1 APPENDICE

1.1 ZETA POTENTIAL TEST RESULT

1.1.1 EMULSION

CRS-2P

Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Aug 27, 2010
Time: 00:14:14
Batch: 0

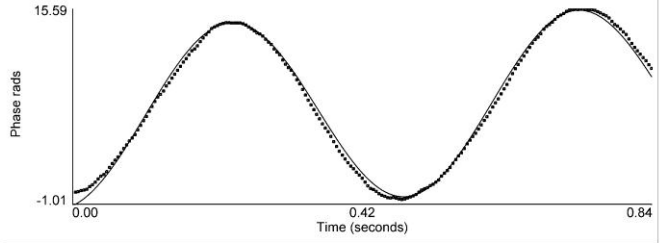
Sample ID **CRS pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:

Mean Zeta Potential	= 73.72 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= 5.76 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 6079 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 100.0 nm

Instrument Parameters:

Sample Count Rate	= 217 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 511 kcps	Electric Field	= 7.70 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 5e-02		



CRS pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	5.55	71.00	0.0437
2	6.02	77.04	0.0392
3	5.84	74.77	0.0473
4	6.05	77.47	0.0321
5	5.49	70.28	0.0439
6	6.07	77.75	0.0442
7	5.39	69.00	0.0454
8	5.93	75.85	0.0484
9	5.33	68.24	0.0479
10	5.92	75.77	0.0282
Mean	5.76	73.72	0.0420
Std. Error	0.09	1.17	0.0022
Combined	5.75	73.62	0.0262

RS-2P

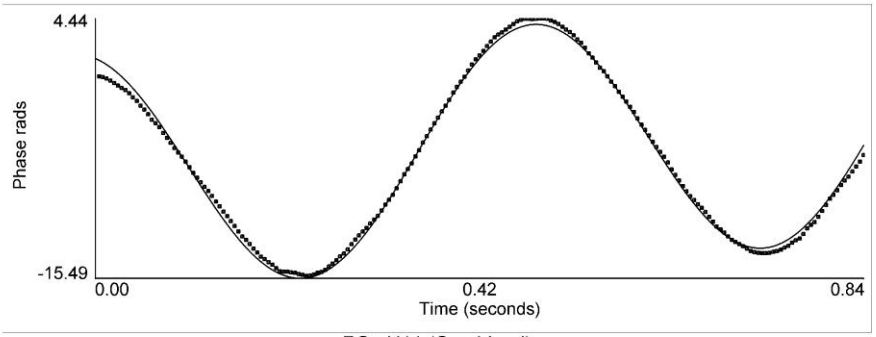
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Aug 27, 2010
Time: 00:00:20
Batch: 0

Sample ID **RS pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -92.51 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -7.23 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 591 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 100.0 nm

Instrument Parameters:			
Sample Count Rate	= 199 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 496 kcps	Electric Field	= 7.33 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 5e-02		



RS pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-6.73	-86.16	0.0489
2	-7.28	-93.12	0.0484
3	-6.06	-77.50	0.0413
4	-8.17	-104.63	0.0342
5	-7.44	-95.19	0.0493
6	-7.70	-98.54	0.0352
7	-6.56	-84.01	0.0461
8	-8.05	-103.01	0.0407
9	-6.29	-80.56	0.0494
10	-8.00	-102.40	0.0431
Mean	-7.23	-92.51	0.0436
Std. Error	0.24	3.13	0.0018
Combined	-7.22	-92.46	0.0280

AE-90S

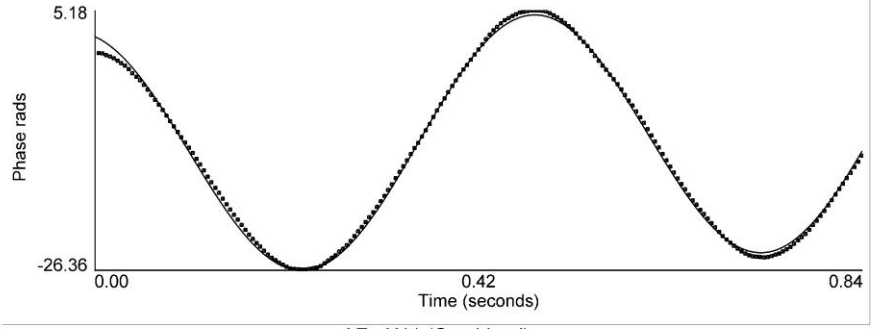
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Aug 26, 2010
Time: 23:13:48
Batch: 0

Sample ID **AE pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -145.92 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -11.40 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 621 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 100.0 nm

Instrument Parameters:			
Sample Count Rate	= 301 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 696 kcps	Electric Field	= 7.59 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 5e-02		



AE pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-11.70	-149.80	0.0603
2	-11.55	-147.78	0.0499
3	-10.14	-129.76	0.0499
4	-12.84	-164.38	0.0676
5	-10.73	-137.38	0.0471
6	-11.74	-150.27	0.0430
7	-11.80	-151.02	0.0379
8	-12.20	-156.20	0.0447
9	-12.48	-159.66	0.0496
10	-8.82	-112.91	0.0495
Mean	-11.40	-145.92	0.0500
Std. Error	0.38	4.86	0.0027
Combined	-11.40	-145.87	0.0330

1.1.2 AGGREGATE

CRUSHED GRAVEL WITH TWO FACES

Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 23, 2010
Time: 13:18:20
Batch: 0

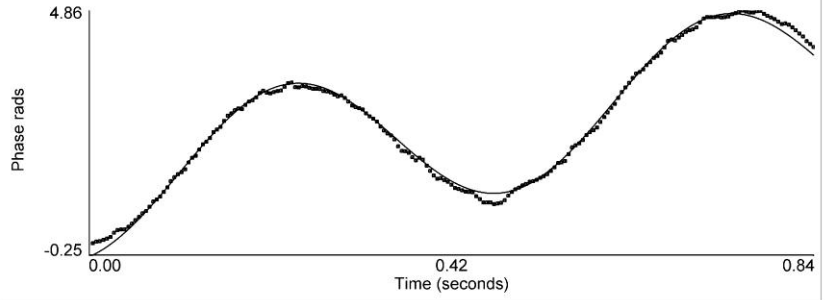
Sample ID **#11 CG pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:

Mean Zeta Potential	= 16.57 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= 1.29 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 6644 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:

Sample Count Rate	= 135 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 549 kcps	Electric Field	= 6.73 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



#11 CG pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	1.32	16.85	0.0197
2	1.20	15.39	0.0194
3	1.30	16.67	0.0195
4	1.41	18.09	0.0180
5	1.56	19.91	0.0186
6	1.12	14.38	0.0154
7	1.10	14.06	0.0177
8	1.44	18.47	0.0200
9	1.25	16.05	0.0188
10	1.23	15.80	0.0185
Mean	1.29	16.57	0.0186
Std. Error	0.05	0.58	0.0004
Combined	1.29	16.45	0.0064

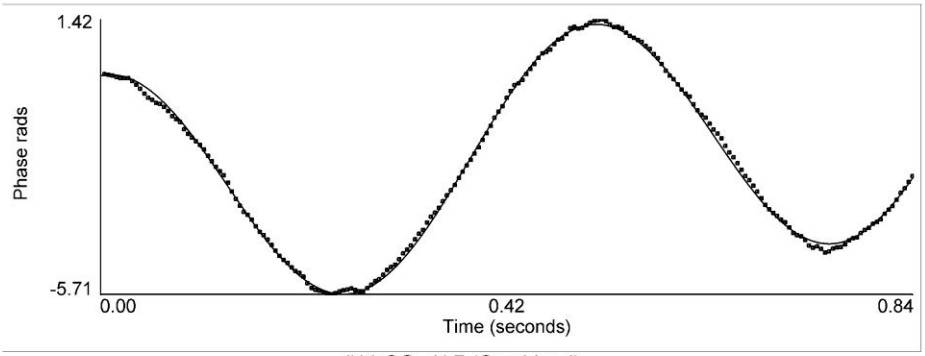
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 21, 2010
Time: 01:59:01
Batch: 0

Sample ID **#11 CG pH 7 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -24.59 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.92 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 7.00	Refractive Index	= 1.330
Conductance	= 27 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 207 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 488 kcps	Electric Field	= 9.58 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



#11 CG pH 7 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-1.87	-23.98	0.0196
2	-2.19	-27.99	0.0198
3	-1.74	-22.32	0.0199
4	-1.84	-23.54	0.0179
5	-1.77	-22.68	0.0200
6	-2.00	-25.64	0.0197
7	-1.59	-20.32	0.0197
8	-2.31	-29.57	0.0195
9	-2.07	-26.55	0.0188
10	-1.82	-23.29	0.0194
Mean	-1.92	-24.59	0.0194
Std. Error	0.07	0.89	0.0002
Combined	-1.91	-24.47	0.0060

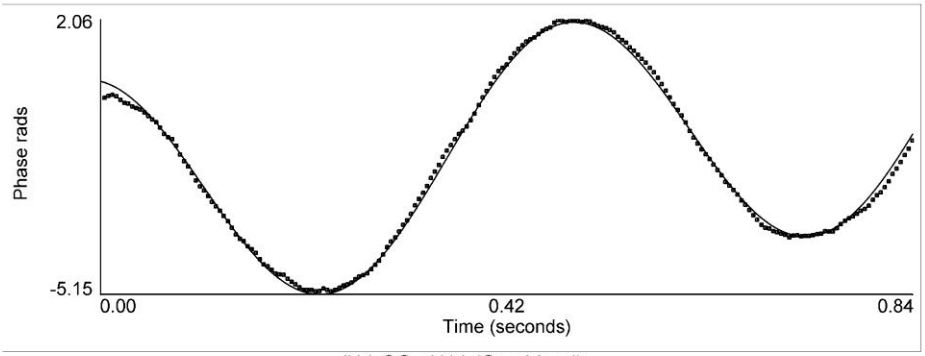
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Aug 1, 2010
Time: 03:28:27
Batch: 0

Sample ID **#11 CG pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -32.14 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -2.51 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 416 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 249 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 519 kcps	Electric Field	= 7.34 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



#11 CG pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-2.59	-33.16	0.0174
2	-2.60	-33.28	0.0198
3	-2.70	-34.56	0.0145
4	-2.68	-34.25	0.0181
5	-2.49	-31.89	0.0181
6	-2.47	-31.62	0.0179
7	-2.00	-25.56	0.0157
8	-2.60	-33.30	0.0198
9	-2.59	-33.20	0.0186
10	-2.39	-30.56	0.0180
Mean	-2.51	-32.14	0.0178
Std. Error	0.06	0.83	0.0005
Combined	-2.51	-32.08	0.0081

BLAST FURNACE

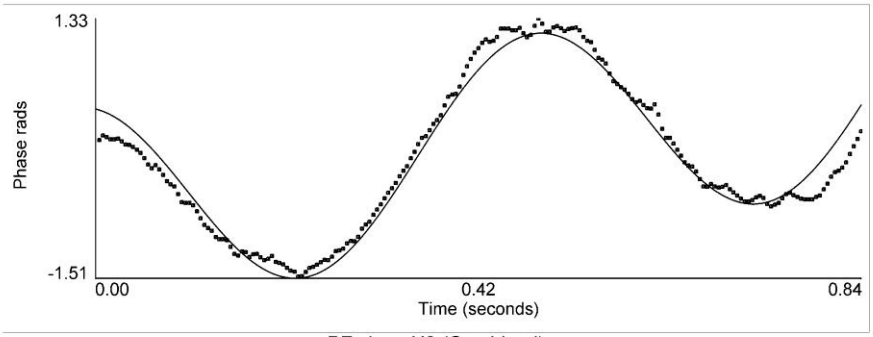
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 23, 2010
Time: 10:53:03
Batch: 0

Sample ID **BF slag pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -12.87 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.01 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 4979 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 278 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 675 kcps	Electric Field	= 6.65 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



BF slag pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-0.94	-11.99	0.0199
2	-0.76	-9.69	0.0169
3	-0.94	-12.05	0.0199
4	-1.04	-13.37	0.0190
5	-1.25	-16.06	0.0165
6	-0.92	-11.83	0.0191
7	-1.00	-12.77	0.0195
8	-0.69	-8.78	0.0193
9	-1.13	-14.50	0.0185
10	-1.38	-17.67	0.0196
Mean	-1.01	-12.87	0.0188
Std. Error	0.07	0.85	0.0004
Combined	-0.98	-12.55	0.0104

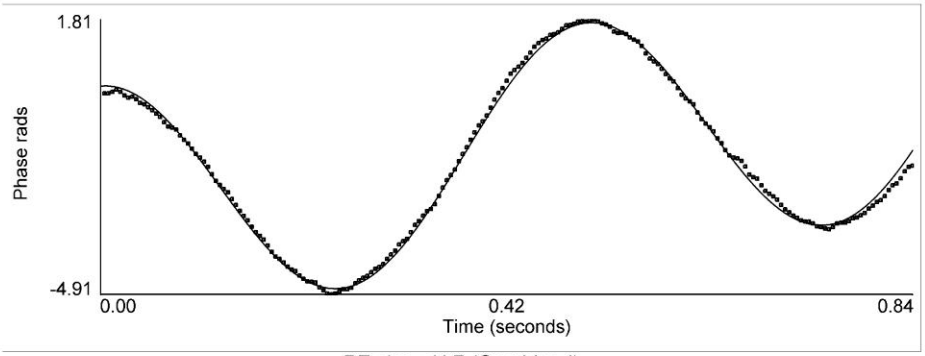
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 21, 2010
Time: 00:38:29
Batch: 0

Sample ID **BF slag pH 7 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -21.46 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.68 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 7.00	Refractive Index	= 1.330
Conductance	= 21 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 223 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 473 kcps	Electric Field	= 9.86 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



BF slag pH 7 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-1.57	-20.06	0.0168
2	-1.92	-24.59	0.0190
3	-1.74	-22.27	0.0132
4	-1.86	-23.77	0.0195
5	-1.54	-19.67	0.0195
6	-1.56	-19.99	0.0199
7	-1.70	-21.81	0.0146
8	-1.29	-16.46	0.0192
9	-1.94	-24.79	0.0180
10	-1.66	-21.22	0.0173
Mean	-1.68	-21.46	0.0177
Std. Error	0.06	0.81	0.0007
Combined	-1.67	-21.43	0.0075

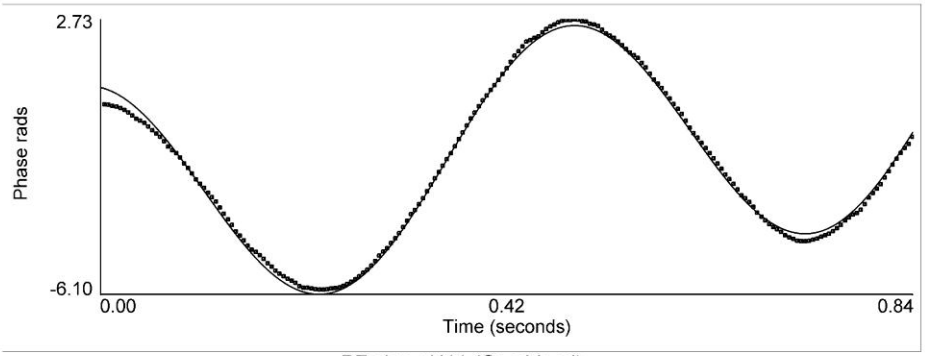
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 31, 2010
Time: 15:54:32
Batch: 0

Sample ID **BF slag pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -37.99 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -2.97 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 421 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 254 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 552 kcps	Electric Field	= 7.45 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



BF slag pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-3.04	-38.87	0.0270
2	-2.34	-29.92	0.0175
3	-3.07	-39.35	0.0225
4	-3.14	-40.23	0.0200
5	-2.99	-38.30	0.0199
6	-3.07	-39.26	0.0177
7	-3.22	-41.16	0.0160
8	-3.15	-40.37	0.0190
9	-2.73	-34.99	0.0194
10	-2.93	-37.44	0.0194
Mean	-2.97	-37.99	0.0198
Std. Error	0.08	1.05	0.0010
Combined	-2.97	-37.96	0.0108

CRUSHED GRAVEL WITH ONE FACE

Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 23, 2010
Time: 02:04:35
Batch: 0

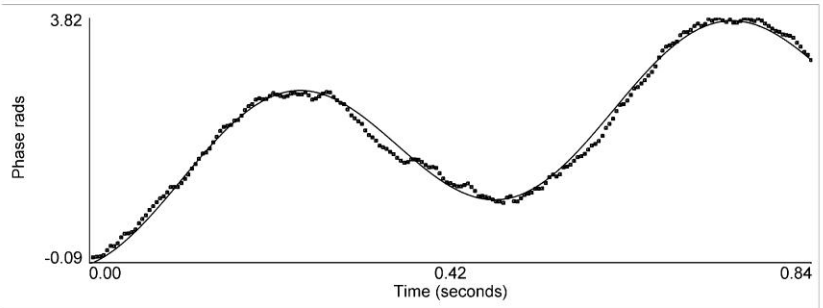
Sample ID **CA16 CG pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:

Mean Zeta Potential	= 12.88 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= 1.01 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 7663 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:

Sample Count Rate	= 208 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 483 kcps	Electric Field	= 6.63 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



CA16 CG pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	0.67	8.52	0.0190
2	1.02	13.00	0.0198
3	1.15	14.70	0.0183
4	1.30	16.60	0.0149
5	1.15	14.68	0.0180
6	0.80	10.24	0.0195
7	1.15	14.67	0.0183
8	1.02	13.09	0.0181
9	0.86	10.98	0.0179
10	0.96	12.32	0.0198
Mean	1.01	12.88	0.0184
Std. Error	0.06	0.77	0.0005
Combined	0.99	12.71	0.0064

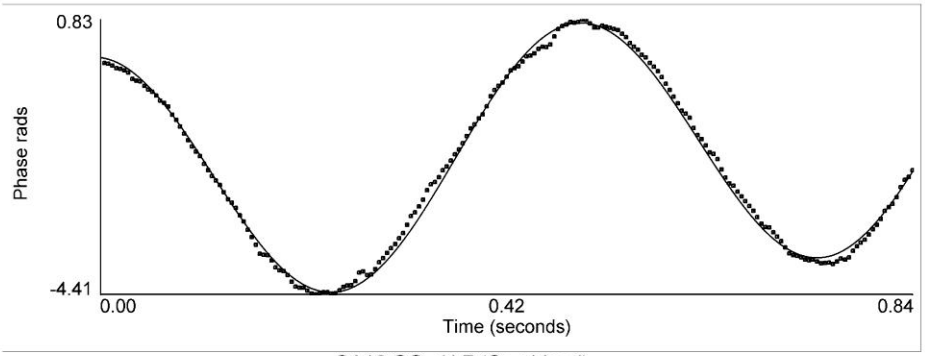
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 21, 2010
Time: 02:41:18
Batch: 0

Sample ID **CA16 CG pH 7 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -19.32 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.51 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 7.00	Refractive Index	= 1.330
Conductance	= 40 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 193 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 520 kcps	Electric Field	= 9.24 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



CA16 CG pH 7 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-1.44	-18.48	0.0190
2	-1.86	-23.81	0.0199
3	-1.28	-16.45	0.0188
4	-1.39	-17.82	0.0176
5	-1.46	-18.62	0.0169
6	-1.64	-21.02	0.0181
7	-1.74	-22.31	0.0173
8	-1.36	-17.40	0.0198
9	-1.48	-18.91	0.0159
10	-1.44	-18.42	0.0199
Mean	-1.51	-19.32	0.0183
Std. Error	0.06	0.73	0.0004
Combined	-1.51	-19.26	0.0074

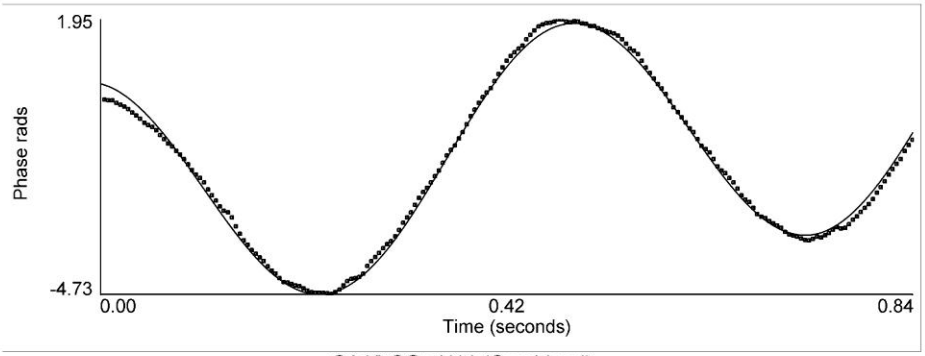
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Aug 2, 2010
Time: 01:47:39
Batch: 0

Sample ID **CA16 CG pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -29.67 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -2.32 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 414 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 164 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 490 kcps	Electric Field	= 7.31 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



CA16 CG pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-2.18	-27.93	0.0193
2	-1.73	-22.15	0.0200
3	-2.37	-30.32	0.0192
4	-2.21	-28.22	0.0200
5	-2.37	-30.33	0.0193
6	-2.11	-26.95	0.0186
7	-2.68	-34.27	0.0189
8	-2.63	-33.63	0.0196
9	-2.65	-33.94	0.0198
10	-2.26	-28.92	0.0198
Mean	-2.32	-29.67	0.0194
Std. Error	0.09	1.18	0.0002
Combined	-2.31	-29.61	0.0088

DOLOMITE

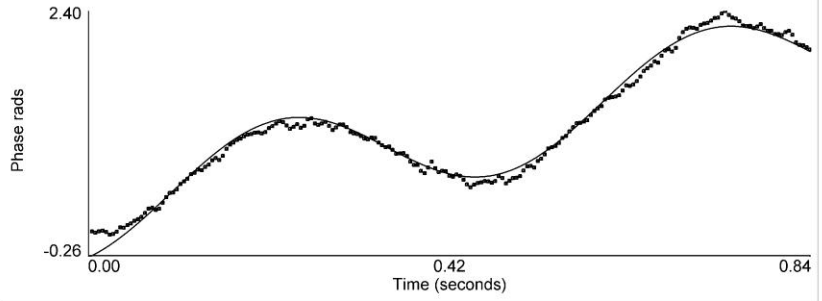
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 23, 2010
Time: 00:04:55
Batch: 0

Sample ID **Dolomite pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= 6.62 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= 0.52 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 7176 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 87 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 545 kcps	Electric Field	= 6.69 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 1e-02		



Dolomite pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	0.54	6.95	0.0141
2	0.48	6.19	0.0149
3	0.56	7.15	0.0146
4	0.65	8.36	0.0138
5	0.36	4.66	0.0136
6	0.70	9.01	0.0149
7	0.75	9.55	0.0144
8	0.31	3.91	0.0123
9	0.60	7.66	0.0130
10	0.22	2.79	0.0148
Mean	0.52	6.62	0.0140
Std. Error	0.06	0.71	0.0003
Combined	0.48	6.09	0.0048

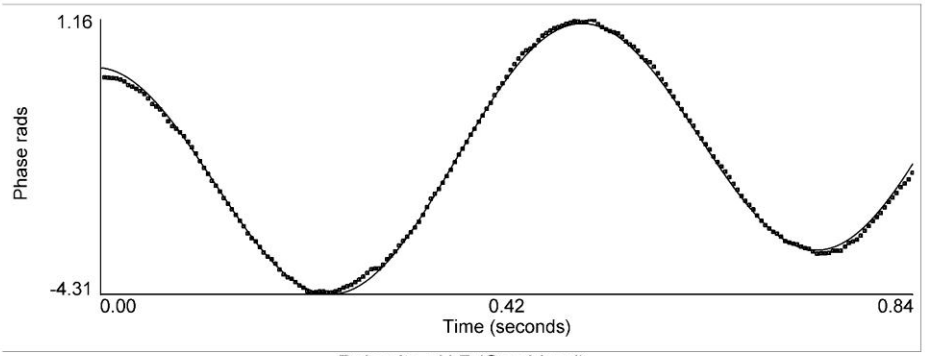
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 19, 2010
Time: 23:56:43
Batch: 0

Sample ID **Dolomite pH 7 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -19.17 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.50 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 7.00	Refractive Index	= 1.330
Conductance	= 35 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 203 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 541 kcps	Electric Field	= 9.54 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Cycles Per Run	= 20		



Dolomite pH 7 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-1.35	-17.33	0.0077
2	-1.55	-19.83	0.0091
3	-1.54	-19.69	0.0152
4	-1.40	-17.91	0.0113
5	-1.46	-18.64	0.0091
6	-1.39	-17.78	0.0178
7	-1.66	-21.22	0.0120
8	-1.57	-20.06	0.0235
9	-1.47	-18.75	0.0132
10	-1.60	-20.51	0.0121
Mean	-1.50	-19.17	0.0131
Std. Error	0.03	0.41	0.0015
Combined	-1.50	-19.15	0.0046

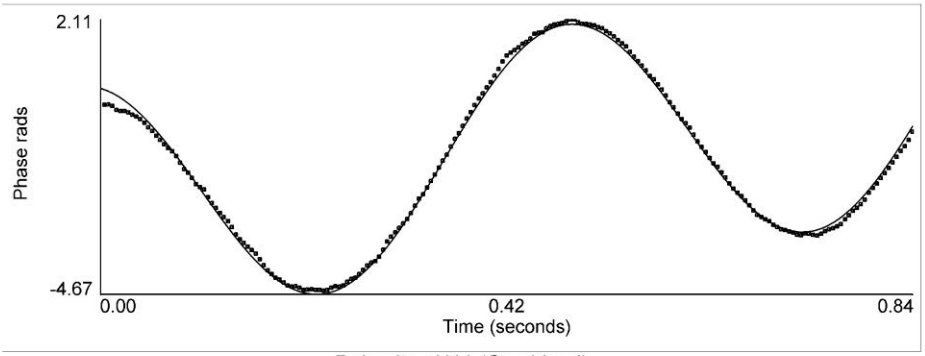
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 31, 2010
Time: 16:55:27
Batch: 0

Sample ID **Dolomite pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -29.61 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -2.31 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 403 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 225 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 511 kcps	Electric Field	= 7.35 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Dolomite pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-2.45	-31.39	0.0196
2	-2.35	-30.10	0.0196
3	-2.32	-29.68	0.0192
4	-2.05	-26.27	0.0188
5	-2.35	-30.12	0.0158
6	-2.22	-28.39	0.0159
7	-2.48	-31.80	0.0189
8	-2.38	-30.42	0.0172
9	-2.37	-30.33	0.0197
10	-2.16	-27.59	0.0160
Mean	-2.31	-29.61	0.0181
Std. Error	0.04	0.54	0.0005
Combined	-2.31	-29.56	0.0075

LIMESTONE

Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 23, 2010
Time: 14:19:59
Batch: 0

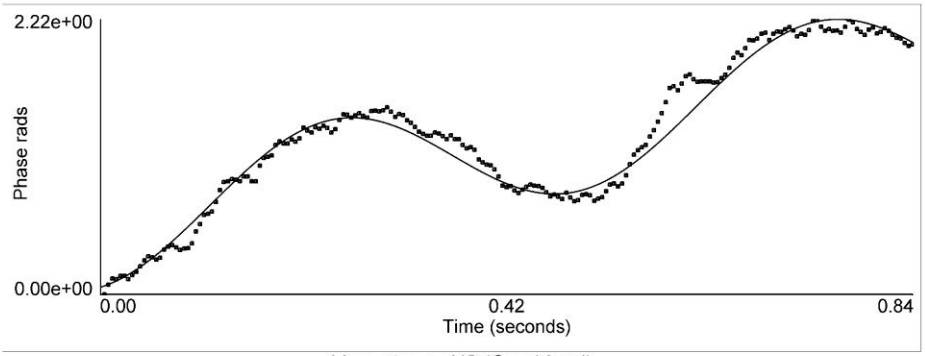
Sample ID **Lime stone pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:

Mean Zeta Potential	= 6.01 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= 0.47 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 4389 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:

Sample Count Rate	= 48 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 456 kcps	Electric Field	= 6.70 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Lime stone pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	0.74	9.43	0.0182
2	0.35	4.54	0.0199
3	0.29	3.69	0.0187
4	0.71	9.06	0.0197
5	0.37	4.76	0.0194
6	0.46	5.91	0.0187
7	0.45	5.73	0.0182
8	0.49	6.31	0.0179
9	0.52	6.66	0.0197
10	0.32	4.06	0.0185
Mean	0.47	6.01	0.0189
Std. Error	0.05	0.62	0.0002
Combined	0.42	5.42	0.0068

Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 20, 2010
Time: 01:33:11
Batch: 0

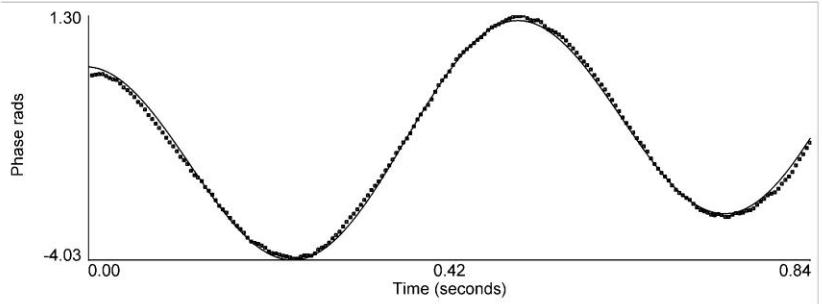
Sample ID **Lime Stone pH 7 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:

Mean Zeta Potential	= -19.71 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.54 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 7.00	Refractive Index	= 1.330
Conductance	= 74 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:

Sample Count Rate	= 196 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 519 kcps	Electric Field	= 8.86 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Cycles Per Run	= 20		



Lime Stone pH 7 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-1.51	-19.27	0.0104
2	-1.69	-21.68	0.0089
3	-1.50	-19.23	0.0169
4	-1.52	-19.45	0.0097
5	-1.57	-20.13	0.0137
6	-1.46	-18.75	0.0083
7	-1.58	-20.26	0.0189
8	-1.48	-18.93	0.0122
9	-1.59	-20.30	0.0105
10	-1.50	-19.14	0.0168
Mean	-1.54	-19.71	0.0126
Std. Error	0.02	0.28	0.0012
Combined	-1.54	-19.67	0.0056

Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 27, 2010
Time: 02:23:04
Batch: 0

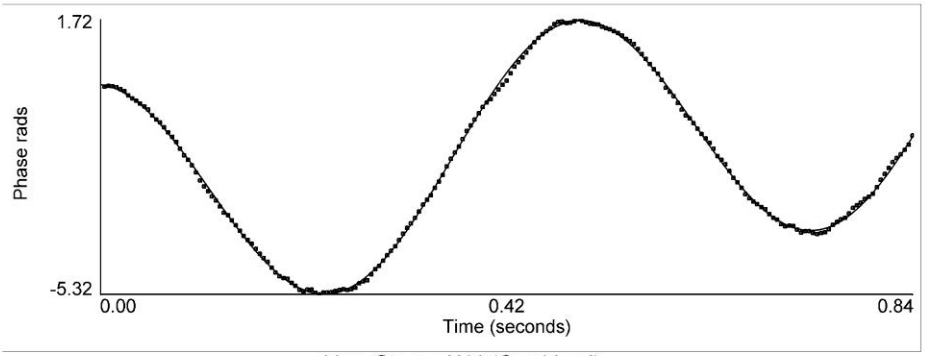
Sample ID **Lime Stone pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:

Mean Zeta Potential	= -30.63 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -2.39 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 370 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:

Sample Count Rate	= 219 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 548 kcps	Electric Field	= 7.46 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Lime Stone pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-2.12	-27.14	0.0191
2	-2.48	-31.68	0.0187
3	-2.23	-28.52	0.0190
4	-2.52	-32.26	0.0183
5	-2.67	-34.17	0.0192
6	-2.42	-30.92	0.0196
7	-2.48	-31.80	0.0182
8	-2.42	-31.01	0.0190
9	-2.64	-33.77	0.0193
10	-1.95	-25.01	0.0196
Mean	-2.39	-30.63	0.0190
Std. Error	0.07	0.92	0.0002
Combined	-2.39	-30.60	0.0039

SANDSTONE

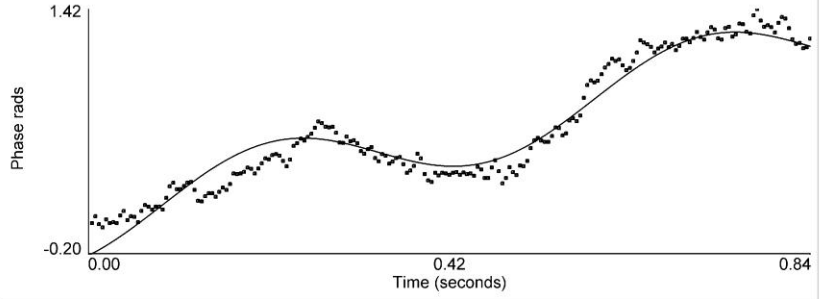
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 23, 2010
Time: 13:49:05
Batch: 0

Sample ID **Sand stone pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= 2.91 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= 0.23 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 7597 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 198 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 495 kcps	Electric Field	= 6.67 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Sand stone pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	4.52e-01	5.78e+00	0.0197
2	6.06e-01	7.75e+00	0.0146
3	4.37e-01	5.59e+00	0.0184
4	-6.98e-01	-8.94e+00	0.0189
5	-1.44e-01	-1.85e+00	0.0195
6	4.13e-01	5.29e+00	0.0180
7	3.63e-01	4.64e+00	0.0187
8	-9.53e-02	-1.22e+00	0.0183
9	4.68e-01	5.99e+00	0.0197
10	4.76e-01	6.09e+00	0.0197
Mean	2.28e-01	2.91e+00	0.0186
Std. Error	1.29e-01	1.66e+00	0.0005
Combined	2.10e-01	2.69e+00	0.0064

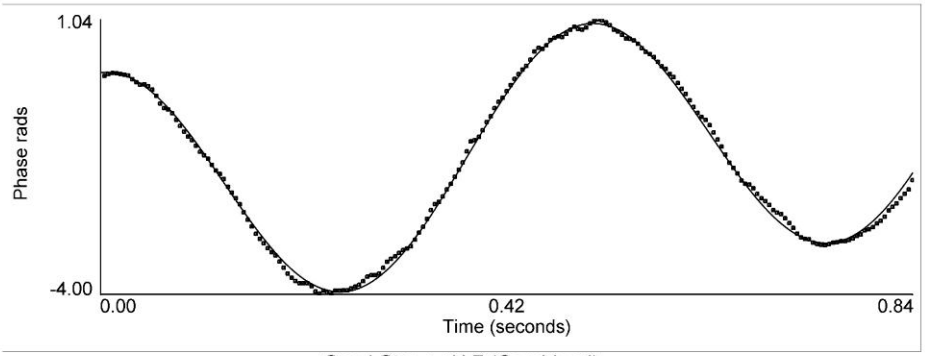
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 20, 2010
Time: 23:22:20
Batch: 0

Sample ID **Sand Stone pH 7 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -16.73 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.31 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 7.00	Refractive Index	= 1.330
Conductance	= 20 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 279 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 694 kcps	Electric Field	= 9.92 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Sand Stone pH 7 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-1.37	-17.48	0.0181
2	-1.23	-15.79	0.0174
3	-1.39	-17.78	0.0199
4	-1.17	-14.97	0.0182
5	-1.20	-15.37	0.0194
6	-1.29	-16.50	0.0157
7	-1.40	-17.97	0.0193
8	-1.38	-17.64	0.0167
9	-1.30	-16.61	0.0191
10	-1.34	-17.14	0.0181
Mean	-1.31	-16.73	0.0182
Std. Error	0.03	0.34	0.0004
Combined	-1.30	-16.67	0.0053

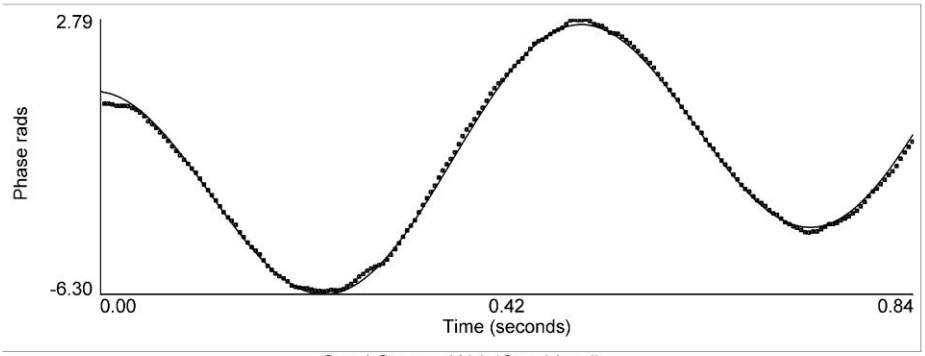
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 31, 2010
Time: 02:56:47
Batch: 0

Sample ID **Sand Stone pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -37.94 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -2.96 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 376 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 163 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 472 kcps	Electric Field	= 7.61 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Sand Stone pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-3.42	-43.82	0.0194
2	-2.84	-36.36	0.0185
3	-3.16	-40.49	0.0319
4	-3.08	-39.45	0.0196
5	-2.83	-36.28	0.0173
6	-2.69	-34.41	0.0186
7	-2.65	-33.91	0.0195
8	-2.96	-37.88	0.0179
9	-3.15	-40.35	0.0173
10	-2.85	-36.47	0.0191
Mean	-2.96	-37.94	0.0199
Std. Error	0.08	0.97	0.0014
Combined	-2.96	-37.86	0.0077

STEEL SLAG

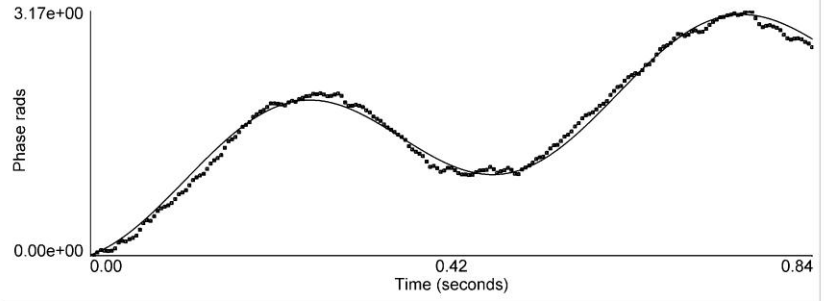
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 23, 2010
Time: 15:35:04
Batch: 0

Sample ID **Steel slag pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= 7.87 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= 0.62 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 6783 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 87 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 425 kcps	Electric Field	= 7.02 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 1e-02		



Steel slag pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	0.39	5.03	0.0149
2	0.77	9.88	0.0143
3	0.50	6.40	0.0143
4	0.52	6.71	0.0146
5	0.65	8.31	0.0149
6	0.68	8.71	0.0148
7	0.52	6.69	0.0139
8	0.84	10.76	0.0142
9	0.58	7.38	0.0149
10	0.69	8.83	0.0103
Mean	0.62	7.87	0.0141
Std. Error	0.04	0.55	0.0004
Combined	0.61	7.79	0.0053

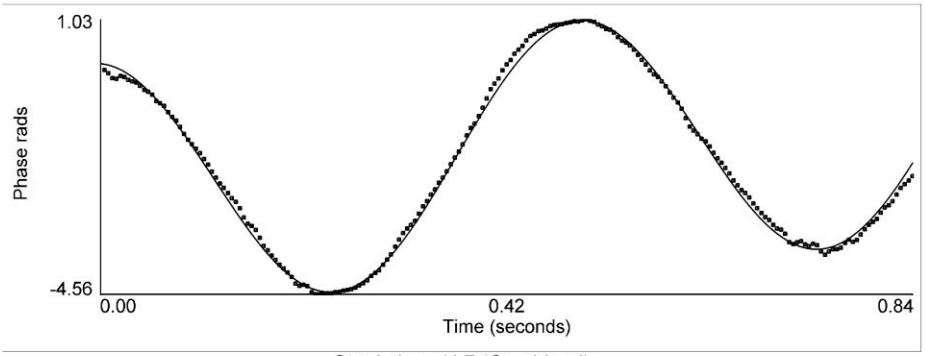
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 21, 2010
Time: 00:10:32
Batch: 0

Sample ID **Steel slag pH 7 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -21.21 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.66 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 7.00	Refractive Index	= 1.330
Conductance	= 61 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 192 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 518 kcps	Electric Field	= 8.89 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Steel slag pH 7 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-1.57	-20.16	0.0163
2	-1.56	-19.94	0.0189
3	-1.87	-23.99	0.0177
4	-1.75	-22.44	0.0160
5	-1.79	-22.92	0.0179
6	-1.66	-21.28	0.0193
7	-1.72	-21.95	0.0182
8	-1.43	-18.29	0.0194
9	-1.56	-19.91	0.0193
10	-1.66	-21.21	0.0172
Mean	-1.66	-21.21	0.0180
Std. Error	0.04	0.53	0.0004
Combined	-1.65	-21.15	0.0074

Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 27, 2010
Time: 03:24:28
Batch: 0

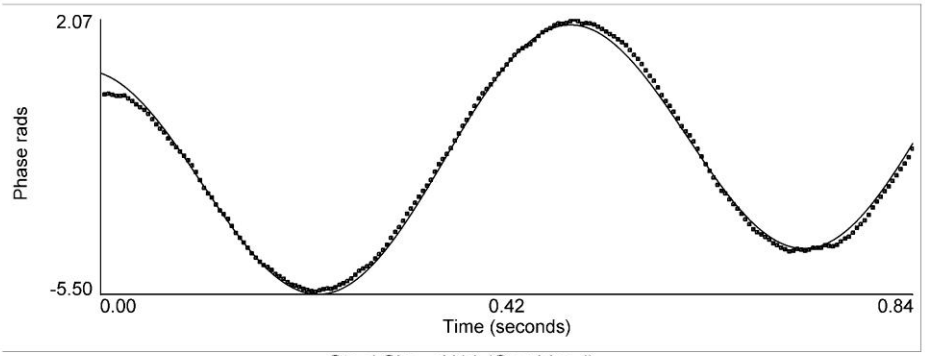
Sample ID **Steel Slag pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:

Mean Zeta Potential	= -33.50 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -2.62 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 546 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:

Sample Count Rate	= 198 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 540 kcps	Electric Field	= 7.50 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Steel Slag pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-2.49	-31.81	0.0179
2	-2.35	-30.03	0.0156
3	-2.26	-28.92	0.0189
4	-2.62	-33.50	0.0188
5	-2.91	-37.31	0.0180
6	-2.81	-35.95	0.0127
7	-2.66	-34.08	0.0177
8	-2.85	-36.45	0.0185
9	-2.48	-31.68	0.0198
10	-2.75	-35.24	0.0194
Mean	-2.62	-33.50	0.0177
Std. Error	0.07	0.89	0.0007
Combined	-2.62	-33.48	0.0098

TRAP ROCK

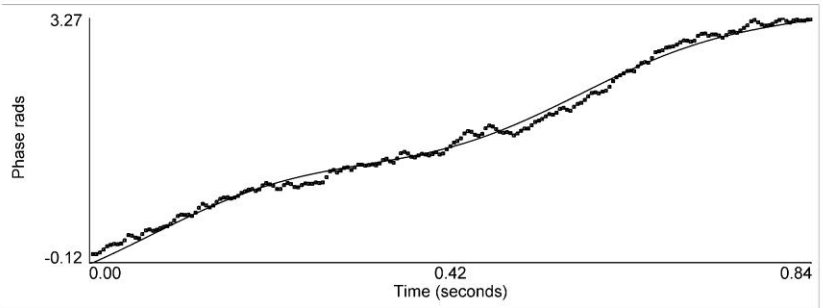
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 23, 2010
Time: 15:14:58
Batch: 0

Sample ID **Trap rock pH2 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= 2.01 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= 0.16 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 2.00	Refractive Index	= 1.330
Conductance	= 8458 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 169 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 491 kcps	Electric Field	= 6.73 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 1e-02		



Trap rock pH2 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	3.11e-01	3.98e+00	0.0135
2	3.01e-01	3.85e+00	0.0138
3	-1.20e-01	-1.54e+00	0.0149
4	4.28e-01	5.48e+00	0.0147
5	-2.98e-01	-3.81e+00	0.0139
6	-6.75e-02	-8.64e-01	0.0134
7	1.51e-01	1.93e+00	0.0148
8	5.70e-01	7.30e+00	0.0138
9	2.19e-01	2.81e+00	0.0141
10	7.93e-02	1.01e+00	0.0131
Mean	1.57e-01	2.01e+00	0.0140
Std. Error	8.38e-02	1.07e+00	0.0002
Combined	1.35e-01	1.73e+00	0.0053

Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 20, 2010
Time: 23:42:15
Batch: 0

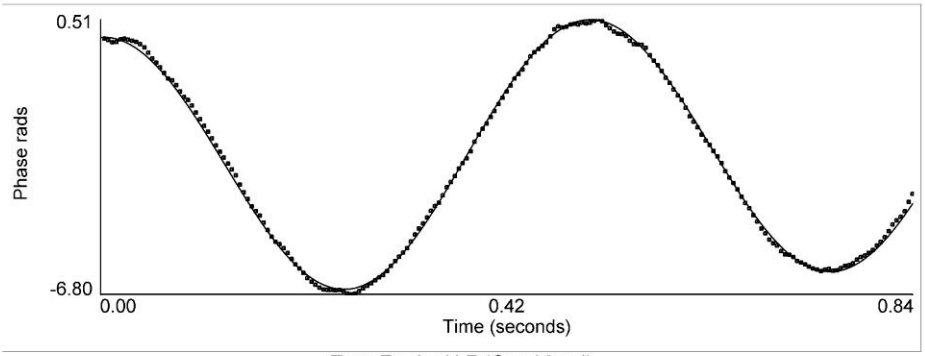
Sample ID **Trap Rock pH 7 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:

Mean Zeta Potential	= -24.67 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -1.93 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 7.00	Refractive Index	= 1.330
Conductance	= 7 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:

Sample Count Rate	= 219 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 604 kcps	Electric Field	= 10.43 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		



Trap Rock pH 7 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-1.85	-23.72	0.0190
2	-1.96	-25.09	0.0177
3	-1.97	-25.22	0.0164
4	-1.87	-23.95	0.0183
5	-2.10	-26.82	0.0194
6	-1.77	-22.69	0.0198
7	-1.77	-22.66	0.0170
8	-1.96	-25.11	0.0179
9	-2.14	-27.43	0.0183
10	-1.88	-24.03	0.0198
Mean	-1.93	-24.67	0.0184
Std. Error	0.04	0.50	0.0004
Combined	-1.92	-24.61	0.0060

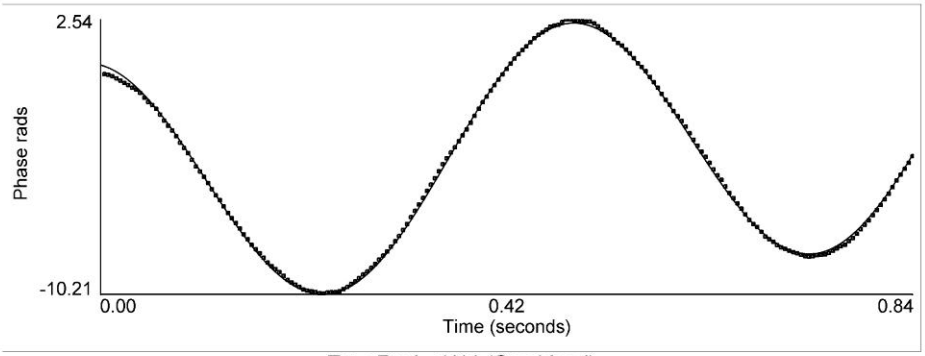
Brookhaven Instruments Corp.
PALS Zeta Potential Analyzer Ver. 3.29

Date: Jul 31, 2010
Time: 01:46:54
Batch: 0

Sample ID **Trap Rock pH11 (Combined)**
Operator ID **Daehwan**
Notes

Measurement Parameters:			
Mean Zeta Potential	= -56.03 mv	Liquid	= Aqueous
Zeta Potential Model	= Smoluchowski	Temperature	= 25.0 °C
Mean Mobility	= -4.38 (μ/s) / (V/cm)	Viscosity	= 0.890 cP
pH	= 11.00	Refractive Index	= 1.330
Conductance	= 359 μS	Dielectric Constant	= 78.54
Concentration	= 0.10 mg/mL	Particle Size	= 1000.0 nm

Instrument Parameters:			
Sample Count Rate	= 257 kcps	Voltage	= 4.00 volts
Ref. Count Rate	= 530 kcps	Electric Field	= 7.69 V/cm
Wavelength	= 659.0 nm	User1	= 0.00
Field Frequency	= 2.00 Hz	User2	= 0.00
Target Residual	= 2e-02		

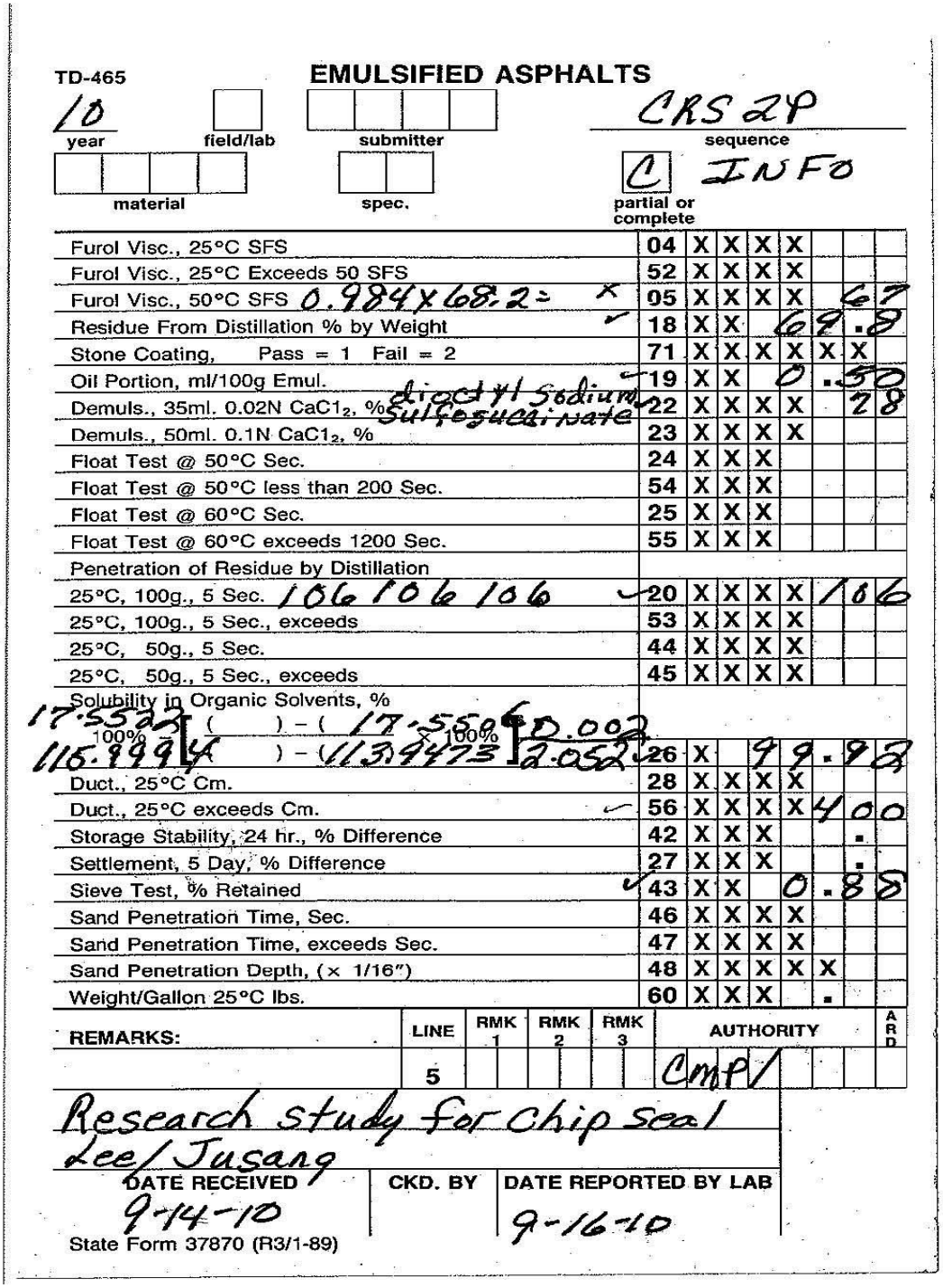


Trap Rock pH11 (Combined)

Run	Mobility	Zeta Potential (mV)	Rel. Residual
1	-4.10	-52.44	0.0192
2	-4.49	-57.47	0.0179
3	-4.55	-58.20	0.0183
4	-4.37	-55.93	0.0188
5	-4.23	-54.15	0.0156
6	-4.26	-54.55	0.0200
7	-4.12	-52.71	0.0200
8	-4.71	-60.33	0.0187
9	-4.31	-55.22	0.0194
10	-4.63	-59.27	0.0187
Mean	-4.38	-56.03	0.0187
Std. Error	0.07	0.86	0.0004
Combined	-4.37	-55.99	0.0076

1.2 EMULSION LAB TEST RESULTS

1.2.1 CRS-2P



TD-465

EMULSIFIED ASPHALTS

10 (year) | field/lab | submitter | CRS 2P (sequence)

material | spec. | C (partial or complete) INFO

Furol Visc., 25°C SFS	04	X	X	X	X			
Furol Visc., 25°C Exceeds 50 SFS	52	X	X	X	X			
Furol Visc., 50°C SFS 0.984 x 68.2 = x	05	X	X	X	X		67	
Residue From Distillation % by Weight ✓	18	X	X		69	.	8	
Stone Coating, Pass = 1 Fail = 2	71	X	X	X	X	X	X	
Oil Portion, ml/100g Emul. ✓	19	X	X		0	.	50	
Demuls., 35ml. 0.02N $CaCl_2$, % dioctyl sodium sulfosuccinate ✓	22	X	X	X	X		28	
Demuls., 50ml. 0.1N $CaCl_2$, %	23	X	X	X	X			
Float Test @ 50°C Sec.	24	X	X	X				
Float Test @ 50°C less than 200 Sec.	54	X	X	X				
Float Test @ 60°C Sec.	25	X	X	X				
Float Test @ 60°C exceeds 1200 Sec.	55	X	X	X				
Penetration of Residue by Distillation								
25°C, 100g., 5 Sec. 106 106 106 ✓	20	X	X	X	X	1	06	
25°C, 100g., 5 Sec., exceeds	53	X	X	X	X			
25°C, 50g., 5 Sec.	44	X	X	X	X			
25°C, 50g., 5 Sec., exceeds	45	X	X	X	X			
Solubility in Organic Solvents, %								
17.5522 / 100% [( ) − (17.5506 / x 100%] 0.002								
115.9994 [( ) − (113.9473] 2.052	26	X		99	.	92		
Duct., 25°C Cm.	28	X	X	X	X			
Duct., 25°C exceeds Cm. ✓	56	X	X	X	X	4	00	
Storage Stability, 24 hr., % Difference	42	X	X	X			.	
Settlement, 5 Day, % Difference	27	X	X	X			.	
Sieve Test, % Retained ✓	43	X	X		0	.	88	
Sand Penetration Time, Sec.	46	X	X	X	X			
Sand Penetration Time, exceeds Sec.	47	X	X	X	X			
Sand Penetration Depth, (× 1/16")	48	X	X	X	X	X		
Weight/Gallon 25°C lbs.	60	X	X	X		.		

REMARKS:	LINE	RMK 1	RMK 2	RMK 3	AUTHORITY	ARD
	5				CMP/	

Research study for Chip Seal
Lee/Jusang

DATE RECEIVED	CKD. BY	DATE REPORTED BY LAB
9-14-10		9-16-10

State Form 37870 (R3/1-89)

1.2.2 RS-2P

TD-465

EMULSIFIED ASPHALTS

year	field/lab	submitter	sequence
10			RS 2P

material	spec.	partial or complete
		C INFO

Furol Visc., 25°C SFS	04	X	X	X	X			
Furol Visc., 25°C Exceeds 50 SFS	52	X	X	X	X			
Furol Visc., 50°C SFS 0.999X55.7= ✓	05	X	X	X	X		.56	
Residue From Distillation % by Weight ✓	18	X	X			68	.8	
Stone Coating, Pass = 1 Fail = 2	71	X	X	X	X	X	X	
Oil Portion, ml/100g Emul. ✓	19	X	X		0	.50		
Demuls., 35ml. 0.02N $CaCl_2$, % ✓	22	X	X	X	X		28	
Demuls., 50ml. 0.1N $CaCl_2$, %	23	X	X	X	X			
Float Test @ 50°C Sec.	24	X	X	X				
Float Test @ 50°C less than 200 Sec.	54	X	X	X				
Float Test @ 60°C Sec.	25	X	X	X				
Float Test @ 60°C exceeds 1200 Sec.	55	X	X	X				
Penetration of Residue by Distillation								
25°C, 100g., 5 Sec. 107/106/104 ✓	20	X	X	X	X	106		
25°C, 100g., 5 Sec., exceeds	53	X	X	X	X			
25°C, 50g., 5 Sec.	44	X	X	X	X			
25°C, 50g., 5 Sec., exceeds	45	X	X	X	X			
Solubility in Organic Solvents, % 100% [17.0637 ( ) - (17.0617) / 122.7000 ( ) - (120.6339)] × 100% 0.002 / 2.065 ✓	26	X		99	.89			
Duct., 25°C Cm. ✓	28	X	X	X	X			
Duct., 25°C exceeds Cm. ✓	56	X	X	X	X	400		
Storage Stability, 24 hr., % Difference	42	X	X	X			.	
Settlement, 5 Day, % Difference	27	X	X	X			.	
Sieve Test, % Retained ✓	43	X	X		0	.07		
Sand Penetration Time, Sec.	46	X	X	X	X			
Sand Penetration Time, exceeds Sec.	47	X	X	X	X			
Sand Penetration Depth, (× 1/16")	48	X	X	X	X	X		
Weight/Gallon 25°C lbs.	60	X	X	X		.		

REMARKS:	LINE	RMK 1	RMK 2	RMK 3	AUTHORITY	ARD
	5				CmP/	

Research study for Chip seal
Lee Jusang

DATE RECEIVED	CKD. BY	DATE REPORTED BY LAB
9-14-10		9-16-10

State Form 37870 (R3/1-89)

1.2.3 AE-90S

TD-465

EMULSIFIED ASPHALTS

10 year | field/lab | submitter | CRS 2P sequence

material | spec. | C partial or complete INFO

Furol Visc., 25°C SFS	04	X	X	X	X			
Furol Visc., 25°C Exceeds 50 SFS	52	X	X	X	X			
Furol Visc., 50°C SFS 0.984 x 68.2 = x	05	X	X	X	X		67	
Residue From Distillation % by Weight ✓	18	X	X		69	.	8	
Stone Coating, Pass = 1 Fail = 2	71	X	X	X	X	X	X	
Oil Portion, ml/100g Emul. ✓	19	X	X		0	.	50	
Demuls., 35ml. 0.02N $CaCl_2$, % dioctyl sodium sulfosuccinate ✓	22	X	X	X	X		28	
Demuls., 50ml. 0.1N $CaCl_2$, %	23	X	X	X	X			
Float Test @ 50°C Sec.	24	X	X	X				
Float Test @ 50°C less than 200 Sec.	54	X	X	X				
Float Test @ 60°C Sec.	25	X	X	X				
Float Test @ 60°C exceeds 1200 Sec.	55	X	X	X				
Penetration of Residue by Distillation								
25°C, 100g., 5 Sec. 106 106 106 ✓	20	X	X	X	X	1	06	
25°C, 100g., 5 Sec., exceeds	53	X	X	X	X			
25°C, 50g., 5 Sec.	44	X	X	X	X			
25°C, 50g., 5 Sec., exceeds	45	X	X	X	X			
Solubility in Organic Solvents, % 100% = [17.5522 ( ) − (17.5506] x 100% 0.002 / [116.9994 ( ) − (113.9473] 2.052 ✓	26	X		99	.	92		
Duct., 25°C Cm.	28	X	X	X	X			
Duct., 25°C exceeds Cm. ✓	56	X	X	X	X	4	00	
Storage Stability, 24 hr., % Difference	42	X	X	X			.	
Settlement, 5 Day, % Difference	27	X	X	X			.	
Sieve Test, % Retained ✓	43	X	X		0	.	88	
Sand Penetration Time, Sec.	46	X	X	X	X			
Sand Penetration Time, exceeds Sec.	47	X	X	X	X			
Sand Penetration Depth, (× 1/16")	48	X	X	X	X	X		
Weight/Gallon 25°C lbs.	60	X	X	X		.		

REMARKS:	LINE	RMK 1	RMK 2	RMK 3	AUTHORITY	ARD
	5				CMP/	

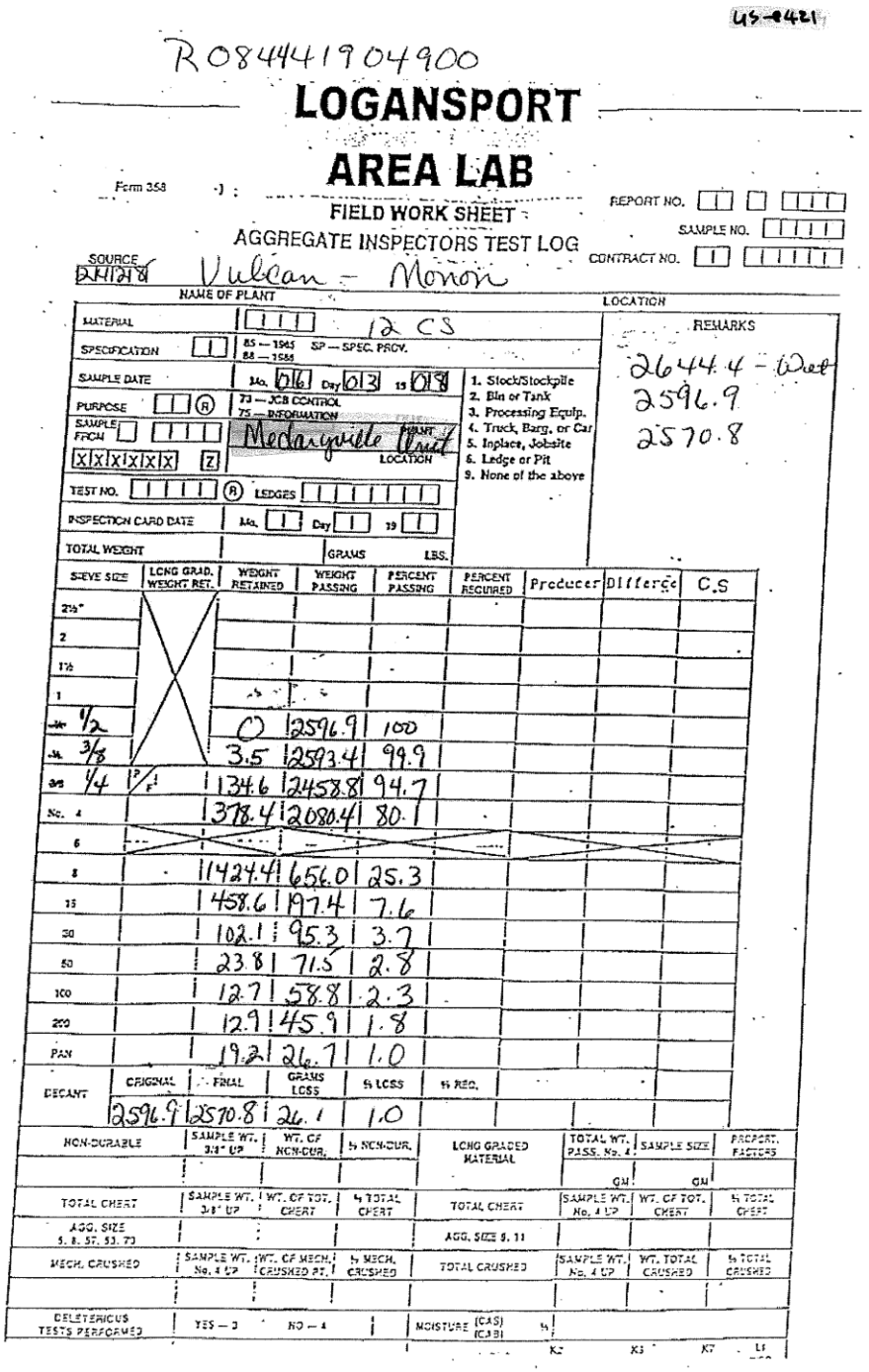
Research study for Chip Seal
Lee/Jusang

DATE RECEIVED	CKD. BY	DATE REPORTED BY LAB
9-14-10		9-16-10

State Form 37870 (R3/1-89)

1.3 AGGREGATE LAB TEST RESULT

1.3.1 US-421



US-0421

R084441904900

LOGANSPORT

AREA LAB

Form 358

FIELD WORK SHEET

AGGREGATE INSPECTORS TEST LOG

REPORT NO.

SAMPLE NO.

CONTRACT NO.

SOURCE 241218 Vulcan - Monon

NAME OF PLANT

LOCATION

MATERIAL 12 CS

SPECIFICATION 85 — 1965 88 — 1988 SP — SPEC. PROV.

SAMPLE DATE Mo. 06 Day 03 19 08

PURPOSE (R) 73 — JCB CONTROL 75 — INFORMATION

SAMPLE FROM Medaryville Unit PLANT LOCATION

XXXXXXX Z

TEST NO. (R) LEDGES

INSPECTION CARD DATE Mo. Day 19

TOTAL WEIGHT GRAMS LBS.

1. Stock/Stockpile
2. Bin or Tank
3. Processing Equip.
4. Truck, Barg, or Car
5. Inplace, Jobsite
6. Ledge or Pit
9. None of the above

REMARKS

2644.4 - Wet
2596.9
2570.8

SIEVE SIZE	LONG GRAD. WEIGHT RET.	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED	Producer	Differge	C.S
2½"								
2								
1½								
1								
1/2		0	2596.9	100				
3/8		3.5	2593.4	99.9				
1/4	P/F	134.6	2458.8	94.7				
No. 4		378.4	2080.4	80.1				
6								
8		1424.4	656.0	25.3				
15		458.6	197.4	7.6				
30		102.1	95.3	3.7				
50		23.8	71.5	2.8				
100		12.7	58.8	2.3				
200		12.9	45.9	1.8				
PAN		19.2	26.7	1.0				

DECANT	ORIGINAL	FINAL	GRAMS LOSS	% LOSS	% REQ.
	2596.9	2570.8	26.1	1.0	

NON-DURABLE	SAMPLE WT. 3/8" UP	WT. OF NON-DUR.	% NON-DUR.	LONG GRADED MATERIAL	TOTAL WT. PASS. No. 4	SAMPLE SIZE	PROPORT. FACTORS
					GM	GM	

TOTAL CHERT	SAMPLE WT. 3/8" UP	WT. OF TOT. CHERT	% TOTAL CHERT	TOTAL CHERT	SAMPLE WT. No. 4 UP	WT. OF TOT. CHERT	% TOTAL CHERT
AGG. SIZE 5, 8, 57, 53, 73				AGG. SIZE 9, 11			

MECH. CRUSHED	SAMPLE WT. No. 4 UP	WT. OF MECH. CRUSHED PT.	% MECH. CRUSHED	TOTAL CRUSHED	SAMPLE WT. No. 4 UP	WT. TOTAL CRUSHED	% TOTAL CRUSHED

DELETERIOUS TESTS PERFORMED	YES — 3	NO — 4		MOISTURE (CAS) (CAB) %			
					K2	K3	K7 L1

Pan
L-14

Specific Gravity & Absorption

Material Size:	12cs
Source of Mat'l:	Vulcan Monon
Sample Marking:	R0844419 04900

T 85 Procedure 8.1

	Coarse	Fine	Wt. Average
Absorption = (DRY - WET) / DRY * 100	3.629		
Bulk Sp. Gr. = DRY / (WET - WATER)	2.506		
Apparent Sp. Gr. = DRY / (DRY - WATER)	2.757		
Bulk Sp. Gr. (SSD) = WET / (WET - WATER)	2.597		

IN AIR - DRY	IN AIR - WET	IN WATER	Fine AGG. Wt.
2366.8	2452.7	1508.2	

T 85 Procedure 8.2

	Coarse	Fine	Wt. Average
Absorption = (DRY - WET) / DRY * 100			
Bulk Sp. Gr. = DRY / (WET - WATER)			
Apparent Sp. Gr. = DRY / (DRY - WATER)			
Bulk Sp. Gr. (SSD) = WET / (WET - WATER)			

IN AIR - DRY	IN AIR - WET	IN WATER	Fine AGG. Wt.

* Equations above for Course Agg. ONLY
** Fine Agg. Data is the same for 8.1 and 8.2

1.3.2 SR-14

SR-14

R084441904898

LOGANSPORT

AREA LAB

Form 358 -) :

FIELD WORK SHEET

AGGREGATE INSPECTORS TEST LOG

REPORT NO. [1] [ ] [ ]

SAMPLE NO. [ ] [ ] [ ] [ ]

CONTRACT NO. [1] [ ] [ ] [ ] [ ] [ ]

SOURCE B14213 Ens Aggs Plant #1

NAME OF PLANT LOCATION

MATERIAL [ ] [ ] [ ] [ ] 12 CS

SPECIFICATION [1] 85 — 1545 SP — SPEC. PROV. 86 — 1536

SAMPLE DATE Mo. 05 Day 30 19 98

PURPOSE [ ] [ ] (R) 73 — JOB CONTROL 75 — INFORMATION

SAMPLE FROM [ ] [ ] [ ] [ ] Wabash Sub PLANT LOCATION

[X][X][X][X][X][X] [Z]

1. Stock/Stockpile
2. Bin or Tank
3. Processing Equip.
4. Truck, Barg, or Car
5. Inplace, Jobsite
6. Ledge or Pit
9. None of the above

TEST NO. [ ] [ ] [ ] [ ] (R) LEDGES [ ] [ ] [ ] [ ] [ ] [ ]

INSPECTION CARD DATE Mo. [ ] [1] Day [ ] [1] 19 [ ] [1]

TOTAL WEIGHT GRAMS LBS.

REMARKS

2470.4

2394.5

2349.9

SIEVE SIZE	LONG GRAD. WEIGHT RET.	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED	Producer	Differ	C.S
2½"								
2								
1½								
1								
~~¾~~ ½		0	2394.5	100				
~~½~~ ⅜		0	2394.5	100				
~~⅜~~ ¼	P/F	217.9	2176.6	90.9				
No. 4		587.5	1589.1	66.4				
6								
8		1399.0	190.1	7.9				
16		107.4	82.7	3.5				
30		11.4	71.3	3.0				
50		5.5	65.8	2.7				
100		4.1	61.7	2.6				
200		4.0	57.7	2.4				
PAN		7.9	49.8	2.1				

DECANT ORIGINAL	FINAL	GRAMS LOSS	% LOSS	% REQ.
2394.5	2349.9	44.6	1.9	

NON-DURABLE	SAMPLE WT. 3/8" UP	WT. OF NON-DUR.	% NON-DUR.

LONG GRADED MATERIAL	TOTAL WT. PASS. No. 4	SAMPLE SIZE	PROPERT. FACTORS
		GM GM	

TOTAL CHERT	SAMPLE WT. 3/8" UP	WT. OF TOT. CHERT	% TOTAL CHERT

TOTAL CHERT	SAMPLE WT. No. 4 UP	WT. OF TOT. CHERT	% TOTAL CHERT

AGG. SIZE 5, 6, 57, 53, 73	

AGG. SIZE 9, 11			

MECH. CRUSHED	SAMPLE WT. No. 4 UP	WT. OF MECH. CRUSHED PT.	% MECH. CRUSHED

TOTAL CRUSHED	SAMPLE WT. No. 4 UP	WT. TOTAL CRUSHED	% TOTAL CRUSHED

DELETERIOUS TESTS PERFORMED	YES — 3	NO — 4

MOISTURE (CA5) (CA31)	%				
		K2	K3	K7	L1

Specific Gravity & Absorption

Pan A-4

Material Size:	12cs
Source of Mat'l:	Eng Agg 1
Sample Marking:	R0844190489B

T 85 Procedure 8.1

	Coarse	Fine	Wt. Average
Absorption = (DRY - WET) / DRY * 100	4.71		
Bulk Sp. Gr. = DRY / (WET - WATER) 899.6	2.421		
Apparent Sp. Gr. = DRY / (DRY - WATER) 797	2.732		
Bulk Sp. Gr. (SSD) = WET / (WET - WATER) 899.6	2.585		

IN AIR - DRY	IN AIR - WET	IN WATER	Fine AGG. Wt.
2177.7	2280.3	1380.7	

T 85 Procedure 8.2

	Coarse	Fine	Wt. Average
Absorption = (DRY - WET) / DRY * 100			
Bulk Sp. Gr. = DRY / (WET - WATER)			
Apparent Sp. Gr. = DRY / (DRY - WATER)			
Bulk Sp. Gr. (SSD) = WET / (WET - WATER)			

IN AIR - DRY	IN AIR - WET	IN WATER	Fine AGG. Wt.

* Equations above for Course Agg. ONLY
** Fine Agg. Data is the same for 8.1 and 8.2

1.3.3 SR-110

SR-110

R084441904897

#1

LOGANSPORT AREA LAB

Form 358 -) :

FIELD WORK SHEET

AGGREGATE INSPECTORS TEST LOG

REPORT NO. [ ] [ ] [ ][ ][ ][ ]

SAMPLE NO. [ ][ ][ ][ ]

CONTRACT NO. [ ] [ ][ ][ ][ ][ ]

SOURCE 212554 Rock Ind. NAME OF PLANT — PERU LOCATION

MATERIAL [ ][ ][ ][ ] 12's

SPECIFICATION [ ] 85 — 1985 88 — 1988 SP — SPEC. PROV.

SAMPLE DATE Mo. 05 Day 30 19 08

PURPOSE [ ] (R) 73 — JCB CONTROL 75 — INFORMATION

SAMPLE FROM [ ][ ][ ][ ] PLANT Rochester Unit LOCATION

[X][X][X][X][X][X] [Z]

1. Stock/Stockpile
2. Bin or Tank
3. Processing Equip.
4. Truck, Barg, or Car
5. Inplace, Jobsite
6. Ledge or Pit
9. None of the above

TEST NO. [ ][ ][ ][ ] (R) LEDGES [ ][ ][ ][ ][ ][ ][ ]

INSPECTION CARD DATE Mo. [ ] Day [ ] 19 [ ]

TOTAL WEIGHT GRAMS LBS.

REMARKS

2268.2 - wet wt.
2225.5 -
2159.9 -

SIEVE SIZE	LONG GRAD. WEIGHT RET.	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED	Producer	Differee	C.S
2½"								
2								
1½								
1								
¾ 1/2		0	2225.5	100				
4¾ 3/8		0	2225.5	100				
3⅜ 4 1/4		244.9	1980.6	89.0				
No. 4		665.2	1315.4	59.1				
6								
8		978.2	337.2	15.2				
15		208.6	136.6	6.1				
30		36.3	100.3	4.5				
50		9.8	90.5	4.1				
100		3.2	87.3	3.9				
200		3.9	83.4	3.7				
PAN		11.3	72.1	3.2				

Fail ⇒

DECANT ORIGINAL	FINAL	GRAMS LOSS	% LOSS	% REQ.
2225.5	2159.9	65.6	2.9	

NON-DURABLE	SAMPLE WT. 3/8" UP	WT. OF NON-DUR.	% NON-DUR.

LONG GRADED MATERIAL	TOTAL WT. PASS. No. 4	SAMPLE SIZE	PROPORT. FACTORS
		GM GM	

TOTAL CHERT	SAMPLE WT. 3/8" UP	WT. OF TOT. CHERT	% TOTAL CHERT

TOTAL CHERT	SAMPLE WT. No. 4 UP	WT. OF TOT. CHERT	% TOTAL CHERT

AGG. SIZE 5, 6, 57, 67, 7	

AGG. SIZE 9, 11	

MECH. CRUSHED	SAMPLE WT. No. 4 UP	WT. OF MECH. CRUSHED PT.	% MECH. CRUSHED

TOTAL CRUSHED	SAMPLE WT. No. 4 UP	WT. TOTAL CRUSHED	% TOTAL CRUSHED

DELETERIOUS TESTS PERFORMED YES — 3 NO — 4

MOISTURE (CAS) (CABI) %

X2 X5 X7 11

Specific Gravity & Absorption

12cc

Pan B-1

Material Size:	Rock Ind 12cc
Source of Mat'l:	
Sample Marking:	R0844190489 7

T 85 Procedure 8.1

	Coarse	Fine	Wt. Average
Absorption = (DRY - WET) / DRY * 100	3.986		
Bulk Sp. Gr. = DRY / (WET - WATER) 851.4	2.469		
Apparent Sp. Gr. = DRY / (DRY - WATER) 767.6	2.739		
Bulk Sp. Gr. (SSD) = WET / (WET - WATER) 851.4	2.568		

IN AIR - DRY	IN AIR - WET	IN WATER	Fine AGG. Wt.
2102.3	2186.1	1334.7	

T 85 Procedure 8.2

	Coarse	Fine	Wt. Average
Absorption = (DRY - WET) / DRY * 100			
Bulk Sp. Gr. = DRY / (WET - WATER)			
Apparent Sp. Gr. = DRY / (DRY - WATER)			
Bulk Sp. Gr. (SSD) = WET / (WET - WATER)			

IN AIR - DRY	IN AIR - WET	IN WATER	Fine AGG. Wt.

* Equations above for Course Agg. ONLY
** Fine Agg. Data is the same for 8.1 and 8.2

SR-110

Sample #2
Different stockpile

K084 44190 4901

LOGANSPORT AREA LAB

Form 358

FIELD WORK SHEET

AGGREGATE INSPECTORS TEST LOG

REPORT NO. [ ] [ ] [ ]

SAMPLE NO. [ ]

CONTRACT NO. [ ] [ ]

SOURCE 2054 Rock IND — NAME OF PLANT

Peru — LOCATION

MATERIAL	[ ] 12 CS
SPECIFICATION	[ ] 85 — 1965 SP — SPEC. PROV. 88 — 1988
SAMPLE DATE	Mo. 016 Day 04 19 08
PURPOSE	[ ] (R) 73 — JOB CONTROL 75 — INFORMATION
SAMPLE FROM	[ ] [ ] PLANT
XXXXXX Z	LOCATION
TEST NO.	[ ] (R) LEDGES [ ]
INSPECTION CARD DATE	Mo. 016 Day 014 19 08
TOTAL WEIGHT	GRAMS LBS.

1. Stock/Stockpile
2. Bin or Tank
3. Processing Equip.
4. Truck, Barg, or Car
5. Inplace, Jobsite
6. Ledge or Pit
9. None of the above

REMARKS
2468.7 - Wet
2391.0
2323.2

SIEVE SIZE	LONG GRAD. WEIGHT RET.	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED	Producer	Difference	C.S
2½"								
2								
1½								
1								
¾" 1/2		0	2391.0	100	100			
½" 3/8		0	2391.0	100	95-100			
3/8" 1/4	P/F	241.3	2149.7	89.9				
No. 4		641.9	1507.8	63.1	50-80			
6								
8		1133.0	348.0	14.6	0-35			
15		238.4	136.4	5.7				
30		36.8	99.6	4.2	0-4			
50		9.5	90.1	3.8				
100		4.3	85.8	3.6				
200		3.9	81.9	3.4				
PAN		7.3	74.6	3.1				
DECANT	ORIGINAL	FINAL	GRAMS LOSS	% LOSS	% REQ.			
	2391.0	2323.2	67.8	2.8	0-2.0			

Fail ⇒

NON-DURABLE	SAMPLE WT. 3/8" UP	WT. OF NON-DUR.	% NON-DUR.	LONG GRADED MATERIAL	TOTAL WT. PASS. No. 4	SAMPLE SIZE	PROPORT. FACTORS
					GM	GM	
TOTAL CHERT	SAMPLE WT. 3/8" UP	WT. OF TOT. CHERT	% TOTAL CHERT	TOTAL CHERT	SAMPLE WT. No. 4 UP	WT. OF TOT. CHERT	% TOTAL CHERT
AGG. SIZE 5, 8, 57, 53, 73				AGG. SIZE 9, 11			
MECH. CRUSHED	SAMPLE WT. No. 4 UP	WT. OF MECH. CRUSHED PT.	% MECH. CRUSHED	TOTAL CRUSHED	SAMPLE WT. No. 4 UP	WT. TOTAL CRUSHED	% TOTAL CRUSHED
DELETERIOUS TESTS PERFORMED	YES — 3	NO — 4		MOISTURE (CAS) (CAB) %			

K2 K5 K7 L1

Specific Gravity & Absorption

Material Size:	Rock 12cs
Source of Mat'l:	
Sample Marking:	R084 44190490 1

Pan F

T 85 Procedure 8.1

	Coarse	Fine	Wt. Average
Absorption = (DRY - WET) / DRY * 100	3.683		
Bulk Sp. Gr. = DRY / (WET - WATER) 2665	2.485		
Apparent Sp. Gr. = DRY / (DRY - WATER) 7872	2.735		
Bulk Sp. Gr. (SSD) = WET / (WET - WATER) 7872	2.836		

IN AIR - DRY	IN AIR - WET	IN WATER	Fine AGG. Wt.
2153.2	2232.5	1366.0	

T 85 Procedure 8.2

	Coarse	Fine	Wt. Average
Absorption = (DRY - WET) / DRY * 100			
Bulk Sp. Gr. = DRY / (WET - WATER)			
Apparent Sp. Gr. = DRY / (DRY - WATER)			
Bulk Sp. Gr. (SSD) = WET / (WET - WATER)			

IN AIR - DRY	IN AIR - WET	IN WATER	Fine AGG. Wt.

* Equations above for Course Agg. ONLY
** Fine Agg. Data is the same for 8.1 and 8.2

1.4 FIELD TEST METHOD FOR MEASURING SEAL COAT AGGREGATE AND EMULSION APPLICATION RATES

EQUIPMENT

Field Balance
32 Gallon Trash Bin
5-gallon Bucket
1 SYD carpet, burlap, or canvas, cut into square
Long-handled Tongs/Hooks/Pliers
Garbage Bags
Marker
Rubber Gloves
Rolled Paper (for walk path)

EMULSION MEASUREMENT METHOD

1. Label each carpet square.
2. Place a clean trash bag in the garbage container.
3. Weigh and record weights of each carpet square and the garbage container/bag.
4. Record location of test.
5. Lay 1 SYD carpet squares in line with distributor – 2 squares, roughly in the wheel paths.
6. Run distributor at application speed and emulsion rate over squares.
7. Place the ground paper on sprayed emulsion to approach the carpets.
8. Immediately pick up carpet square, garbage container, and weigh.
9. Record total weight.
10. Calculate and report application rate.
11. Reseal the area covered the carpets.

AGGREGATE MEASUREMENT METHOD

1. Weigh and record weight of 5-gallon bucket.
2. Record location of test.
3. Lay 1 SYD burlap or canvas in line with aggregate spreader.
4. Run aggregate spreader at application speed and application rate over burlap.
5. Pick up burlap square, and deposit aggregate into 5-gallon bucket.
6. Weigh 5-gallon bucket and aggregate.
7. Record total weight.
8. Calculate and report application rate.
9. Sweep/reseal the area covered by the burlap square.

(a)

(b)

(c)

(d)

FIGURE 1-1 Emulsion application rate measurement procedure at the project site

(a)

(b)

(c)

(d)

FIGURE 1-2 Aggregate application rate measurement procedure at the project site

WORKSHEET

Worksheet for Field Determination of Emulsion Application Rate

Date: _____ Location: _____ Emulsion Type: _____

Emulsion Density = 235 Gal/ton
Emulsion Density = 8.51 lb/gal

		A	B	C	D=C-(A+B)	D/8.51
Location	**Carpet Label**	**Carpet Weight (lbs)**	**Garage Bin + Bag (lbs)**	**Total Weight with Emulsion (lbs)**	**Weight of Emulsion (lbs)**	**Application Rate (gal/SYD)**

Revised 1/1/08

Worksheet for
Field Determination of Aggregate Application Rate

Date: _____ Location: _____

Aggregate Type: _____

	A	B	C=B-A	C
Location	**5 Gallon Bucket Weight (lbs)**	**Total Weight with Aggregate (lbs)**	**Weight of Aggregate (lbs)**	**Application Rate (lb/SYD)**

1.5 INDIANA DEPARTMENT OF TRANSPORTATION OFFICE OF MATERIALS MANAGEMENT QUANTITY DETERMINATION OF ASPHALT MATERIALS AND AGGREGATES FOR SEAL COATS, ITM NO. 579-08P

1.0 SCOPE.
1.1 This method covers the procedure for determination of the quantity of asphalt materials and aggregates in seal coat applications.
1.2 The values stated in either acceptable English or SI metric units are to be regarded separately as standard, as appropriate for a specification with which this ITM is used. Within the text, SI metric units are shown in parentheses. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other, without combining values in any way.
1.3 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

3.0 SIGNIFICANCE AND USE. This ITM shall be used to determine the quantity of asphalt materials and aggregates required for a seal coat application.

4.0 APPARATUS.
4.1 Traffic control equipment and personnel to be furnished by the District
4.2 Pneumatic tire roller or vehicle
4.3 Yield test scales
4.4 Buckets as needed
4.5 5-gallon can with pour spout
4.6 Stove
4.7 0.5 yd^2 template consisting of a 30 x 48 in. metal plate with an 18 x 36 in. opening, ITM 579-08P, Revised 1/1/08
4.8 Aggregate shaker box approximately 18 in. square and 3 in. deep with a 1-in. open slot in the bottom along one side. A piece of 1/2-in. opening screen cloth shall extend under this open slot.
4.9 Squeegee and brushes as needed
4.10 Thermometer, range 50 to 300°F

5.0 MATERIALS.
5.1 A minimum of 5 gallon of the asphalt material that is to be used on the project.
5.2 A minimum of 75 lb. of the aggregate that is to be used on the project.

6.0 PROCEDURE.

6.1 Select a location typical of the project. Sites shall be selected to prevent tracking of asphalt from one test area to another. On the mainline, select a wheel path.
6.2 Set up traffic control.
6.3 Heat the asphalt material according to the following:

Asphalt	Temperature
AE-90, AE-150	140 – 160°F
RS-2	120 – 140°F
RC-800	230 – 250°F
RC-3000	250 – 275°F

6.4 Clean and prepare surface as necessary.
6.5 Place the template on the selected site.
6.6 Weigh the aggregate. The quantity shall be within the values listed in TABLE 1.
6.7 Weigh the heated bituminous material. The quantity shall be within the values listed in TABLE 1.
6.8 Apply the liquid asphalt uniformly on the test area by pouring and using the squeegee, and brush to distribute.
6.9 Place the aggregate uniformly on the test area with the shaker box.
6.10 Remove the template.
6.11 Roll the test area with the pneumatic tire roller or the vehicle tire.
6.12 Repeat the above procedure by varying the quantities of asphalt material and aggregates until the desired result is obtained.

Rate of Application per Square Yard		
Aggregate Size No.	**Cover Aggregate, lb**	**Asphalt Material gal at 60°F**
23, 24	12 – 15	0.12 – 0.16
12	14 – 17	0.29 – 0.33
11	16 – 20	0.36 – 0.40
9	28 – 32	0.63 – 0.68

6.13 Remove traffic control. If test areas are on the mainline, removal of traffic control shall be delayed until the asphalt material has cured sufficiently to hold the aggregate without displacement.
6.14 Return to location the next day, broom off and weigh the excess aggregate for shoulder locations. This procedure is not required for mainline locations.
6.15 Make a visual inspection of the test areas for asphalt content and aggregate retention. Further visual inspection shall be made until the seal coat operation starts. The test area shall appear to be one aggregate particle in depth, and the particle shall be embedded in the asphalt material 50-70%.

7.0 REPORT.

7.1 The quantity of asphalt material and aggregate for the seal coat shall be reported on the appropriate form for use on the proposed project. If there are different pavement sections on the project, several test sections may be necessary.

1.6 SEAL COAT PERFORMANCE EVALUATION

General Information

Name of Recorder		***Time/Date***	
Road	US 421/SR14/SR110		-
Temperature			

Performance Scores

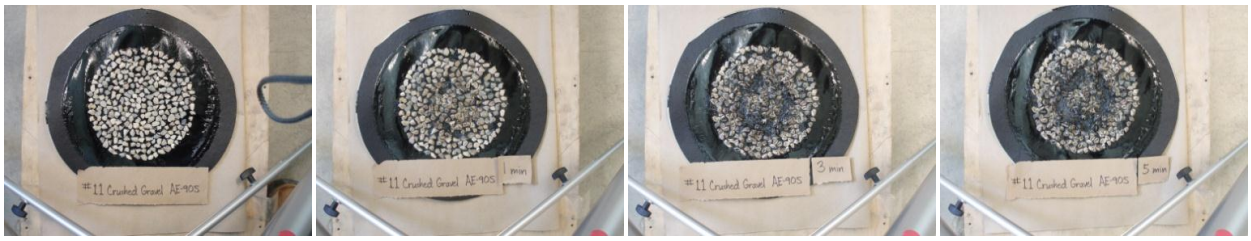
Number	***Distress***	***Sections***												
		421NB-204-205	421NB-205-206	14EB-39-40	14EB-40-41	14EB-41-42	14EB-42-43	110WB-3-4	110WB-4-5	110WB-5-6	110WB-6-7	110EB-3-4	110EB-4-5	110EB-5-6
1	***Aggregate Loss***													
2	***Bleeding /Flushing***													
3	***Excessive Aggregate***													
4	***Delamination***													
5	***Streaking***													
6	***Reflected Bleeding from Crack Seal***													
7	***Polishing***													

Note: 0 being excellent to 10 being unacceptable

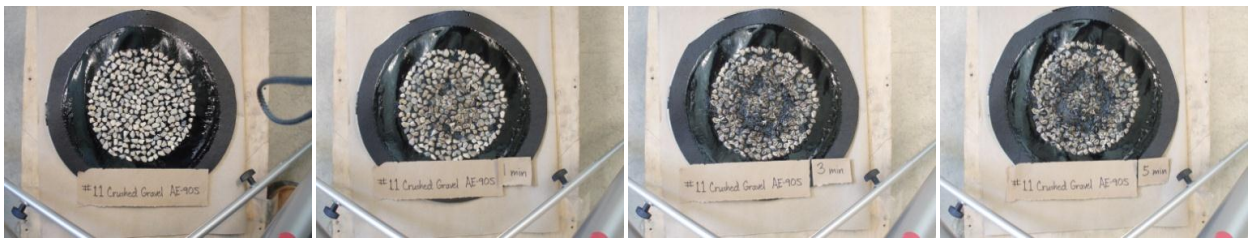
1.7 SWEEP TEST RESULT

1.7.1 AE-90S

CRUSHED GRAVEL WITH TWO FACES

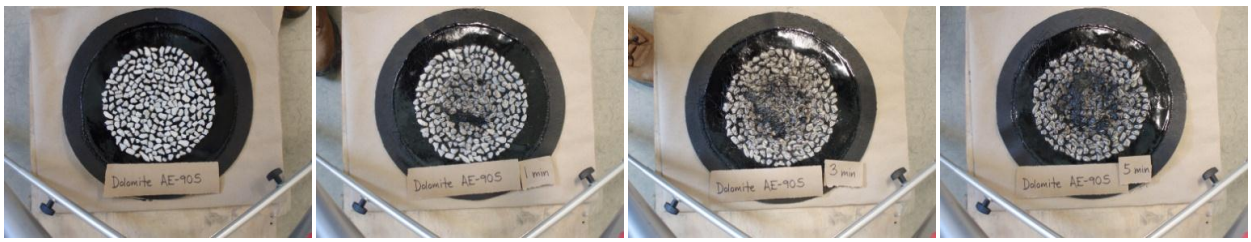


BLAST FURNACE

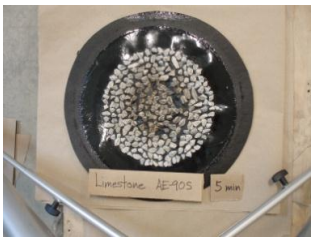


CRUSHED GRAVEL WITH ONE FACE

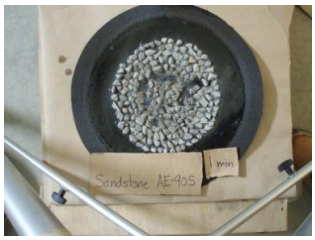
DOLOMITE



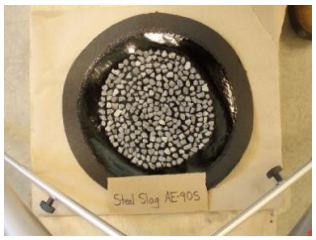
LIMESTONE

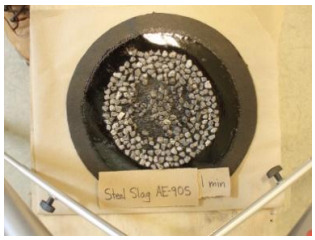


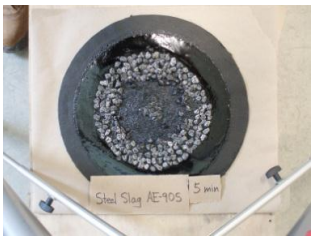
SANDSTONE



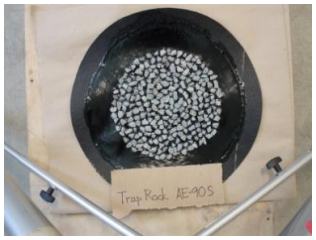
STEEL SLAG





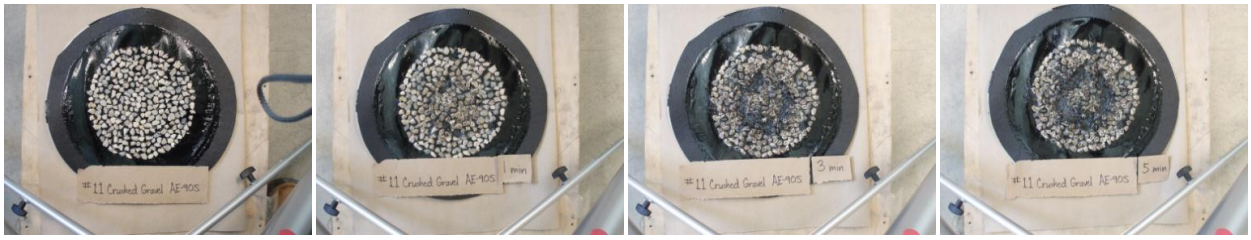


TRAP ROCK

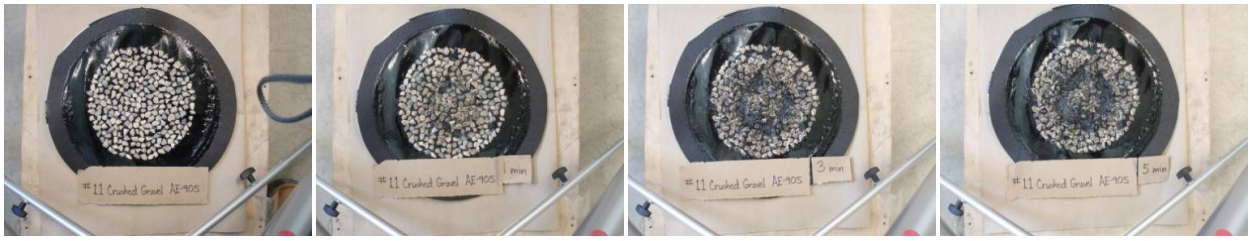


1.7.2 CRS-2P

CRUSHED GRAVEL WITH TWO FACES



BLAST FURNACE

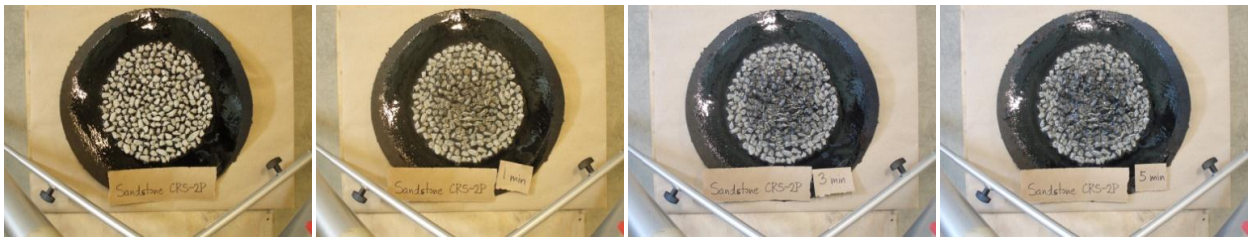


CRUSHED GRAVEL WITH ONE FACE

DOLOMITE

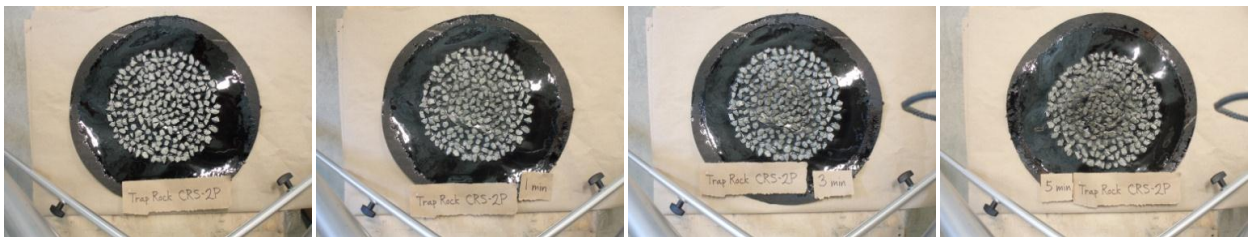
LIMESTONE

SANDSTONE



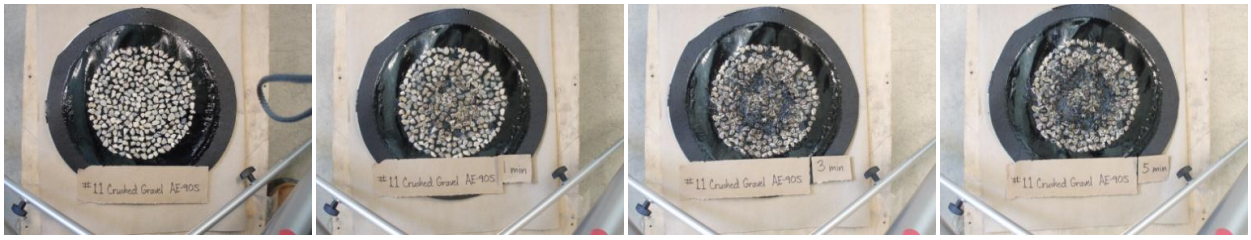
STEEL SLAG

TRAP ROCK



1.7.3 RS-2P

CRUSHED GRAVEL WITH TWO FACES



BLAST FURNACE

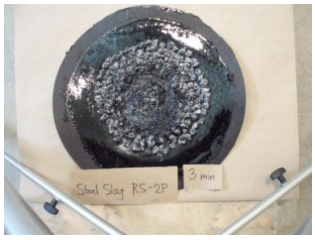
CRUSHED GRAVEL WITH ONE FACE

DOLOMITE

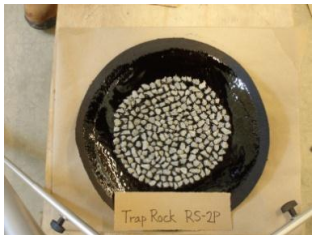
LIMESTONE

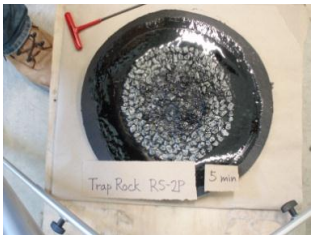
SANDSTONE

STEEL SLAG



TRAP ROCK



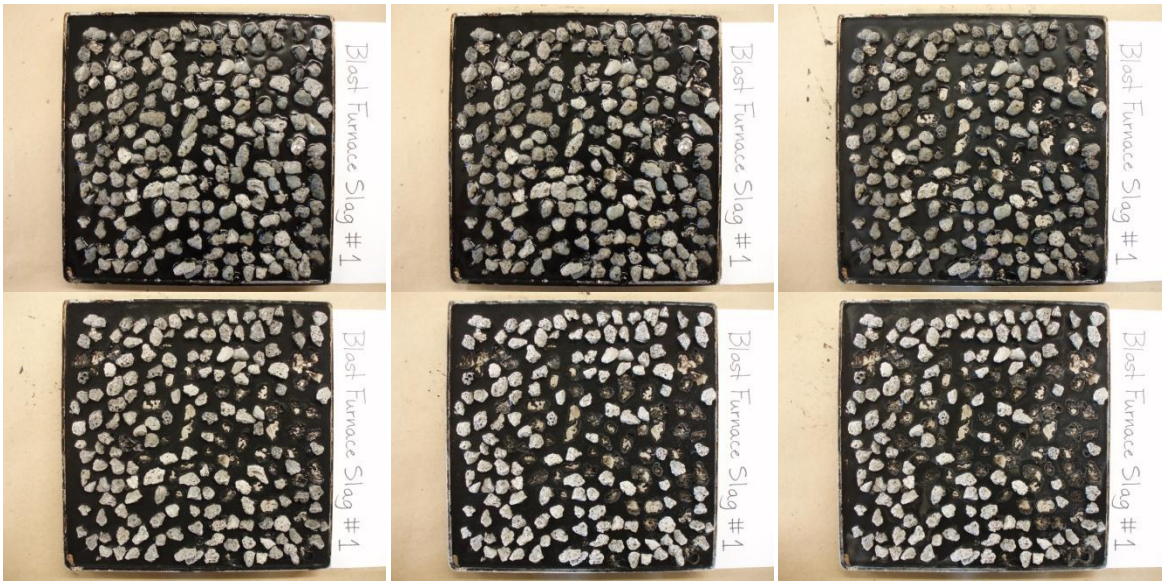


1.8 VIALIT TEST RESULT

1.8.1 AE-90S

CRUSHED GRAVEL WITH TWO FACES

BLAST FURNACE



CRUSHED GRAVEL WITH ONE FACE

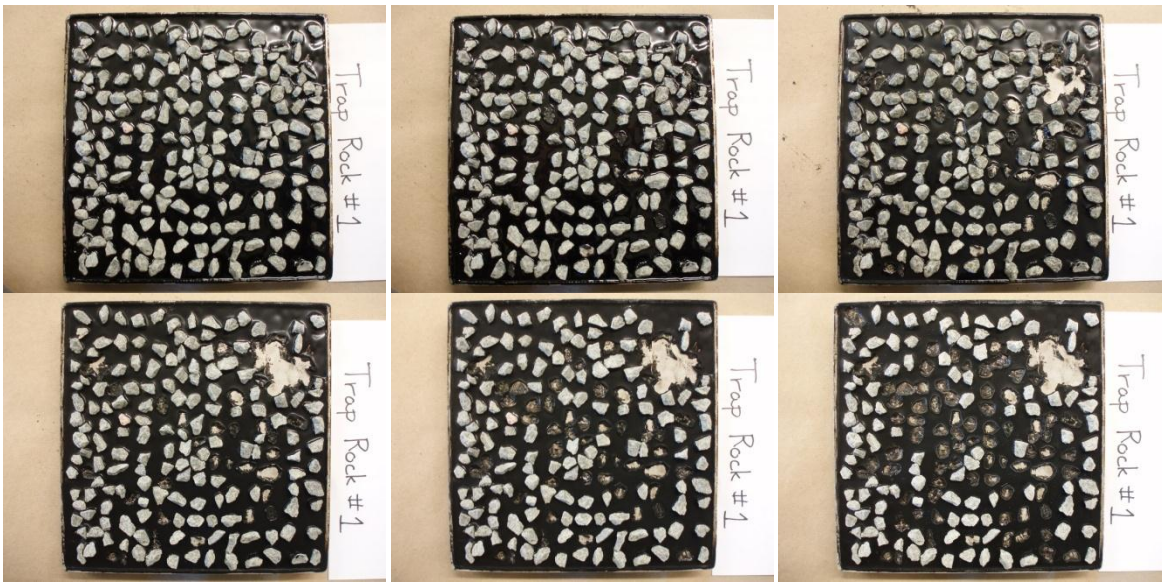
DOLOMITE

LIMESTONE

SANDSTONE

STEEL SLAG

TRAP ROCK



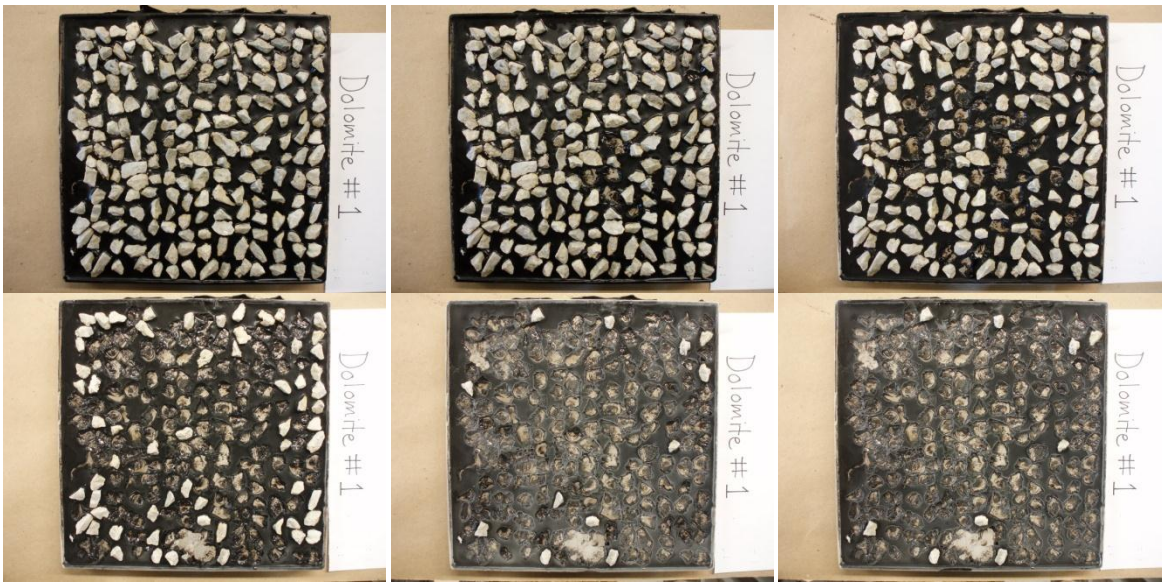
1.8.2 CRS-2P

CRUSHED GRAVEL WITH TWO FACES

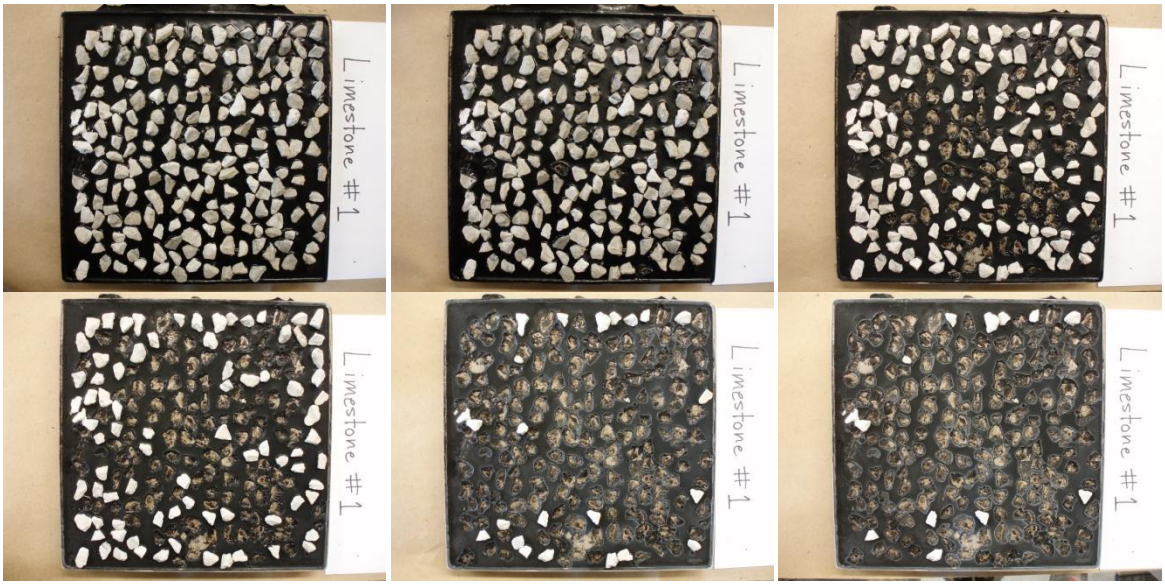
BLAST FURNACE

CRUSHED GRAVEL WITH ONE FACE

DOLOMITE



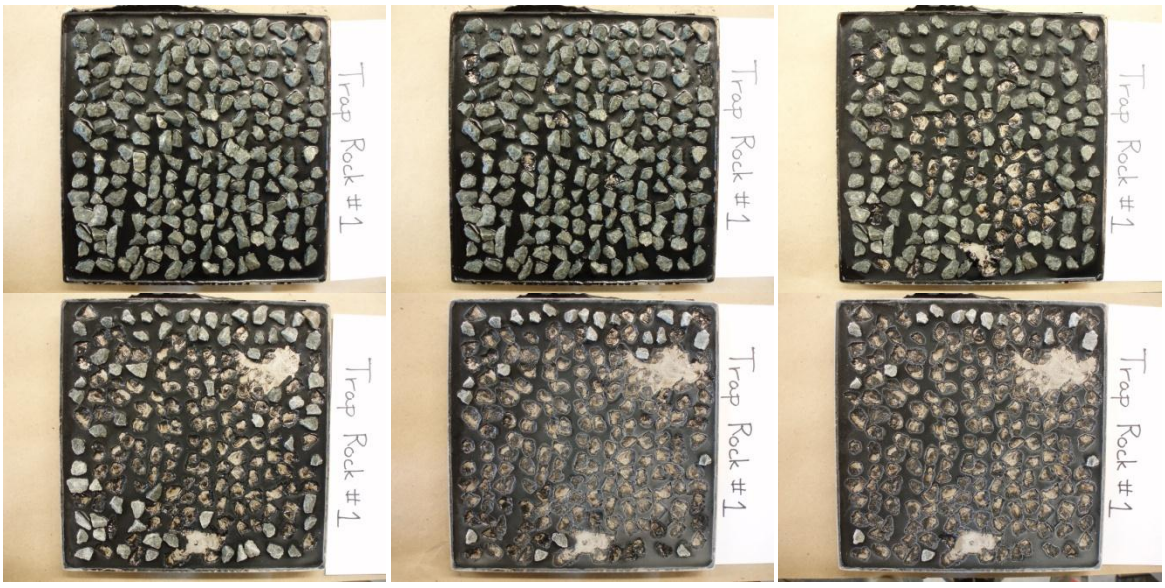
LIMESTONE



SANDSTONE

STEEL SLAG

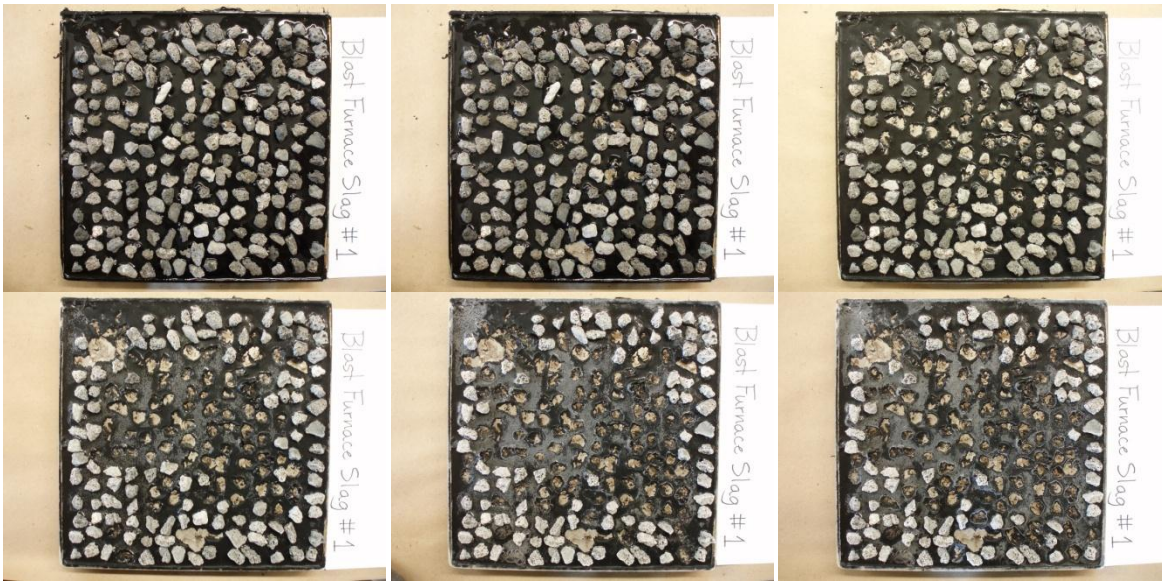
TRAP ROCK



1.8.3 RS-2P

CRUSHED GRAVEL WITH TWO FACES

BLAST FURNACE

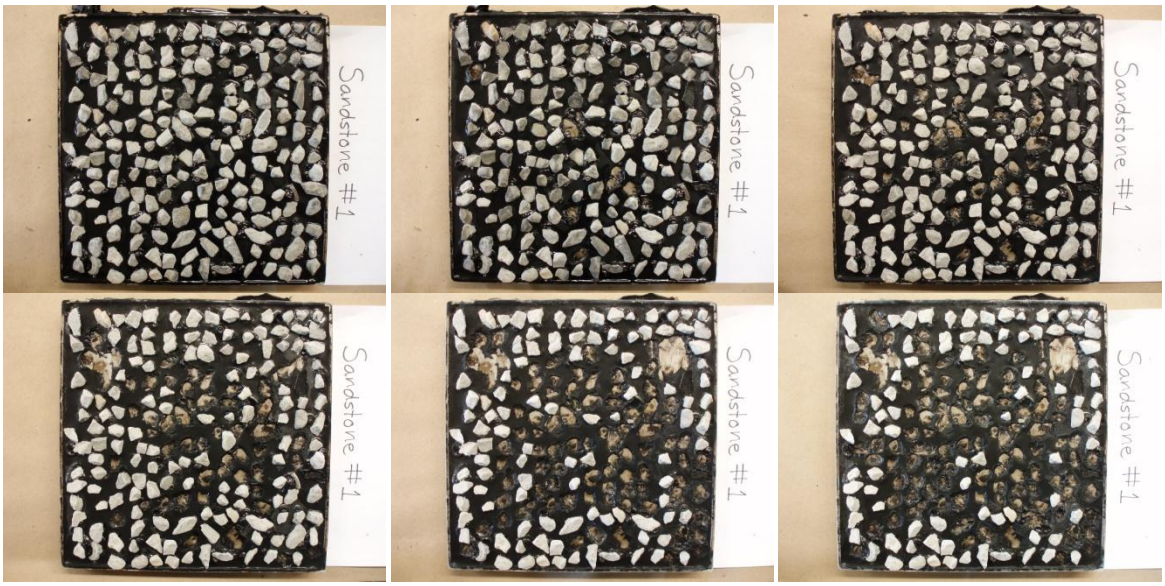


CRUSHED GRAVEL WITH ONE FACE

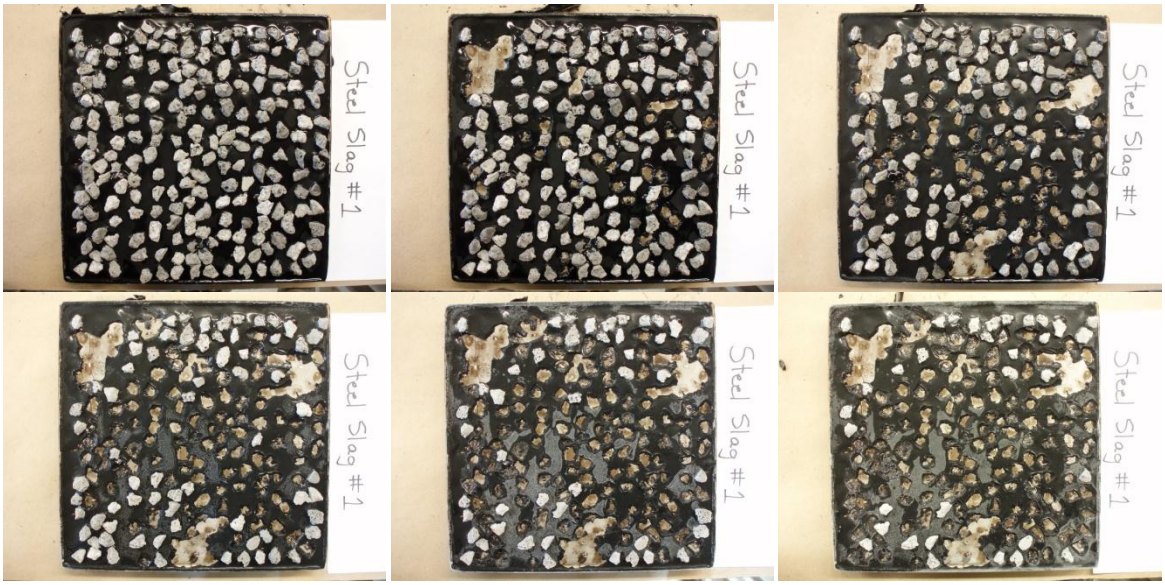
DOLOMITE

LIMESTONE

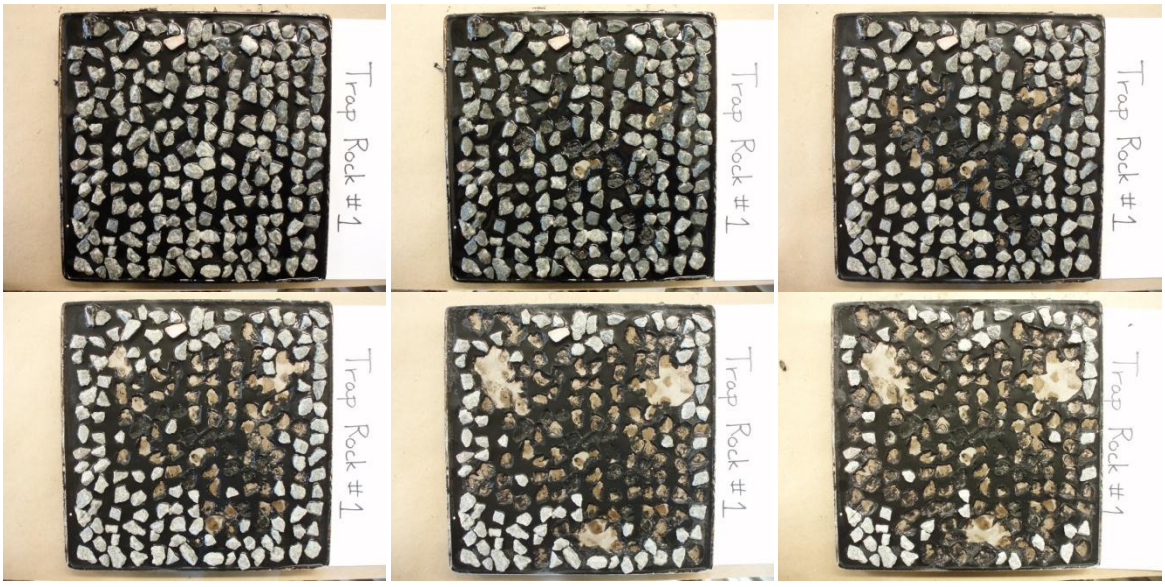
SANDSTONE



STEEL SLAG



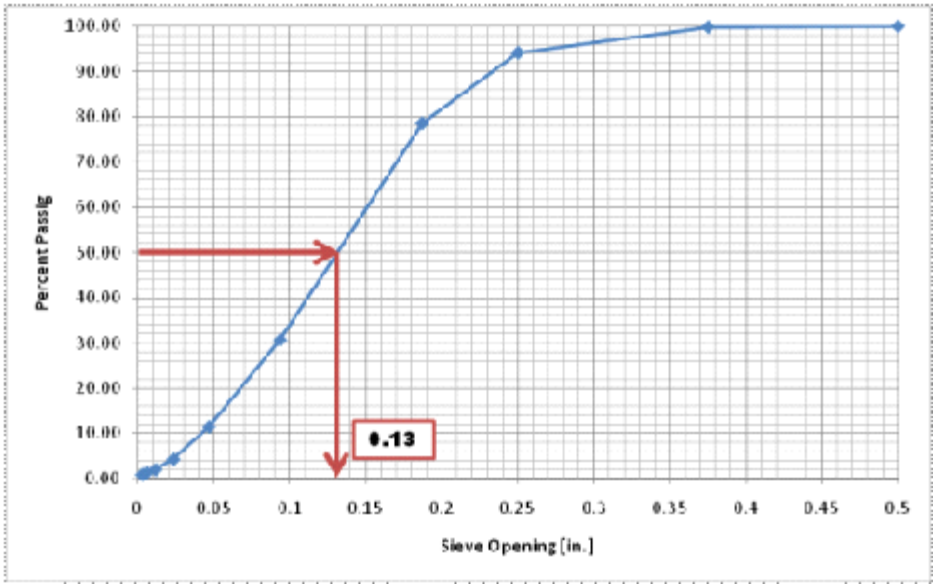
TRAP ROCK



1.9 MCLOED DESIGN CALCULATION

1.9.1 US-421

1. Median Particle Size



$M := 0.13in$

2. Flakiness Index

$FI := 18.35\%$

3. Average Least Dimension (H)

$$H := \frac{M}{1.139285 + (0.011506 \cdot FI)} = 0.114in \qquad H = 0.114in$$

4. Loose Unit Weight (W)

$W_{agg} := 6.63kg$ Weight of aggregates loosely filled in a metal cylinder with volume of 0.005 m^3

$V_{cylinder} := 0.004729m^3$

$$W := \frac{W_{agg}}{V_{cylinder}} = 87.523\frac{lb}{ft^3} \qquad W = 87.523\frac{lb}{ft^3}$$

5. Voids in the Loose Aggregate

$SG := 2.50$ Dry Bulk Specific Gravity

$\gamma_{water} := 62.4\frac{lb}{ft^3}$ Density of water at 4°C

$V := 1 - \frac{W}{\gamma_{water} \cdot SG} = 0.44$ $V = 0.44$

6. Cover Aggregate Application Rate (C)

$E_1 := 1$ $E_2 := 1.1$ Wastage factors of 0% and 10% are assumed

$C_1 := (1 - 0.4V) \cdot H \cdot SG \gamma_{water} E_1 = 11.005\frac{lb}{yd^2}$

$C_2 := (1 - 0.4V) \cdot H \cdot SG \gamma_{water} E_2 = 12.106\frac{lb}{yd^2}$

$C_1 = 11.005\frac{lb}{yd^2}$ 0% wastage assumed $C_2 = 12.106\frac{lb}{yd^2}$ 10% wastage assumed

7. Binder Application Rate

$T := 0.6$ ADT over 2000 has traffic factor of 0.6 (Minnesota Seal Coat Handbook 2006 Table 4.4)

$S := 0.03\frac{gal}{yd^2}$ Surface Correction Factor of 0.03 used for slightly porous and oxidized road (Minnesota Seal Coat Handbook 2006 Table 4.6)

$A := 0.02\frac{gal}{yd^2} 2.8 = 0.056\frac{gal}{yd^2}$ Absorption of 3.6% falls in Class B resulting in correction factor of 2.8 (Minnesota Seal Coat Handbook 2006 Table 4.3)

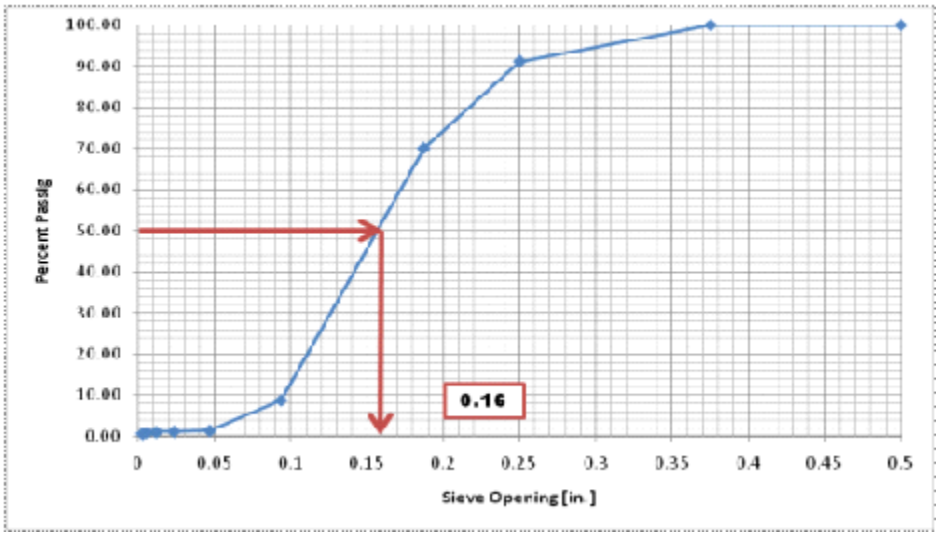
$R := 0.66$ Residual of AE-90S asphalt binder in decimal percent

$B := \frac{0.4V \cdot H \cdot T + S + A}{R} = 0.233\frac{gal}{yd^2}$

$B = 0.233\frac{gal}{yd^2}$

1.9.2 US-14

1. Median Particle Size



$M := 0.16\text{in}$

2. Flakiness Index

$FI := 17.91\%$

3. Average Least Dimension (H)

$$H := \frac{M}{1.139285 + (0.011506)FI} = 0.14\,\text{in} \qquad H = 0.14\,\text{in}$$

4. Loose Unit Weight (W)

$W_{agg} := 6.73\text{kg}$ Weight of aggregates loosely filled in a metal cylinder with volume of 0.005 m^3

$V_{cylinder} := 0.004729\text{m}^3$

$$W := \frac{W_{agg}}{V_{cylinder}} = 88.843\,\frac{\text{lb}}{\text{ft}^3} \qquad W = 88.843\,\frac{\text{lb}}{\text{ft}^3}$$

5. Voids in the Loose Aggregate

$SG := 2.42$ Dry Bulk Specific Gravity

$\gamma_{water} := 62.4 \frac{lb}{ft^3}$ Density of water at 4°C

$V := 1 - \frac{W}{\gamma_{water} \cdot SG} = 0.412$ $V = 0.412$

6. Cover Aggregate Application Rate (C)

$E_1 := 1$ $E_2 := 1.1$ Wastage factors of 0% and 10% are assumed

$C_1 := (1 - 0.4V) \cdot H \cdot SG \gamma_{water} E_1 = 13.266 \frac{lb}{yd^2}$

$C_2 := (1 - 0.4V) \cdot H \cdot SG \gamma_{water} E_2 = 14.593 \frac{lb}{yd^2}$

$C_1 = 13.266 \frac{lb}{yd^2}$ 0% wastage assumed $C_2 = 14.593 \frac{lb}{yd^2}$ 10% wastage assumed

7. Binder Application Rate

$T := 0.6$ ADT over 2000 has traffic factor of 0.6 (Minnesota Seal Coat Handbook 2006 Table 4.4)

$S := 0.03 \frac{gal}{yd^2}$ Surface Correction Factor of 0.03 used for slightly porous and oxidized road (Minnesota Seal Coat Handbook 2006 Table 4.6)

$A := 0.02 \frac{gal}{yd^2} 2.8 = 0.056 \frac{gal}{yd^2}$ Absorption of 4.7% falls in Class B resulting in correction factor of 2.8 (Minnesota Seal Coat Handbook 2006 Table 4.3)

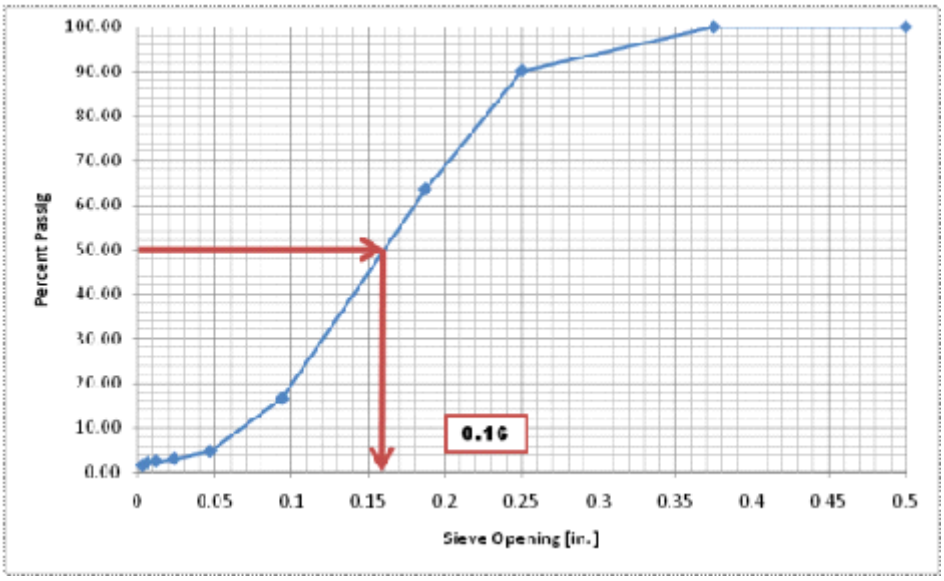
$R := 0.6$ Residual of AE-90S asphalt binder in decimal percent

$B := \frac{0.4V \cdot H \cdot T + S + A}{R} = 0.248 \frac{gal}{yd^2}$

$B = 0.248 \frac{gal}{yd^2}$

1.9.3 SR-110

1. Median Particle Size



$M := 0.16\text{in}$

2. Flakiness Index

$FI := 19.1\%$

3. Average Least Dimension (H)

$$H := \frac{M}{1.139285 + (0.011506)FI} = 0.14\,\text{in} \qquad H = 0.14\,\text{in}$$

4. Loose Unit Weight (W)

$W_{agg} := 6.26\text{kg}$ Weight of aggregates loosely filled in a metal cylinder with volume of 0.005 m^3

$V_{cylinder} := 0.004729\text{m}^3$

$$W := \frac{W_{agg}}{V_{cylinder}} = 82.639\,\frac{\text{lb}}{\text{ft}^3} \qquad W = 82.639\,\frac{\text{lb}}{\text{ft}^3}$$

5. Voids in the Loose Aggregate

$SG := 2.46$ Dry Bulk Specific Gravity

$\gamma_{water} := 62.4\frac{lb}{ft^3}$ Density of water at 4°C

$V := 1 - \frac{W}{\gamma_{water} \cdot SG} = 0.464$ $V = 0.464$

6. Cover Aggregate Application Rate (C)

$E_1 := 1$ $E_2 := 1.1$ Wastage factors of 0% and 10% are assumed

$C_1 := (1 - 0.4V) \cdot H \cdot SG \gamma_{water} E_1 = 13.193\frac{lb}{yd^2}$

$C_2 := (1 - 0.4V) \cdot H \cdot SG \gamma_{water} E_2 = 14.512\frac{lb}{yd^2}$

$C_1 = 13.193\frac{lb}{yd^2}$ 0% wastage assumed $C_2 = 14.512\frac{lb}{yd^2}$ 10% wastage assumed

7. Binder Application Rate

$T := 0.65$ ADT between 1000 and 2000 has traffic factor of 0.65 (Minnesota Seal Coat Handbook 2006 Table 4.4)

$S := 0.03\frac{gal}{yd^2}$ Surface Correction Factor of 0.03 used for slightly porous and oxidized road (Minnesota Seal Coat Handbook 2006 Table 4.6)

$A := 0.02\frac{gal}{yd^2} 2.8 = 0.056\frac{gal}{yd^2}$ Absorption of 3.9% falls in Class B resulting in correction factor of 2.8 (Minnesota Seal Coat Handbook 2006 Table 4.3)

$R := 0.66$ Residual of AE-90S asphalt binder in decimal percent

$B := \frac{0.4V \cdot H \cdot T + S + A}{R} = 0.274\frac{gal}{yd^2}$

$B = 0.274\frac{gal}{yd^2}$

1.10 MCLOED DESIGN FACTOR

1.10.1 AGGREGATE WASTAGE FACTOR, E

Percentage Waste* Allowed For	Wastage Factor, E
1	1.01
2	1.02
3	1.03
4	1.04
5	1.05
6	1.06
7	1.07
8	1.08
9	1.09
10	1.10
11	1.11
12	1.12
13	1.13
14	1.14
15	1.15

*Due to traffic whip-off and handling

1.10.2 TRAFFIC CORRECTION FACTOR, T

Traffic [Vehicles per day]	Traffic Factor
Under 100	0.85
100 to 500	0.75
500 to 1000	0.70
1000 to 2000	0.65
Over 2000	0.60

1.10.3 SURFACE CORRECTION FACTOR, S

Existing Pavement Texture	Correction, S [gal/yd^2]
Black, flushed asphalt	-0.01 to -0.06
Smooth, non-porous	0.00
Slightly porous and oxidized	+0.03
Slightly pocked, porous and oxidized	+0.06
Badly pocked, porous and oxidized	+0.09

1.10.4 AGGREGATE ABSORPTION

Aggregate Type		Class A			Class B		Class C
		Granite	**Quartzite**	**Trap Rock**	**Limestone**	**Red Rock**	**Pea Rock**
Percent Absorption	**Min.**	0.40	0.61	0.31	1.75	N/A	1.14
	Max.	0.92	0.72	0.59	5.44	N/A	2.32
	Avg.	**0.59**	**0.67**	**0.43**	**2.80**	N/A	**1.69**

1.11 CALIBRATION SETTING

Aggregate Spreader Calibration Table

Gate Opening (in)	Speed (ft/min)	Application Rate (lb/SYD)
0.75	340	10
0.75	350	10
0.75	320	10
1.00	350	13
1.00	340	14
1.00	320	15
1.25	350	16
1.25	320	17
1.25	340	18
1.50	350	20
1.50	340	22
1.75	340	24

Distributor Calibration Table

Distributor (Comm #)	Capacity (gal)	Pump Rate (gal/min)	Speed (ft/min)	Computer Setting (gal/SYD)	Application Rate (gal/SYD)
64462	2,500	120	300	N/A	0.38
64462	2,500	120	320	N/A	0.34
64462	2,500	120	340	N/A	0.31
64462	**2,500**	**120**	**350**	**N/A**	**0.30**
64185	2,500	90	300	N/A	0.24
64185	**2,500**	**95**	**300**	**N/A**	**0.25**
64666	3,500			0.40	0.41
64666	**3,500**			**0.35**	**0.35**

1.12 VISUAL OBSERVATION SHEET

General Information

Name of Recorder		***Time/Date***	
Road	US 421/SR14/SR110		-
Temperature			

Performance Scores

Number	***Distress***	***Sections***												
		421NB-204-205	421NB-205-206	14EB-39-40	14EB-40-41	14EB-41-42	14EB-42-43	110WB-3-4	110WB-4-5	110WB-5-6	110WB-6-7	110EB-3-4	110EB-4-5	110EB-5-6
1	***Aggregate Loss***													
2	***Bleeding /Flushing***													
3	***Excessive Aggregate***													
4	***Delamination***													
5	***Streaking***													
6	***Reflected Bleeding from Crack Seal***													
7	***Polishing***													

Note: 0 being excellent to 10 being unacceptable

1.13 FIELD TEST METHOD FOR MEASURING SEAL COAT AGGREGATE AND EMULSION APPLICATION RATES

Equipment:

Field Balance
32 Gallon Trash Bin
5-gallon Bucket
1 SYD carpet, burlap, or canvas, cut into square
Long-handled Tongs/Hooks/Pliers
Garbage Bags
Marker
Rubber Gloves
Rolled Paper (for walk path)

Emulsion Application Rate Measurement Method:

12. Label each carpet square.
13. Place a clean trash bag in the garbage container.
14. Weigh and record weights of each carpet square and the garbage container/bag.
15. Record location of test.
16. Lay 1 SYD carpet squares in line with distributor – 2 squares, roughly in the wheel paths.
17. Run distributor at application speed and emulsion rate over squares.
18. Place the ground paper on sprayed emulsion to approach the carpets.
19. Immediately pick up carpet square, garbage container, and weigh.
20. Record total weight.
21. Calculate and report application rate.
22. Reseal the area covered the carpets.

Aggregate Application Rate Measurement Method:

10. Weigh and record weight of 5-gallon bucket.
11. Record location of test.
12. Lay 1 SYD burlap or canvas in line with aggregate spreader.
13. Run aggregate spreader at application speed and application rate over burlap.
14. Pick up burlap square, and deposit aggregate into 5-gallon bucket.
15. Weigh 5-gallon bucket and aggregate.
16. Record total weight.
17. Calculate and report application rate.
18. Sweep/reseal the area covered by the burlap square.

(a) (b)

(c) (d)

FIGURE 1-3 Emulsion application rate measurement procedure

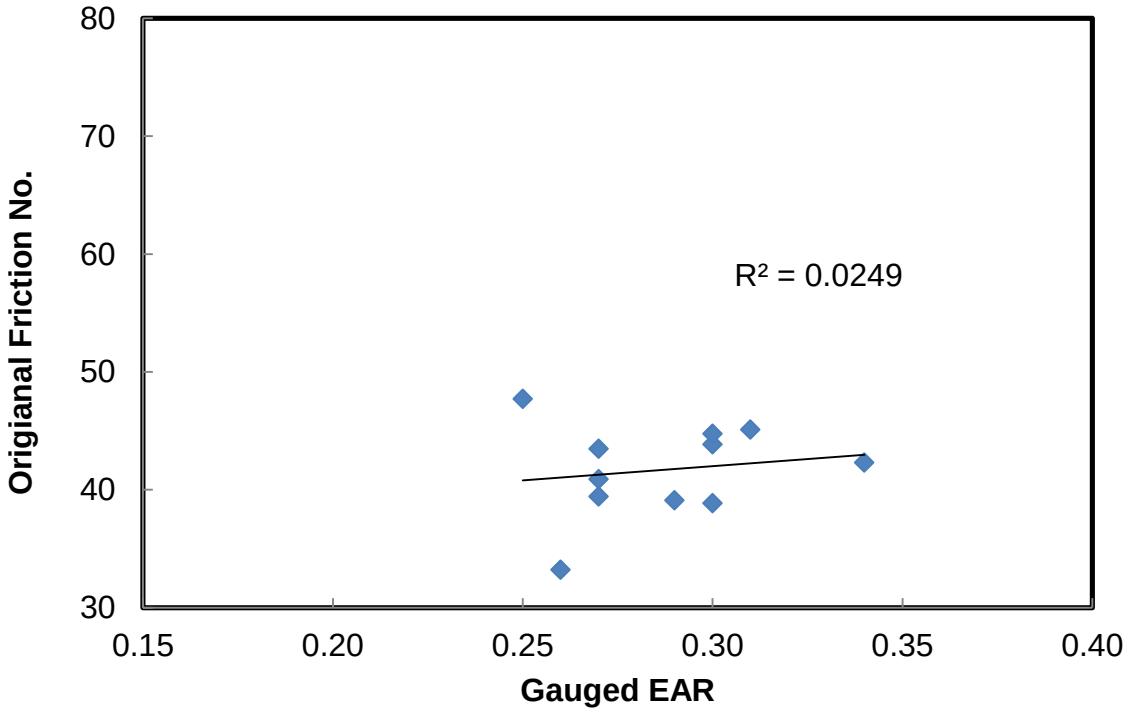
(a) (b)

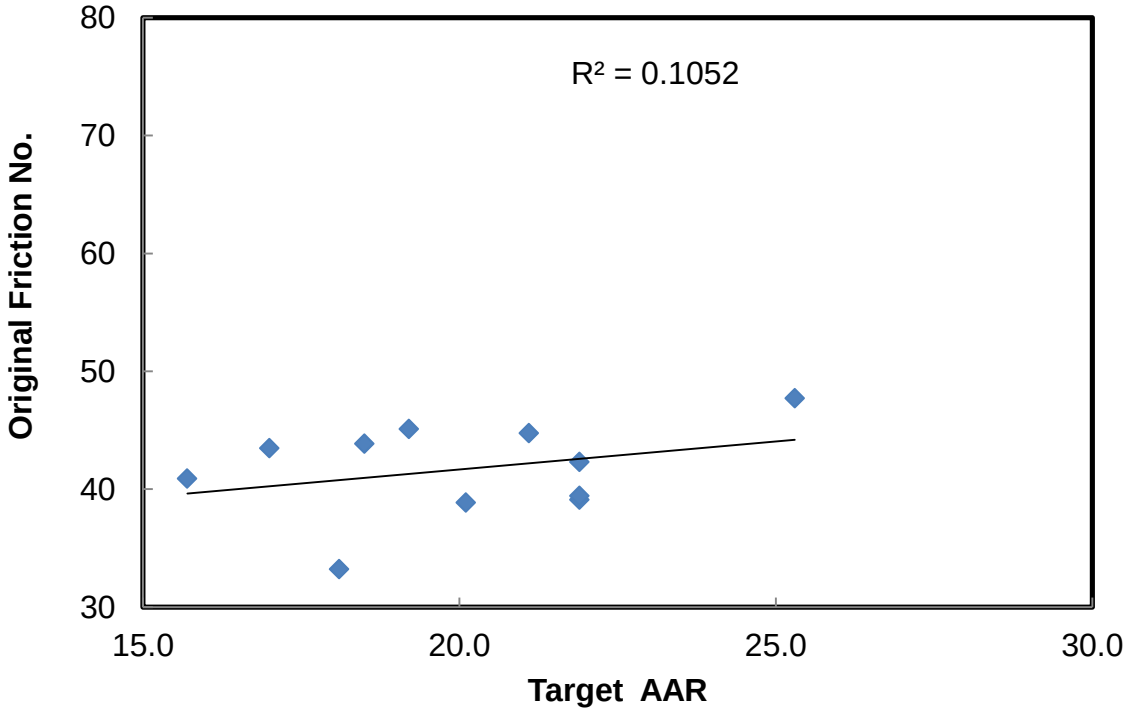
(c) (d)

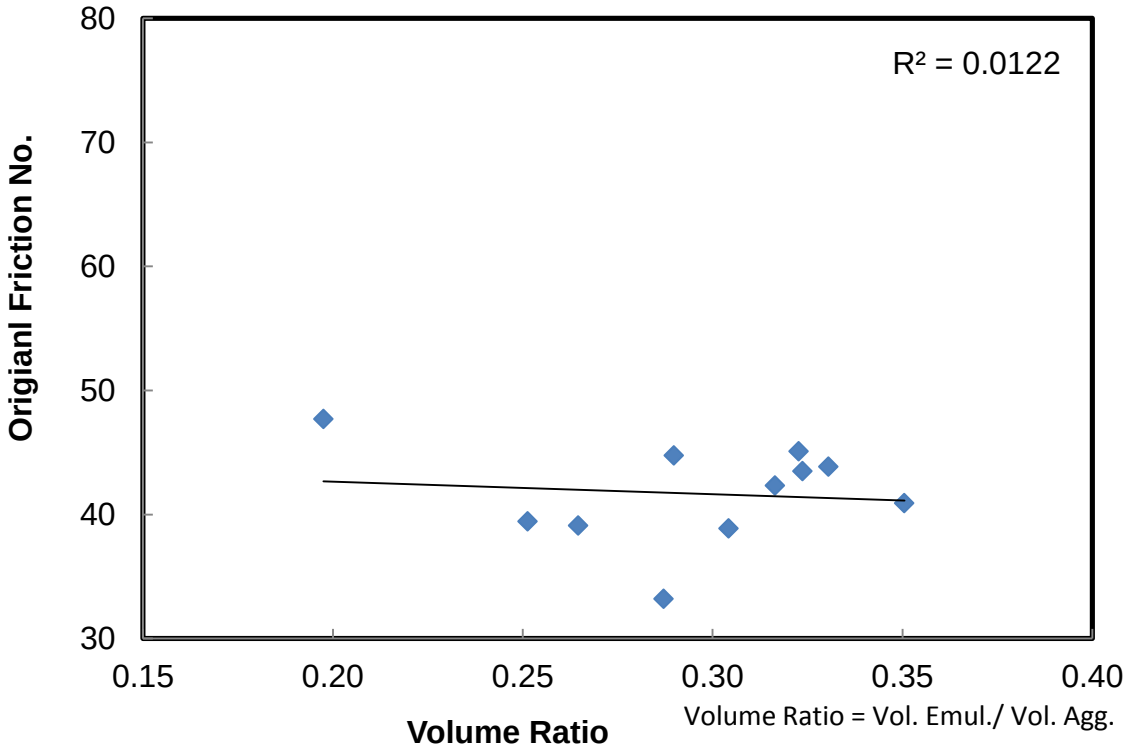
FIGURE 1-4 Aggregate application rate measurement procedure

1.14 CORELATION CHART

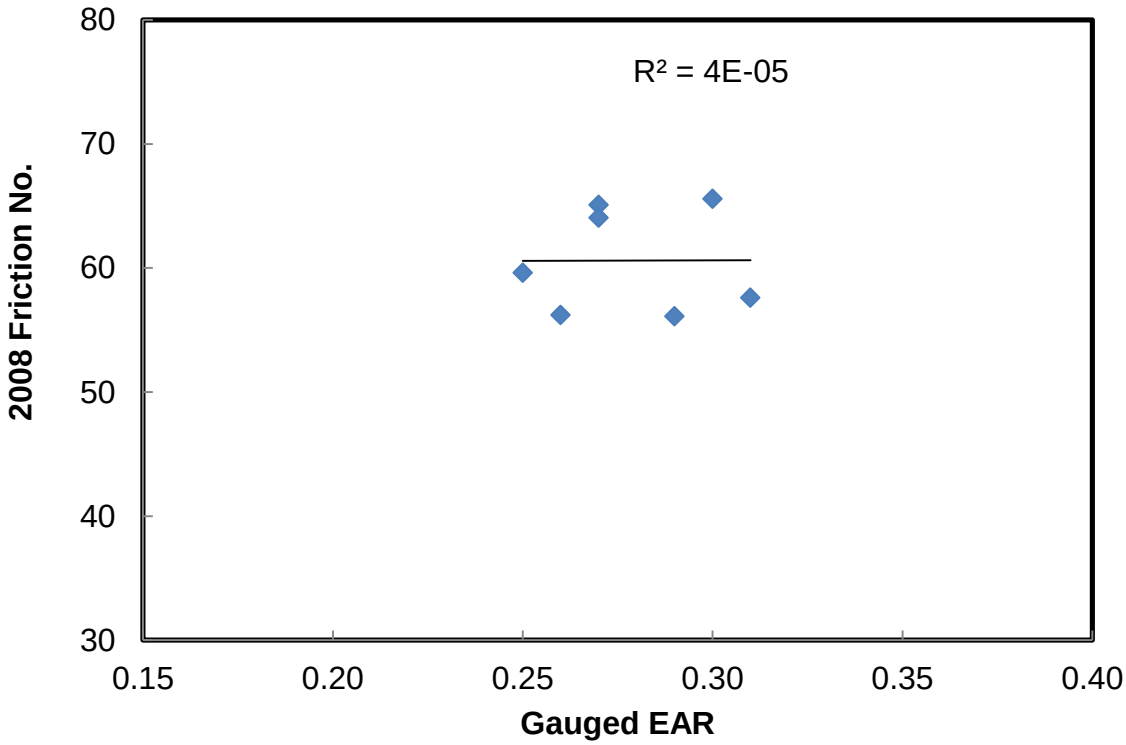
1.14.1 BEFORE SEAL COAT

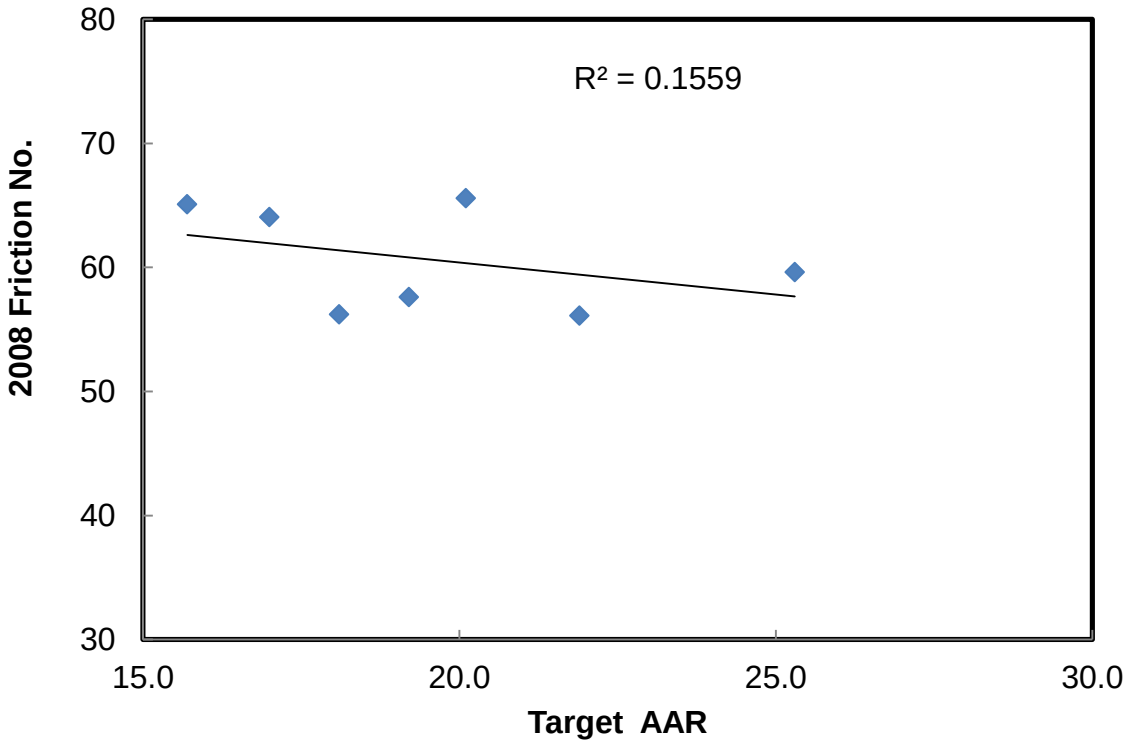


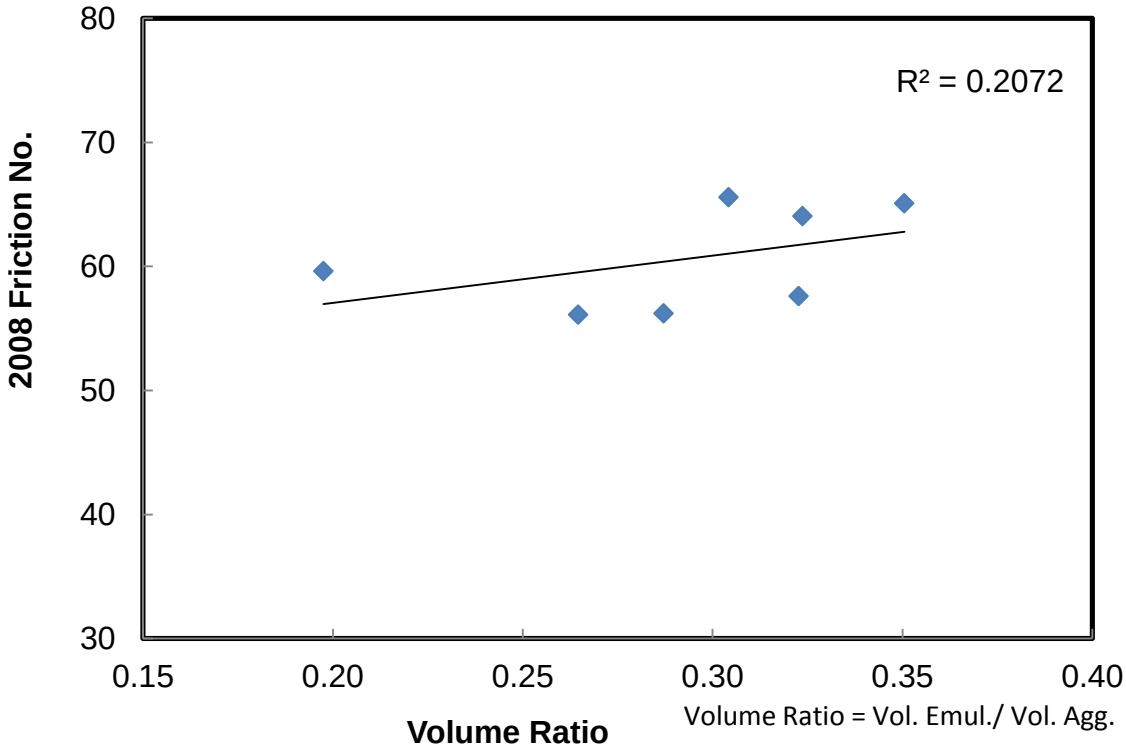



80
70
60
50
40
30
Origianl Friction No.
R² = 0.0122
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
Volume Ratio = Vol. Emul./ Vol. Agg.

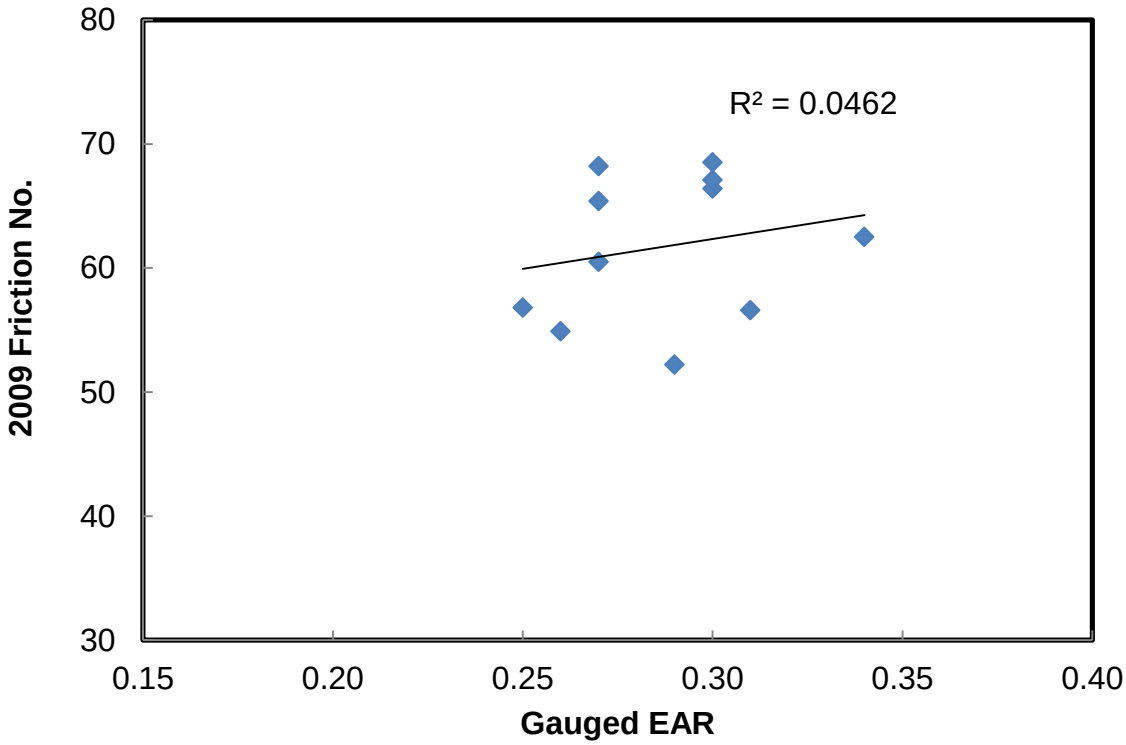
1.14.2 2008

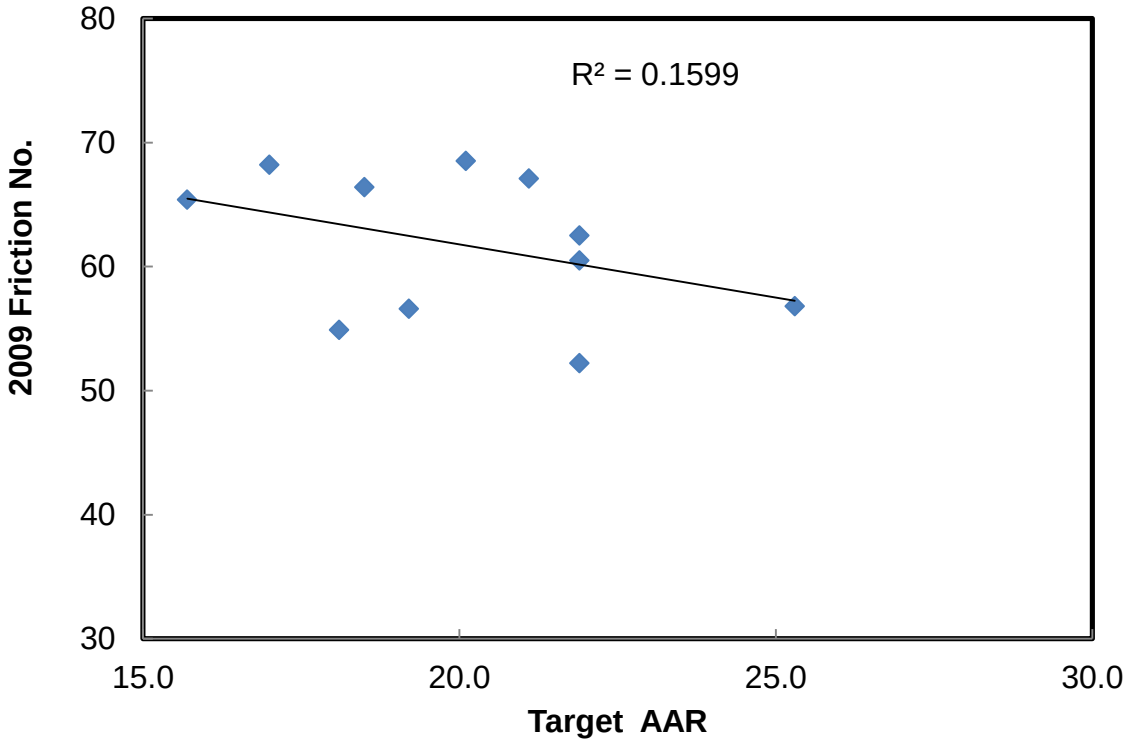

R² = 4E-05
2008 Friction No.
80
70
60
50
40
30
0.15
0.20
0.25
0.30
0.35
0.40
Gauged EAR

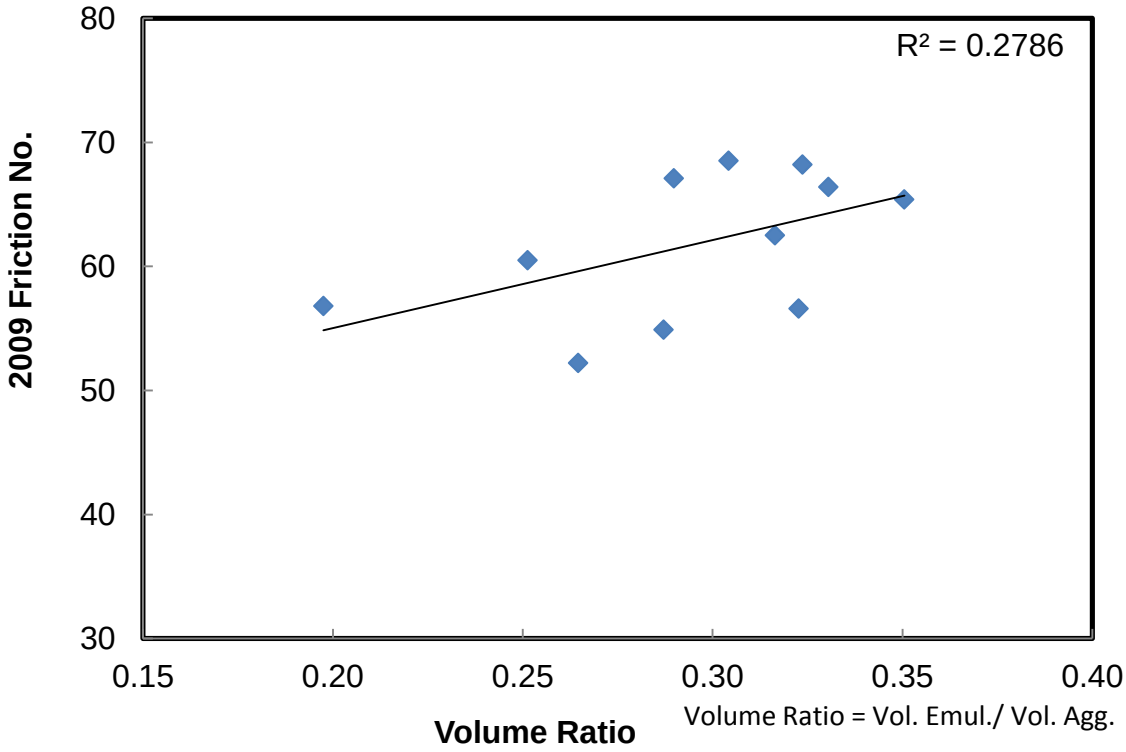

R² = 0.1559
2008 Friction No.
80
70
60
50
40
30
15.0
20.0
25.0
30.0
Target AAR


80
70
60
50
40
30
2008 Friction No.
R² = 0.2072
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
Volume Ratio = Vol. Emul./ Vol. Agg.

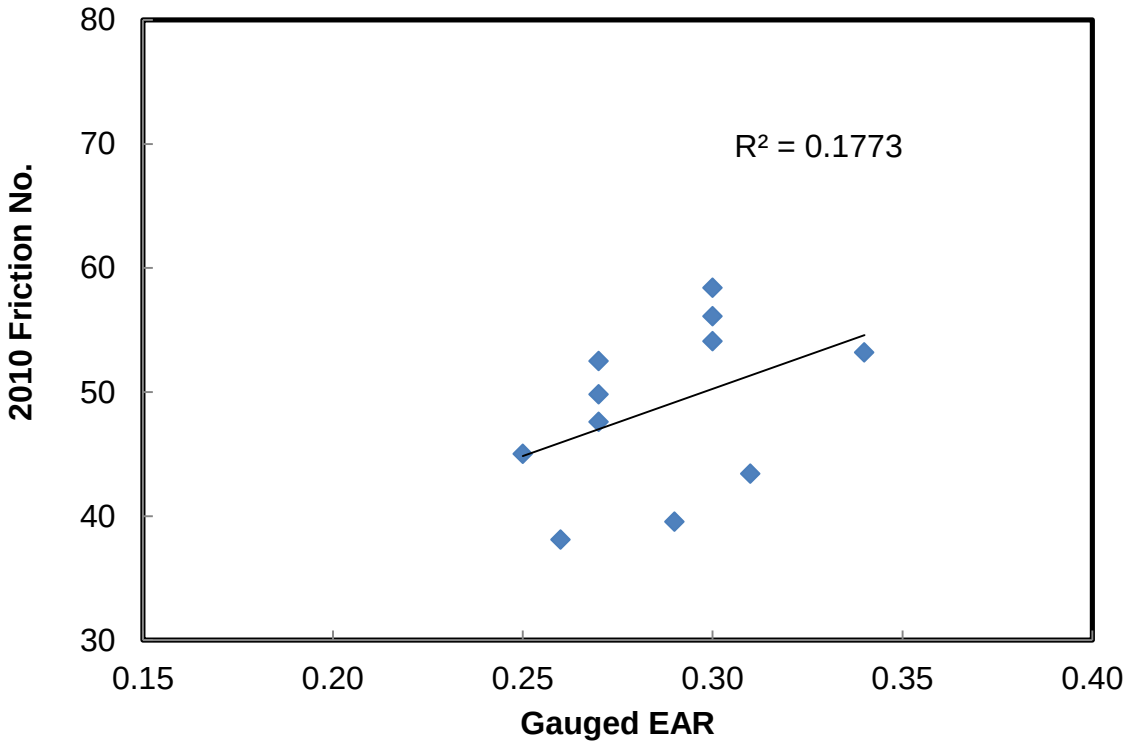
1.14.3 2009

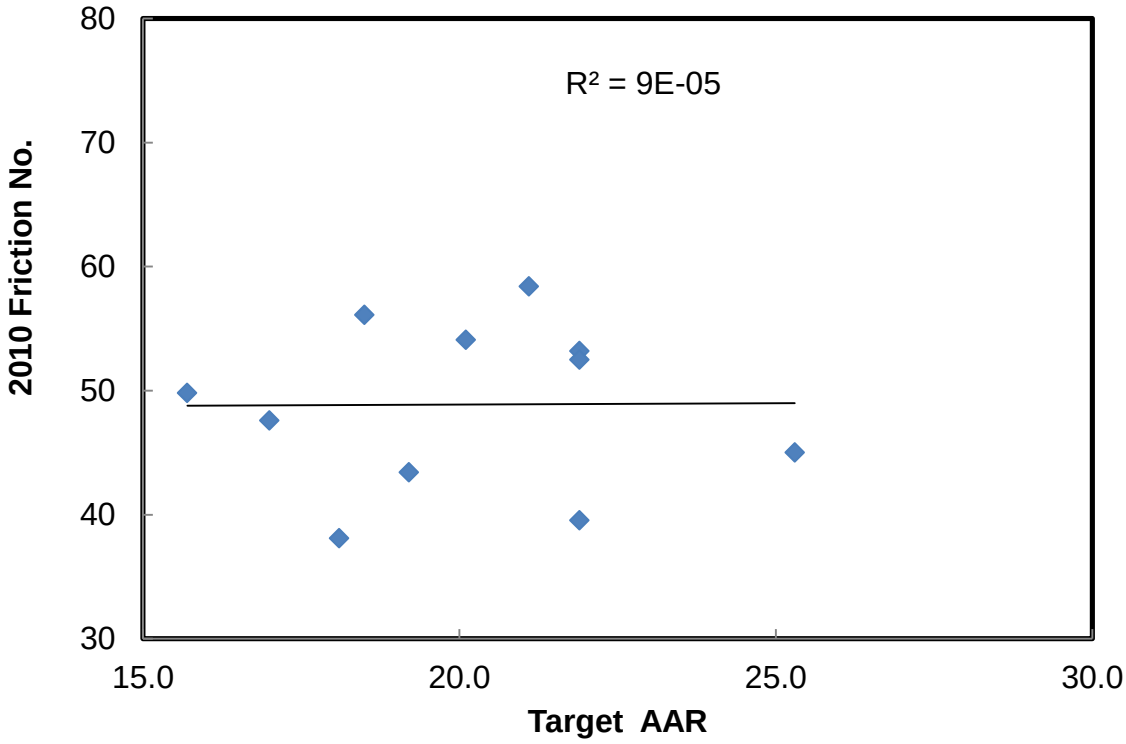

R² = 0.0462
2009 Friction No.
80
70
60
50
40
30
0.15
0.20
0.25
0.30
0.35
0.40
Gauged EAR

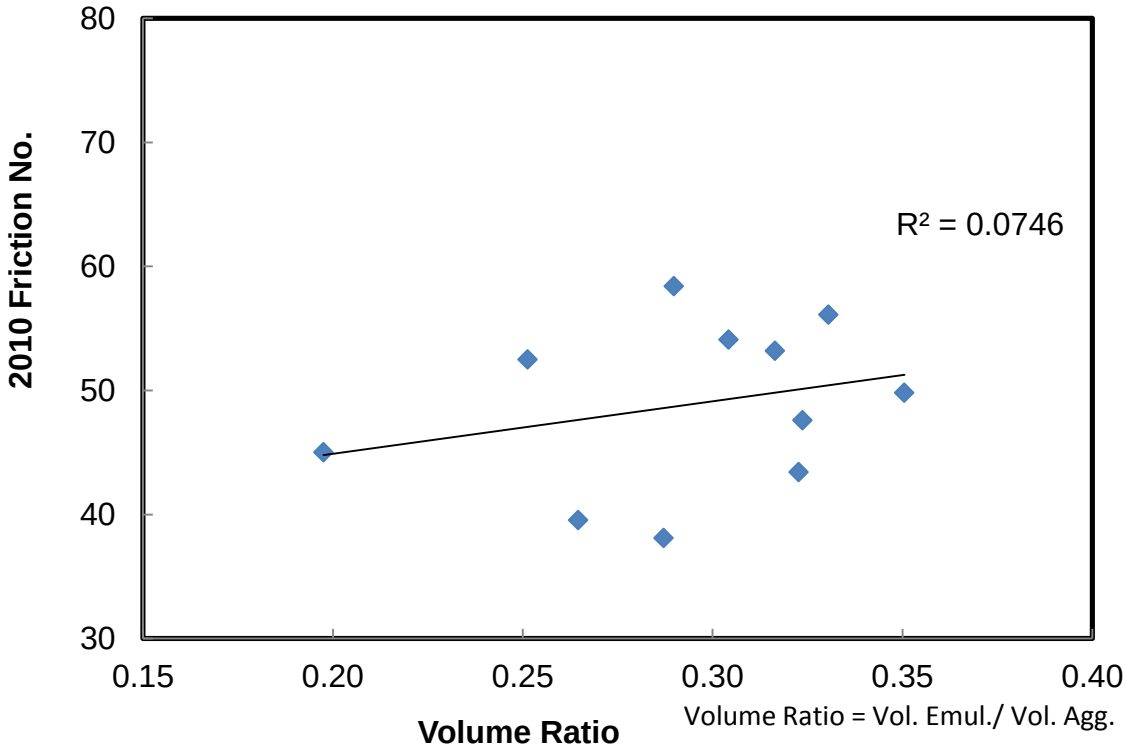

R² = 0.1599
2009 Friction No.
80
70
60
50
40
30
15.0
20.0
25.0
30.0
Target AAR


R² = 0.2786
2009 Friction No.
80
70
60
50
40
30
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
Volume Ratio = Vol. Emul./ Vol. Agg.

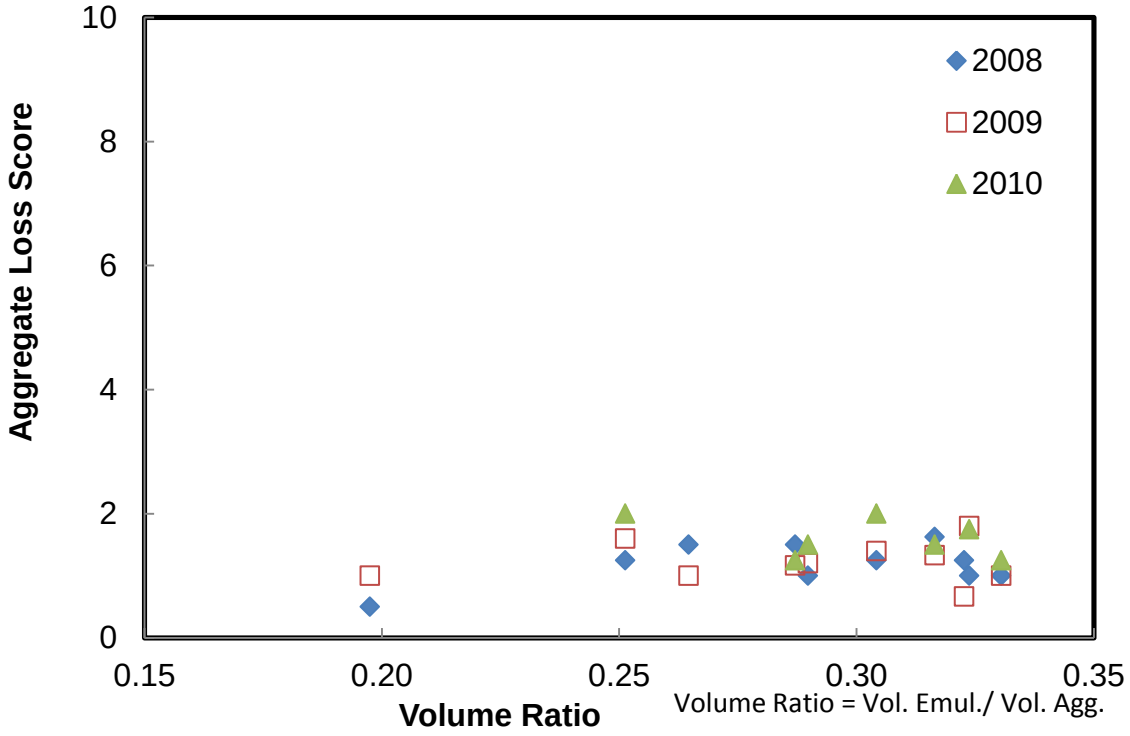
1.14.4 2010

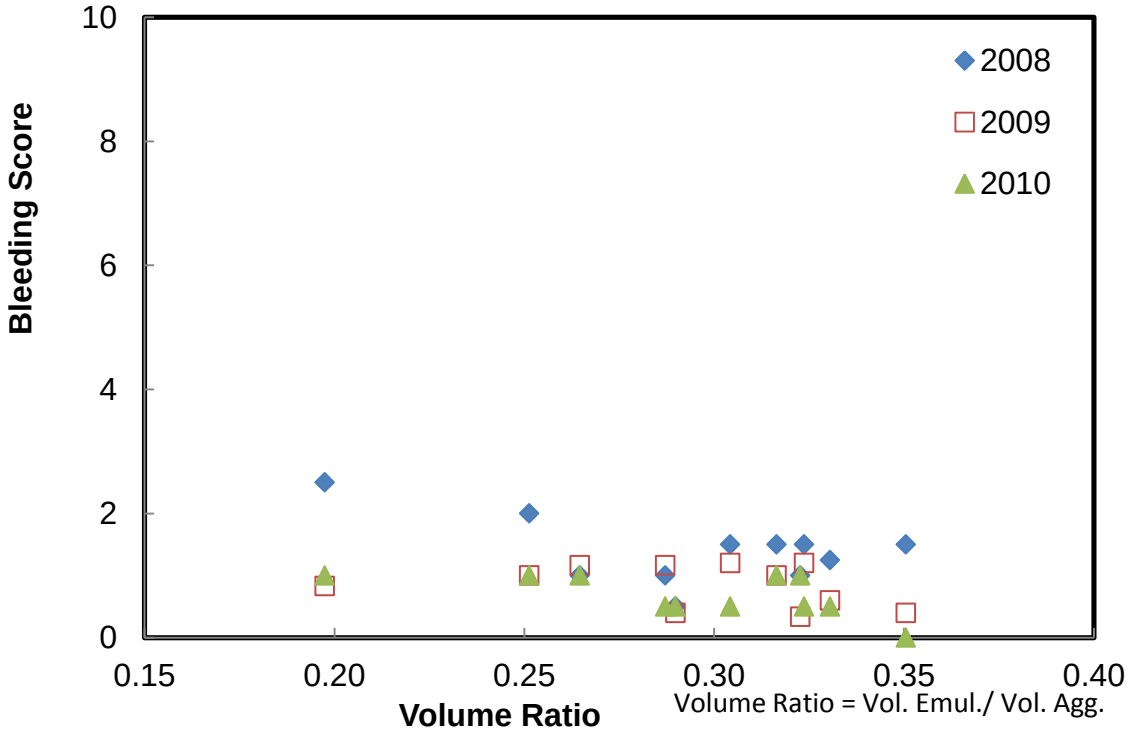

80
70
60
50
40
30
2010 Friction No.
R² = 0.1773
0.15
0.20
0.25
0.30
0.35
0.40
Gauged EAR

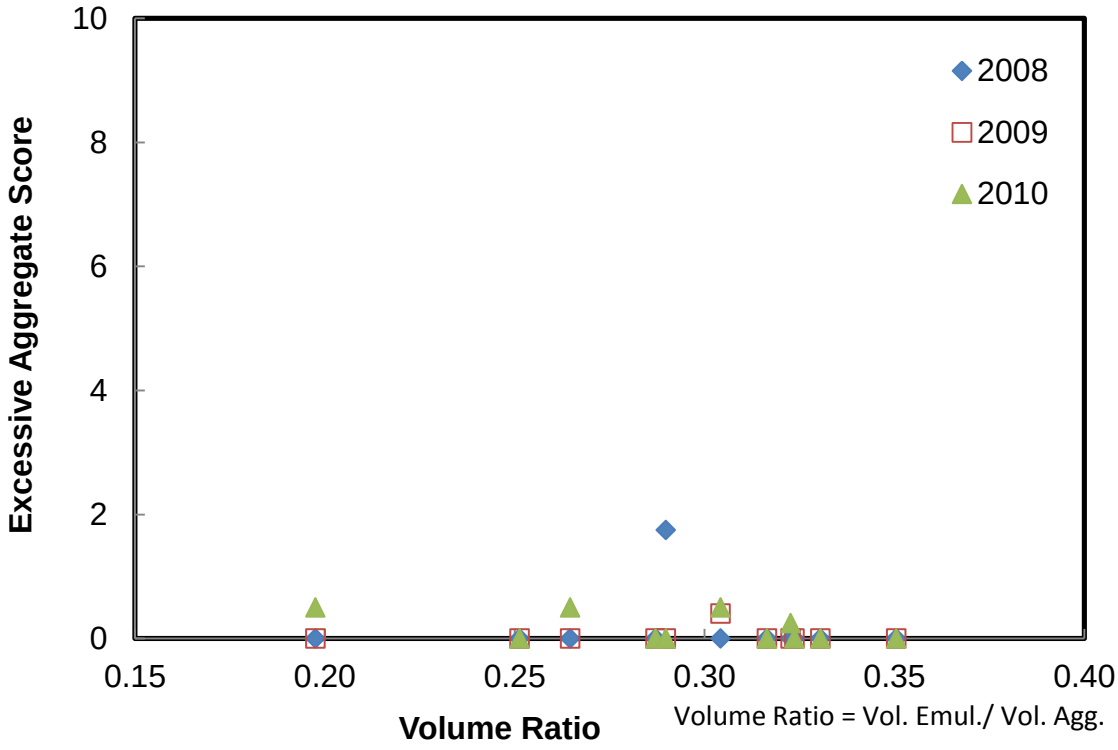

80
70
60
50
40
30
2010 Friction No.
R² = 9E-05
15.0
20.0
25.0
30.0
Target AAR

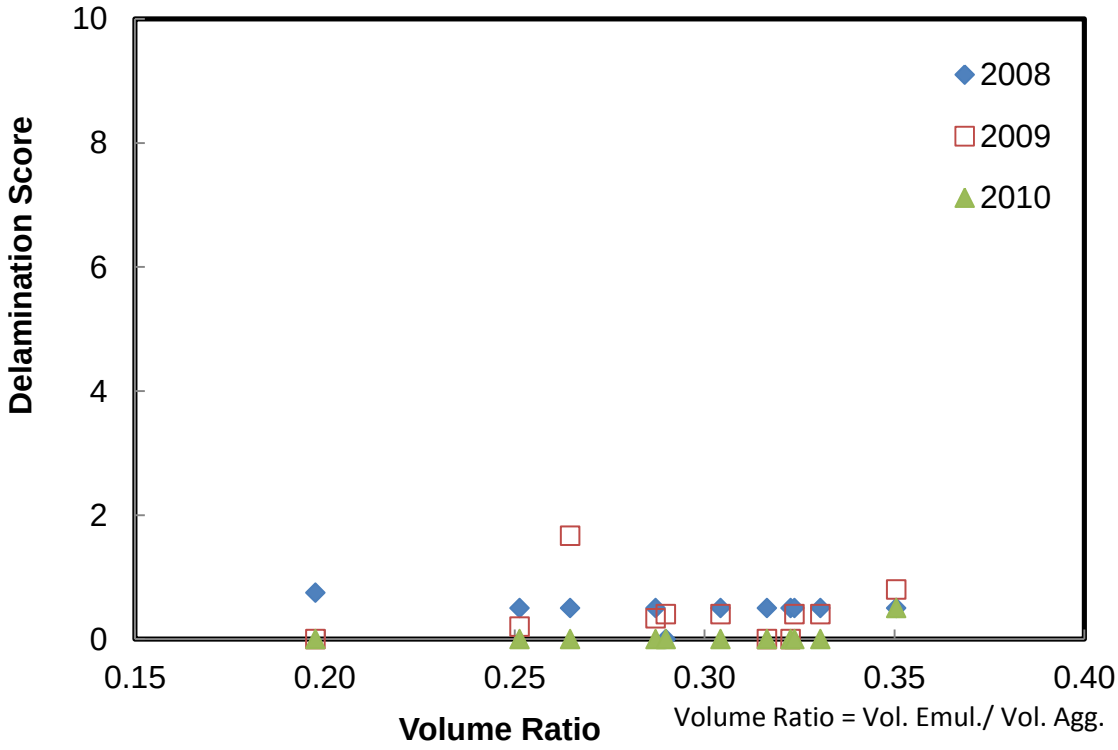

80
70
60
50
40
30
2010 Friction No.
R² = 0.0746
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
Volume Ratio = Vol. Emul./ Vol. Agg.

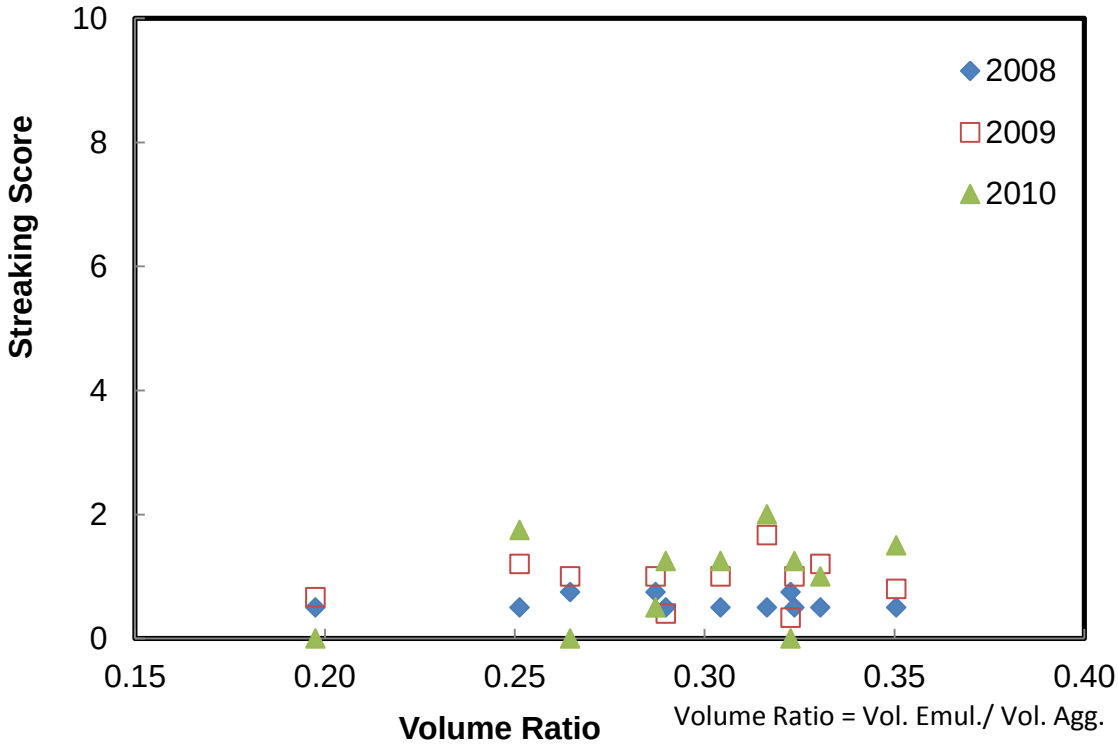
1.15 VISUAL OBSERVATION OVER VOLUME RATIO

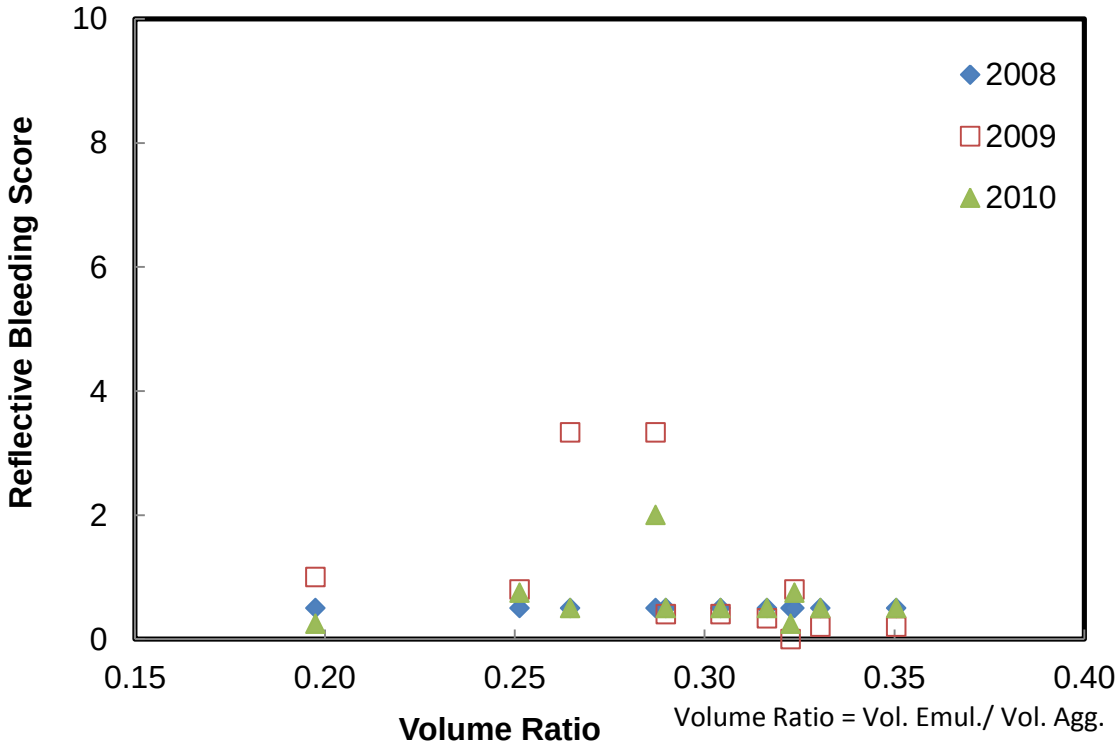


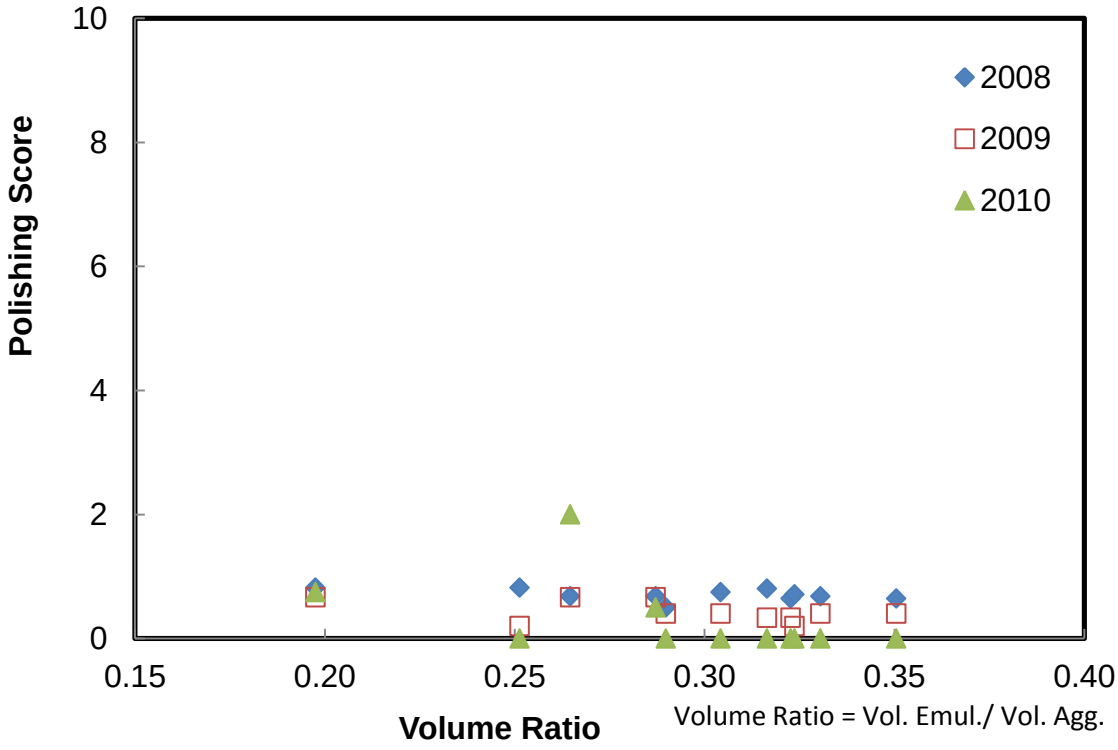


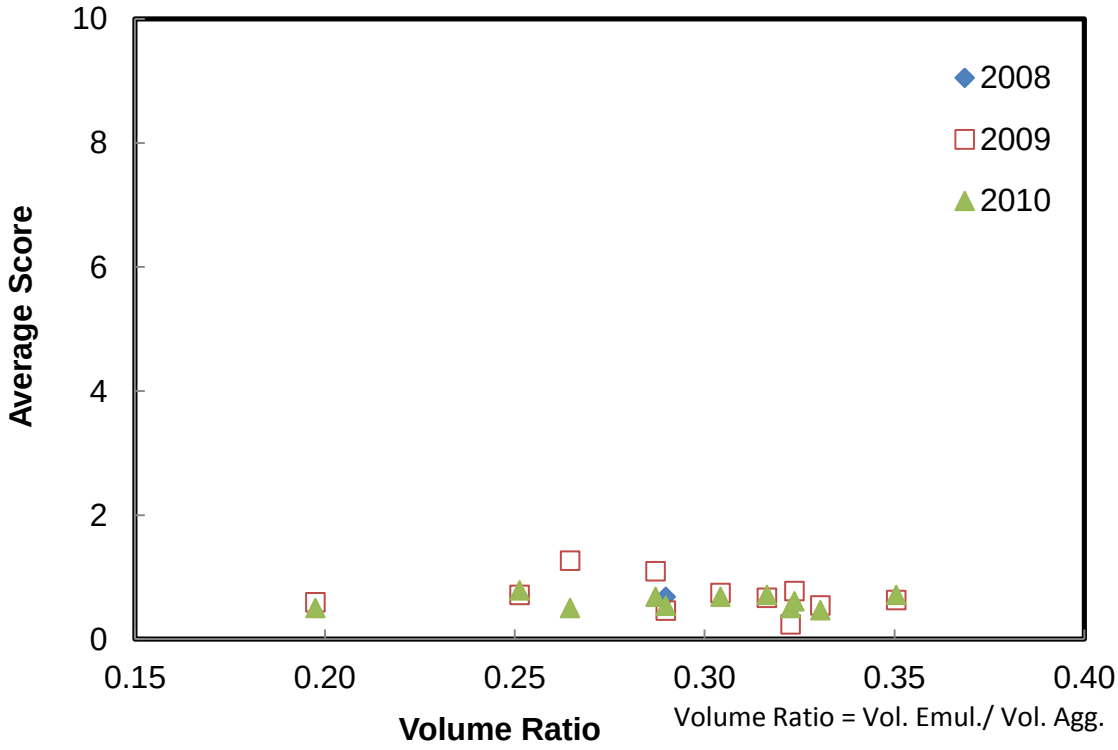

Excessive Aggregate Score
10
8
6
4
2
0
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
Volume Ratio = Vol. Emul./ Vol. Agg.
2008
2009
2010


Delamination Score
10
8
6
4
2
0
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
Volume Ratio = Vol. Emul./ Vol. Agg.
2008
2009
2010


Streaking Score
10
8
6
4
2
0
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
2008
2009
2010
Volume Ratio = Vol. Emul./ Vol. Agg.


Reflective Bleeding Score
10
8
6
4
2
0
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
2008
2009
2010
Volume Ratio = Vol. Emul./ Vol. Agg.


Polishing Score
10
8
6
4
2
0
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
Volume Ratio = Vol. Emul./ Vol. Agg.
2008
2009
2010


Average Score
10
8
6
4
2
0
0.15
0.20
0.25
0.30
0.35
0.40
Volume Ratio
Volume Ratio = Vol. Emul./ Vol. Agg.
2008
2009
2010

1.16 SURVEY QUESTIONNARIE

SURVEY OF SEAL COAT (CHIP SEAL) PRACTICE

1.16.1 RESPONDENT'S INFORMATION

Name of Person Compiling this Response: _____

Title: _____

Email/Phone: _____/_____

1.16.2 OBJECTIVE

The purpose of this survey is to collect technical information of **full width seal coat** (hereinafter called **chip seal**) practices from District engineers. The results of this survey will help developing the Indiana chip seal best practice, updating the Indiana Standard Specification Section 404, developing a study program entitled *Performance Evaluation of Chip Seal Materials and Designs* sponsored by Joint Transportation Research Program.

If you have any question or comment, please contact followings

Jusang Lee
Materials Research Engineer
Office of Research and Development
Email: jlee@indot.in.gov
Office: (765) 463-1521 ext. 349

Todd Shields
Pavement Preservation Engineer
Division of Highway Operations
Email: tshields@indot.in.gov
Office: (317) 233-3345

1.16.3 GENERAL

1. How long have you worked for chip seal work in your District?

( ) years

2. Are you familiar with Indiana Standard Specification Section 404: Seal Coat?

□ Yes, I am fully familiar with it.
□ Yes, I am partially familiar with it.
□ No, I am not familiar with it but I have read it.
□ No, I haven't even heard about it.

3. What is the typical life of a chip seal in your District?

Approximately ( ) years

4. How do you rate your District's experience with the performance chip seals (aggregate loss, bleeding, etc.)? (Check one box only.)

□ Excellent: very little difficulty
□ Good: minor difficulties
□ Fair: routine, manageable difficulties
□ Poor: Serious difficulties
□ Unacceptable difficulties

5. What are the major reasons for your District's decision to apply a chip seal to a given pavement? (check all that apply)

□ Distress (cracking)
□ Improve skid resistance
□ Prevent water infiltration
□ Provide a wearing surface
□ Oxidation
□ Raveling
□ Eliminate surface rutting
□ Improve night vision
□ Improve contrast between stripes and road surface
□ To meet annual work plan
□ Other, please specify:

6. What is the "trigger point" in your chip seal decision-making process?

□ Pavement condition rating or index
□ Level/amount of cracking
□ Skid number
□ Amount of oxidation
□ Age of the surface
□ No trigger point
□ Other reason, please specify:

7. How would you describe the level of distress (cracks or deformations) on roads that generally receive a chip seal?

□ Severe □ Moderate □ Slight □ None

8. What is the major problem associated with chip seal work in your District? (Check one box only.)

□ Early loss of aggregate
□ Loss of aggregate due to cool evenings
□ Premature flushing/bleeding
□ Loss of aggregate over patches
□ Flushing/bleeding over patches
□ Flushing/bleeding at intersections and turning areas
□ Other, please specify:

1.16.4 DESIGN

9. How do you determine the emulsion application rates?

□ Compute using design procedure
□ Based on past experience
□ Based on INDOT standard specification
□ Other, please specify:

10. How do you determine the aggregate application rates?

□ Compute using design procedure
□ Based on past experience
□ Based on INDOT standard specification
□ Other, please specify:

11. Do you apply different emulsion-aggregate application rate in different types of existing pavement condition?

□ Yes □ No if No, please answer Question 10.

12. Please provide your typical chip seal application rate used for your District in 2007?

Aggregate Size	Aggregate Application Rate (lb/yd^2)	Emulsion Application Rate (gal/yd^2)
11		
12		

13. What is the maximum traffic volume on roads on which your District constructs chip seals?

□ ADT < 500
□ ADT < 1,000
□ ADT < 2,000
□ ADT < 5,000
□ ADT < 20,000
□ ADT > 20,000

Materials

14. What aggregates gradation or size do you use for your chip seal jobs? (Check all that apply.)

□ 11
□ 12
□ Other, please specify:

15. What types of aggregate are used on your chip seal projects? (Check all that apply and indicate the single type of aggregate that is most typical.)

□ Limestone	□ most typical
□ Quartzite	□ most typical
□ Granite	□ most typical
□ Dolomite	□ most typical
□ Trap rock	□ most typical
□ Sandstone	□ most typical
□ Natural gravels	□ most typical
□ Crushed gravels	□ most typical
□ Slag	□ most typical
□ Other, please specify.	□ most typical

16. What are major aggregate providers (quarries) in your District?

Names of providers:

17. What is your major concern in aggregate for chip seal jobs?

□ Cleanness

□ Size and gradation
□ Particle shape
□ Source (ex. Limestone, Sandstone, etc)
□ Other, please specify:

18. How do you select the emulsion type for chip seal jobs?

□ Local climate
□ Traffic level of road to be sealed
□ Season in which seal will be applied
□ Local availability
□ Other, please specify:

19. What are the names of emulsions normally used for your chip seals?
(example: AE-90)

1.16.5 EQUIPMENT

20. Please provide your equipment information of chip seal job in the following table?

	Spreader	Distributor	Roller	Bloom
Number of equipment				
Company Name and Model you are using				
Please provide reason if you have any preference to specific model				

21. Do your emulsion distributors have computerized controls?

□ Yes □ No

22. Is your emulsion distributor calibrated periodically?

□ Yes □ No If Yes, how often? What procedure/method is used?

23. What is the allowable tolerance of emulsion application rate in your district? (example: the target rate: 0.2 gal/yd2, but it was found that your actual rate on chip seal job is 0.25 gal/yd2. This over application rate with +0.05 gal/yd2 can or cannot be acceptable in your District)

□ ±( ) gal/yd^2

24. Do your aggregate spreaders have computerized gate controls?

□ Yes □ No

25. Is your aggregate spreader calibrated periodically?

□ Yes □ No If Yes, how often? What procedure/method is used?

26. What is the allowable tolerance of aggregate application rate in your district?

± ( ) lb/yd^2

1.16.6 CONSTRUCTION

27. What is your typical chip seal construction season? What were the dates you work in 2007?

From the month of to the month (From to)
Dates worked in 2007:

28. What are your temperature or weather limitations for chip seal job?

□ Temperature: Upper limitation ( )˚F, Lower limitation ( ) ˚F,
□ If you have any weather limitations, please describe it.

29. Do you broom prior to emulsion application?

□ Yes □ No If Yes, how far in advance of the emulsion application? ( ) ft

30. How soon after the emulsion spray operation is aggregate spread?

( ) seconds or ( ) minutes or ( ) feet or ( ) miles

31. What is the typical time span between aggregate spread and initial rolling?

( ) seconds or ( ) minutes or ( ) feet or ( ) miles

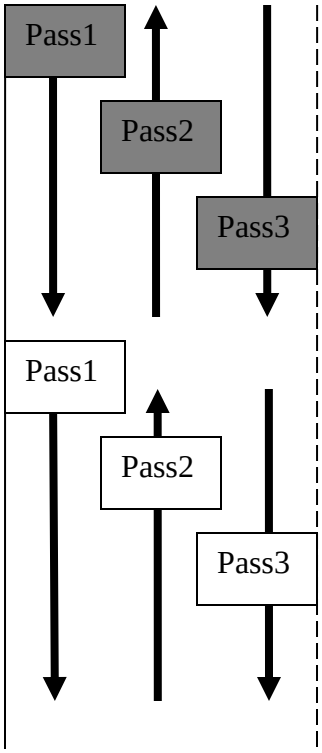
32. Which of the following controls are in place for your roller operations?

□ Number of passes
□ Rolling patterns
□ Speed limits
□ Roller weight
□ Other, please specify:

33. Which of the following rolling pattern is used for your chip seal jobs in your District?

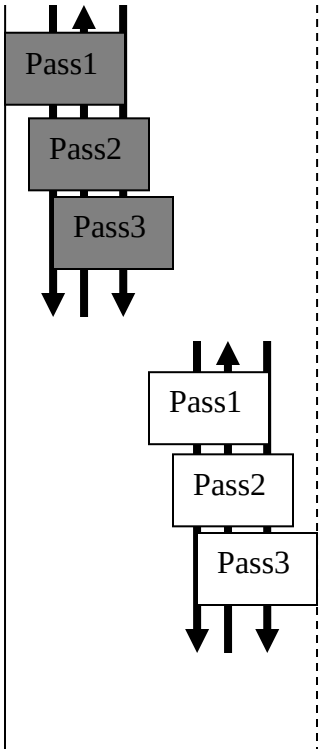
□ Pattern 1

Number of rollers: 2
Number of passes: 3/roller



□ Pattern 2

Number of rollers: 2
Number of passes: 3/roller



□ Other, please specify

Number of rollers: ( )
Number of passes: ( )

34. What is the typical time span between final rolling and initial brooming?

( ) Hours or ( ) days

35. What is the typical speed of roller in your chip seal job?

( ) mph

36. What is the typical weight of roller in your chip seal job?

( ) lbs or ( ) tons

37. What is the typical number of broom passes?

□ One
□ Two
□ Three
□ Other, please specify:

38. What traffic control measures are typically for you chip seal jobs? (Select all you use)

□ Reduced speed
□ Interim pavement markings and devices
□ Pilot vehicles
□ Flaggers
□ Safety cones
□ Other, please specify:

1.16.7 PERFORMANCE

39. What common distresses are observed in your chip seals? please indicate the top three distresses in order of occurrence.

□ Potholes
□ Raveling
□ Bleeding
□ Corrugation
□ Crack reflection
□ Streaking
□ Transverse joints
□ Longitudinal joints
□ Other, please specify:

1._____ 2. _____ 3. _____

40. Which factor is most important in improving chip seal performance in your District? (Check one box only.)

□ Construction procedure
□ Design method
□ Better emulsion
□ Better aggregates
□ Quality control
□ Other, please specify:

41. What is the most common public-user complaint about a chip seal? (Check one box only.)

□ Loose stone
□ Road noise
□ Vehicle ride
□ Appearance
□ Other, please specify:

42. How would you describe the pavement ride on roads that generally receive a chip seal?

□ Excellent
□ Good
□ Fair
□ Poor
□ Very Poor

43. Of your District's chip seal failures, which of the following was a likely cause? Please indicate the top three causes in order of importance.

□ Weather
□ Insufficient rolling
□ Improper emulsion application rate
□ Improper aggregate rate
□ Aggregate spread early
□ Aggregate spread late
□ Dirty or dusty aggregate
□ Aggregate gradation

DRAFT

□ Improper emulsion viscosity
□ Improper emulsion temperature
□ Other, please specify:
1._____ 2. _____ 3. _____

44. Which factors are most critical in determining the life of your chip seals?

□ Original quality of pavement
□ Traffic
□ Underlying structure
□ Maintenance spending
□ Friction loss
□ Materials of chip seal
□ Cold climate considerations (freeze–thaw cycles, snowplowing, etc.)

45. Do you perform any field tests to monitor the quality of your chip seal?

□ Yes □ No If Yes, what are they?

46. Do you have any maintenance method for your chip seals?

□ Yes □ No If Yes, please specify:

47. Any comment about your chip seal practice? Thank you for your cooperation!

DRAFT

1.17 FLAKINESS INDEX ITM

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

DETERMINING THE FLAKINESS INDEX OF AGGREGATES
ITM No. 2xx-07p

1.17.1 SCOPE

- This method describes a procedure to determine the Flakiness Index (FI) of aggregates. The sieve analysis shall be performed in accordance with AASHTO T 27. The (FI) will be determined in accordance with section 5.
- The values stated in either acceptable English or SI metric units are to be regarded separately as standard, as appropriate for the specification with which this ITM is used. Within the text, SI metric units are shown in parenthesis. The values stated in each system may not be exact equivalents: therefore each system shall be used independently of the other system, without combining values in any way.
- This ITM may involve hazardous materials, operation, and equipment. This ITM does not purport to address all of the safety problems associated with the ITM's use. The ITM user's responsibility is to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.17.2 SIGNIFICANCE AND USE

- This ITM provides guidance for determining the FI of aggregates.

1.17.3 APPARATUS

- An appropriate size scale or general purpose balance conforming to AASHTO M 231.
- A metal plate approximately 0.0625 inches thick with slotted openings conforming to the dimensions shown in Figure 1.
- Appropriate sieves conforming to AASHTO M 92

DRAFT

1.17.4 SIEVE ANALYSIS PROCEDURE

- Initial sample will be obtained in accordance with ITM 207
- The sample will be further reduce in accordance AASHTO T 248 to weight appropriate for the aggregate size being tested as indicated in the Inspection and Sampling Procedures for Fine and Coarse Aggregates.
- The percentage of materials finer than the #200 (75mm) sieve will be determined in accordance with AASHTO T 11.
- The particle distribution of the oven dried sample will be
- determined in accordance the AASHTO T 27.

1.17.5 FLAKINESS INDEX PROCEDURE

- Aggregates retained on each sieve (No. 4 and larger) which comprises at least 4 percent of the total sample shall be tested particle by particle for its ability to pass through the an appropriate slotted sieve or plate with elongated opening. The size of the slot for each size aggregate is given in table 1.
- For aggregates with a nominal maximum size of ½" or larger, where the FI is to be determined on material retained on the No. 4 (4.74mm)sieve, the test sample may be separated on 3/8" (9.5mm) sieve. The portion passing the 3/8" (9.5mm) sieve may then be further reduced, in accordance with ASTM Practice C 702 to a minimum of 0.5 lb (200 g). This will reduce the number of particles to be evaluated during the procedure. In this case, the percentage of particles found to be flakey is determined on each portion; and a weighted average percentage of flakey particles is calculated based on the mass of each of the portions to reflect the total percentage of flakey particles in the entire sample.
- Record the weights of the aggregates particles retained on each slot opening and the weight that passes each slot on the FI worksheet (form IT xxx). The total amount passing the appropriate slot opening shall be weighed to an accuracy of at least 0.1% of the mass of the test sample.
- Compute the FI using the worksheet in Figure 2. The FI is the total weight of the material passing the appropriate slot openings expressed as a percentage of the combined weight of the fractions tested on the slotted opening. Record the nearest whole percent.

DRAFT

Table 1

Slot Size for Each Aggregate Fraction

Range of Aggregate Size		Width of Slotted Sieve Opening (inches)
Material Passing	**Material Retained**	
1"	3/4"	0.525
3/4"	1/2"	0.375
1/2"	3/8"	0.263
3/8"	1/4"	0.183
1/4"	No. 4	0.131

FIGURE 1 – SLOTTED SIEVE OPENINGS.

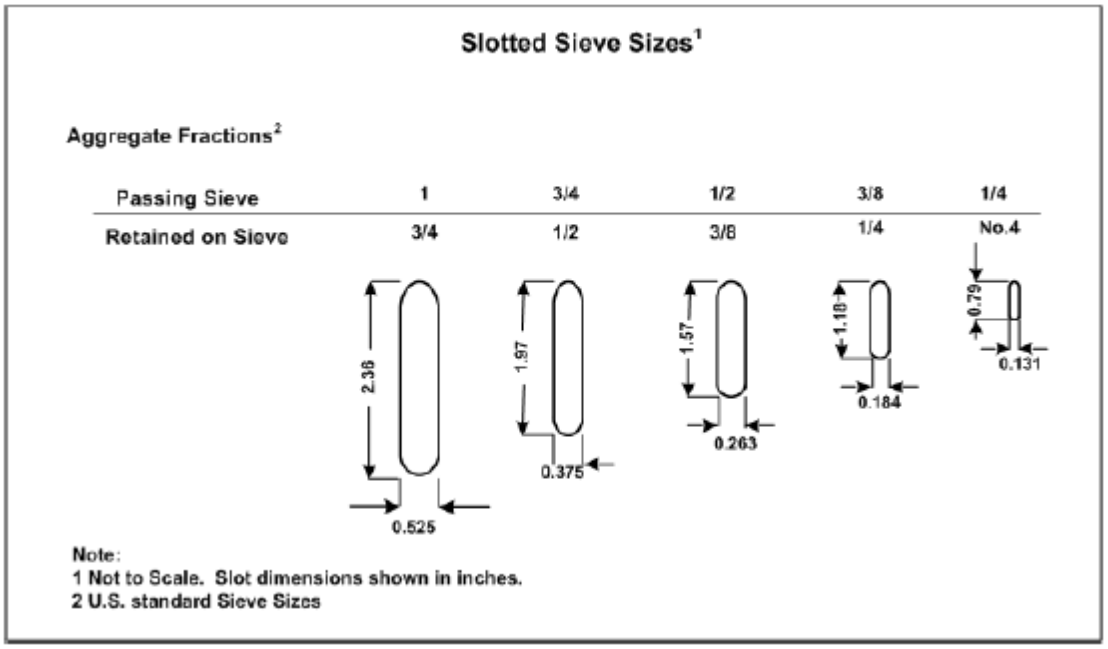


Figure 2 - FLAKINESS INDEX WORKSHEET ITM XXX

Project: _____ Source: _____

Where Sampled: _____ Quantity Represented: _____

Sample of: _____ Lot No.: _____

Sampled By: _____ Tested By: _____

	A	B	C	D	E	F
Sieve Size (inches)	Weight Retained (grams)	Total Passing (grams)	Flakiness Plate Slot Size Identification	Weight Retained on Flakiness Plate (grams)	Weight Passing Slot on Flakiness Plate (grams)	Total Weight (grams) (D + E)
1			1 to ¾			
¾			¾ to ½			
½			½ to 3/8			
3/8			3/8 to ¼			
¼			¼ to No. 4			
No. 4						
			TOTAL			
Total						

Flakiness Index [(2)] = $\frac{\text{Total of Column E}}{\text{Total of Column F}}$ = _____ (100) = [ ]

DRAFT