Asphalt Research Consortium

Work element E2b:
Design System for HMA Containing a High Percentage of RAP Material

E2b-1.a:

Develop a System to Evaluate the Properties of RAP Aggregates:

RAP ETG, Phoenix, AZ

Oct 28-29, 2008

E2b-1.a: Develop a System to Evaluate the Properties of RAP Aggregates

ARC

- *Objective:* recommend a system to evaluate the properties of RAP aggregates.
- Evaluate impact of current extraction techniques on properties of extracted RAP aggregates.
- Produce RAP mixes in the lab & extract aggregates using different extraction techniques.
- Evaluate physical properties of the aggregates before mixing with the asphalt binder and after extraction.

E2b-1.a: Develop a System to Evaluate the Properties of RAP Aggregates

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- Evaluate: centrifuge, reflux, & ignition oven.

Experimental plan:

- Identify 4 aggr. sources with different mineralogy
  - 2 sources from the east (NCAT)
    - Limestone FL-Soft
    - Limestone AL-Hard
  - 3 sources from the west (UNR, PG64-22)
    - UNR:
      - Lockwood: Andesite
      - Handley Ranch
      - South Dakota: soft aggregates

E2b-1.a: Develop a System to Evaluate the Properties of RAP Aggregates

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- SP mix design (intermediate gradation, 6 millions ESALs for a top lift).
- Physical properties of blend aggr.: Gradation, LAA, Absorption, SG, FAA, CAA, SE, Durability Index, AIMS, and Cleanness Value.
- Subject ***loose*** samples to STOA as recommended by SP followed by LTOA as recommended by SP for compacted samples (samples stirred once a day).
- Extract aggregates from aged loose specimens.
- Measure extracted aggregates physical properties.

E2b-1.a: Develop a System to Evaluate the Properties of RAP Aggregates

- *Binder Work:*

  Evaluate impact of reflux & centrifuge on properties of recovered binder.

  - Recover asphalt binder from centrifuge & reflux methods using Rota-vap method.

  - Evaluate recovered binders according to
    - SP grading system
    - & guidelines provided by NCHRP RRD No. 253.

Spec. Gravity & Abs. of Coarse Aggregates

AASHTO T85

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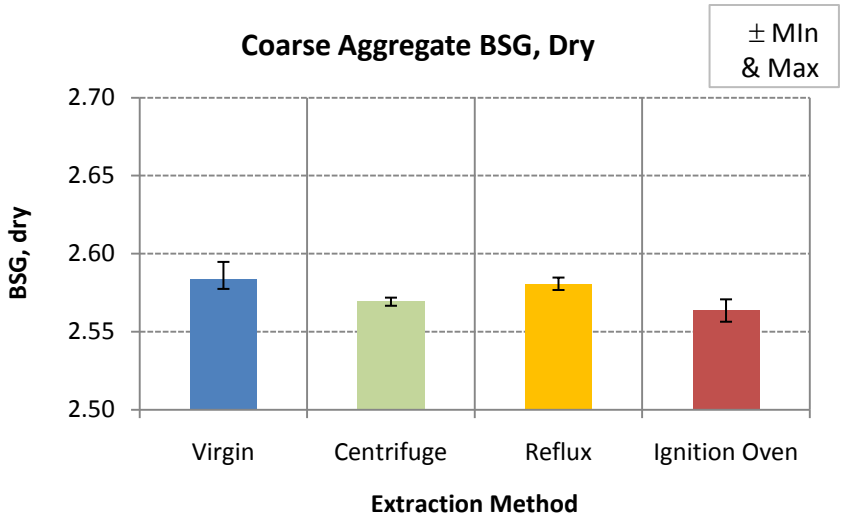
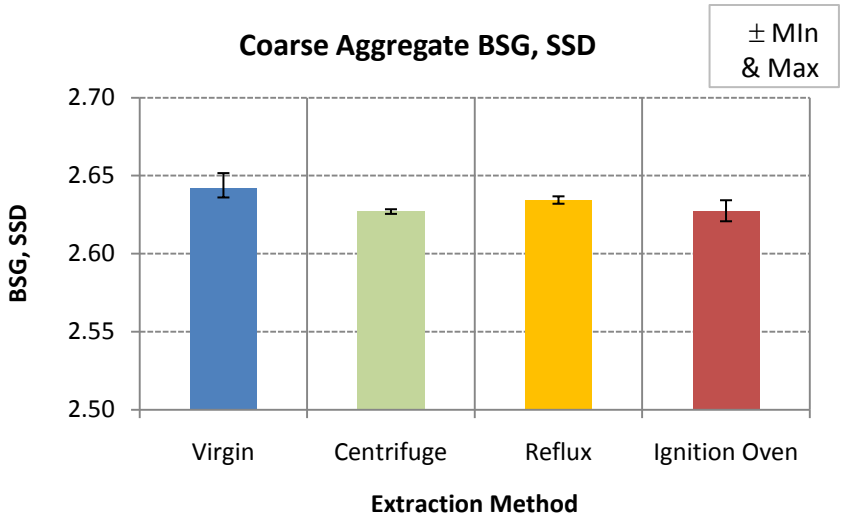
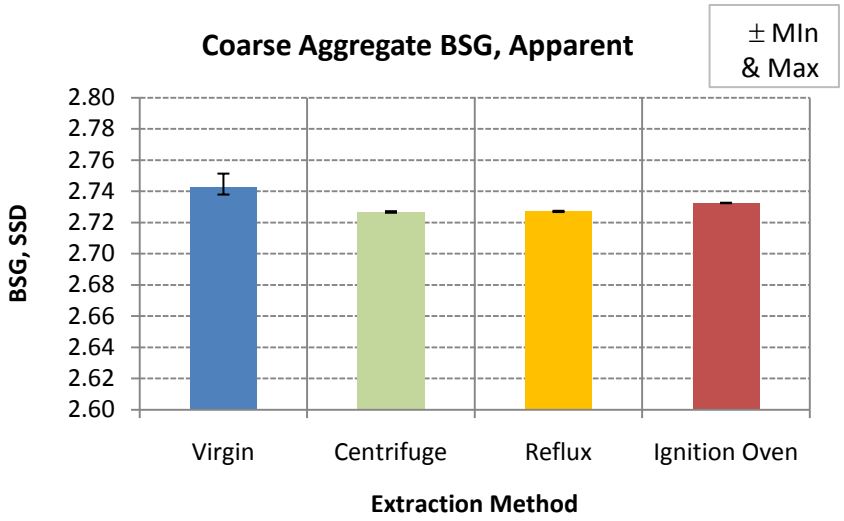
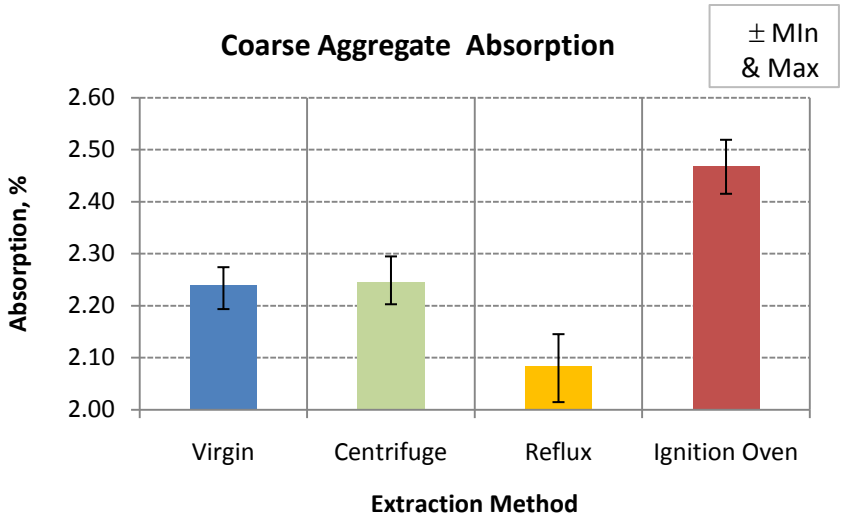








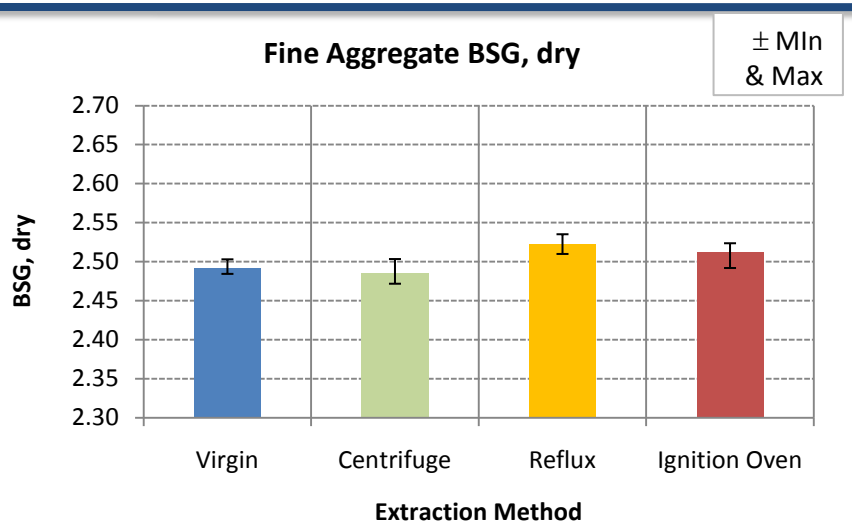
WESTERN REGIONAL CENTER SuperPave

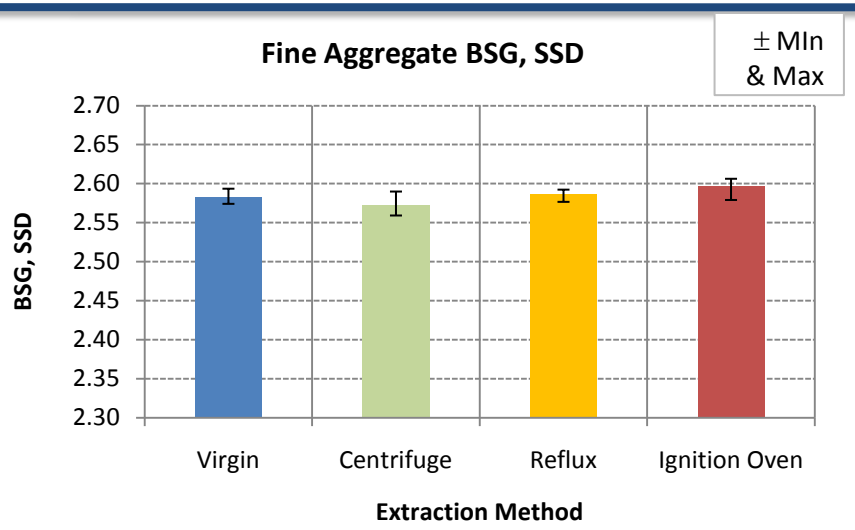
University of Nevada, Reno

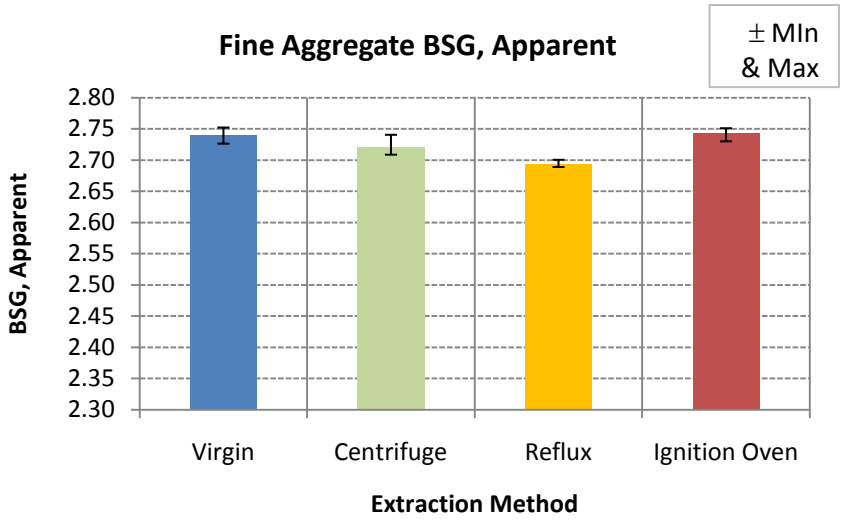
Spec. Gravity & Abs. of Fine Aggregates

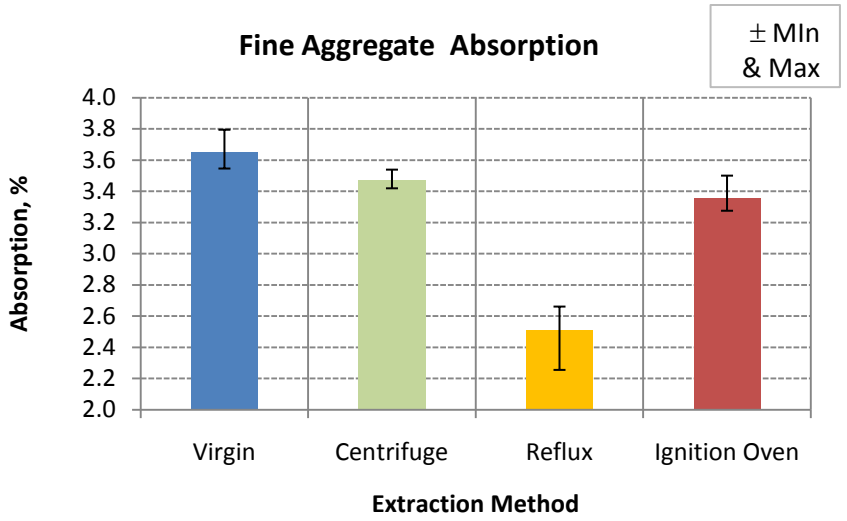
AASHTO T84

ARC









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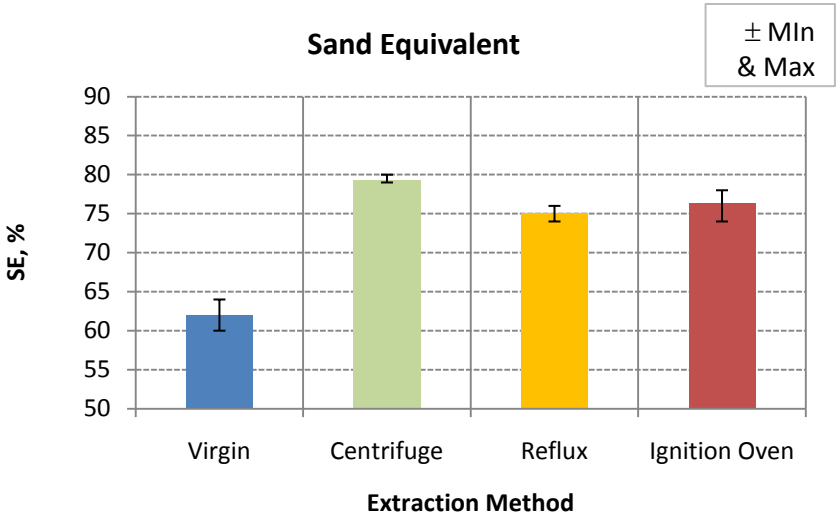
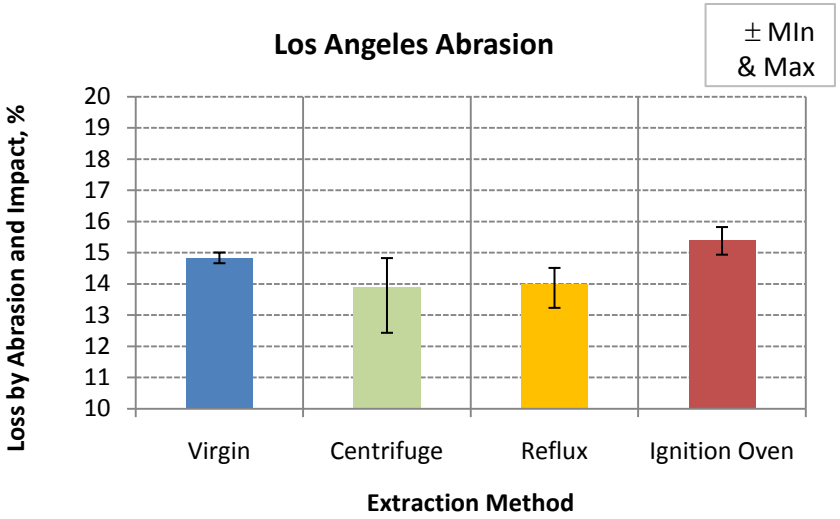
Sand Equivalent & LA Abrasion
AASHTO T176 & T96

ARC

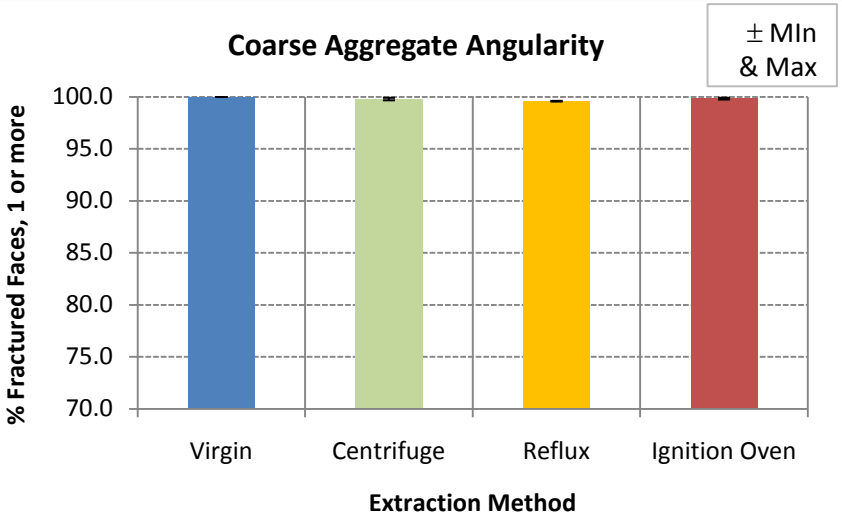


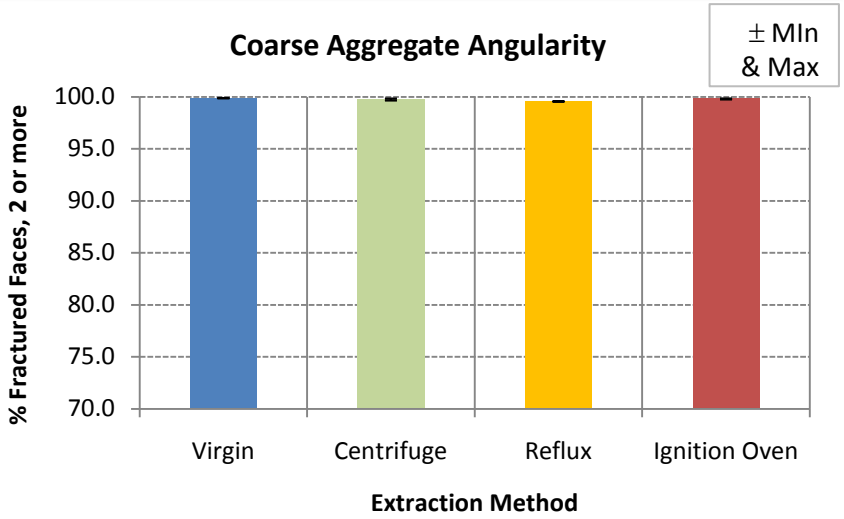


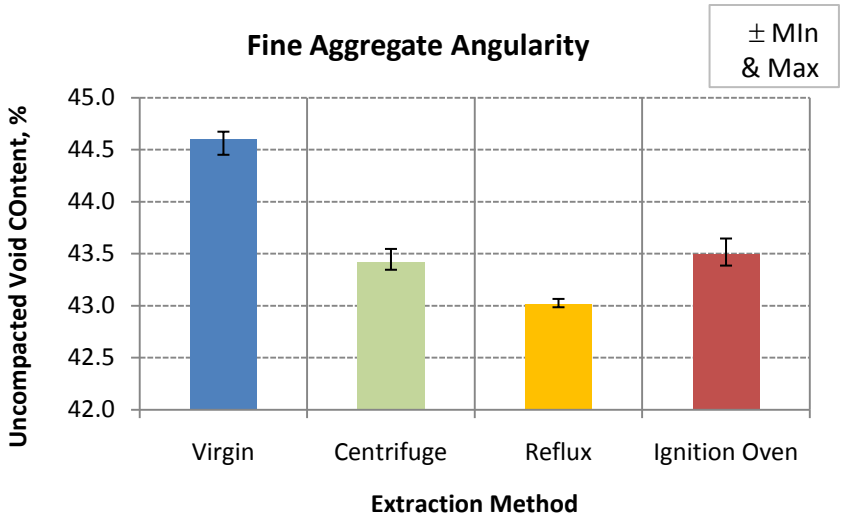
Coarse & Fine Aggregate Angularity

ASTM D5821 & AASHTO T304 - Method A

ARC



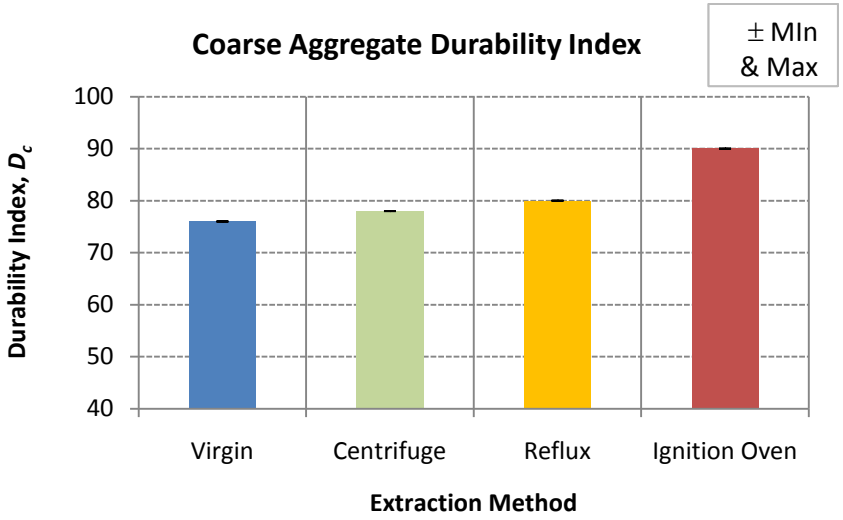


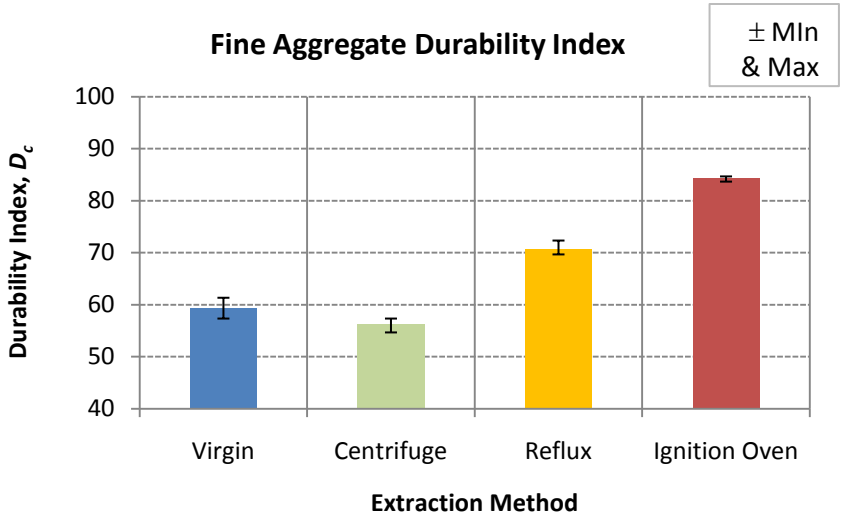


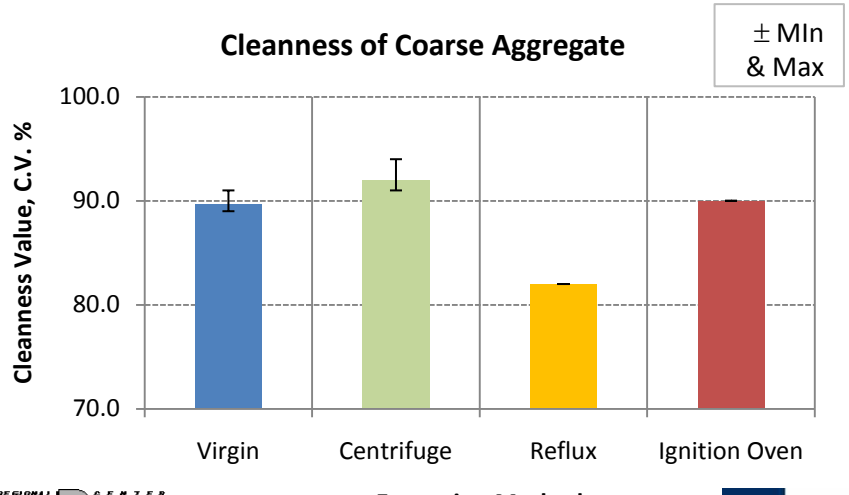
Durability Index & Cleanness

AASHTO T210 & Caltrans CT 227

ARC

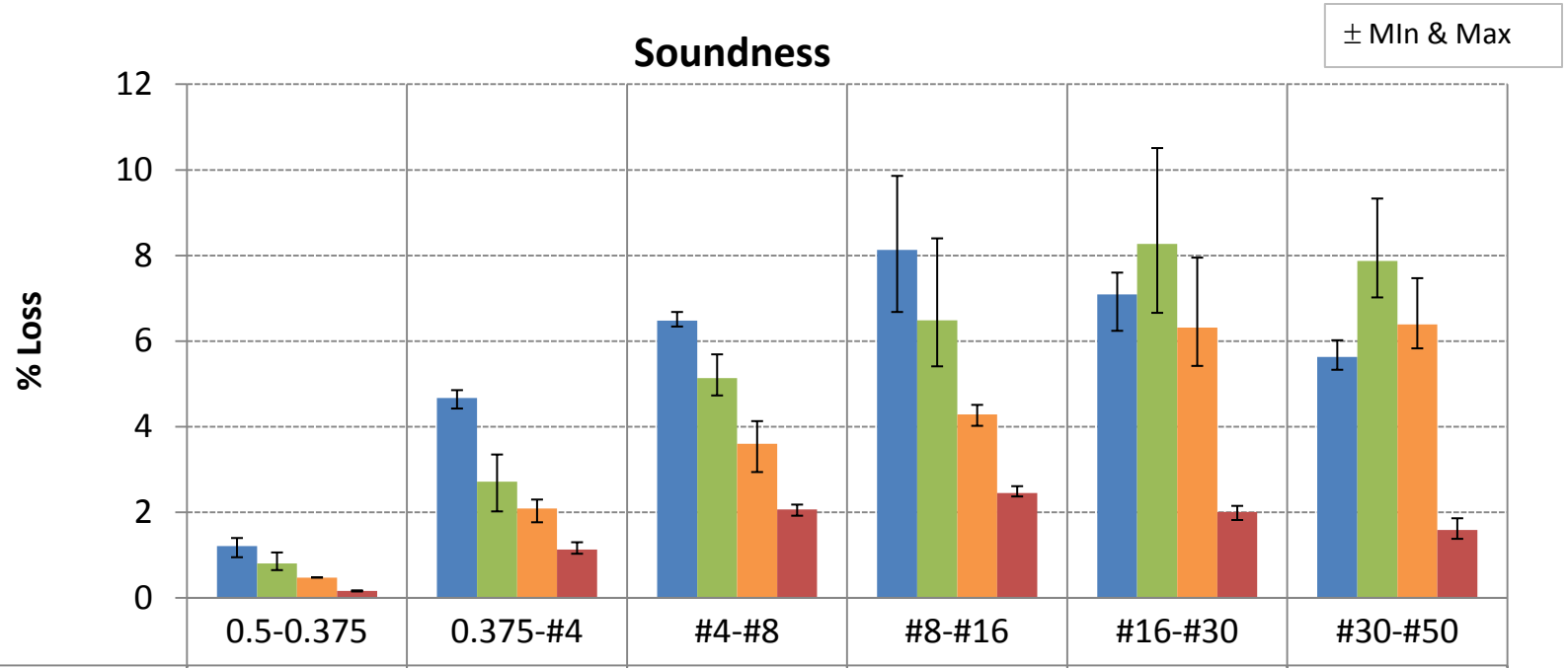






Soundness
AASHTO T104

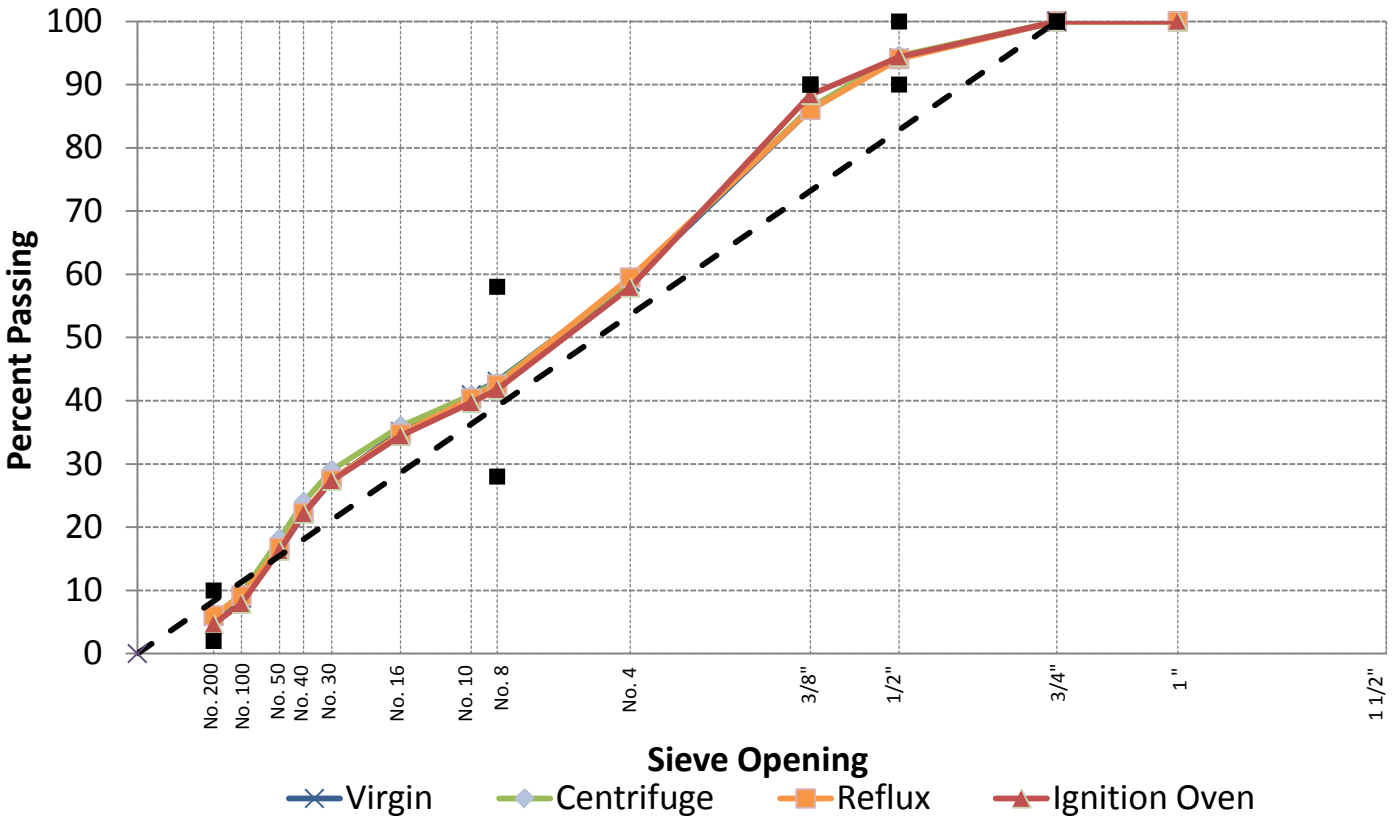
ARC



	0.5-0.375	0.375-#4	#4-#8	#8-#16	#16-#30	#30-#50
Virgin	1.2	4.7	6.5	8.1	7.1	5.6
Centrifuge	0.8	2.7	5.1	6.5	8.3	7.9
Reflux	0.5	2.1	3.6	4.3	6.3	6.4
Ignition Oven	0.2	1.1	2.1	2.5	2.0	1.6

Gradation

ARC



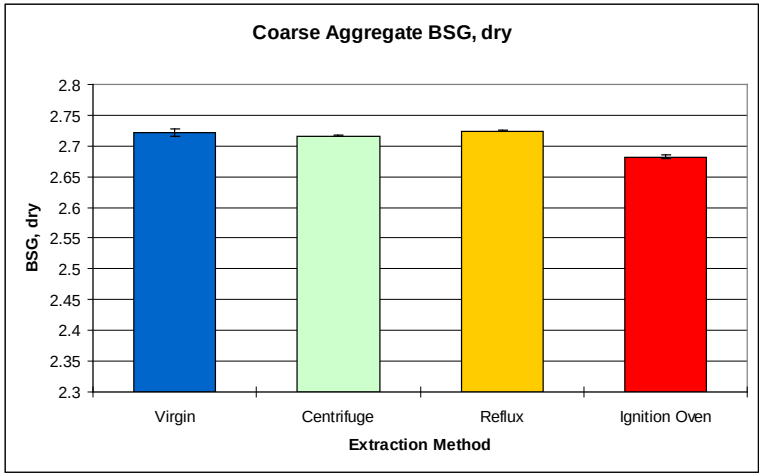
Gradation

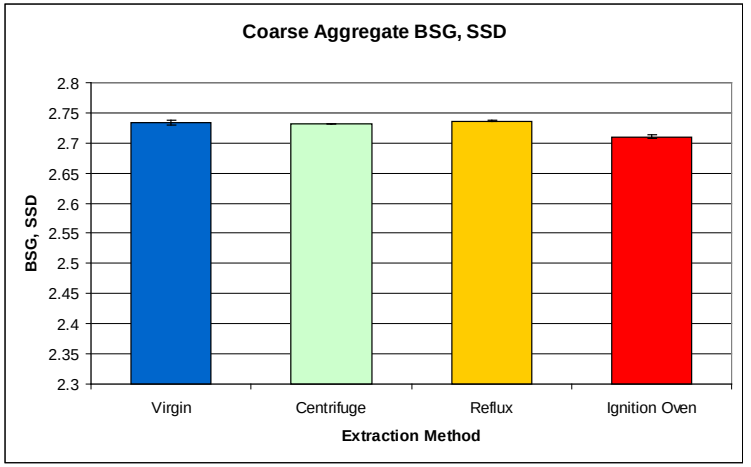
ARC

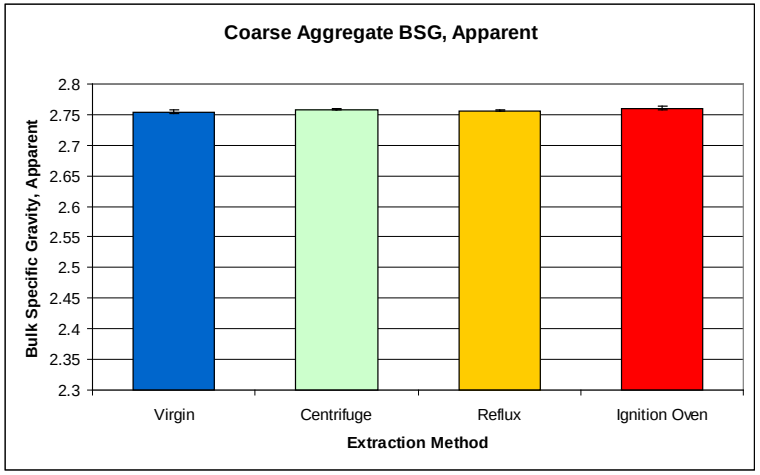
Sieve Size	Virgin		Centrifuge		Reflux		Ignition Oven	
	Average %Passing	Std Deviation	Average %Passing	Std Deviation	Average %Passing	Std Deviation	Average %Passing	Std Deviation
19.0 mm (3/4")	**100.0**	**0.00**	**100.0**	**0.00**	**100.0**	**0.00**	**100.0**	**0.00**
12.5 mm (1/2")	94.2	0.27	94.6	0.09	94.1	0.35	94.3	0.14
9.5 mm (3/8")	**86.1**	**0.24**	**86.4**	**0.26**	**86.0**	**0.35**	**88.4**	**3.83**
4.75 mm (No. 4)	*58.8*	*0.21*	*59.0*	*0.20*	*59.5*	*1.10*	*57.9*	*0.04*
2.36 mm (No. 8)	**43.1**	**0.26**	**42.9**	**0.50**	**42.5**	**0.20**	**41.8**	**0.11**
2.00 mm (No. 10)	40.9	0.27	40.9	0.42	40.4	0.25	39.7	0.14
1.18 mm (No. 16)	**35.2**	**1.37**	**36.0**	**0.23**	**34.8**	**0.33**	**34.4**	**0.14**
0.6 mm (No. 30)	27.4	2.33	29.0	0.32	27.5	0.42	27.4	0.21
0.425 mm (No. 40)	**22.0**	**2.39**	**23.9**	**0.31**	**22.3**	**0.50**	**22.2**	**0.45**
0.3 mm (No. 50)	16.3	2.01	18.1	0.26	16.8	0.43	16.3	0.66
0.15 mm (No. 100)	**8.8**	**1.29**	**9.4**	**0.46**	**9.1**	**0.23**	**7.9**	**0.69**
0.075 mm (No. 200)	*5.90*	*0.84*	*5.78*	*0.68*	*6.02*	*0.08*	*4.68*	*0.56*

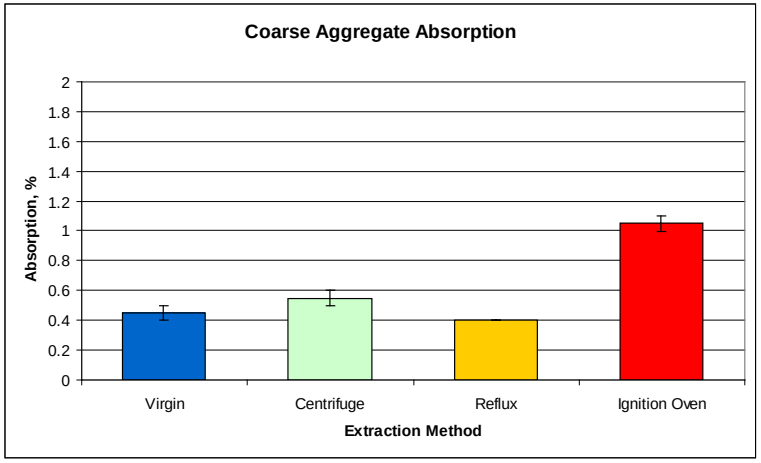
Specific Gravity and Abs. of Coarse Calera Limestone

ARC







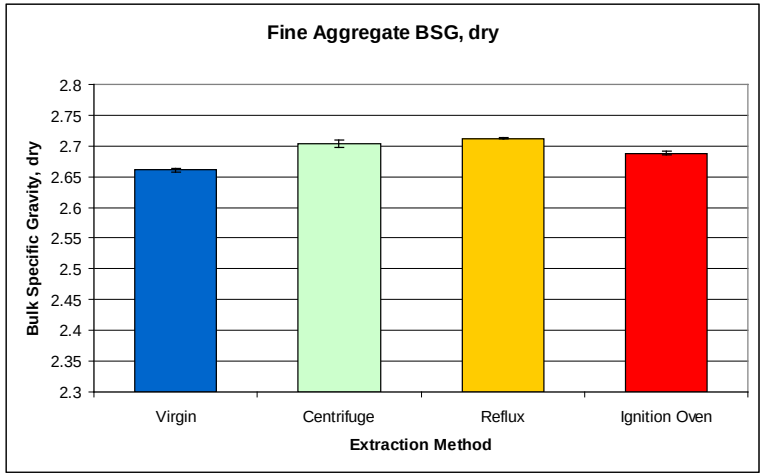


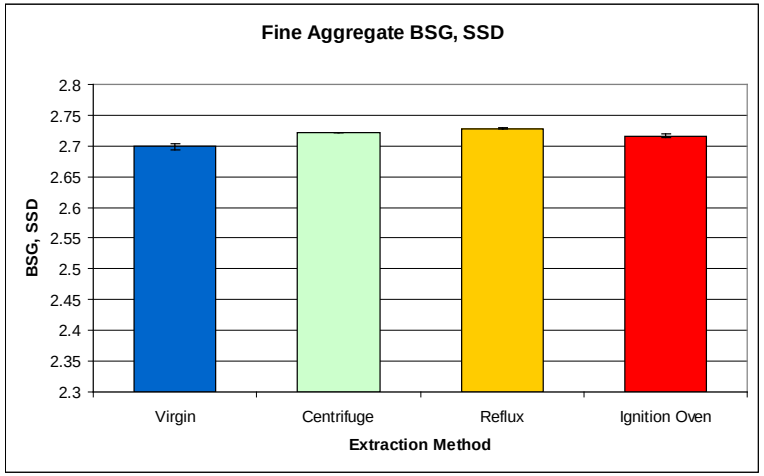
WESTERN REGIONAL CENTER SuperPave

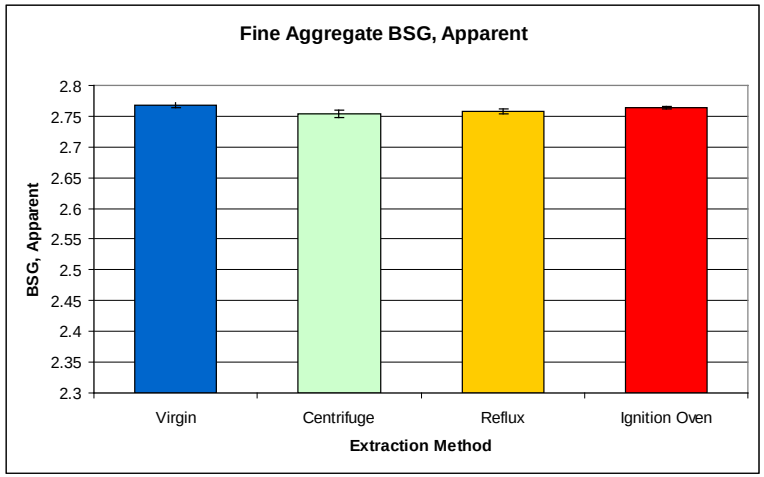
University of Nevada, Reno
Statewide • Worldwide

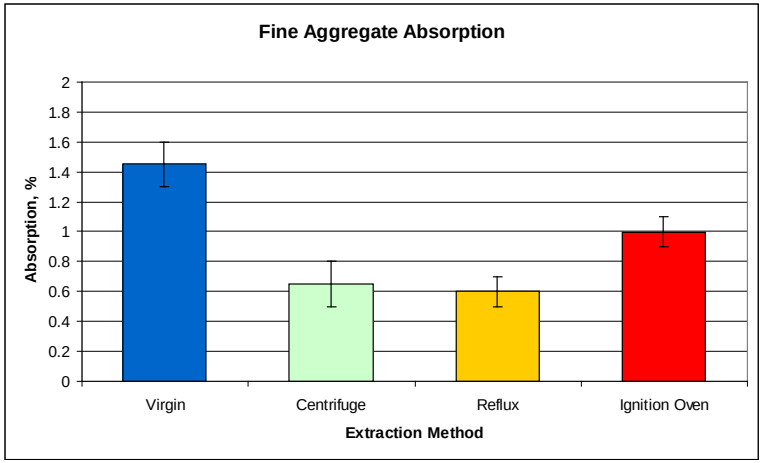
Spec. Grav. & Abs. of Fine Calera Limestone

ARC



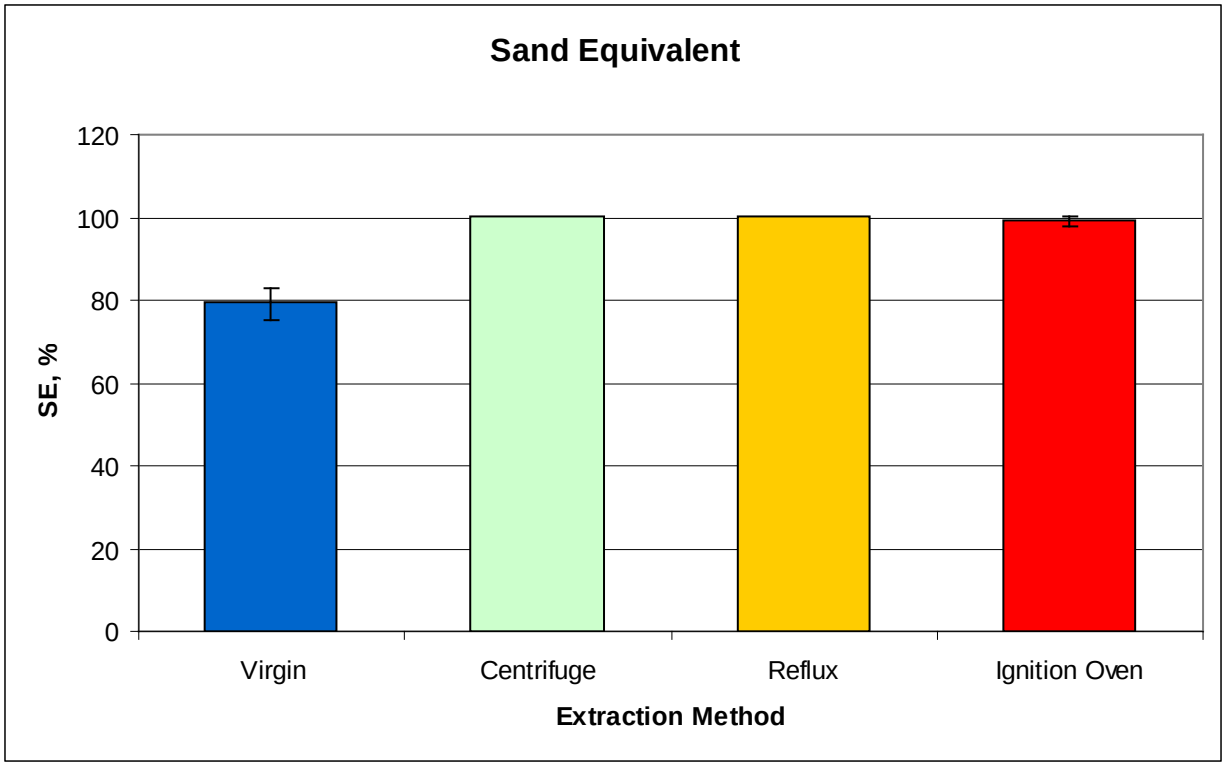






Sand Equivalent & LA Abrasion
Calera Limestone
AASHTO T176 & T96

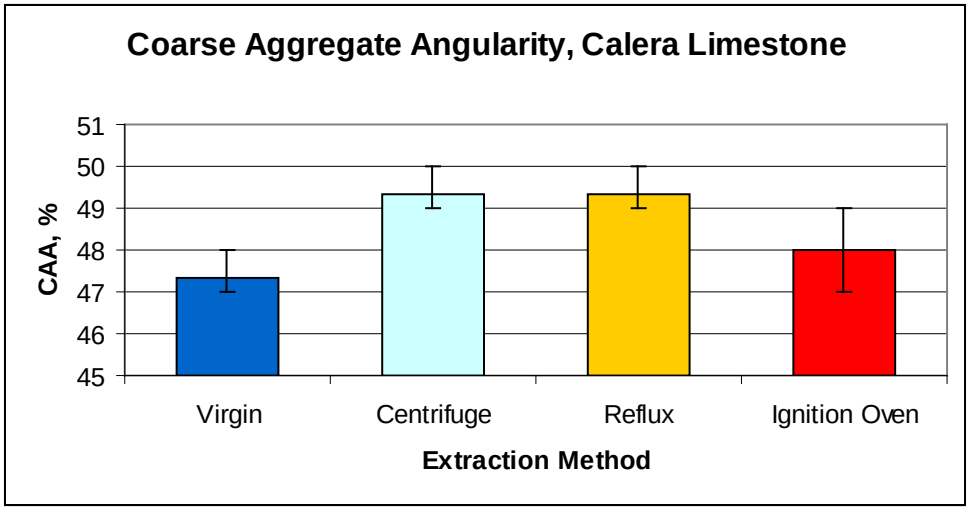
ARC

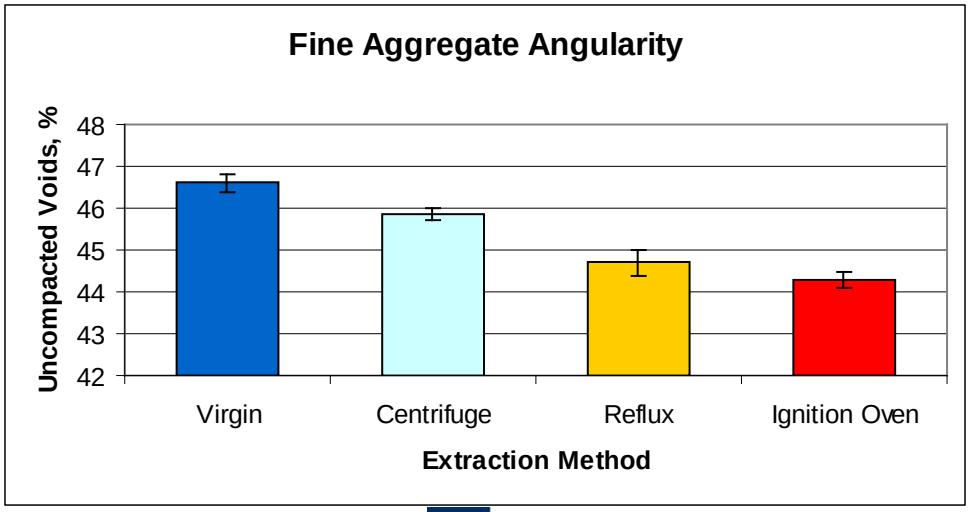


Coarse & Fine Aggregate Angularity

ASTM D5821 & AASHTO T304 - Method A

ARC

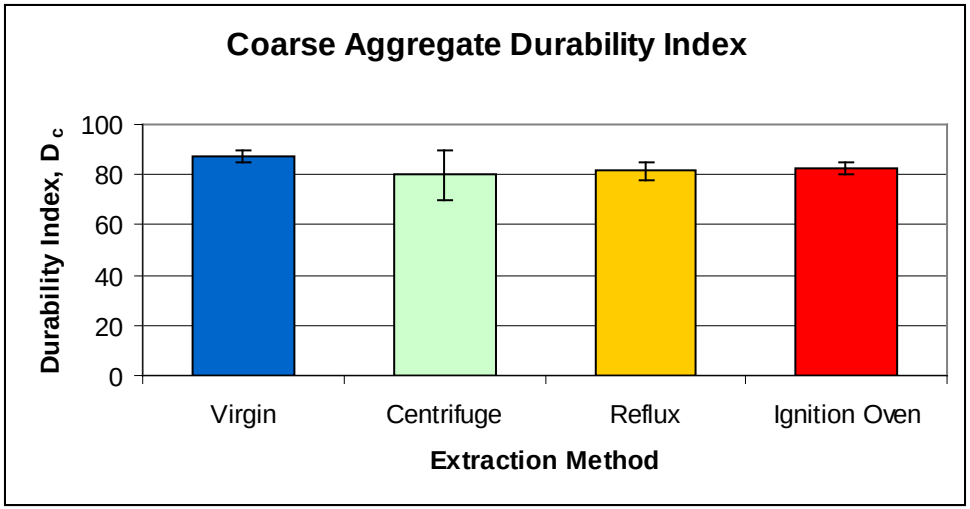




Durability Index Calera Limestone

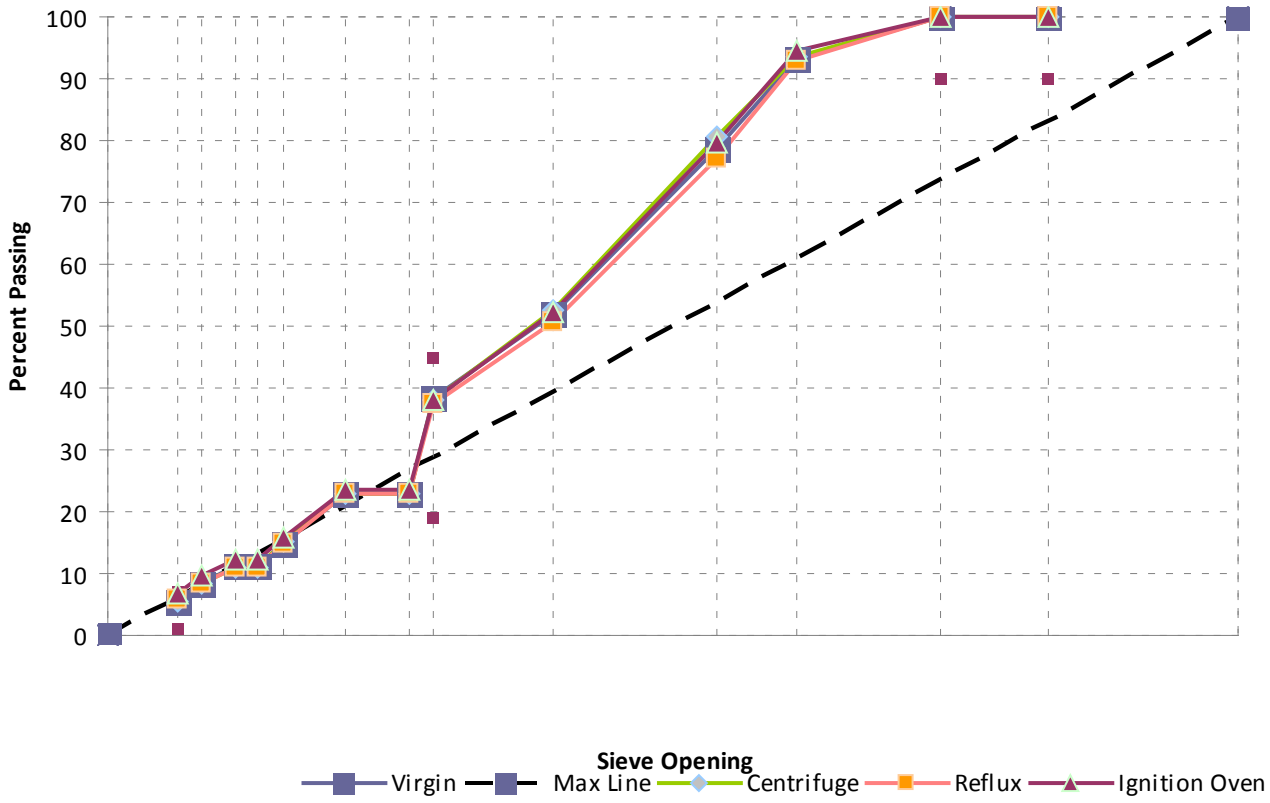
AASHTO T210

ARC



Gradation

ARC

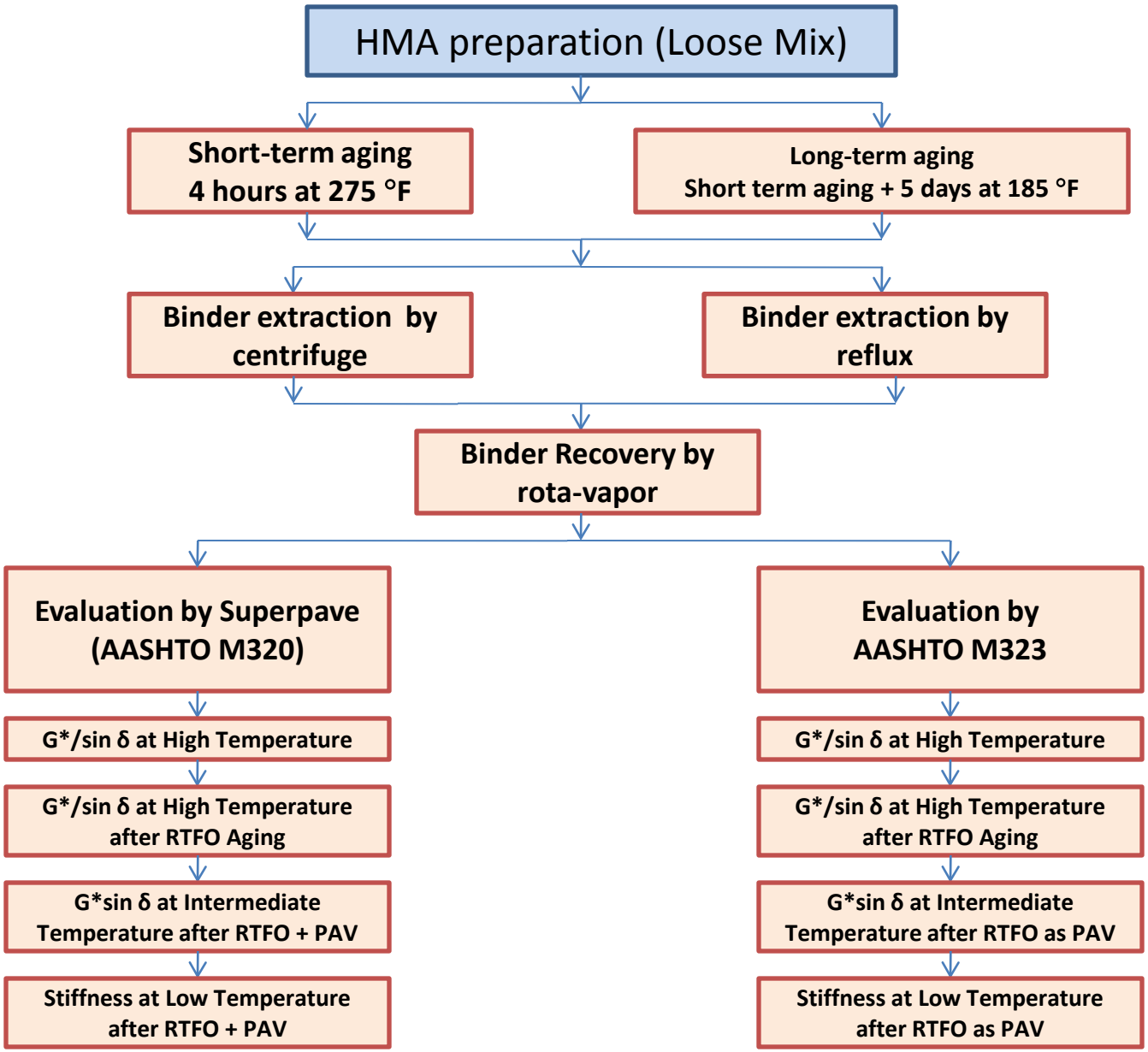


Gradation Calera Limestone

ARC

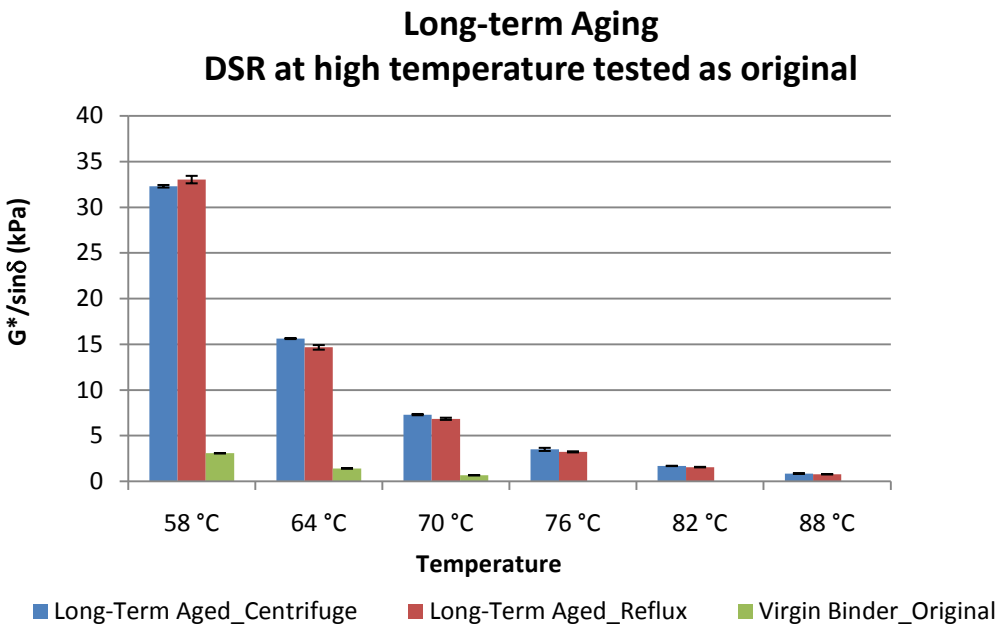
Sieve Size	Virgin		Centrifuge		Reflux		Ignition Oven	
	Average % Passing	Std Deviation	Average % Passing	Std Deviation	Average % Passing	Std Deviation	Average % Passing	Std Deviation
25.0 mm (1")	100.0	0.00	100.0	0.00	100.0	0.00	100.0	0.00
19.0 mm (3/4")	100.0	0.00	100.0	0.00	100.0	0.00	100.0	0.00
12.5 mm (1/2")	93.2	0.31	93.6	1.12	92.9	1.49	94.4	0.89
9.5 mm (3/8")	78.9	0.36	80.5	0.26	77.2	2.44	79.8	1.52
4.75 mm (No. 4)	52.1	0.10	52.5	0.78	50.6	2.11	52.3	0.35
2.36 mm (No. 8)	38.4	0.09	38.1	0.05	37.3	1.01	38.2	0.28
2.00 mm (No. 10)	22.9	0.07	23.0	0.08	22.8	0.55	23.5	0.36
1.18 mm (No. 16)	22.9	0.07	23.0	0.08	22.8	0.55	23.5	0.36
0.6 mm (No. 30)	14.8	0.14	15.1	0.08	15.0	0.42	15.9	0.33
0.425 mm (No. 40)	11.1	0.04	11.1	0.10	11.0	0.32	12.2	0.33
0.3 mm (No. 50)	11.1	0.04	11.1	0.10	11.0	0.32	12.2	0.33
0.15 mm (No. 100)	8.5	0.01	8.3	0.21	8.4	0.22	9.6	0.39
0.075 mm (No. 200)	5.44	0.02	5.41	0.31	5.67	0.17	6.75	0.63

Binder Evaluation



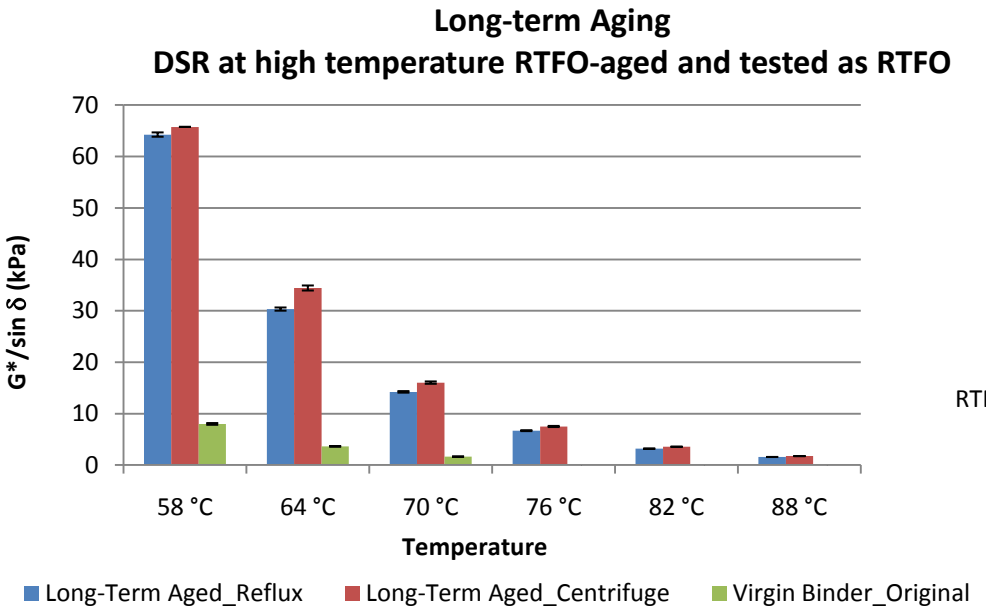
Binder Evaluation (PG64-22)

DSR at High Temperature



Binder Evaluation (PG64-22)

DSR at High Temperature after RTFO

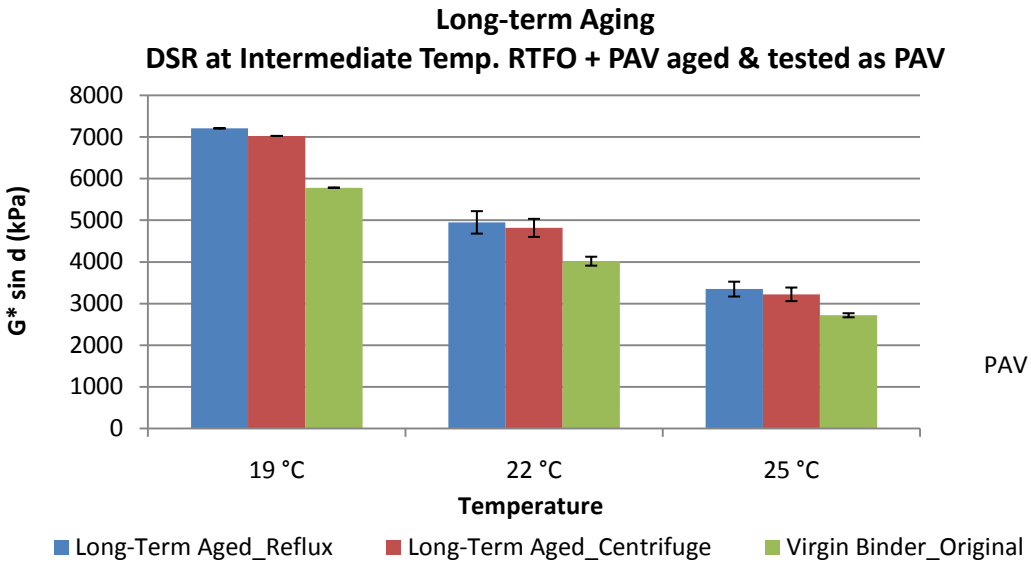


RTFO

RTFO

Binder Evaluation (PG64-22)

DSR at Intermediate Temperature after RTFO + PAV (SUPERPAVE)

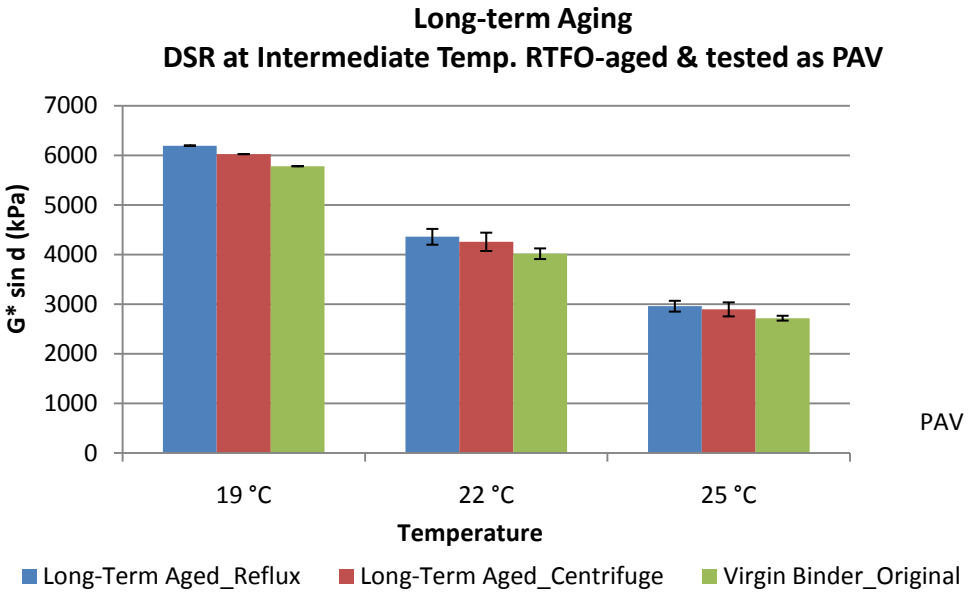


PAV

PAV

Binder Evaluation (PG64-22)

DSR at Intermediate Temperature after RTFO (AASHTO M323)

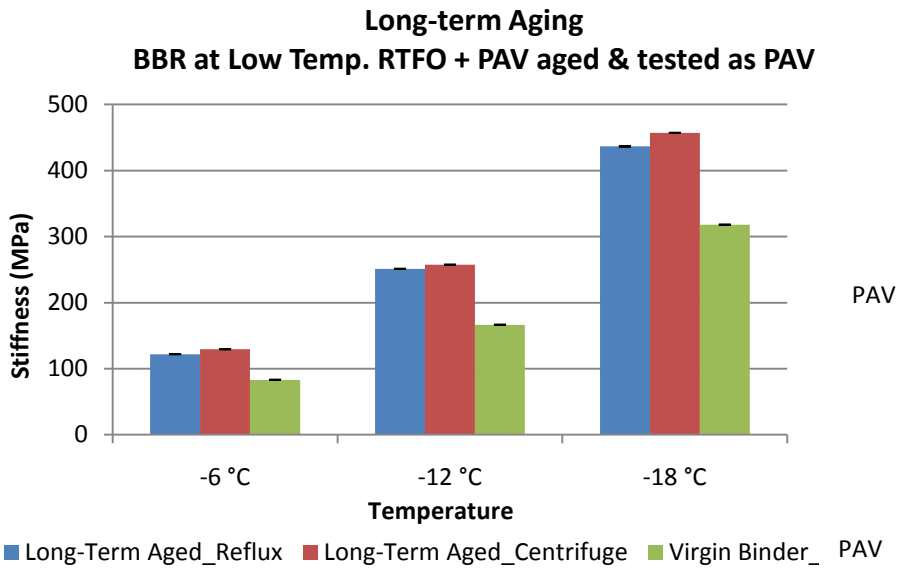


PAV

PAV

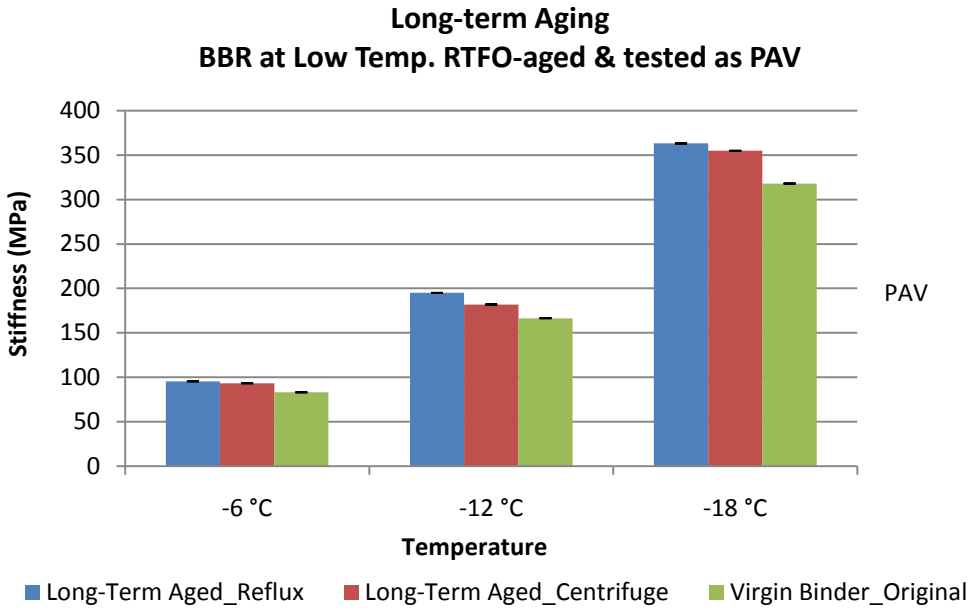
Binder Evaluation (PG64-22)

BBR at Low Temperature after RTFO + PAV (Superpave)



Binder Evaluation (PG64-22)

BBR at Low Temperature after RTFO (AASHTO M323)



PAV

PAV