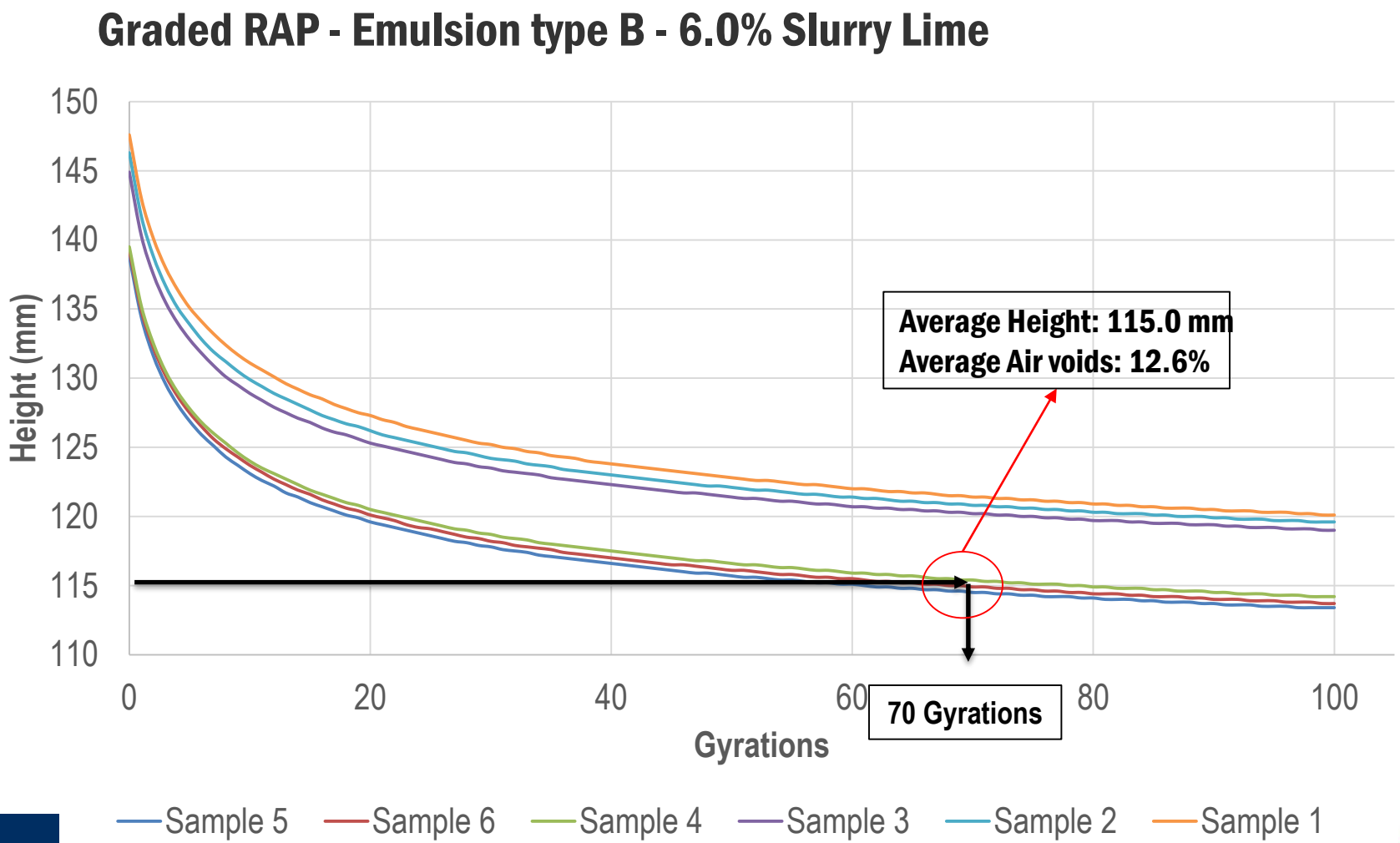
Samples Fabrications



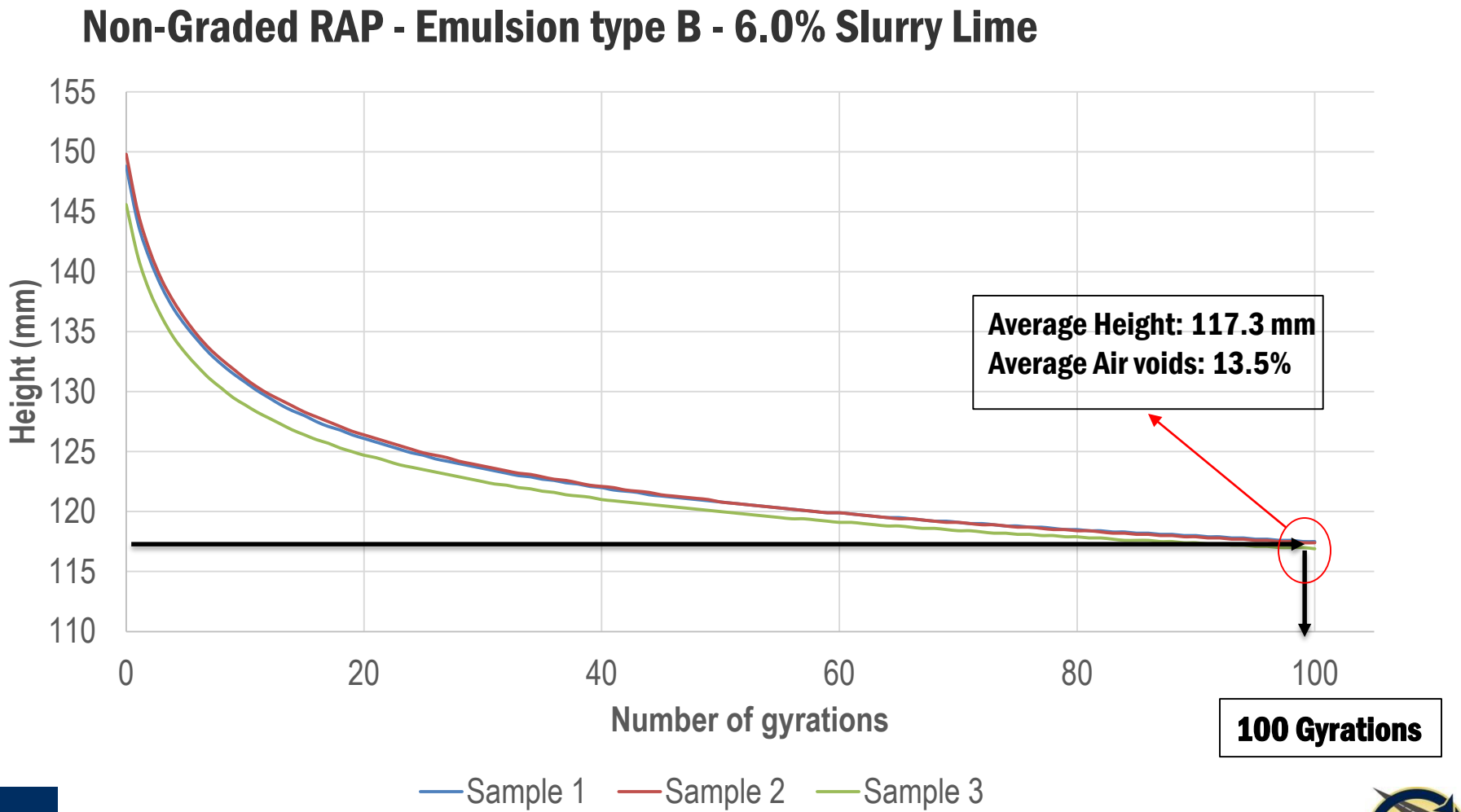
Identify N_{design}

- Emulsion content: 3.0%
- Compact to 100 gyrations
- Measure Theoretical Maximum (G_{mm}) & Bulk Specific (G_{mb}) Gravities
- Identify the number of gyrations:
  - Height: 115±5mm
  - Air voids (%AV): 13±1%

Number of SGC Gyrations



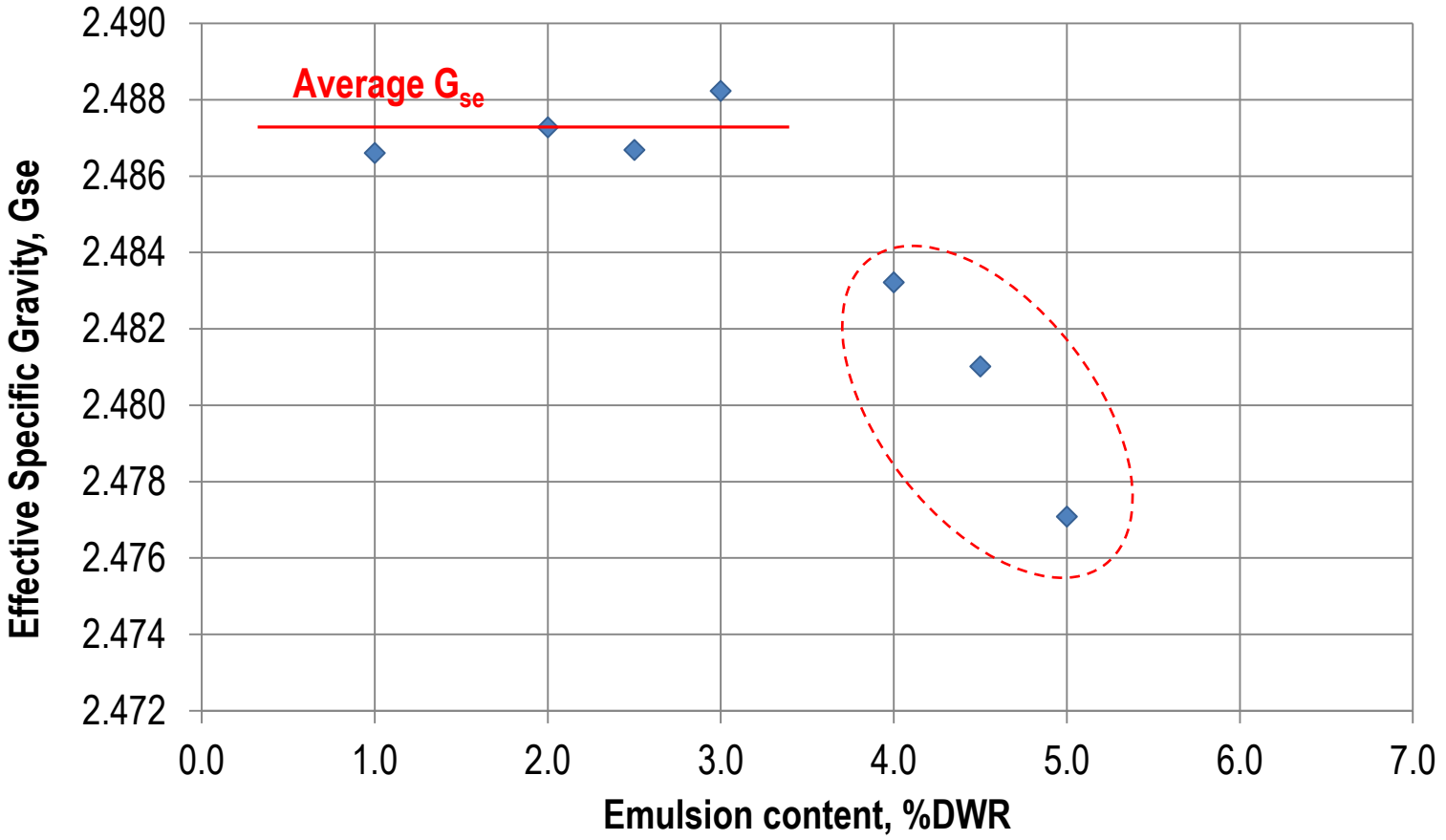
Number of SGC Gyrations



Identify Optimum Emulsion Content

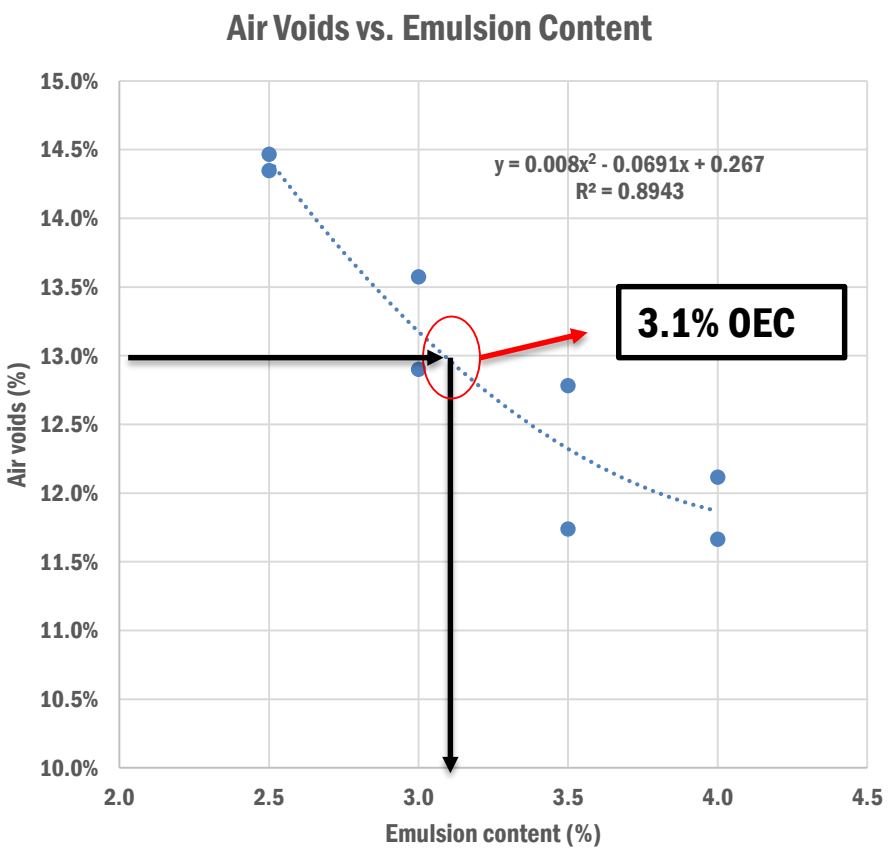
- Mix samples at: 2.5, 3.0, 3.5, and 4.5% emulsion
- Lime slurry: 4.5% and 6.0%
- Measure G_{mm} at 3.0% and calculate at others
- Compact to N_{design} and measure G_{mb}
- Identify OEC:
  - %AV and Height

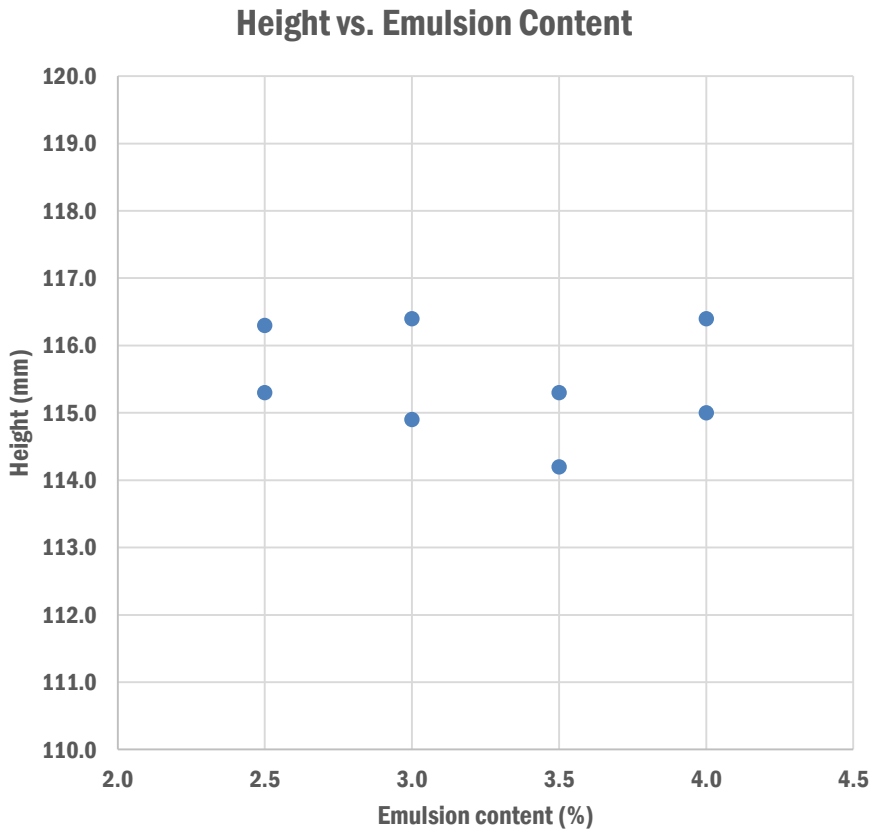
Effective Specific Gravity



Optimum Emulsion Content (OEC)

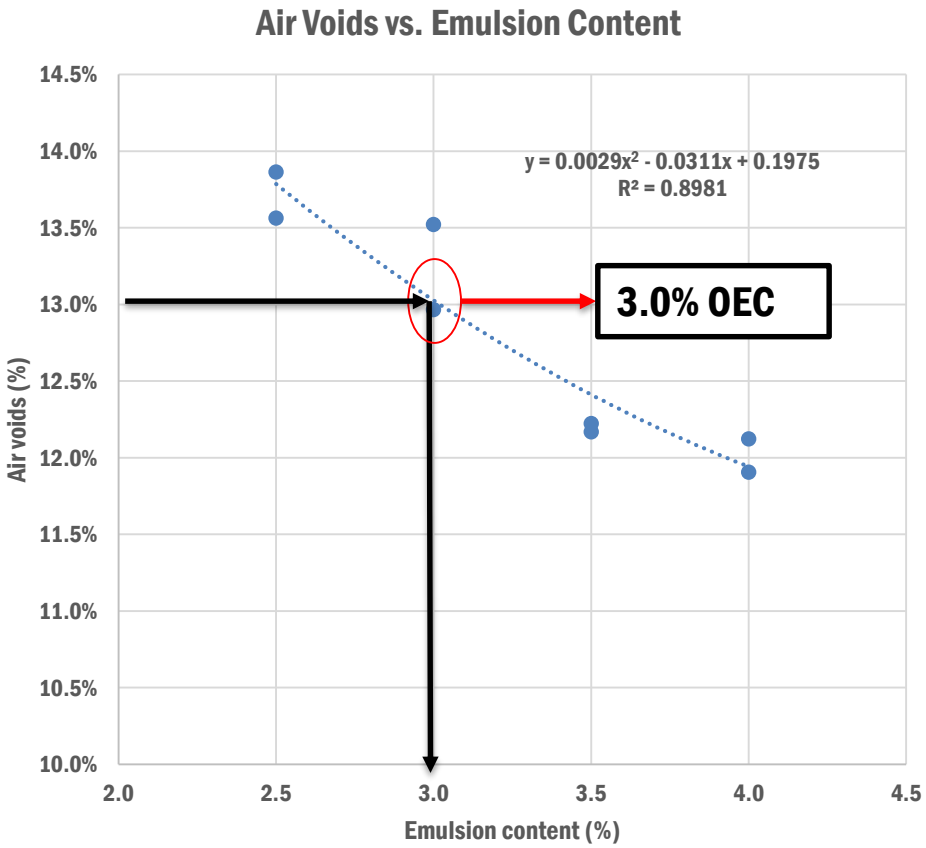
Graded RAP - Emulsion type B - 6.0% Slurry Lime – 70 Gyrations

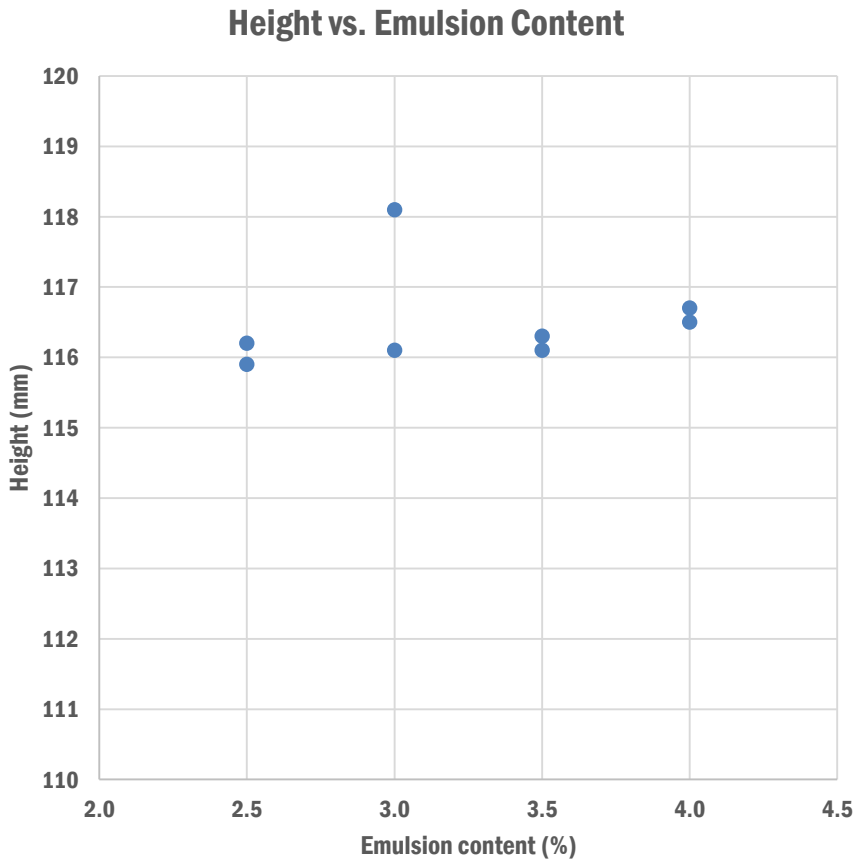




Optimum Emulsion Content (OEC)

Non-Graded RAP - Emulsion type B - 6.0% Slurry Lime – 100 Gyrations





Samples Acceptance Criteria

- Additional Samples are Compacted if:
  - Repeatability of the G_{mb} does not meet:
    - Standard Deviation d2s
    - Maximum Difference
  - The Fit of the data is unacceptable
    - $R^2 < 0.75$

Superpave Mix Designs

Emulsion	Slurry Lime (%)	Aggregate	Superpave Mix Design						
			Air Voids (%)	OEC(%)	R^2	No. of Gyration	No. of Samples	Cohesion (hrs)	Raveling (%)
A	4.5	Graded	13.0	3.4	0.90	100	8	4.5	10.5
		Non graded	13.0	3.6	0.89	100	9		
	6.0	Graded	13.0	3.0	0.93	100	8	5.5	2.5
		Non graded	13.0	4.0	0.92	100	10		
B	4.5	Graded	13.0	3.8	0.92	85	9	9	11.9
		Non graded	13.0	4.0	0.72	100	11		
	6.0	Graded	13.0	3.1	0.89	70	9	8.5	8.6
		Non graded	13.0	3.0	0.90	100	10		
C	4.5	Graded	13.0	2.9	0.88	80	8	5.5	1.2
		Non graded	13.0	3.3	0.88	100	8		
	6.0	Graded	13.0	2.5	0.79	75	9	6.5	0.2
		Non graded	13.0	2.5	0.77	100	8		
D	4.5	Graded	13.0	3.0	0.73	60	11	4.5	5.0
		Non graded	13.0	3.9	0.88	100	12		
	6.0	Graded	13.0	3.5	0.78	65	8	5.5	2.2
		Non graded	13.0	4.0	0.83	100	12		

Some Trends

- All Non Graded Mixtures Required N = 100
- Graded Mixtures N = 70 – 85 **(D: 60-65)**
- Number of Required Samples Higher for Non Graded Mixtures
- Optimum Emulsion Content Higher for Non Graded

Next Task: Hveem Mix Design

- Air Voids: 13±1%
- Identify Leveling Load
- Identify OEC
- Check:
  - Moisture Sensitivity
  - Raveling
  - Cohesion

Identify Number of Tamps

- Emulsion content: 3.0%
- Compact to 150 tamps
- Measure G_{mm} and G_{mb}
- Identify the leveling load:
  - Height: 2.5±0.1inch
  - Air voids (%AV): 13±1%

Identify Optimum Emulsion Content

- Mix samples at: 2.5, 3.0, 3.5, and 4.5% emulsion
- Lime slurry: 4.5% and 6.0%
- Measure G_{mm} at 3.0% and calculate at others
- Compact and apply leveling load: measure G_{mb}
- Identify OEC:
  - %AV and Height

Hveem Mix Designs

Emulsion	Slurry Lime (%)	Aggregate	Hveem Mix Design			
			Air Voids (%)	OEC(%)	R^2	Leveling Load (psi)
A	4.5	Graded	13.0			
		Non graded	13.0			
	6.0	Graded	13.0			
		Non graded	13.0			
B	4.5	Graded	13.0	3.5	0.89	300
		Non graded	13.0	3.8	0.74	1000
	6.0	Graded	13.0	3.2	0.91	300
		Non graded				
C	4.5	Graded	13.0	3.0	0.88	300
		Non graded				
	6.0	Graded				
		Non graded				
D	4.5	Graded	13.0	3.5	0.94	450
		Non graded				
	6.0	Graded	13.4	4.0	0.93	300
		Non graded				

Thank You!