Report No. K-TRAN: KSU-13-6 ▪ APPENDICES ▪ June 2015

Air Void Clustering

Kyle A. Riding, Ph.D., P.E.
Asad Esmaeily, Ph.D., P.E.
Jan Vosahlik

Kansas State University Transportation Center

Kansas
Department of Transportation

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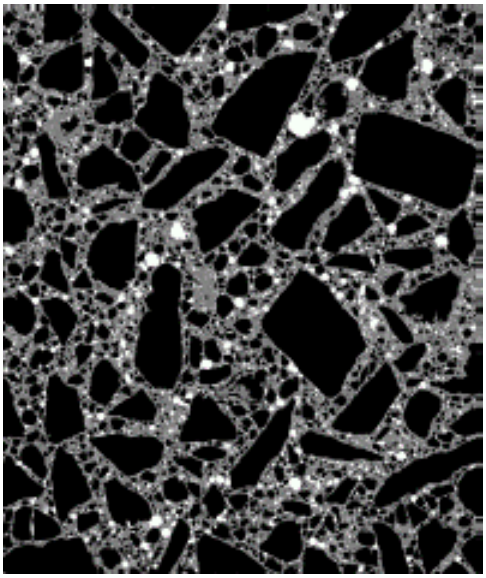
Due to file size, the full report without appendices is available in a separate file located at:

http://kdotapp.ksdot.org/kdotlib/kdotlib2.aspx

or by contacting the KDOT Library at library@ksdot.org or 785-291-3463.

Appendix A: Hardened Void Analysis Results

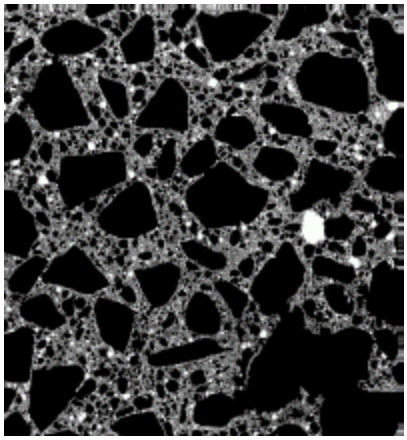
1-I



False-Color Image

Air Void Content	6.29	%
Spacing Factor	0.0043	in.
Air Void Area	0.55	in²
# of Air Voids	48724	
Paste Area	2.65	in²
Paste Content	30.12	%
Aggregate Area	5.6	in²
Clustering Index	2.3	
# Agg Analyzed	17	
Minimum Clustering Rate	5.45	%
Maximum Clustering Rate	26.98	%

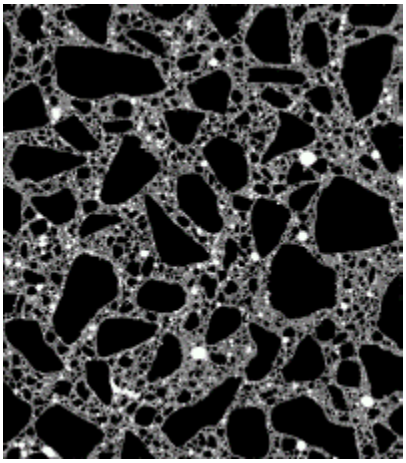
1-I-R



False-Color Image

Air Void Content	7.27	%
Spacing Factor	0.0036	in.
Air Void Area	0.69	in²
# of Air Voids	48380	
Paste Area	2.5	in²
Paste Content	26.48	%
Aggregate Area	6.27	in²
Clustering Index	1.78	
# Agg Analyzed	6.85	
Minimum Clustering Rate	685	%
Maximum Clustering Rate	17.8	%

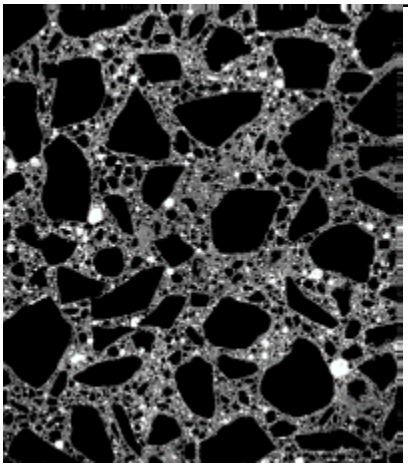
1-II



False-Color Image

Air Void Content	6.39	%
Spacing Factor	0.0068	in.
Air Void Area	0.77	in²
# of Air Voids	28108	
Paste Area	3.69	in²
Paste Content	29.59	%
Aggregate Area	7.77	in²
Clustering Index	1.57	
# Agg Analyzed	24	
Minimum Clustering Rate	4.27	%
Maximum Clustering Rate	17.07	%

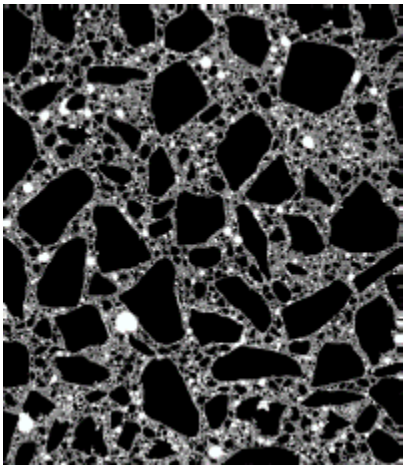
1-II-R



False-Color Image

Air Void Content	7.5	%
Spacing Factor	0.0044	in.
Air Void Area	0.9	in²
# of Air Voids	46917	
Paste Area	3.19	in²
Paste Content	26.52	%
Aggregate Area	7.95	in²
Clustering Index	1.54	
# Agg Analyzed	25	
Minimum Clustering Rate	1.85	%
Maximum Clustering Rate	19.03	%

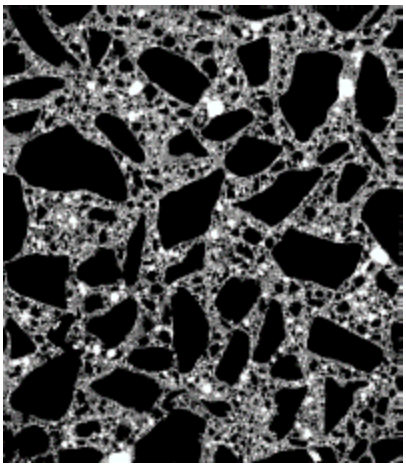
1-III



False-Color Image

Air Void Content	8.17 %
Spacing Factor	0.0059 in.
Air Void Area	0.99 in²
# of Air Voids	31833
Paste Area	3.49 in²
Paste Content	28.65 %
Aggregate Area	7.69 in²
Clustering Index	1.45
# Agg Analyzed	23
Minimum Clustering Rate	4.32 %
Maximum Clustering Rate	19.26 %

1-III-R



False-Color Image

Air Void Content	11.08 %
Spacing Factor	0.0038 in.
Air Void Area	1.34 in²
# of Air Voids	44843
Paste Area	3.42 in²
Paste Content	28.26 %
Aggregate Area	7.35 in²
Clustering Index	1.36
# Agg Analyzed	22
Minimum Clustering Rate	7.15 %
Maximum Clustering Rate	24.97 %

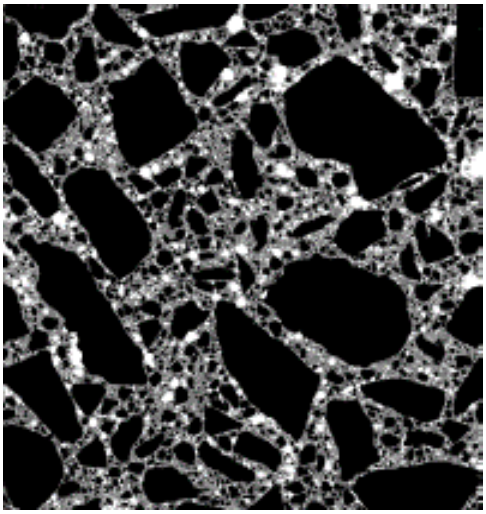
1-IV

N/A

False-Color Image

Air Void Content	7.39	%
Spacing Factor	0.0047	in.
Air Void Area	0.9	in²
# of Air Voids	38146	
Paste Area	3.06	in²
Paste Content	25.19	%
Aggregate Area	8.18	in²
Clustering Index	1.91	
# Agg Analyzed	23	
Minimum Clustering Rate	7	%
Maximum Clustering Rate	23.86	%

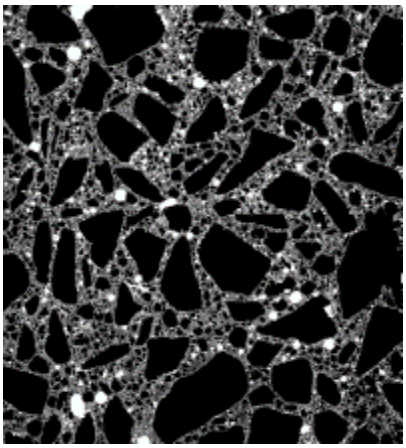
1-IV-R



False-Color Image

Air Void Content	9.74	%
Spacing Factor	0.0027	in.
Air Void Area	N/A	in²
# of Air Voids	N/A	
Paste Area	N/A	in²
Paste Content	N/A	%
Aggregate Area	N/A	in²
Clustering Index	2.22	
# Agg Analyzed	N/A	
Minimum Clustering Rate	N/A	%
Maximum Clustering Rate	N/A	%

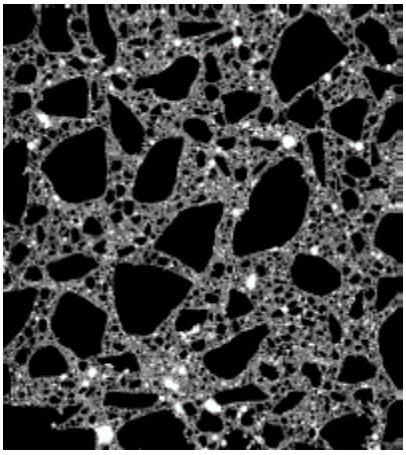
1-V



False-Color Image

Air Void Content	7.44 %
Spacing Factor	0.0046 in.
Air Void Area	0.9 in²
# of Air Voids	34349
Paste Area	2.93 in²
Paste Content	24.21 %
Aggregate Area	8.27 in²
Clustering Index	1.86
# Agg Analyzed	24
Minimum Clustering Rate	3.81 %
Maximum Clustering Rate	27.64 %

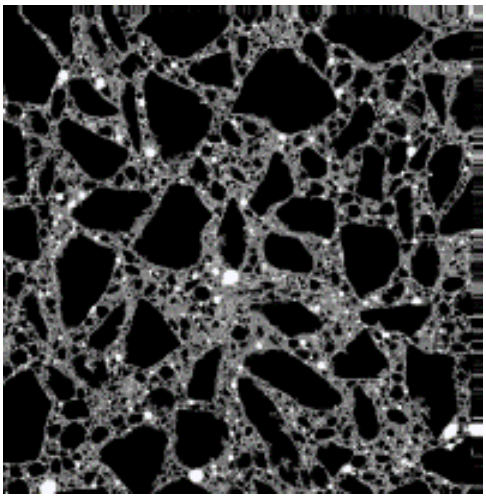
1-V-R



False-Color Image

Air Void Content	7.76 %
Spacing Factor	0.005 in.
Air Void Area	0.091 in²
# of Air Voids	43084
Paste Area	3.6 in²
Paste Content	30.73 %
Aggregate Area	7.21 in²
Clustering Index	18.88
# Agg Analyzed	18
Minimum Clustering Rate	8.27 %
Maximum Clustering Rate	20.24 %

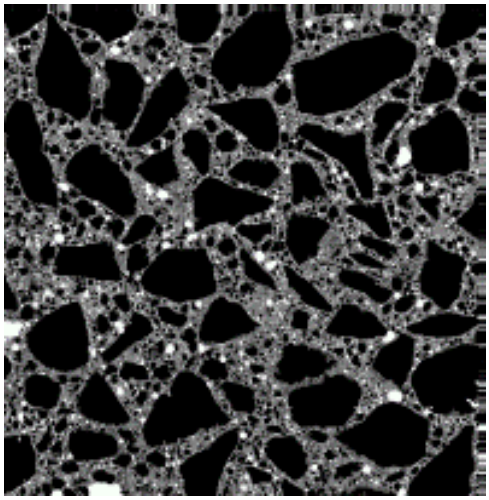
2-I



False-Color Image

Air Void Content	6	%
Spacing Factor	0.0047	in.
Air Void Area	N/A	in²
# of Air Voids	N/A	
Paste Area	N/A	in²
Paste Content	N/A	%
Aggregate Area	N/A	in²
Clustering Index	1.52	
# Agg Analyzed	22	
Minimum Clustering Rate	3.8	%
Maximum Clustering Rate	13.01	%

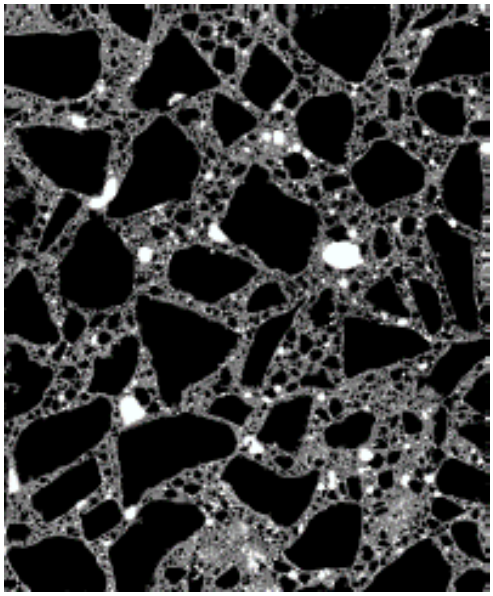
2-I-R



False-Color Image

Air Void Content	7.45	%
Spacing Factor	0.0047	in.
Air Void Area	N/A	in²
# of Air Voids	N/A	
Paste Area	N/A	in²
Paste Content	N/A	%
Aggregate Area	N/A	in²
Clustering Index	1.45	
# Agg Analyzed	23	
Minimum Clustering Rate	5.23	%
Maximum Clustering Rate	18.17	%

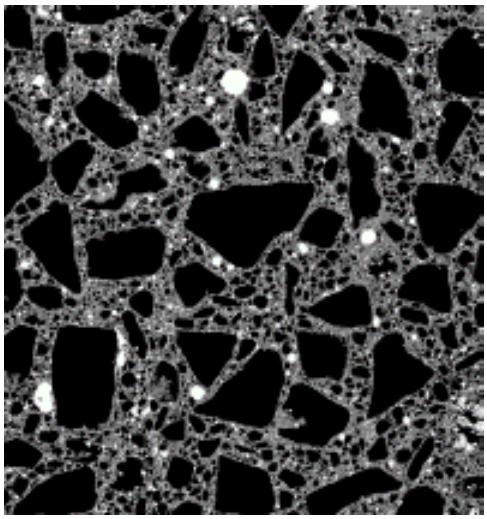
2-II



False-Color Image

Air Void Content	5.73	%
Spacing Factor	0.0072	in.
Air Void Area	0.68	in²
# of Air Voids	26386	
Paste Area	3.26	in²
Paste Content	27.42	%
Aggregate Area	7.95	in²
Clustering Index	1.42	
# Agg Analyzed	N/A	
Minimum Clustering Rate	N/A	%
Maximum Clustering Rate	N/A	%

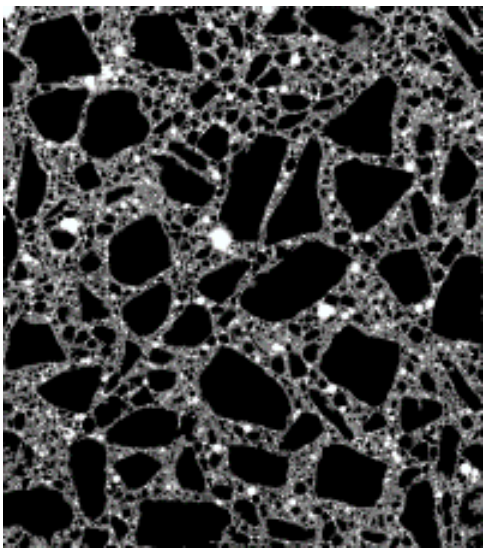
2-II-R



False-Color Image

Air Void Content	6.41	%
Spacing Factor	0.006	in.
Air Void Area	0.75	in²
# of Air Voids	37569	
Paste Area	3.76	in²
Paste Content	32.00	%
Aggregate Area	7.23	in²
Clustering Index	1.42	
# Agg Analyzed	22	
Minimum Clustering Rate	4.02	%
Maximum Clustering Rate	16.17	%

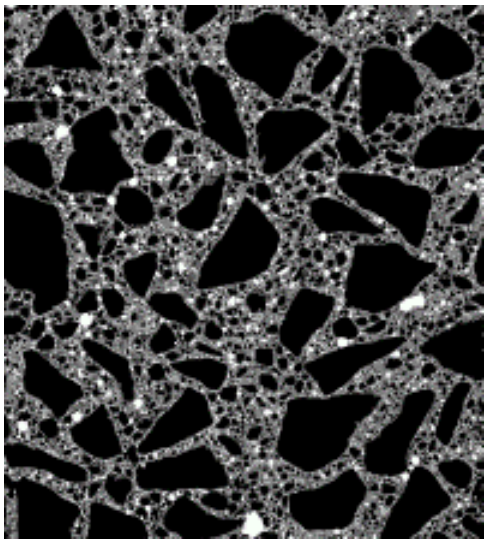
2-III



False-Color Image

Air Void Content	6.85 %
Spacing Factor	0.0070 in.
Air Void Area	0.83 in²
# of Air Voids	32564
Paste Area	3.67 in²
Paste Content	30.47 %
Aggregate Area	7.55 in²
Clustering Index	1.2
# Agg Analyzed	24
Minimum Clustering Rate	4.66 %
Maximum Clustering Rate	14.46 %

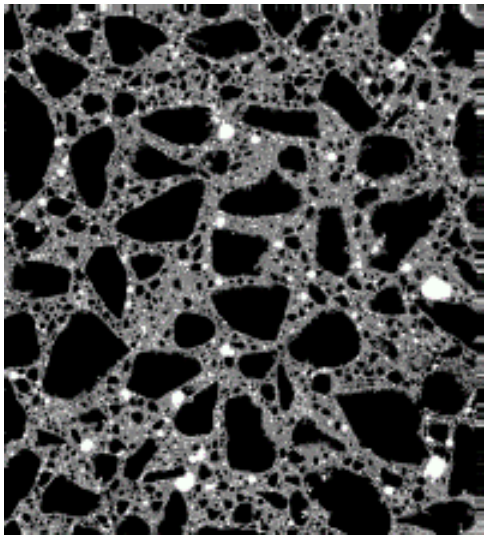
2-III-R



False-Color Image

Air Void Content	7.93 %
Spacing Factor	0.0050 in.
Air Void Area	0.94 in²
# of Air Voids	44094
Paste Area	3.46 in²
Paste Content	29.22 %
Aggregate Area	7.45 in²
Clustering Index	1.44
# Agg Analyzed	25
Minimum Clustering Rate	5.03 %
Maximum Clustering Rate	21.39 %

2-IV



False-Color Image

Air Void Content	6.81	%
Spacing Factor	0.0073	in.
Air Void Area	0.86	in²
# of Air Voids	33397	
Paste Area	4.69	in²
Paste Content	37.34	%
Aggregate Area	7.02	in²
Clustering Index	0.98	
# Agg Analyzed	29	
Minimum Clustering Rate	2.51	%
Maximum Clustering Rate	12.98	%

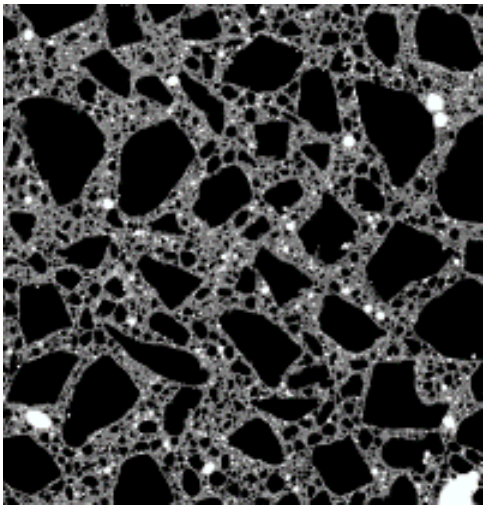
2-IV-R

N/A

False-Color Image

Air Void Content	6.87	%
Spacing Factor	0.0047	in.
Air Void Area	N/A	in²
# of Air Voids	N/A	
Paste Area	N/A	in²
Paste Content	N/A	%
Aggregate Area	N/A	in²
Clustering Index	1.47	
# Agg Analyzed	N/A	
Minimum Clustering Rate	N/A	%
Maximum Clustering Rate	N/A	%

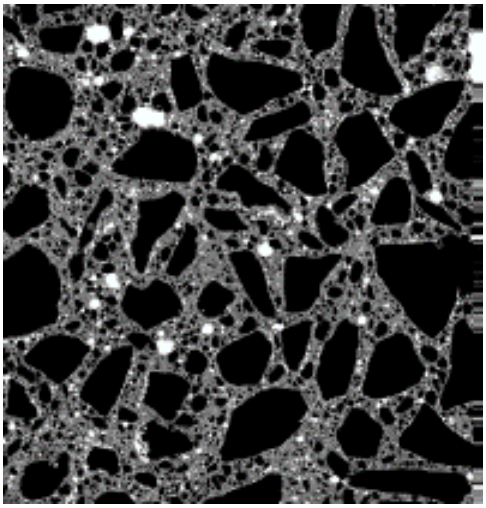
2-V



False-Color Image

Air Void Content	6.19 %
Spacing Factor	0.0058 in.
Air Void Area	0.72 in²
# of Air Voids	42512
Paste Area	3.72 in²
Paste Content	32.13 %
Aggregate Area	7.15 in²
Clustering Index	1.72
# Agg Analyzed	22
Minimum Clustering Rate	4.96 %
Maximum Clustering Rate	14.53 %

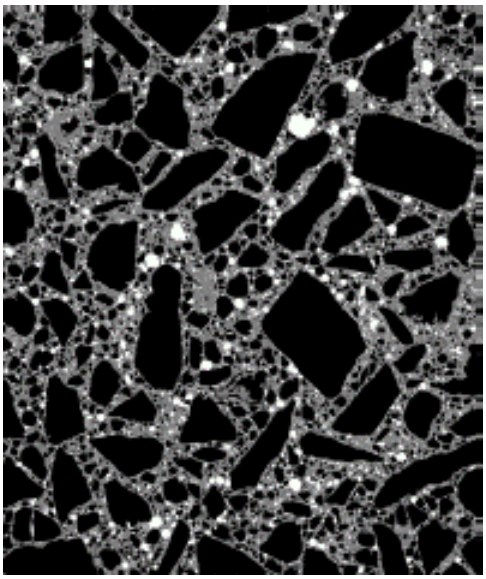
2-V-R



False-Color Image

Air Void Content	7.83 %
Spacing Factor	0.0038 in.
Air Void Area	0.95 in²
# of Air Voids	69076
Paste Area	3.48 in²
Paste Content	28.64 %
Aggregate Area	6.27 in²
Clustering Index	1.71
# Agg Analyzed	26
Minimum Clustering Rate	7.19 %
Maximum Clustering Rate	24.95 %

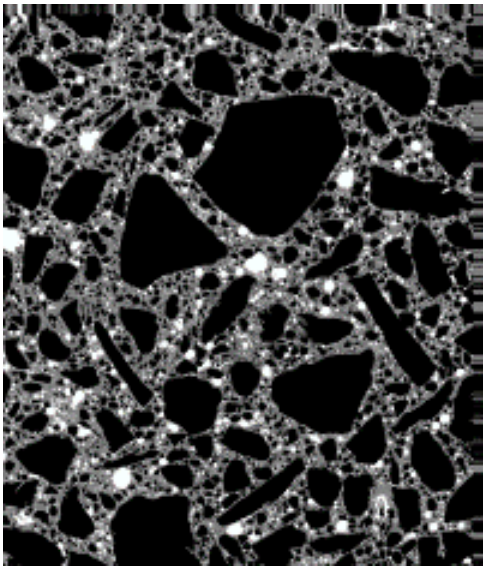
3-I



False-Color Image

Air Void Content	6.19 %
Spacing Factor	0.0091 in.
Air Void Area	0.69 in²
# of Air Voids	18329
Paste Area	3.55 in²
Paste Content	31.74 %
Aggregate Area	6.93 in²
Clustering Index	0.89
# Agg Analyzed	17
Minimum Clustering Rate	1.91 %
Maximum Clustering Rate	11.79 %

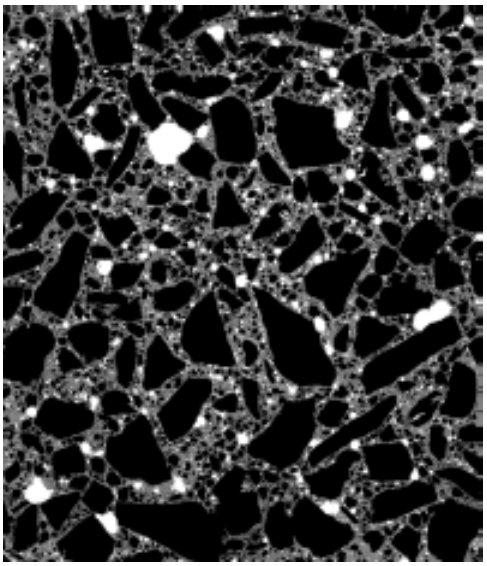
3-I-R



False-Color Image

Air Void Content	7.92 %
Spacing Factor	0.00637 in.
Air Void Area	0.93 in²
# of Air Voids	30489
Paste Area	3.59 in²
Paste Content	30.62 %
Aggregate Area	7.19 in²
Clustering Index	1.06
# Agg Analyzed	15
Minimum Clustering Rate	3.41 %
Maximum Clustering Rate	13.57 %

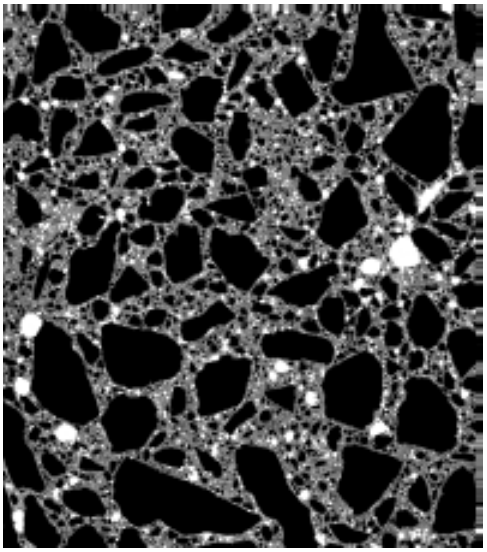
3-II



False-Color Image

Air Void Content	6.04 %
Spacing Factor	0.0107 in.
Air Void Area	0.8 in²
# of Air Voids	18576
Paste Area	3.6 in²
Paste Content	27.22 %
Aggregate Area	8.83 in²
Clustering Index	0.76
# Agg Analyzed	28
Minimum Clustering Rate	1.36 %
Maximum Clustering Rate	8.14 %

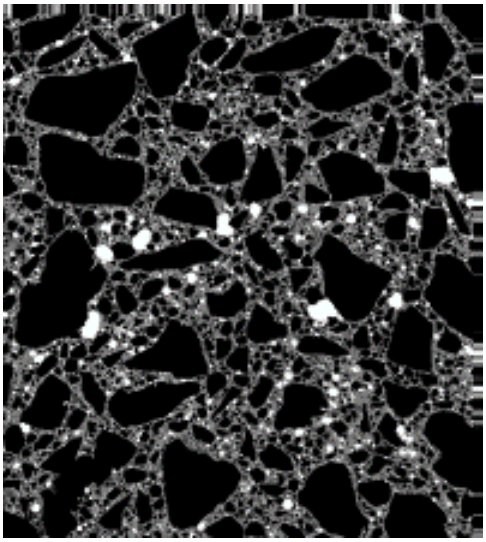
3-II-R



False-Color Image

Air Void Content	8.31 %
Spacing Factor	0.0068 in.
Air Void Area	1.03 in²
# of Air Voids	31124
Paste Area	3.81 in²
Paste Content	30.80 %
Aggregate Area	7.53 in²
Clustering Index	1.26
# Agg Analyzed	19
Minimum Clustering Rate	3.49 %
Maximum Clustering Rate	24.11 %

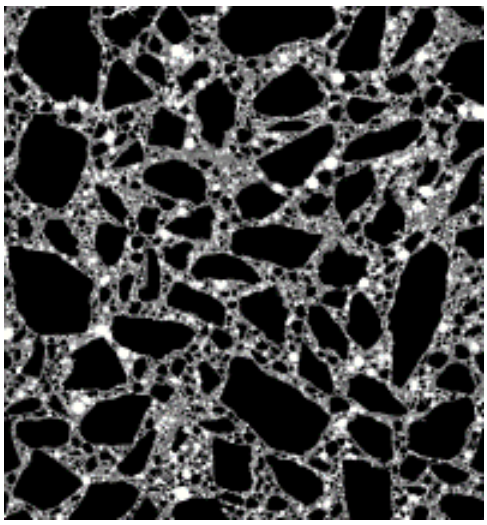
3-III



False-Color Image

Air Void Content	6.07 %
Spacing Factor	0.0078 in.
Air Void Area	0.7 in²
# of Air Voids	23396
Paste Area	3.04 in²
Paste Content	26.36 %
Aggregate Area	7.79 in²
Clustering Index	1.24
# Agg Analyzed	19
Minimum Clustering Rate	2.78 %
Maximum Clustering Rate	14.32 %

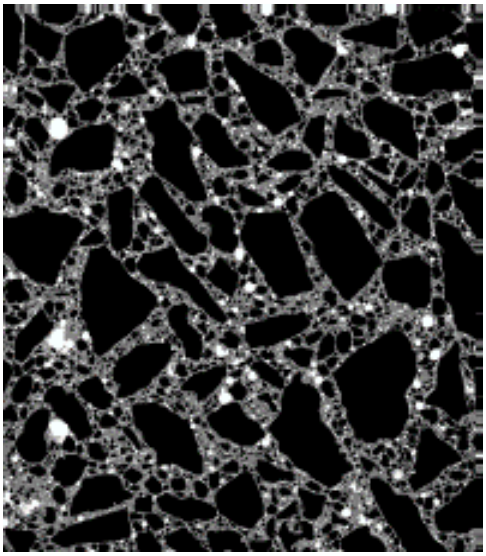
3-III-R



False-Color Image

Air Void Content	10.32 %
Spacing Factor	0.0052 in.
Air Void Area	1.24 in²
# of Air Voids	30705
Paste Area	3.21 in²
Paste Content	26.79 %
Aggregate Area	7.53 in²
Clustering Index	1.11
# Agg Analyzed	23
Minimum Clustering Rate	6.96 %
Maximum Clustering Rate	22.01 %

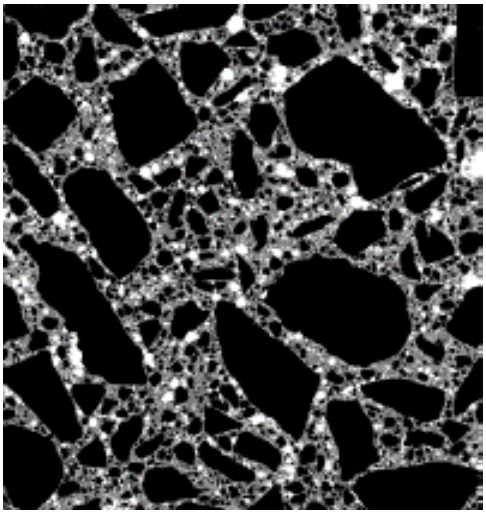
3-IV



False-Color Image

Air Void Content	6.93 %
Spacing Factor	0.0056 in.
Air Void Area	0.81 in²
# of Air Voids	31097
Paste Area	2.94 in²
Paste Content	25.21 %
Aggregate Area	7.91 in²
Clustering Index	1.65
# Agg Analyzed	19
Minimum Clustering Rate	5.61 %
Maximum Clustering Rate	18.6 %

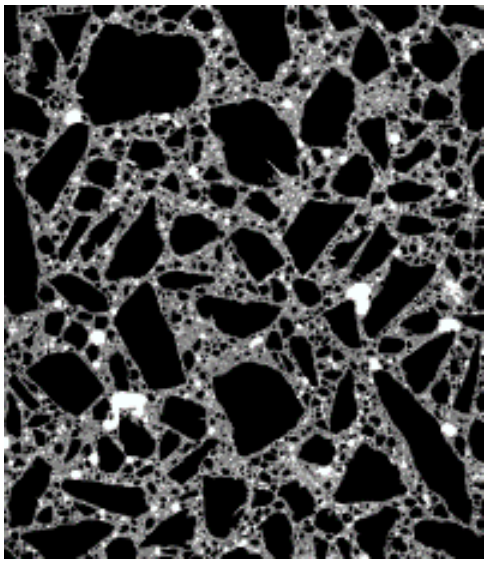
3-IV-R



False-Color Image

Air Void Content	10.34 %
Spacing Factor	0.0048 in.
Air Void Area	1.26 in²
# of Air Voids	29004
Paste Area	2.94 in²
Paste Content	24.07 %
Aggregate Area	8.02 in²
Clustering Index	1.09
# Agg Analyzed	16
Minimum Clustering Rate	5.03 %
Maximum Clustering Rate	20.55 %

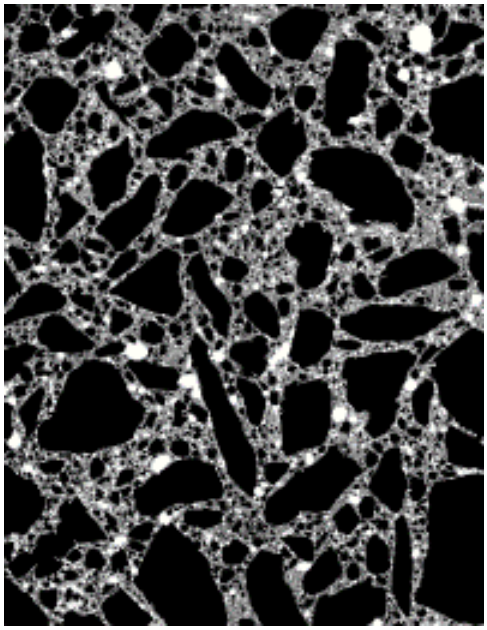
3-V



False-Color Image

Air Void Content	8.36 %
Spacing Factor	0.0053 in.
Air Void Area	1 in²
# of Air Voids	39221
Paste Area	3.57 in²
Paste Content	29.9 %
Aggregate Area	7.36 in²
Clustering Index	1.35
# Agg Analyzed	19
Minimum Clustering Rate	1.67 %
Maximum Clustering Rate	20.42 %

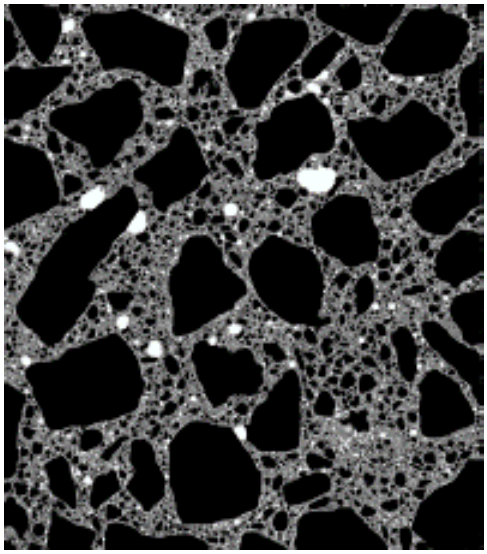
3-V-R



False-Color Image

Air Void Content	10.61 %
Spacing Factor	0.0037 in.
Air Void Area	1.03 in²
# of Air Voids	34758
Paste Area	2.45 in²
Paste Content	25.16 %
Aggregate Area	6.27 in²
Clustering Index	1.57
# Agg Analyzed	19
Minimum Clustering Rate	11.83 %
Maximum Clustering Rate	24.82 %

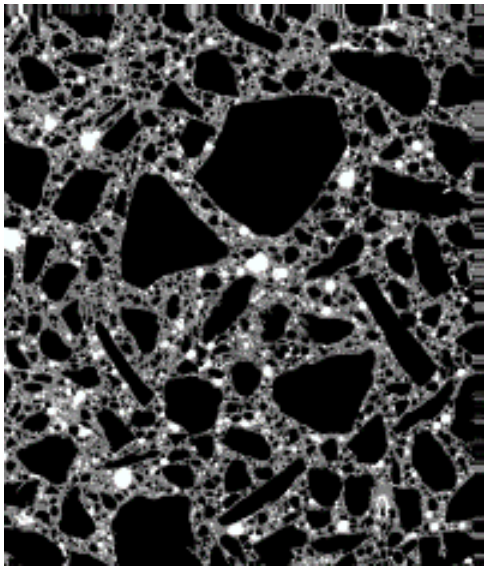
4-I



False-Color Image

Air Void Content	6.11 %
Spacing Factor	0.0054 in.
Air Void Area	0.68 in²
# of Air Voids	39329
Paste Area	3.21 in²
Paste Content	28.63 %
Aggregate Area	7.32 in²
Clustering Index	1.86
# Agg Analyzed	23
Minimum Clustering Rate	5.92 %
Maximum Clustering Rate	18.71 %

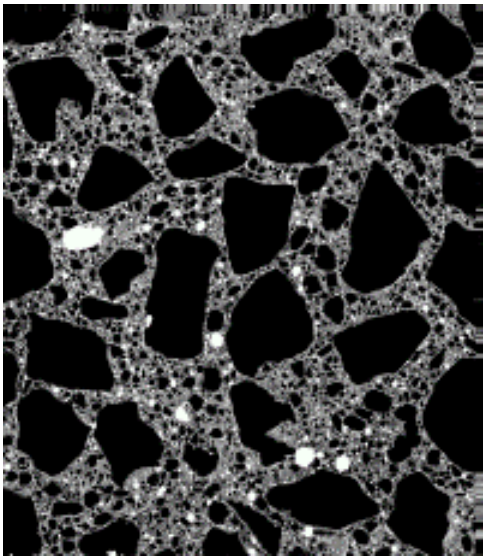
4-I-R



False-Color Image

Air Void Content	8.73 %
Spacing Factor	0.0042 in.
Air Void Area	1.02 in²
# of Air Voids	52614
Paste Area	3.61 in²
Paste Content	30.75 %
Aggregate Area	7.1 in²
Clustering Index	1.64
# Agg Analyzed	26
Minimum Clustering Rate	6.53 %
Maximum Clustering Rate	23.96 %

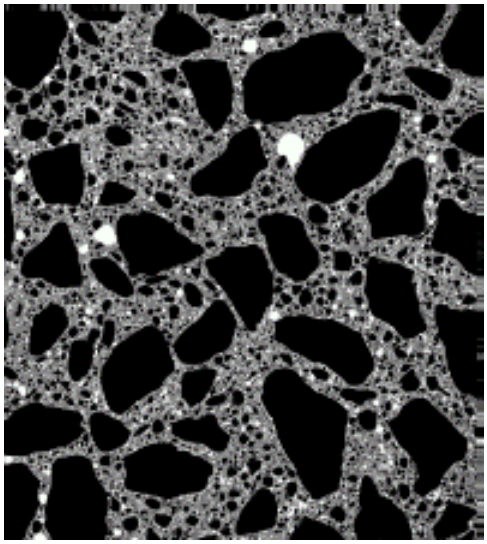
4-II



False-Color Image

Air Void Content	7.84 %
Spacing Factor	0.0045 in.
Air Void Area	0.87 in²
# of Air Voids	37124
Paste Area	3.07 in²
Paste Content	27.52 %
Aggregate Area	7.2 in²
Clustering Index	1.74
# Agg Analyzed	24
Minimum Clustering Rate	7.01 %
Maximum Clustering Rate	21.44 %

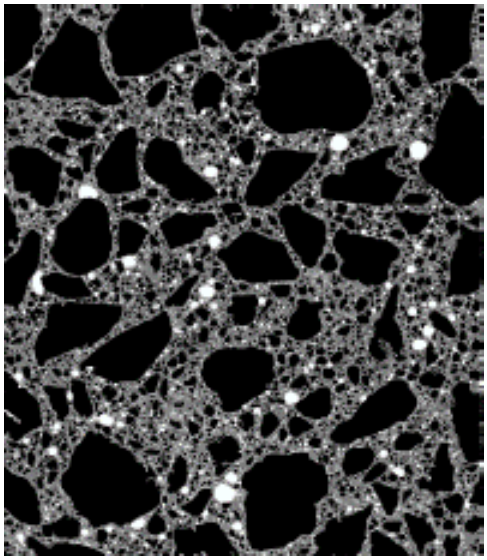
4-II-R



False-Color Image

Air Void Content	8.57 %
Spacing Factor	0.0037 in.
Air Void Area	1 in²
# of Air Voids	49215
Paste Area	3.21 in²
Paste Content	27.69 %
Aggregate Area	7340 in²
Clustering Index	1.74
# Agg Analyzed	23
Minimum Clustering Rate	6.87 %
Maximum Clustering Rate	20.84 %

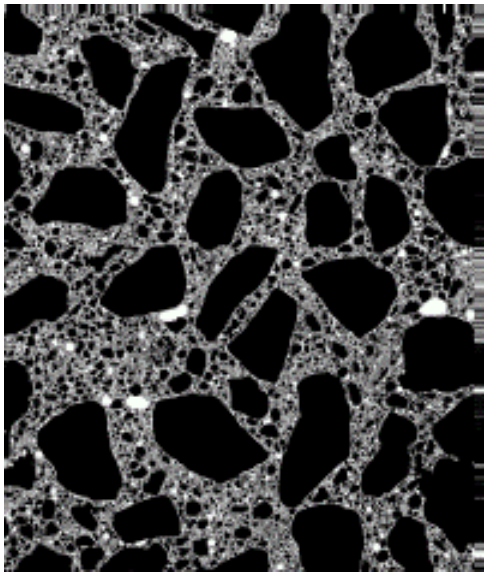
4-III



False-Color Image

Air Void Content	6.43 %
Spacing Factor	0.0063 in.
Air Void Area	0.76 in²
# of Air Voids	37145
Paste Area	3.69 in²
Paste Content	31.37 %
Aggregate Area	7.32 in²
Clustering Index	1.53
# Agg Analyzed	22
Minimum Clustering Rate	3.59 %
Maximum Clustering Rate	14.13 %

4-III-R



False-Color Image

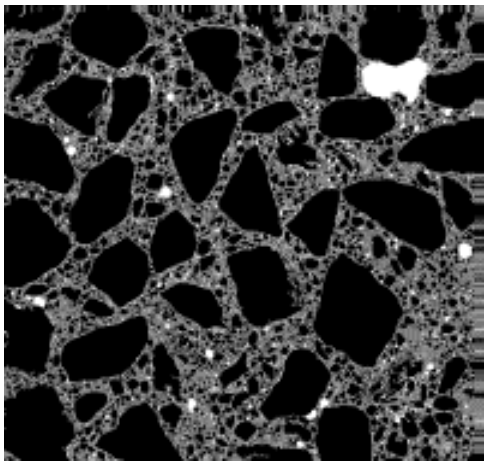
Air Void Content	9.4 %
Spacing Factor	0.003 in.
Air Void Area	1.7 in²
# of Air Voids	53216
Paste Area	2.8 in²
Paste Content	24.49 %
Aggregate Area	7.55 in²
Clustering Index	2.13
# Agg Analyzed	25
Minimum Clustering Rate	12.81 %
Maximum Clustering Rate	30.16 %

4-IV

Air Void Content	5.16	%
Spacing Factor	0.0061	in.
Air Void Area	0.6	in²
# of Air Voids	32849	
Paste Area	3.32	in²
Paste Content	28.67	%
Aggregate Area	7.67	in²
Clustering Index	1.65	
# Agg Analyzed	19	
Minimum Clustering Rate	5.61	%
Maximum Clustering Rate	18.6	%

False-Color Image

4-IV-R



Air Void Content	6.8	%
Spacing Factor	0.0039	in.
Air Void Area	N/A	in²
# of Air Voids	N/A	
Paste Area	N/A	in²
Paste Content	N/A	%
Aggregate Area	N/A	in²
Clustering Index	2	
# Agg Analyzed	N/A	
Minimum Clustering Rate	N/A	%
Maximum Clustering Rate	N/A	%

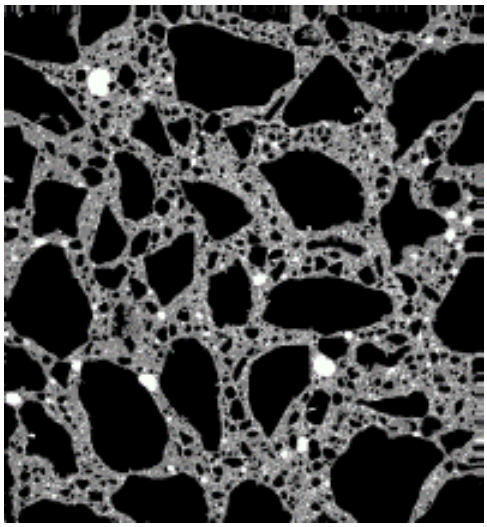
False-Color Image

4-V

Air Void Content	7.98	%
Spacing Factor	0.0036	in.
Air Void Area	N/A	in²
# of Air Voids	N/A	
Paste Area	N/A	in²
Paste Content	N/A	%
Aggregate Area	N/A	in²
Clustering Index	1.84	
# Agg Analyzed	N/A	
Minimum Clustering Rate	N/A	%
Maximum Clustering Rate	N/A	%

False-Color Image

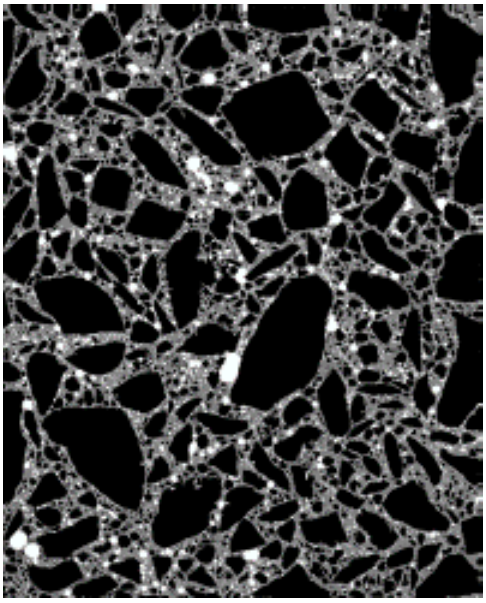
4-V-R



Air Void Content	8.23	%
Spacing Factor	0.0042	in.
Air Void Area	0.93	in²
# of Air Voids	57293	
Paste Area	3.62	in²
Paste Content	31.99	%
Aggregate Area	6.77	in²
Clustering Index	1.67	
# Agg Analyzed	24	
Minimum Clustering Rate	6.19	%
Maximum Clustering Rate	25.68	%

False-Color Image

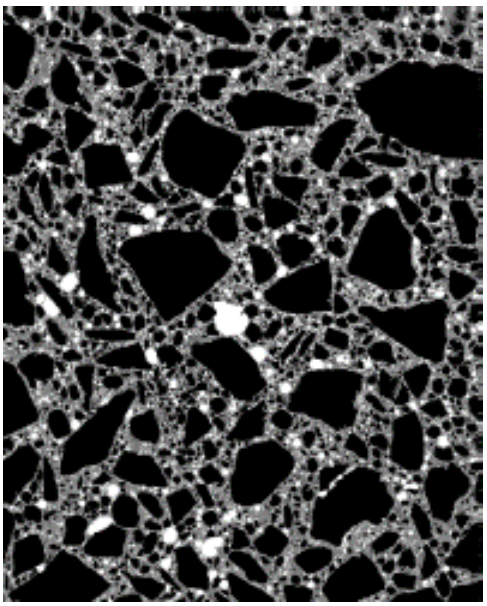
5-I



False-Color Image

Air Void Content	7.89 %
Spacing Factor	0.0057 in.
Air Void Area	0.86 in²
# of Air Voids	35336
Paste Area	3.3 in²
Paste Content	30.39 %
Aggregate Area	6.7 in²
Clustering Index	1.47
# Agg Analyzed	10
Minimum Clustering Rate	5.55 %
Maximum Clustering Rate	16.52 %

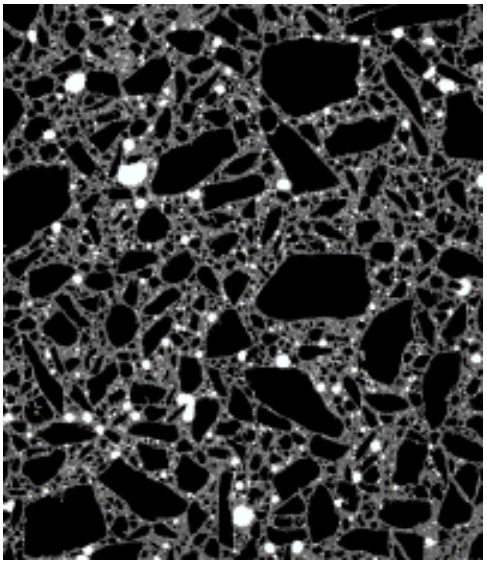
5-I-R



False-Color Image

Air Void Content	9.6 %
Spacing Factor	0.0045 in.
Air Void Area	0.98 in²
# of Air Voids	41733
Paste Area	3.07 in²
Paste Content	30.10 %
Aggregate Area	6.15 in²
Clustering Index	1.44
# Agg Analyzed	13
Minimum Clustering Rate	9.76 %
Maximum Clustering Rate	20.83 %

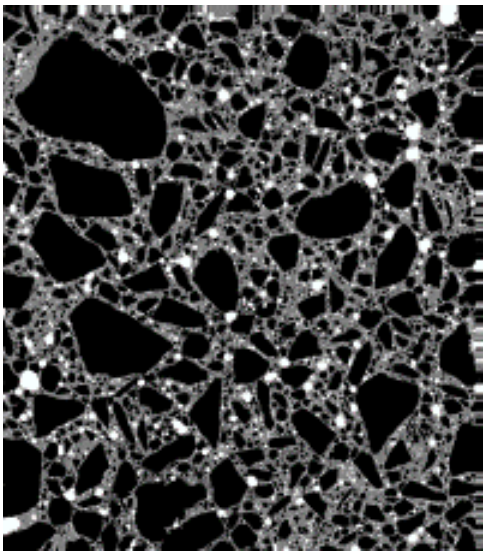
5-II



False-Color Image

Air Void Content	7.88 %
Spacing Factor	0.0061 in.
Air Void Area	0.87 in²
# of Air Voids	43098
Paste Area	3.7 in²
Paste Content	33.39 %
Aggregate Area	6.51 in²
Clustering Index	1.4
# Agg Analyzed	11
Minimum Clustering Rate	8.34 %
Maximum Clustering Rate	16.34 %

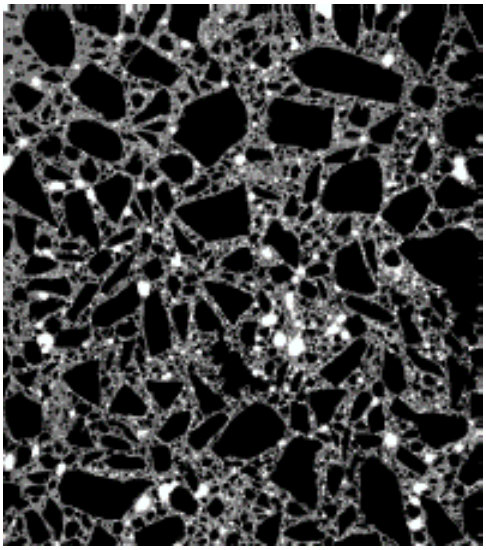
5-II-R



False-Color Image

Air Void Content	7.14 %
Spacing Factor	0.0078 in.
Air Void Area	0.82 in²
# of Air Voids	28196
Paste Area	3.73 in²
Paste Content	32.52 %
Aggregate Area	6.92 in²
Clustering Index	1.02
# Agg Analyzed	10
Minimum Clustering Rate	5.23 %
Maximum Clustering Rate	12.3 %

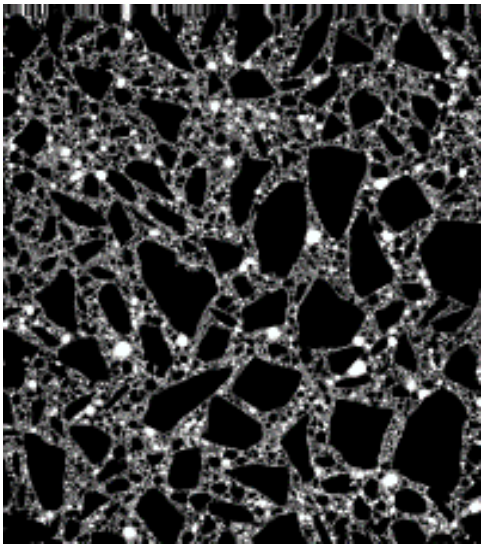
5-III



False-Color Image

Air Void Content	7.24 %
Spacing Factor	0.0058 in.
Air Void Area	0.93 in²
# of Air Voids	48254
Paste Area	3.76 in²
Paste Content	29.29 %
Aggregate Area	8.15 in²
Clustering Index	1.23
# Agg Analyzed	18
Minimum Clustering Rate	1 %
Maximum Clustering Rate	13.34 %

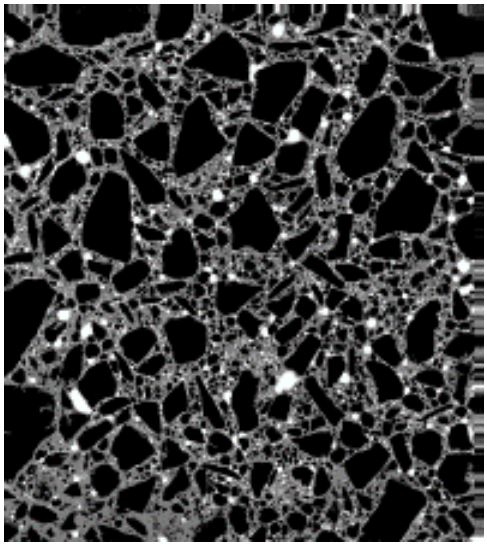
5-III-R



False-Color Image

Air Void Content	8.49 %
Spacing Factor	0.0047 in.
Air Void Area	1.06 in²
# of Air Voids	37359
Paste Area	3.02 in²
Paste Content	24.07 %
Aggregate Area	8.46 in²
Clustering Index	1.48
# Agg Analyzed	21
Minimum Clustering Rate	9.28 %
Maximum Clustering Rate	17.77 %

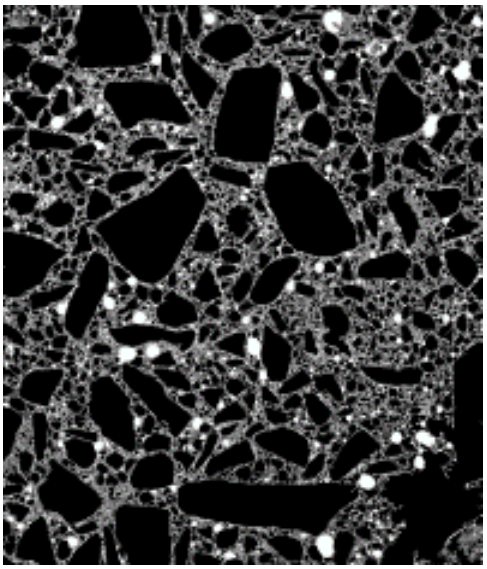
5-IV



False-Color Image

Air Void Content	6.74 %
Spacing Factor	0.0064 in.
Air Void Area	0.85 in²
# of Air Voids	38733
Paste Area	3.92 in²
Paste Content	31.15 %
Aggregate Area	7.82 in²
Clustering Index	1.45
# Agg Analyzed	15
Minimum Clustering Rate	1.65 %
Maximum Clustering Rate	15.43 %

5-IV-R



False-Color Image

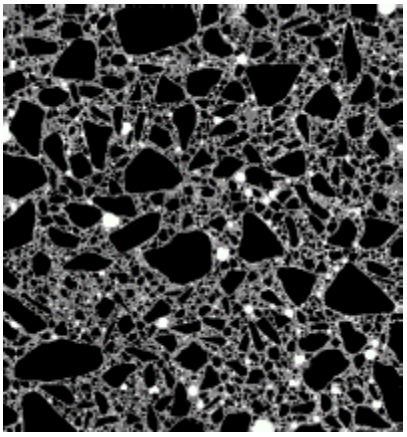
Air Void Content	8.27 %
Spacing Factor	0.0039 in.
Air Void Area	0.95 in²
# of Air Voids	46475
Paste Area	2.84 in²
Paste Content	24.72 %
Aggregate Area	7.7 in²
Clustering Index	2.18
# Agg Analyzed	14
Minimum Clustering Rate	11.57 %
Maximum Clustering Rate	26.1 %

5-V

Air Void Content	8.73	%
Spacing Factor	0.0054	in.
Air Void Area	N/A	in²
# of Air Voids	N/A	
Paste Area	N/A	in²
Paste Content	N/A	%
Aggregate Area	N/A	in²
Clustering Index	1.38	
# Agg Analyzed	N/A	
Minimum Clustering Rate	N/A	%
Maximum Clustering Rate	N/A	%

False-Color Image

5-V-R

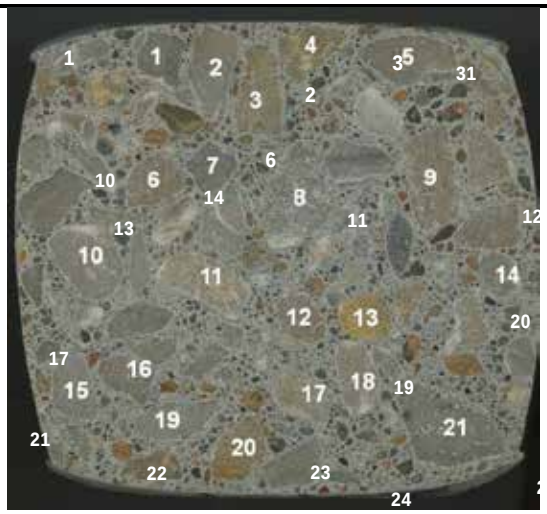


Air Void Content	9.35	%
Spacing Factor	0.0031	in.
Air Void Area	1.02	in²
# of Air Voids	76475	
Paste Area	3.17	in²
Paste Content	29.14	%
Aggregate Area	6.69	in²
Clustering Index	2.06	
# Agg Analyzed	10	
Minimum Clustering Rate	14.58	%
Maximum Clustering Rate	28.96	%

False-Color Image

Appendix B: Visual Clustering Rating

Sample ID	1-I



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	2	32	
3	2	18	2	33	
4	3	19	3	34	
5	3	20	3	35	
6	2	21	3	36	
7	2	22		37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	3	26		41	
12	2	27		42	
13	2	28		43	
14	3	29		44	
15	3	30		45	

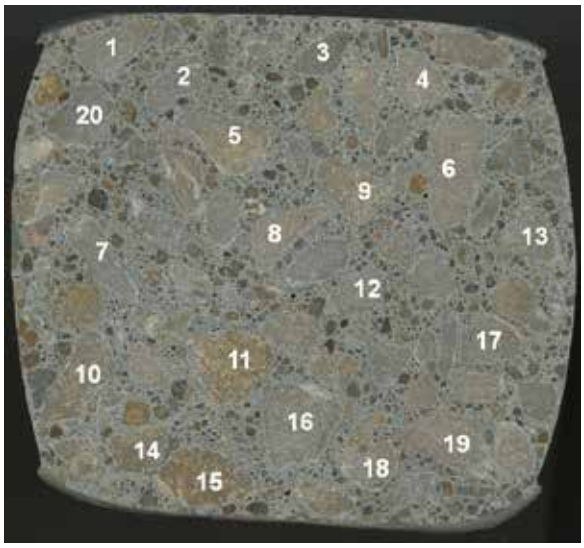
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	10	2	20
Rating 3	11	3	33
		Sum	**53**
		# of agg	21

RATE **2.52**

(sum / # of agg)

Sample ID	**1-II**



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	2	17	2	32	
3	3	18	3	33	
4	3	19	3	34	
5	2	20	3	35	
6	2	21		36	
7	2	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	2	30		45	

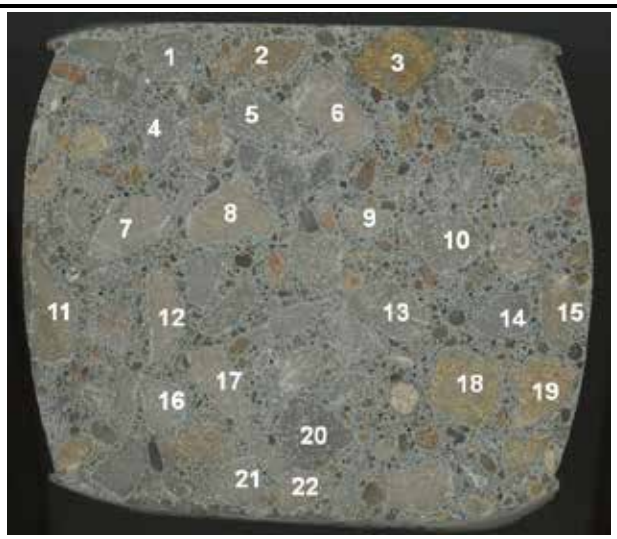
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	8	2	16
Rating 3	12	3	36
		Sum	**52**
		# of agg	20

RATE **2.60**

(sum / # of agg)

Sample ID	**1-III**



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	2	17	2	32	
3	3	18	2	33	
4	2	19	2	34	
5	3	20	2	35	
6	3	21	3	36	
7	3	22	3	37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	3	26		41	
12	2	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

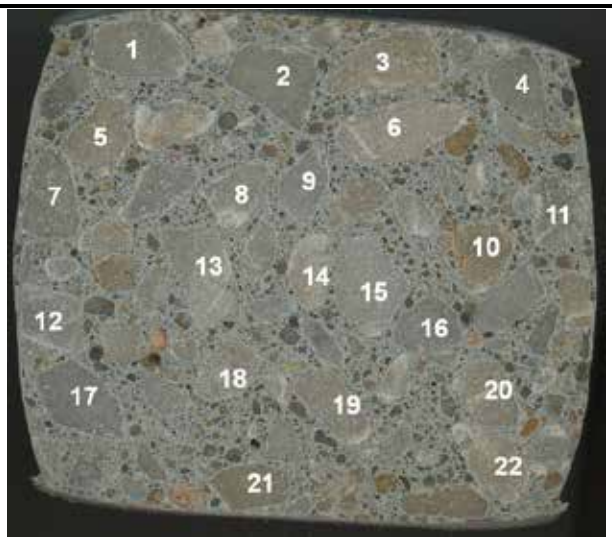
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	11	2	22
Rating 3	11	3	33
		Sum	**55**
		# of agg	22

RATE **2.50**

(sum / # of agg)

Sample ID	**1-IV**



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	3	35	
6	2	21	3	36	
7	2	22	3	37	
8	2	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	2	28		43	
14	2	29		44	
15	2	30		45	

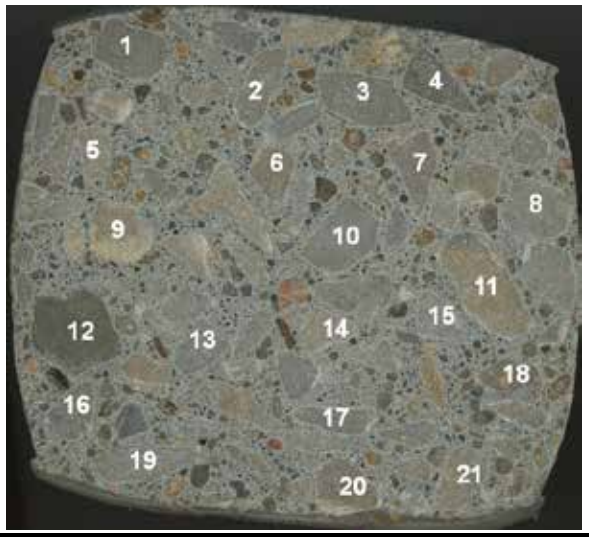
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	7	2	14
Rating 3	15	3	45
		Sum	**59**
		# of agg	22

RATE **2.68**

(sum / # of agg)

Sample ID	1-V



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	3	35	
6	2	21	3	36	
7	2	22		37	
8	3	23		38	
9	2	24		39	
10	3	25		40	
11	3	26		41	
12	2	27		42	
13	3	28		43	
14	2	29		44	
15	3	30		45	

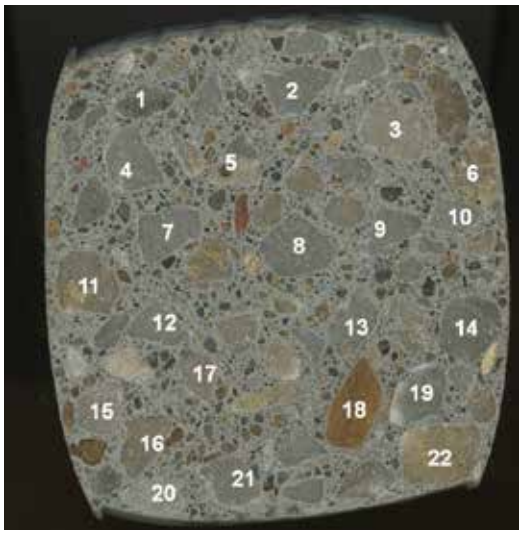
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	6	2	12
Rating 3	15	3	45
		Sum	**57**
		# of agg	21

RATE **2.71**

(sum / # of agg)

Sample ID	**1-I-R**



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	2	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	3	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	2	30		45	

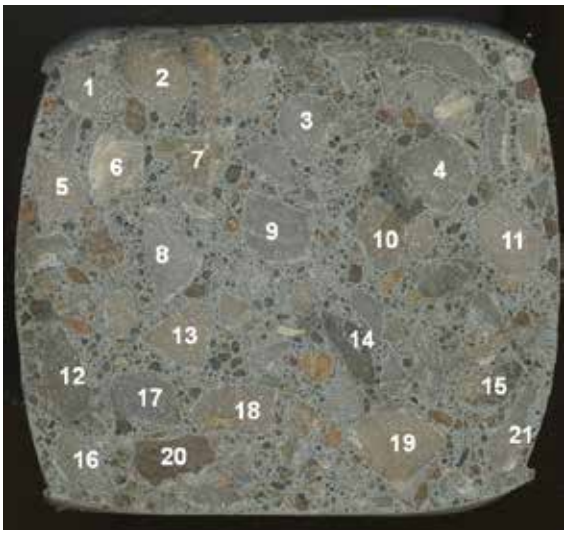
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	3	2	6
Rating 3	19	3	57
		Sum	**63**
		# of agg	22

RATE **2.86**

(sum / # of agg)

Sample ID	**1-II-R**



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	2	32	
3	2	18	3	33	
4	3	19	3	34	
5	3	20	2	35	
6	3	21	3	36	
7	2	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

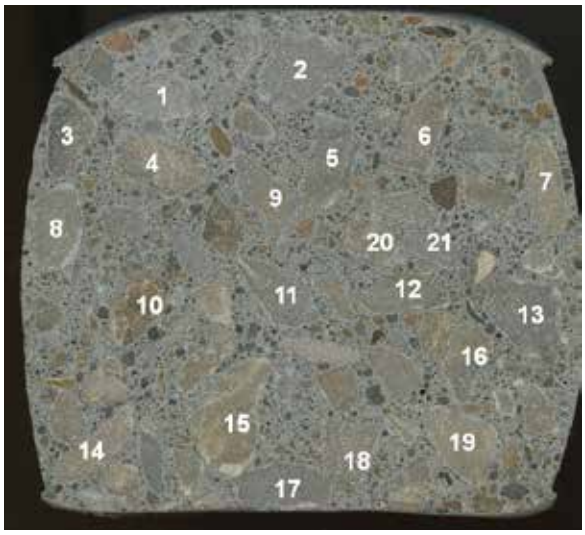
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	4	2	8
Rating 3	17	3	51
		Sum	**59**
		# of agg	21

RATE **2.81**

(sum / # of agg)

Sample ID	**1-III-R**



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	2	19	3	34	
5	3	20	2	35	
6	2	21	3	36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

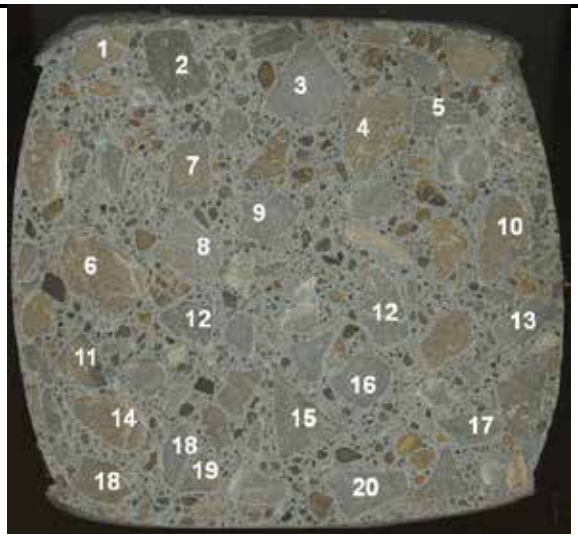
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	4	2	8
Rating 3	17	3	51
		Sum	**59**
		# of agg	21

RATE **2.81**

(sum / # of agg)

Sample ID	**1-IV-R**



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	3	18	3	33	
4	2	19	3	34	
5	3	20	3	35	
6	3	21	2	36	
7	3	22	3	37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	2	30		45	

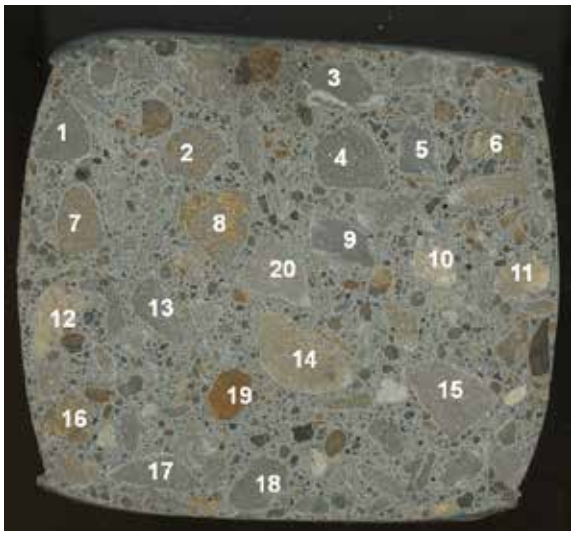
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	4	2	8
Rating 3	18	3	54
		Sum	**62**
		# of agg	22

RATE **2.82**

(sum / # of agg)

Sample ID	**1-V-R**



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	2	19	2	34	
5	3	20	2	35	
6	3	21		36	
7	3	22		37	
8	2	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	2	28		43	
14	2	29		44	
15	3	30		45	

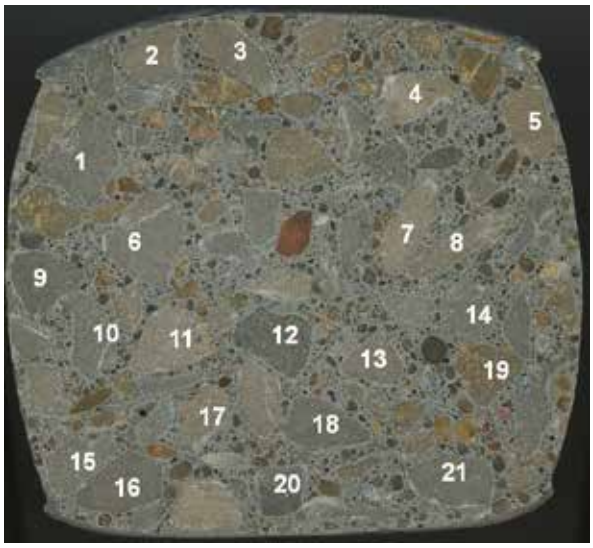
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	6	2	12
Rating 3	14	3	42
		Sum	**54**
		# of agg	20

RATE **2.70**

(sum / # of agg)

Sample Name:	2-I



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	2	32	
3	3	18	2	33	
4	2	19	2	34	
5	2	20	2	35	
6	2	21	3	36	
7	2	22		37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	1	26		41	
12	2	27		42	
13	2	28		43	
14	2	29		44	
15	3	30		45	

ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	1	1	1
Rating 2	15	2	30
Rating 3	5	3	15
		Sum	**46**
		# of agg	21

RATE **2.19**

(sum / # of agg)

Sample Name:	2-II

Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	3	31	
2	3	17	3	32	
3	3	18	2	33	
4	3	19	2	34	
5	3	20	2	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23	2	38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

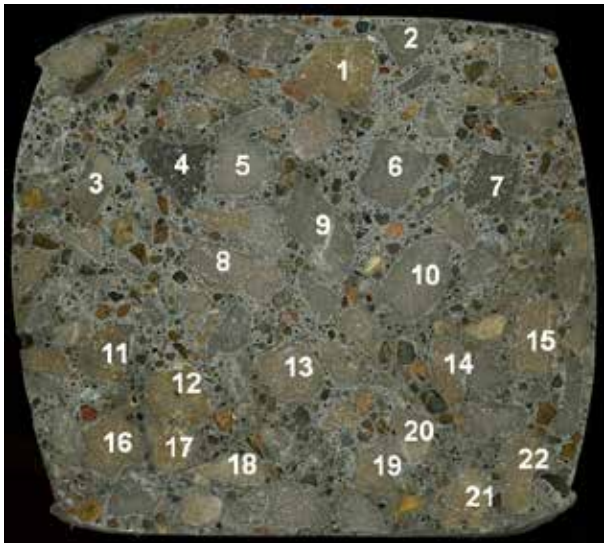
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	6	2	12
Rating 3	17	3	51
		Sum	**63**
		# of agg	23

RATE **2.74**

(sum / # of agg)

Sample Name:	2-III



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	3	31	
2	2	17	3	32	
3	2	18	2	33	
4	2	19	3	34	
5	3	20	2	35	
6	2	21	3	36	
7	3	22	3	37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	2	26		41	
12	3	27		42	
13	3	28		43	
14	2	29		44	
15	3	30		45	

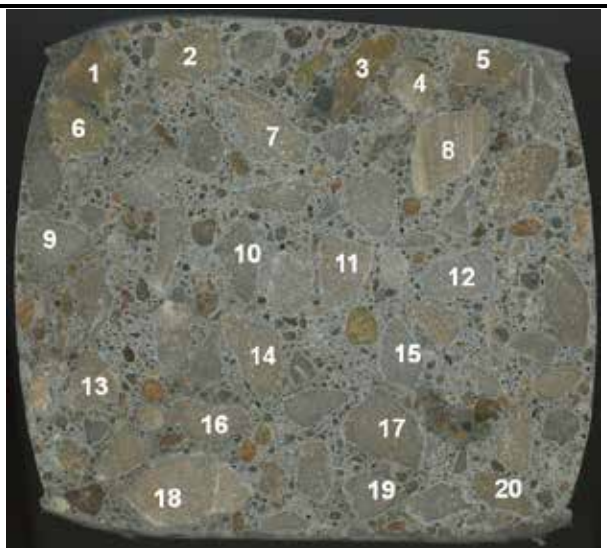
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	12	2	24
Rating 3	10	3	30
		Sum	**54**
		# of agg	22

RATE **2.45**

(sum / # of agg)

Sample Name:	2-IV



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	2	32	
3	3	18	3	33	
4	3	19	2	34	
5	3	20	3	35	
6	3	21		36	
7	2	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	2	27		42	
13	3	28		43	
14	2	29		44	
15	2	30		45	

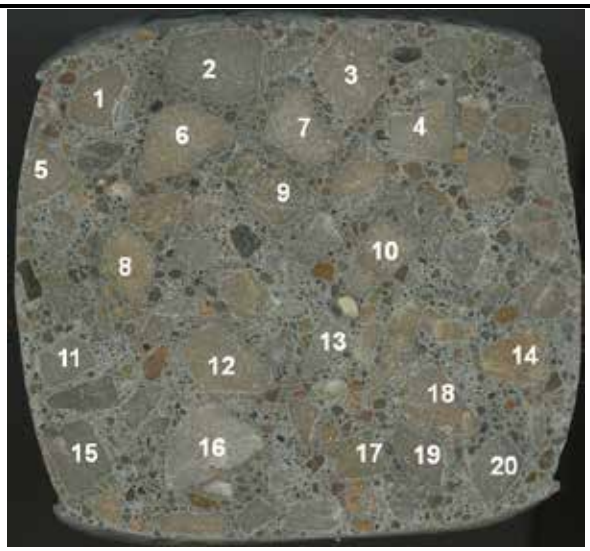
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	8	2	16
Rating 3	12	3	36
		Sum	**52**
		# of agg	20

RATE **2.60**

(sum / # of agg)

Sample Name:	2-V



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	3	35	
6	2	21		36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

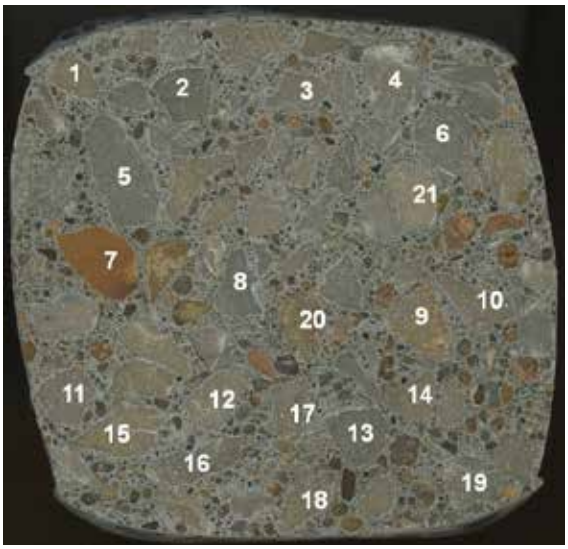
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	1	2	2
Rating 3	19	3	57
		Sum	**59**
		# of agg	20

RATE **2.95**

(sum / # of agg)

Sample Name:	2-I-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	3	32	
3	2	18	3	33	
4	3	19	3	34	
5	3	20	2	35	
6	2	21	2	36	
7	3	22		37	
8	3	23		38	
9	2	24		39	
10	2	25		40	
11	3	26		41	
12	3	27		42	
13	2	28		43	
14	3	29		44	
15	3	30		45	

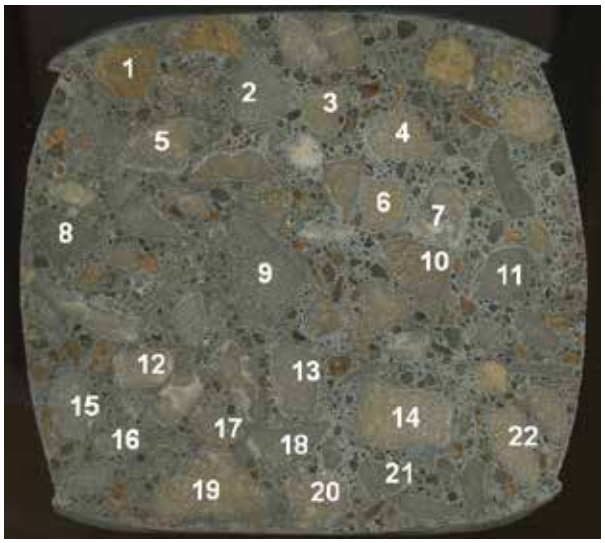
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	8	2	16
Rating 3	13	3	39
		Sum	**55**
		# of agg	21

RATE **2.62**

(sum / # of agg)

Sample Name:	2-II-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	2	20	3	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	3	27		42	
13	3	28		43	
14	2	29		44	
15	3	30		45	

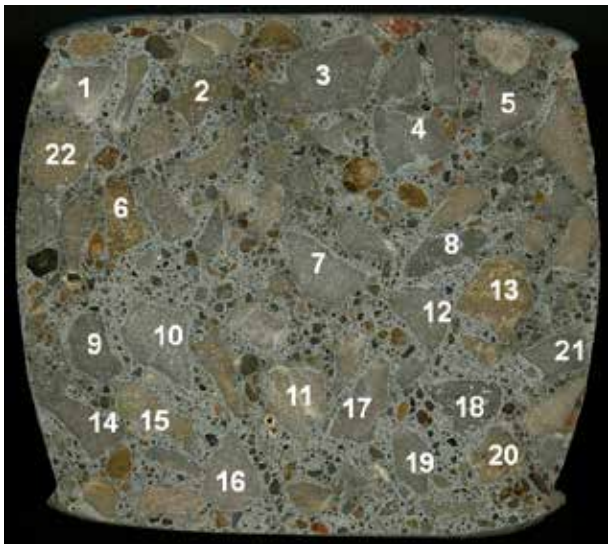
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	3	2	6
Rating 3	19	3	57
		Sum	**63**
		# of agg	22

RATE **2.86**

(sum / # of agg)

Sample Name:	2-III-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	2	34	
5	3	20	3	35	
6	2	21	3	36	
7	2	22	3	37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	2	30		45	

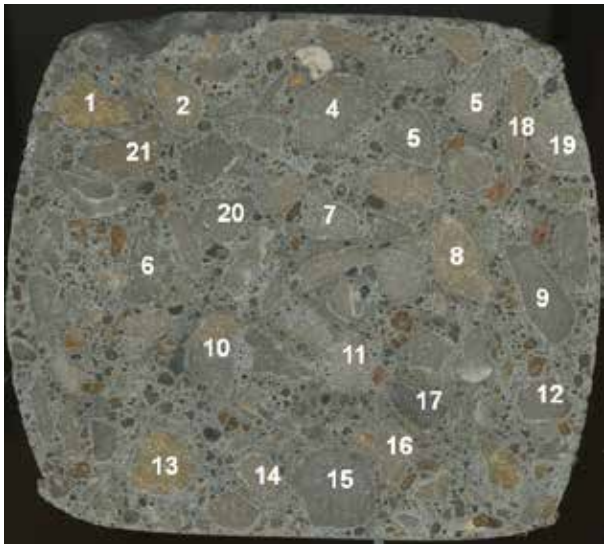
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	6	2	12
Rating 3	16	3	48
		Sum	**60**
		# of agg	22

RATE	**2.73**

(sum / # of agg)

Sample Name:	2-IV-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	2	18	3	33	
4	2	19	2	34	
5	3	20	2	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23		38	
9	3	24		39	
10	2	25		40	
11	2	26		41	
12	2	27		42	
13	3	28		43	
14	3	29		44	
15	2	30		45	

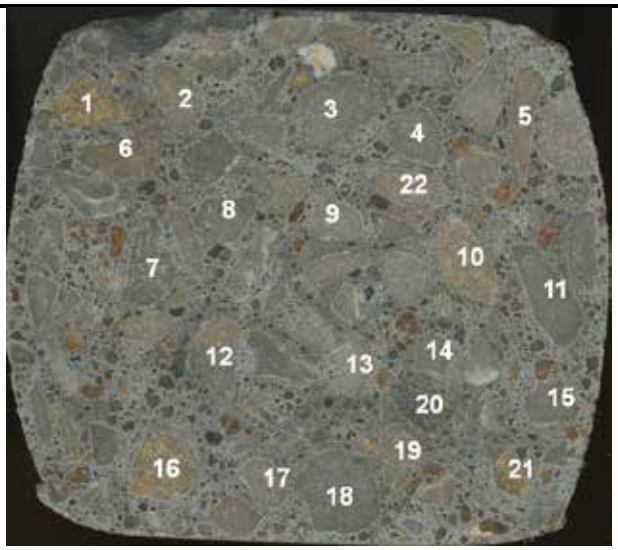
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	9	2	18
Rating 3	13	3	39
		Sum	**57**
		# of agg	22

RATE **2.59**

(sum / # of agg)

Sample Name:	2-V-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	2	34	
5	3	20	3	35	
6	3	21	3	36	
7	2	22	3	37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	2	29		44	
15	2	30		45	

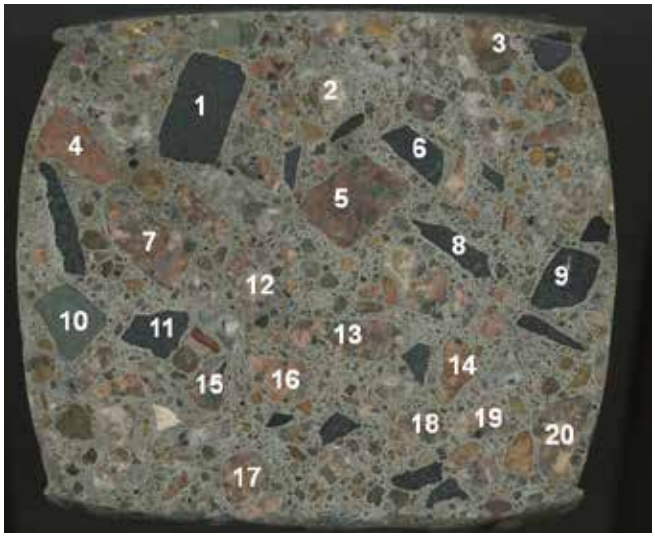
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	4	2	8
Rating 3	18	3	54
		Sum	**62**
		# of agg	22

RATE **2.82**

(sum / # of agg)

Sample Name:	3-I



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	3	18	2	33	
4	3	19	3	34	
5	3	20	3	35	
6	3	21		36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	2	27		42	
13	2	28		43	
14	2	29		44	
15	2	30		45	

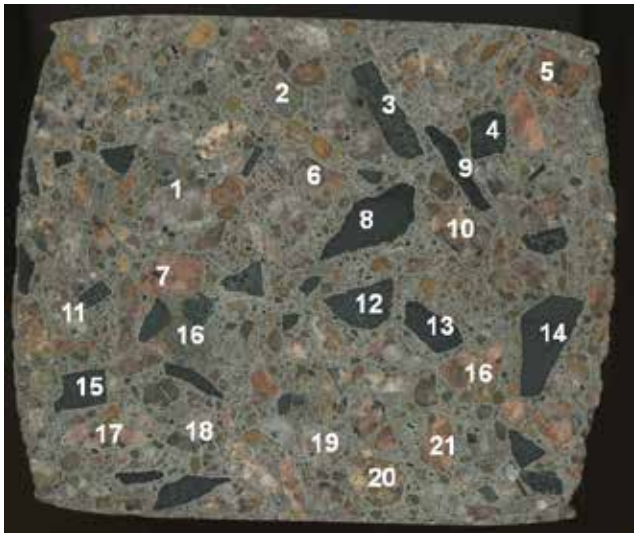
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	7	2	14
Rating 3	13	3	39
		Sum	**53**
		# of agg	20

RATE **2.65**

(sum / # of agg)

Sample Name:	3-II



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	2	18	2	33	
4	2	19	2	34	
5	3	20	3	35	
6	2	21	2	36	
7	2	22		37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	3	26		41	
12	3	27		42	
13	2	28		43	
14	2	29		44	
15	3	30		45	

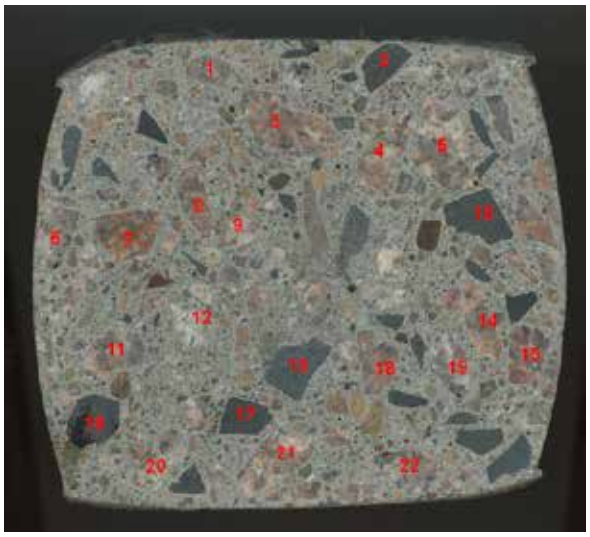
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	13	2	26
Rating 3	8	3	24
		Sum	**50**
		# of agg	21

RATE **2.38**

(sum / # of agg)

Sample Name:	3-III



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	3	31	
2	2	17	2	32	
3	2	18	2	33	
4	2	19	2	34	
5	2	20	2	35	
6	3	21	2	36	
7	2	22	2	37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	2	26		41	
12	2	27		42	
13	2	28		43	
14	2	29		44	
15	2	30		45	

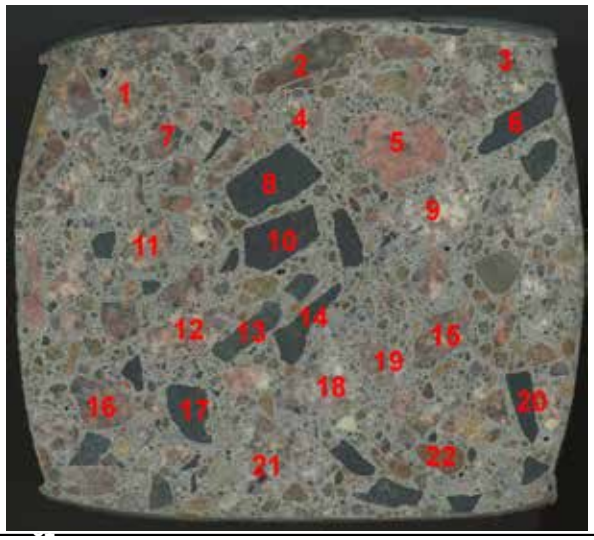
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	20	2	40
Rating 3	2	3	6
		Sum	**46**
		# of agg	22

RATE **2.09**

(sum / # of agg)

Sample Name:	3-IV



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	2	32	
3	2	18	2	33	
4	2	19	2	34	
5	2	20	2	35	
6	2	21	2	36	
7	1	22	2	37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	1	26		41	
12	2	27		42	
13	2	28		43	
14	2	29		44	
15	2	30		45	

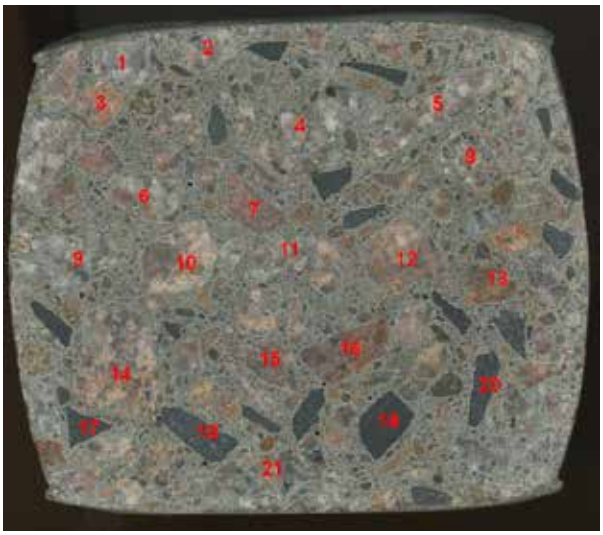
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	2	1	2
Rating 2	18	2	36
Rating 3	2	3	6
		Sum	**44**
		# of agg	22

RATE **2.00**

(sum / # of agg)

Sample Name:	3-V



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	3	18	2	33	
4	2	19	2	34	
5	2	20	2	35	
6	3	21	3	36	
7	2	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	2	27		42	
13	2	28		43	
14	3	29		44	
15	3	30		45	

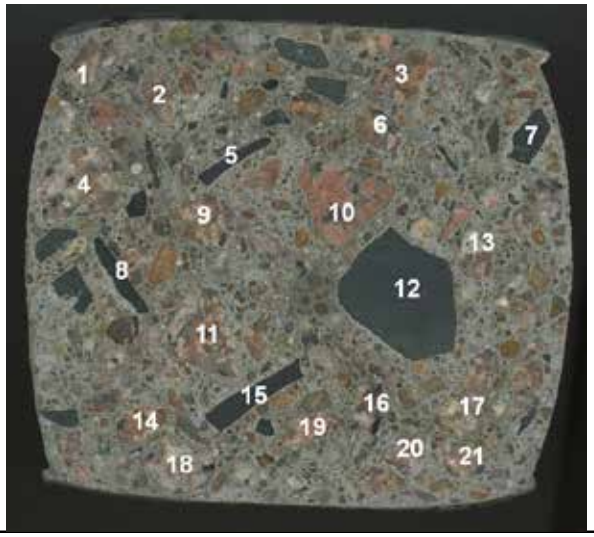
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	10	2	20
Rating 3	11	3	33
		Sum	**53**
		# of agg	21

RATE **2.52**

(sum / # of agg)

Sample Name:	3-I-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	3	18	2	33	
4	3	19	2	34	
5	2	20	3	35	
6	3	21	3	36	
7	3	22		37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	2	26		41	
12	2	27		42	
13	3	28		43	
14	2	29		44	
15	2	30		45	

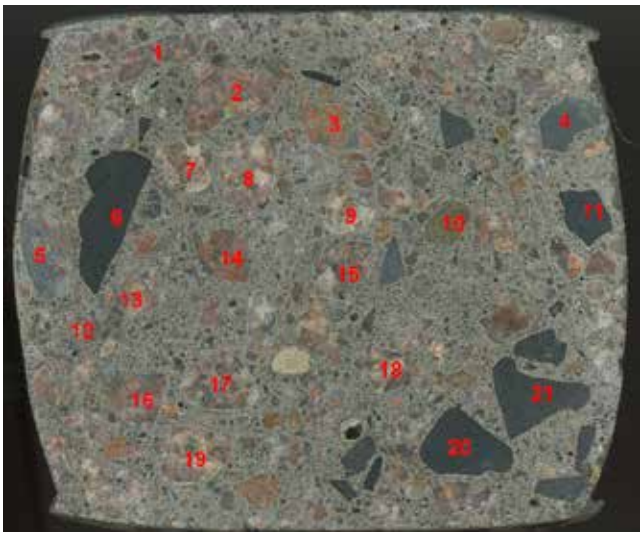
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	11	2	22
Rating 3	10	3	30
		Sum	**52**
		# of agg	21

RATE **2.48**

(sum / # of agg)

Sample Name:	3-II-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	2	32	
3	2	18	2	33	
4	3	19	2	34	
5	3	20	2	35	
6	2	21	3	36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	2	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	2	29		44	
15	2	30		45	

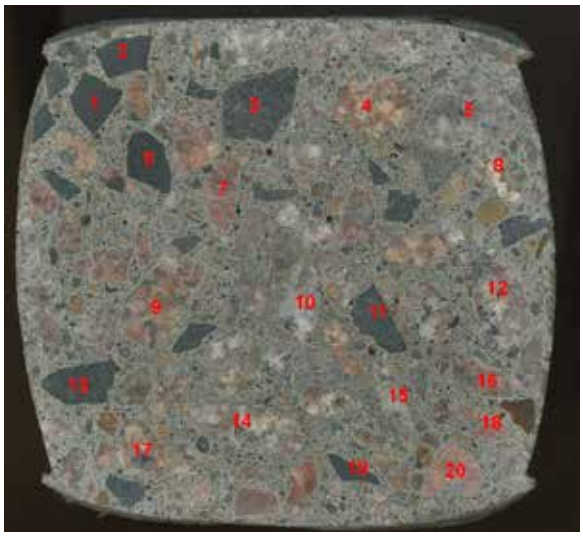
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	10	2	20
Rating 3	11	3	33
		Sum	**53**
		# of agg	21

RATE **2.52**

(sum / # of agg)

Sample Name:	3-III-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	2	34	
5	3	20	3	35	
6	3	21		36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	2	25		40	
11	2	26		41	
12	2	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

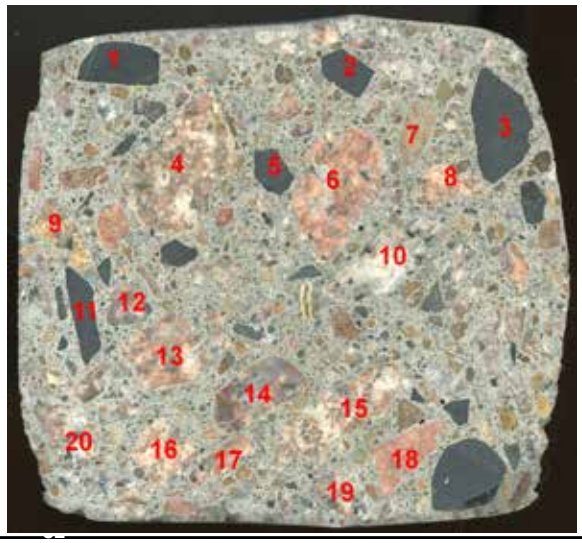
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	5	2	10
Rating 3	15	3	45
		Sum	**55**
		# of agg	20

RATE **2.75**

(sum / # of agg)

Sample Name:	3-IV-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	2	20	3	35	
6	2	21		36	
7	2	22		37	
8	3	23		38	
9	3	24		39	
10	2	25		40	
11	2	26		41	
12	2	27		42	
13	2	28		43	
14	2	29		44	
15	3	30		45	

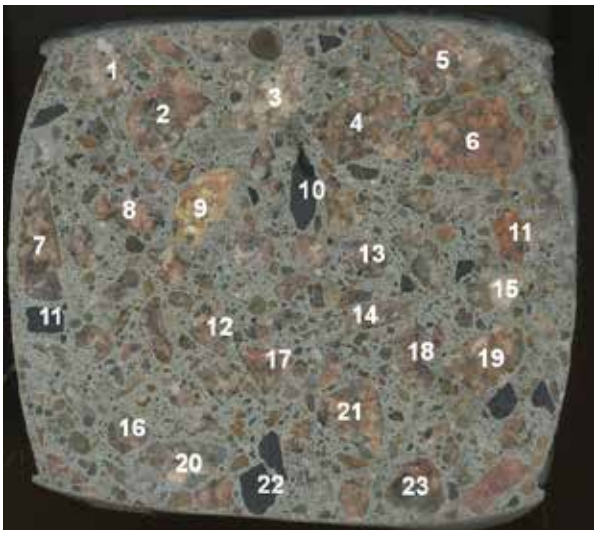
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	9	2	18
Rating 3	11	3	33
		Sum	**51**
		# of agg	20

RATE **2.55**

(sum / # of agg)

Sample Name:	3-V-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	2	32	
3	3	18	2	33	
4	3	19	2	34	
5	3	20	2	35	
6	3	21	2	36	
7	3	22	3	37	
8	2	23	3	38	
9	2	24	2	39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	2	29		44	
15	2	30		45	

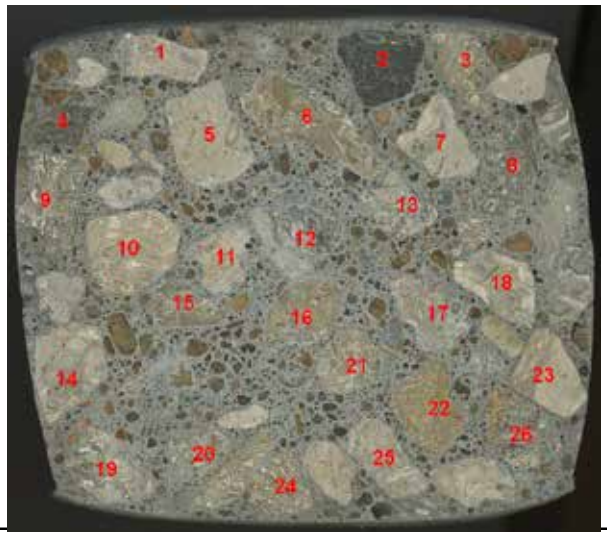
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	11	2	22
Rating 3	13	3	39
		Sum	**61**
		# of agg	24

RATE **2.54**

(sum / # of agg)

Sample Name:	4-I



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	1	16	2	31	1
2	2	17	1	32	1
3	1	18	1	33	2
4	2	19	2	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23	2	38	
9	2	24	1	39	
10	2	25	1	40	
11	1	26	1	41	
12	1	27	2	42	
13	2	28	1	43	
14	1	29	1	44	
15	1	30	2	45	

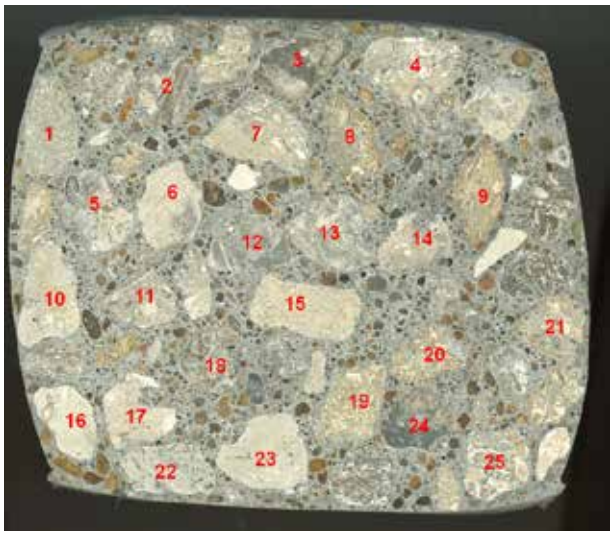
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	15	1	15
Rating 2	18	2	36
Rating 3	0	3	0
		Sum	**51**
		# of agg	33

RATE **1.55**

(sum / # of agg)

Sample Name:	4-II



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	1	16	2	31	1
2	2	17	1	32	1
3	1	18	1	33	2
4	2	19	2	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23	2	38	
9	2	24	1	39	
10	2	25	1	40	
11	1	26	1	41	
12	1	27	2	42	
13	2	28	1	43	
14	1	29	1	44	
15	1	30	2	45	

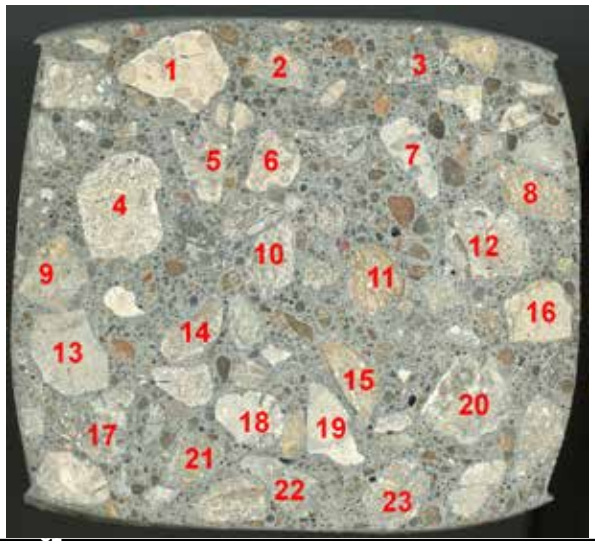
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	15	1	15
Rating 2	18	2	36
Rating 3	0	3	0
		Sum	**51**
		# of agg	33

RATE **1.55**

(sum / # of agg)

Sample Name:	4-III



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	3	32	
3	2	18	2	33	
4	3	19	2	34	
5	2	20	3	35	
6	2	21	2	36	
7	2	22	2	37	
8	3	23	3	38	
9	3	24		39	
10	2	25		40	
11	2	26		41	
12	3	27		42	
13	3	28		43	
14	2	29		44	
15	2	30		45	

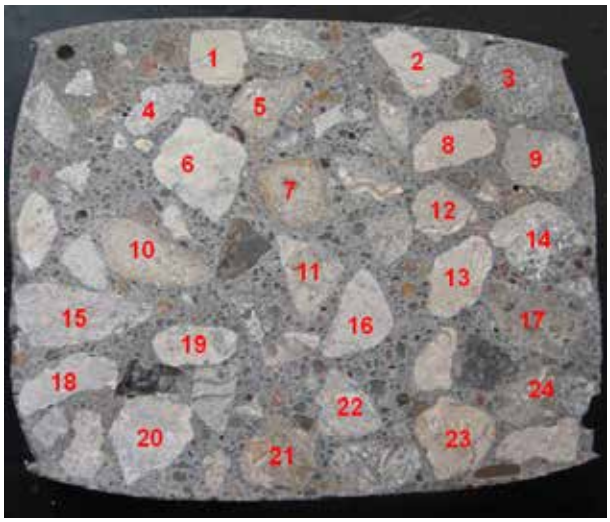
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	13	2	26
Rating 3	10	3	30
		Sum	**56**
		# of agg	23

RATE **2.43**

(sum / # of agg)

Sample Name:	2/19 4-IVb



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	3	32	
3	2	18	2	33	
4	3	19	2	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	3	37	
8	2	23	3	38	
9	2	24	3	39	
10	2	25		40	
11	2	26		41	
12	2	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

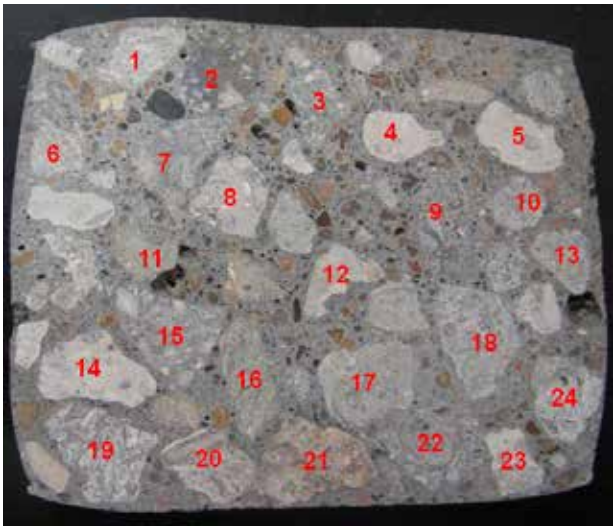
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	14	2	28
Rating 3	10	3	30
		Sum	**58**
		# of agg	24

RATE **2.42**

(sum / # of agg)

Sample Name:	2/11 4-V



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	3	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23	3	38	
9	3	24	3	39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

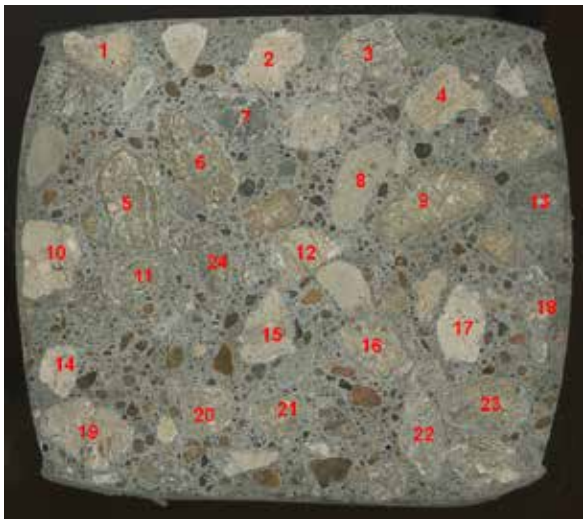
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	0	2	0
Rating 3	24	3	72
		Sum	**72**
		# of agg	24

RATE **3.00**

(sum / # of agg)

Sample Name:	4-I-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	1	16	2	31	1
2	2	17	1	32	1
3	1	18	1	33	2
4	2	19	2	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23	2	38	
9	2	24	1	39	
10	2	25	1	40	
11	1	26	1	41	
12	1	27	2	42	
13	2	28	1	43	
14	1	29	1	44	
15	1	30	2	45	

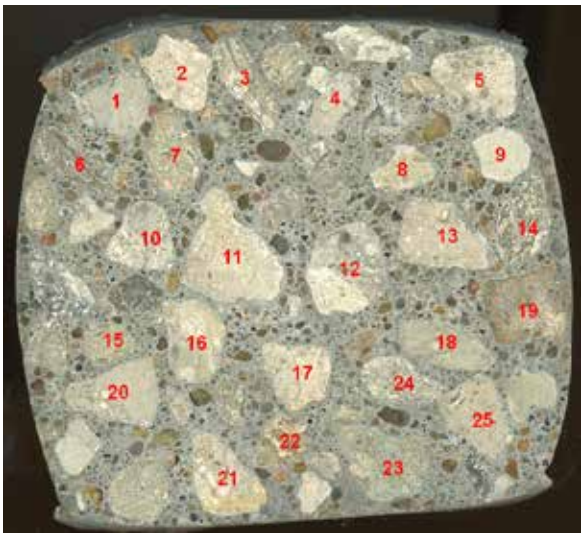
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	15	1	15
Rating 2	18	2	36
Rating 3	0	3	0
		Sum	**51**
		# of agg	33

RATE **1.55**

(sum / # of agg)

Sample Name:	4-II-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	1	16	2	31	1
2	2	17	1	32	1
3	1	18	1	33	2
4	2	19	2	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23	2	38	
9	2	24	1	39	
10	2	25	1	40	
11	1	26	1	41	
12	1	27	2	42	
13	2	28	1	43	
14	1	29	1	44	
15	1	30	2	45	

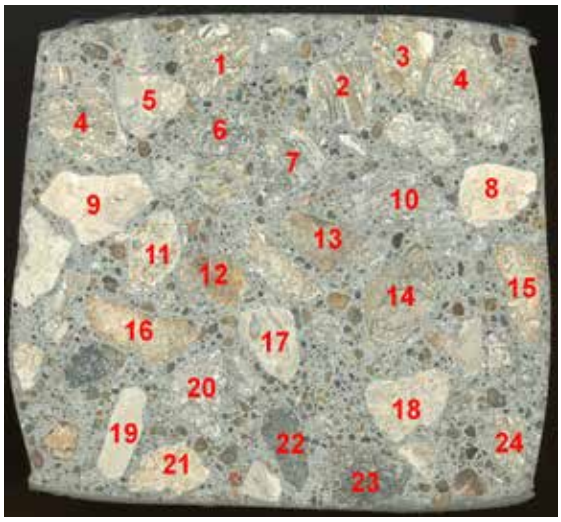
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	15	1	15
Rating 2	18	2	36
Rating 3	0	3	0
		Sum	**51**
		# of agg	33

RATE	**1.55**

(sum / # of agg)

Sample Name:	4-III-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	2	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	3	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23	3	38	
9	3	24	3	39	
10	3	25	3	40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	2	29		44	
15	3	30		45	

ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	2	2	4
Rating 3	23	3	69
		Sum	**73**
		# of agg	25

RATE **2.92**

(sum / # of agg)

Sample Name:	4-IV-R

Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	2	20	2	35	
6	3	21	3	36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	2	27		42	
13	3	28		43	
14	2	29		44	
15	3	30		45	

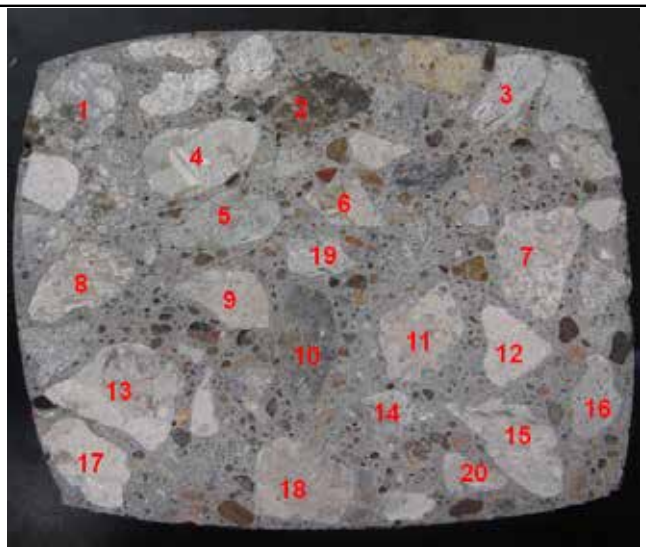
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	5	2	10
Rating 3	16	3	48
		Sum	**58**
		# of agg	21

RATE **2.76**

(sum / # of agg)

Sample Name:	4-V-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	3	35	
6	3	21		36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

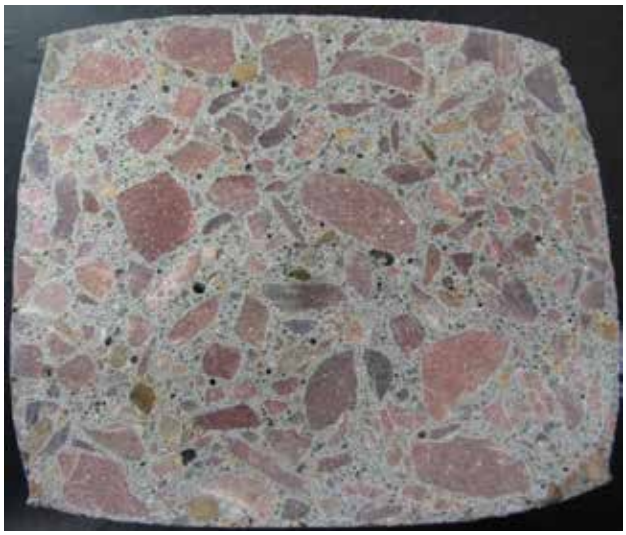
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	0	2	0
Rating 3	20	3	60
		Sum	**60**
		# of agg	20

RATE **3.00**

(sum / # of agg)

Sample Name:	5-I



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	2
2	3	17	3	32	3
3	2	18	2	33	3
4	2	19	2	34	
5	3	20	3	35	
6	3	21	2	36	
7	3	22	2	37	
8	2	23	3	38	
9	2	24	3	39	
10	2	25	3	40	
11	2	26	3	41	
12	2	27	3	42	
13	2	28	3	43	
14	2	29	2	44	
15	2	30	2	45	

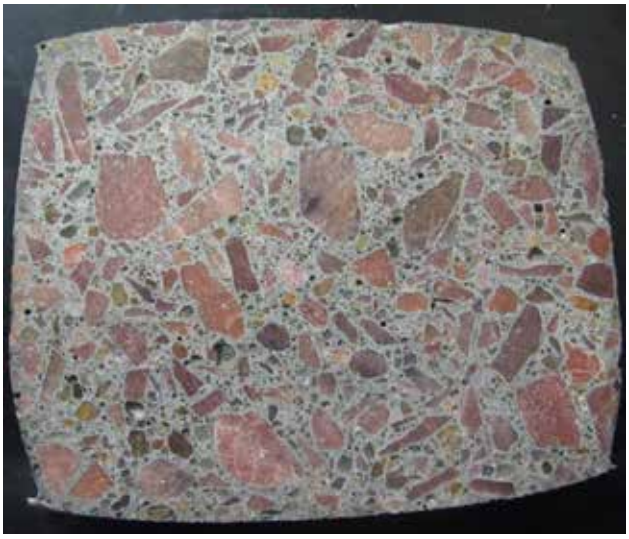
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	18	2	36
Rating 3	15	3	45
		Sum	**81**
		# of agg	33

RATE **2.45**

(sum / # of agg)

Sample Name:	5-II



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	2	31	
2	2	17	2	32	
3	2	18	2	33	
4	2	19	1	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23	2	38	
9	2	24	2	39	
10	2	25	2	40	
11	1	26	1	41	
12	1	27	2	42	
13	2	28		43	
14	1	29		44	
15	1	30		45	

ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	6	1	6
Rating 2	21	2	42
Rating 3	0	3	0
		Sum	**48**
		# of agg	27

RATE **1.78**

(sum / # of agg)

Sample Name:	5-III

Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	3	31	2
2	2	17	2	32	2
3	2	18	2	33	2
4	2	19	2	34	2
5	2	20	2	35	2
6	2	21	2	36	2
7	2	22	2	37	2
8	2	23	1	38	
9	2	24	2	39	
10	2	25	2	40	
11	2	26	1	41	
12	2	27	1	42	
13	1	28	2	43	
14	2	29	2	44	
15	2	30	2	45	

ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	4	1	4
Rating 2	32	2	64
Rating 3	1	3	3
		Sum	**71**
		# of agg	37

RATE **1.92**

(sum / # of agg)

Sample Name:	5-IV

Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	1	16	1	31	1
2	1	17	1	32	1
3	1	18	1	33	1
4	1	19	1	34	1
5	1	20	2	35	
6	1	21	2	36	
7	2	22	2	37	
8	1	23	2	38	
9	2	24	2	39	
10	2	25	2	40	
11	1	26	1	41	
12	1	27	2	42	
13	1	28	2	43	
14	0	29	2	44	
15	0	30	1	45	

ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	2	0	0
Rating 1	20	1	20
Rating 2	12	2	24
Rating 3	0	3	0
		Sum	**44**
		# of agg	34

RATE **1.29**

(sum / # of agg)

Sample Name:	5-V

Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	2	31	2
2	2	17	2	32	1
3	1	18	2	33	2
4	2	19	2	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23	1	38	
9	2	24	1	39	
10	2	25	2	40	
11	2	26	1	41	
12	2	27	2	42	
13	2	28	1	43	
14	2	29	2	44	
15	2	30	2	45	

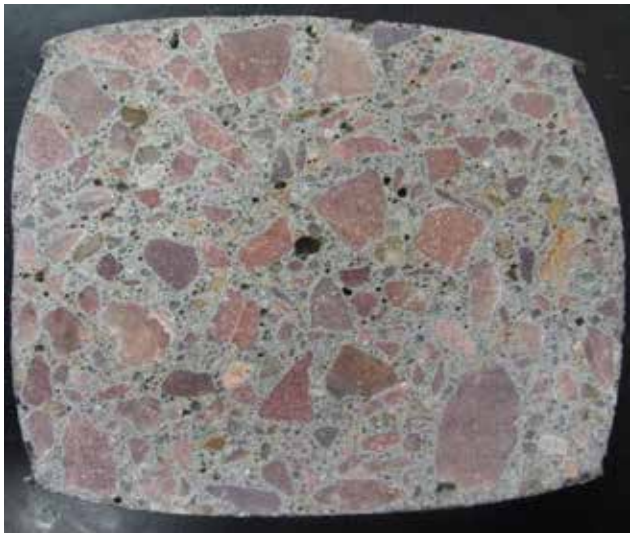
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	6	1	6
Rating 2	27	2	54
Rating 3	0	3	0
		Sum	**60**
		# of agg	33

RATE	**1.82**

(sum / # of agg)

Sample Name:	5-I-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	2	17	2	32	
3	3	18	2	33	
4	2	19	3	34	
5	3	20	2	35	
6	3	21	2	36	
7	2	22	3	37	
8	2	23	2	38	
9	2	24	2	39	
10	3	25	2	40	
11	3	26	2	41	
12	2	27	3	42	
13	2	28	3	43	
14	2	29	2	44	
15	2	30	3	45	

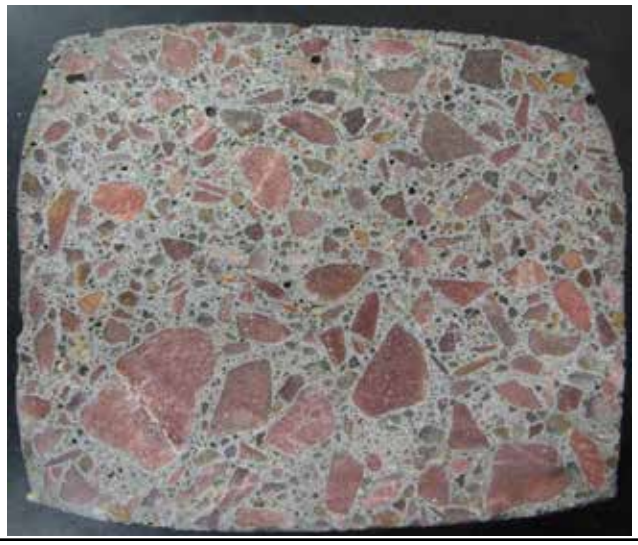
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	19	2	38
Rating 3	11	3	33
		Sum	**71**
		# of agg	30

RATE **2.37**

(sum / # of agg)

Sample Name:	5-II-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	2	31	
2	2	17	3	32	
3	2	18	3	33	
4	2	19	3	34	
5	1	20	3	35	
6	2	21	3	36	
7	2	22	3	37	
8	1	23	3	38	
9	1	24	3	39	
10	2	25	3	40	
11	2	26	3	41	
12	2	27	3	42	
13	3	28	3	43	
14	2	29		44	
15	1	30		45	

ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	4	1	4
Rating 2	11	2	22
Rating 3	13	3	39
		Sum	**65**
		# of agg	28

RATE **2.32**

(sum / # of agg)

Sample Name:	5-III-R

Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	2	31	2
2	2	17	2	32	2
3	2	18	3	33	2
4	2	19	2	34	2
5	2	20	3	35	2
6	3	21	2	36	
7	2	22	2	37	
8	2	23	2	38	
9	2	24	2	39	
10	2	25	2	40	
11	2	26	3	41	
12	3	27	3	42	
13	3	28	3	43	
14	2	29	2	44	
15	2	30	2	45	

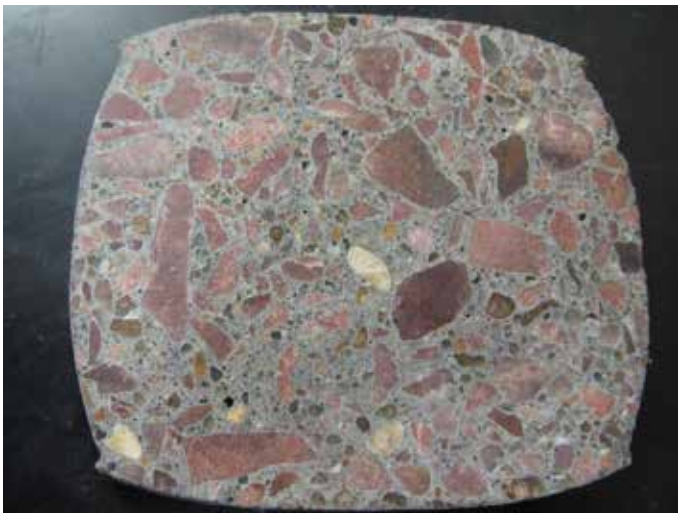
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	0	1	0
Rating 2	27	2	54
Rating 3	8	3	24
		Sum	**78**
		# of agg	35

RATE **2.23**

(sum / # of agg)

Sample Name:	5-IV-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	1	16	2	31	1
2	2	17	1	32	1
3	1	18	1	33	2
4	2	19	2	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23	2	38	
9	2	24	1	39	
10	2	25	1	40	
11	1	26	1	41	
12	1	27	2	42	
13	2	28	1	43	
14	1	29	1	44	
15	1	30	2	45	

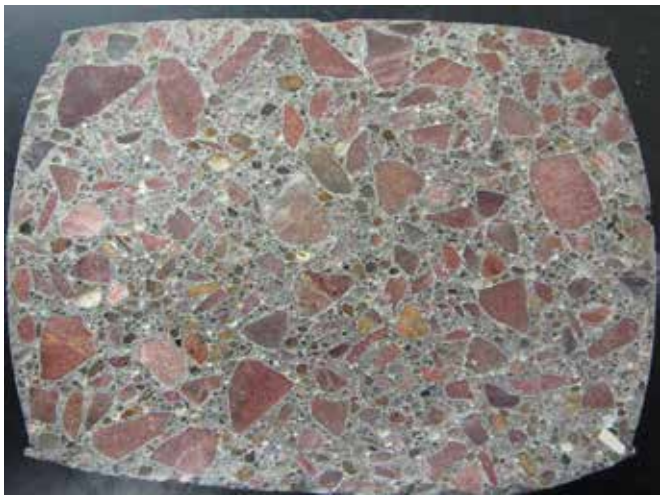
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	15	1	15
Rating 2	18	2	36
Rating 3	0	3	0
		Sum	**51**
		# of agg	33

RATE **1.55**

(sum / # of agg)

Sample Name:	5-V-R



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	2	31	
2	1	17	2	32	
3	2	18	2	33	
4	2	19	2	34	
5	3	20	3	35	
6	3	21	2	36	
7	3	22	2	37	
8	2	23	2	38	
9	3	24	3	39	
10	3	25	2	40	
11	2	26	3	41	
12	2	27	1	42	
13	3	28	3	43	
14	2	29	2	44	
15	2	30	1	45	

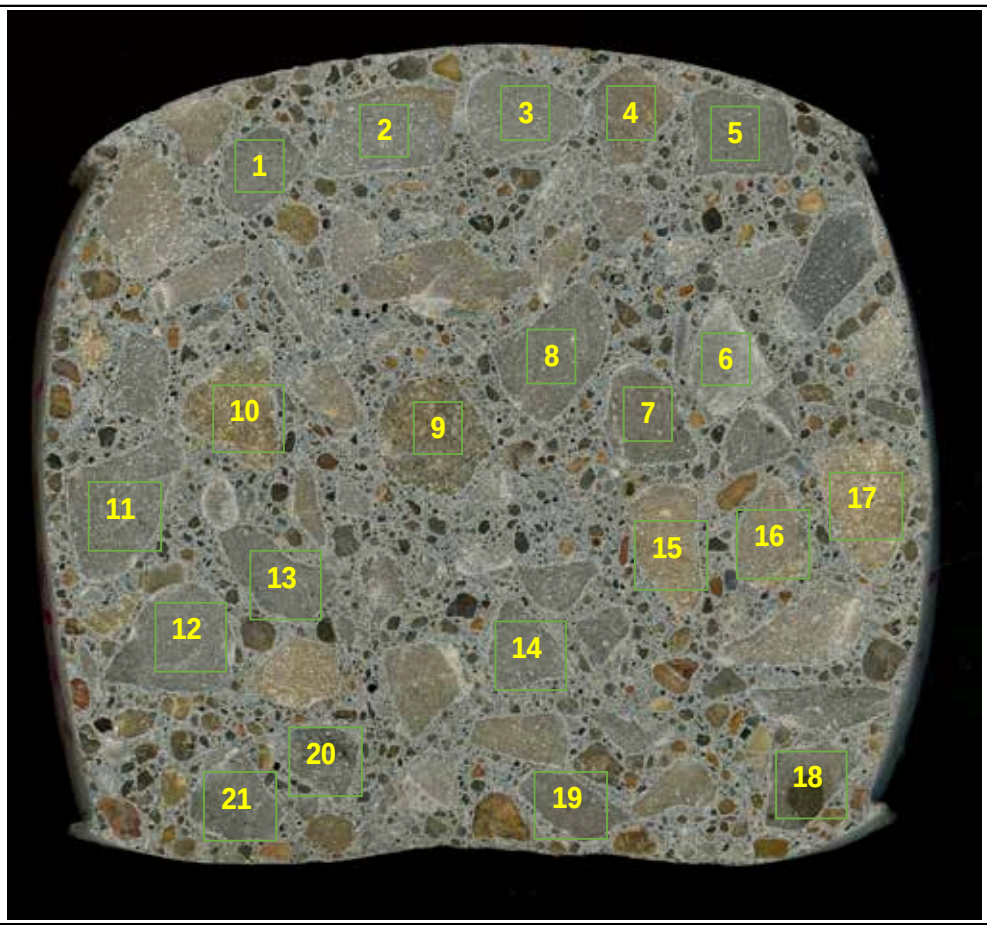
ANALYSIS

	Total	**Rating #**	**Total * Rating #**
Rating 0	0	0	0
Rating 1	3	1	3
Rating 2	17	2	34
Rating 3	10	3	30
		Sum	**67**
		# of agg	30

RATE	**2.23**

(sum / # of agg)

Sample Name:	1-I-C

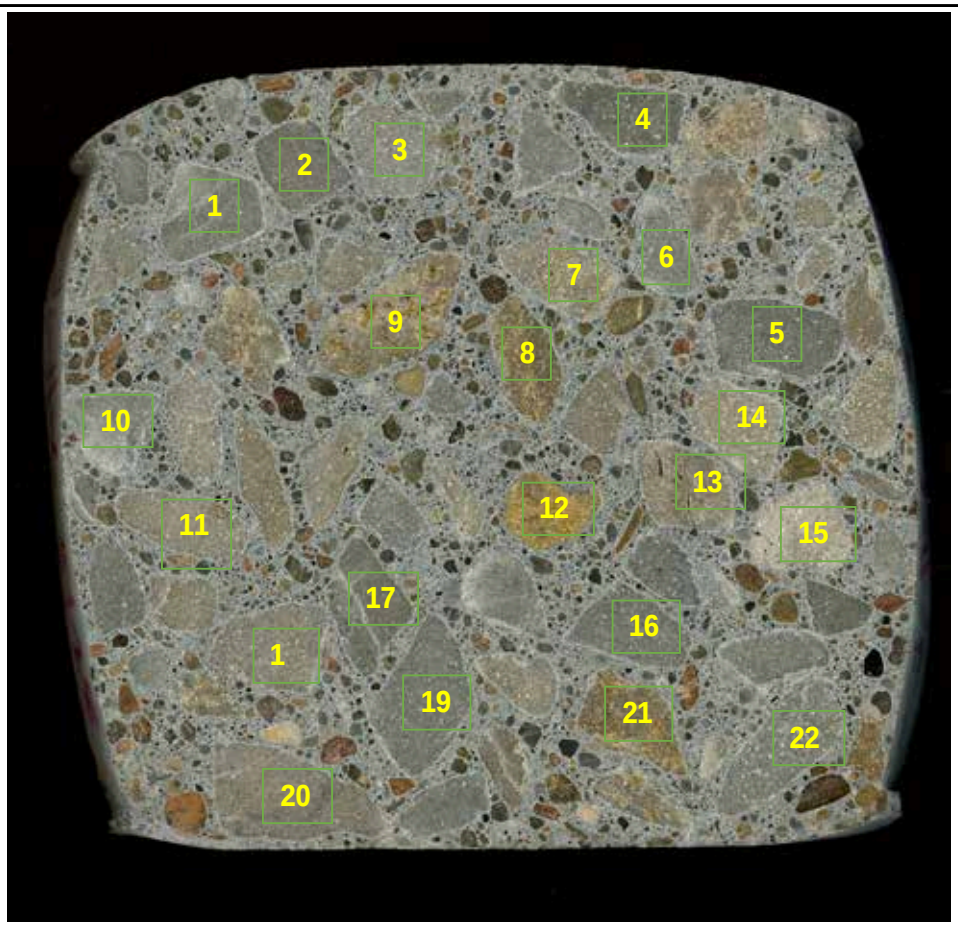


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	2	31	
2	3	17	2	32	
3	2	18	2	33	
4	2	19	2	34	
5	2	20	2	35	
6	3	21	2	36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	2	27		42	
13	2	28		43	
14	2	29		44	
15	3	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	50
Rating 1	0	1	0	# of agg	21
Rating 2	13	2	26	**RATE**	**2.38**
Rating 3	8	3	24		

Sample Name:	1-II-C

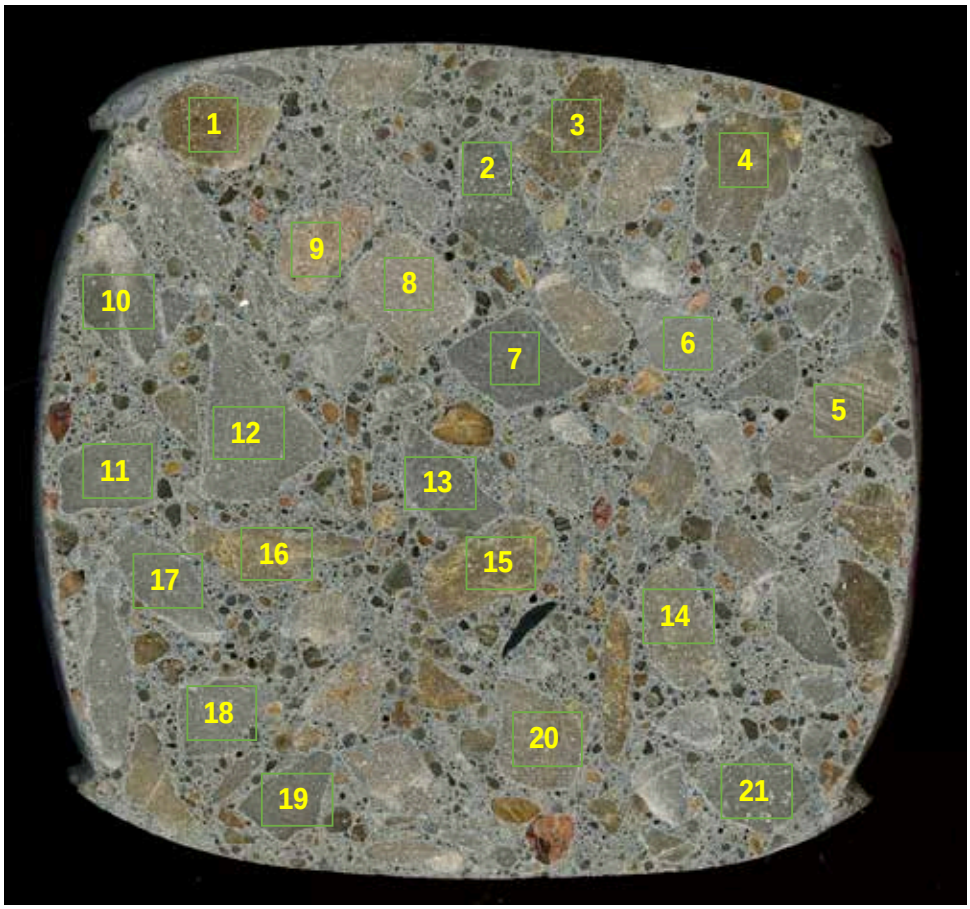


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	2	32	
3	3	18	2	33	
4	2	19	3	34	
5	2	20	2	35	
6	3	21	3	36	
7	3	22	3	37	
8	2	23		38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	2	27		42	
13	2	28		43	
14	3	29		44	
15	2	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	55
Rating 1	0	1	0	# of agg	22
Rating 2	11	2	22	**RATE**	**2.50**
Rating 3	11	3	33		

Sample Name:	1-III-C

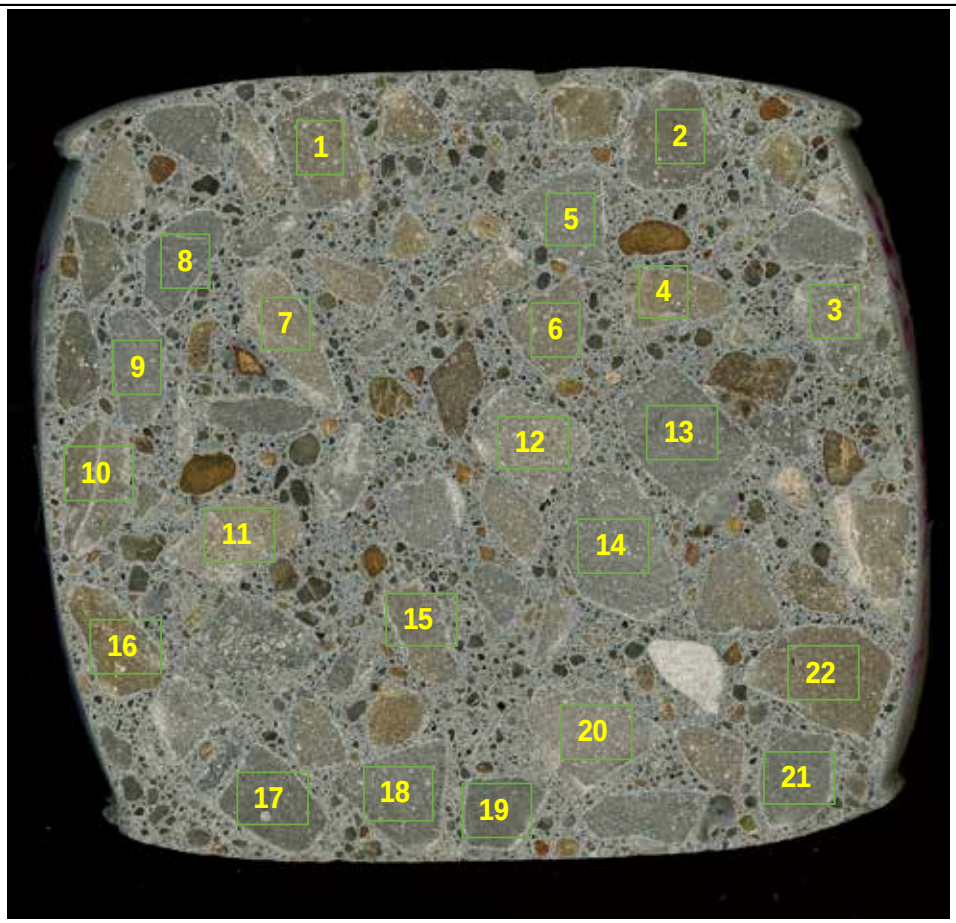


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	2	34	
5	3	20	3	35	
6	3	21	2	36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	2	28		43	
14	3	29		44	
15	3	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	59
Rating 1	0	1	0	# of agg	21
Rating 2	4	2	8	**RATE**	**2.81**
Rating 3	17	3	51		

Sample Name:	1-IV-C

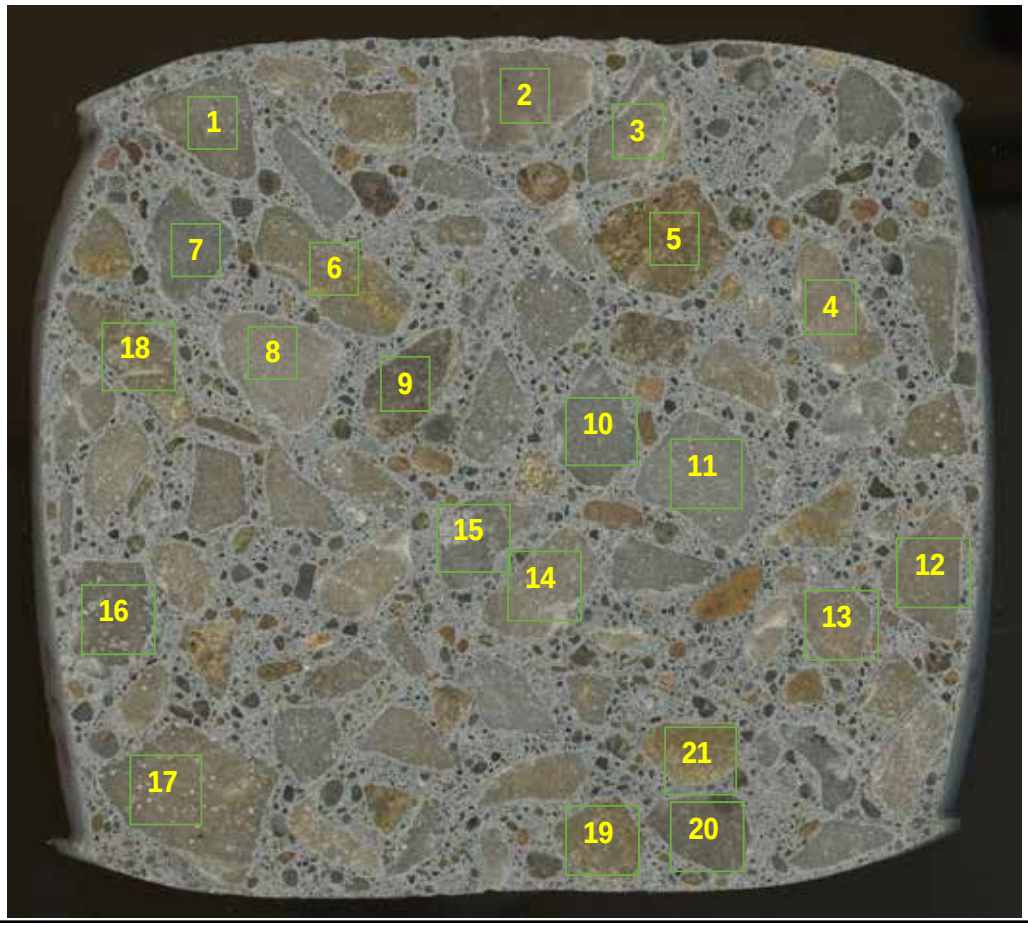


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	2	17	2	32	
3	2	18	2	33	
4	2	19	2	34	
5	2	20	3	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	2	26		41	
12	3	27		42	
13	2	28		43	
14	2	29		44	
15	3	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	48
Rating 1	0	1	0	# of agg	22
Rating 2	18	2	36	**RATE**	**2.18**
Rating 3	4	3	12		

Sample Name:	1-V-C

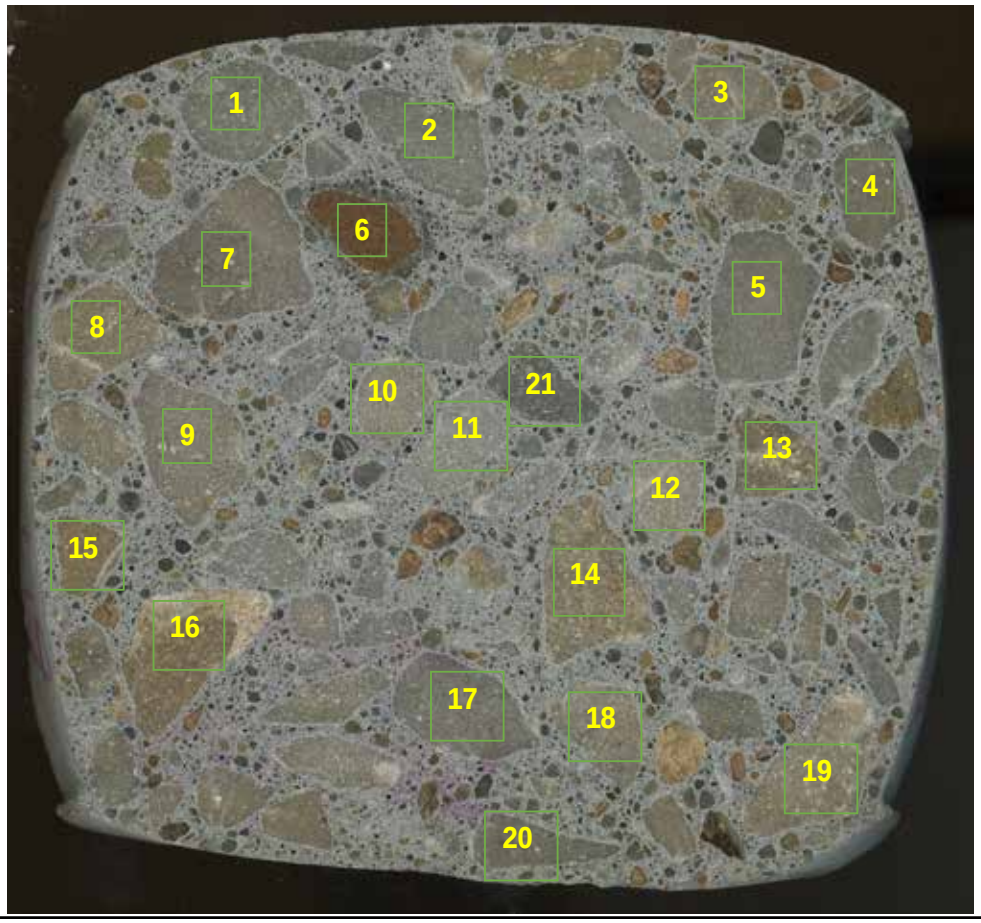


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	2	20	3	35	
6	3	21	2	36	
7	3	22		37	
8	3	23		38	
9	2	24		39	
10	2	25		40	
11	3	26		41	
12	3	27		42	
13	2	28		43	
14	2	29		44	
15	2	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	56
Rating 1	0	1	0	# of agg	21
Rating 2	7	2	14	**RATE**	**2.67**
Rating 3	14	3	42		

Sample Name:	2-I-C

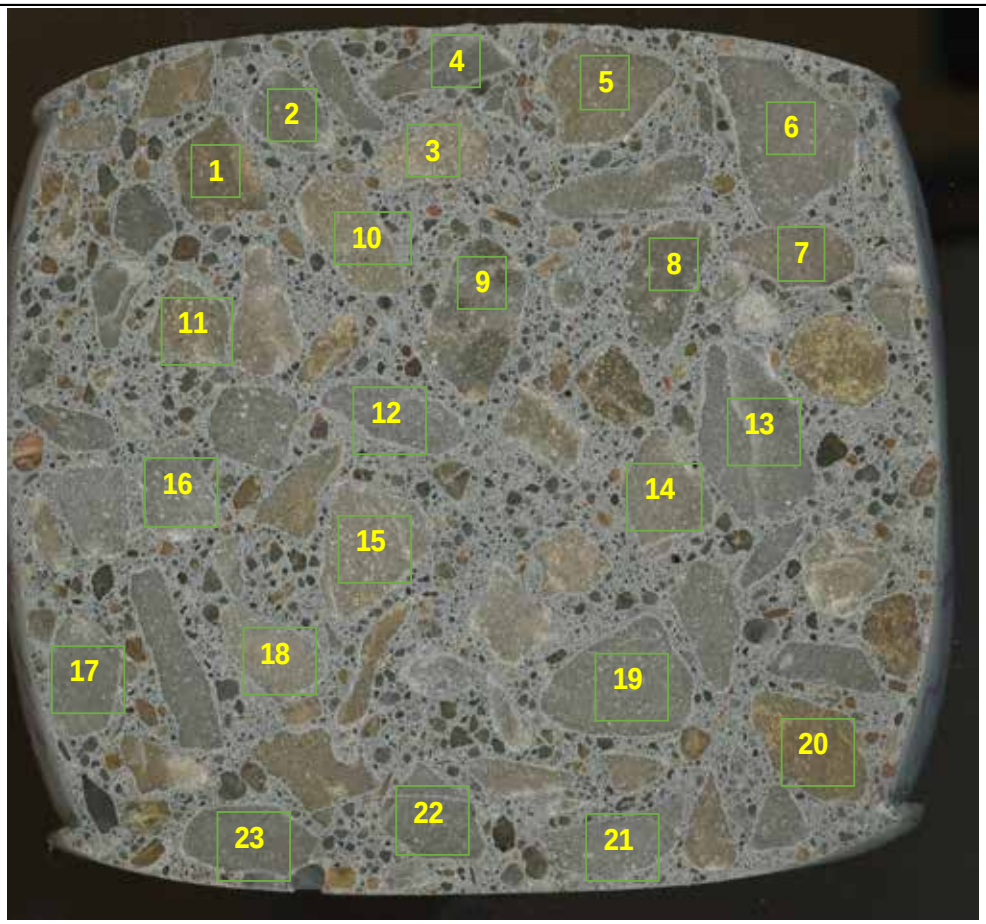


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	2	32	
3	2	18	2	33	
4	2	19	3	34	
5	2	20	3	35	
6	3	21	2	36	
7	3	22		37	
8	2	23		38	
9	2	24		39	
10	2	25		40	
11	2	26		41	
12	3	27		42	
13	2	28		43	
14	2	29		44	
15	2	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	50
Rating 1	0	1	0	# of agg	21
Rating 2	13	2	26	**RATE**	**2.38**
Rating 3	8	3	24		

Sample Name:	2-II-C

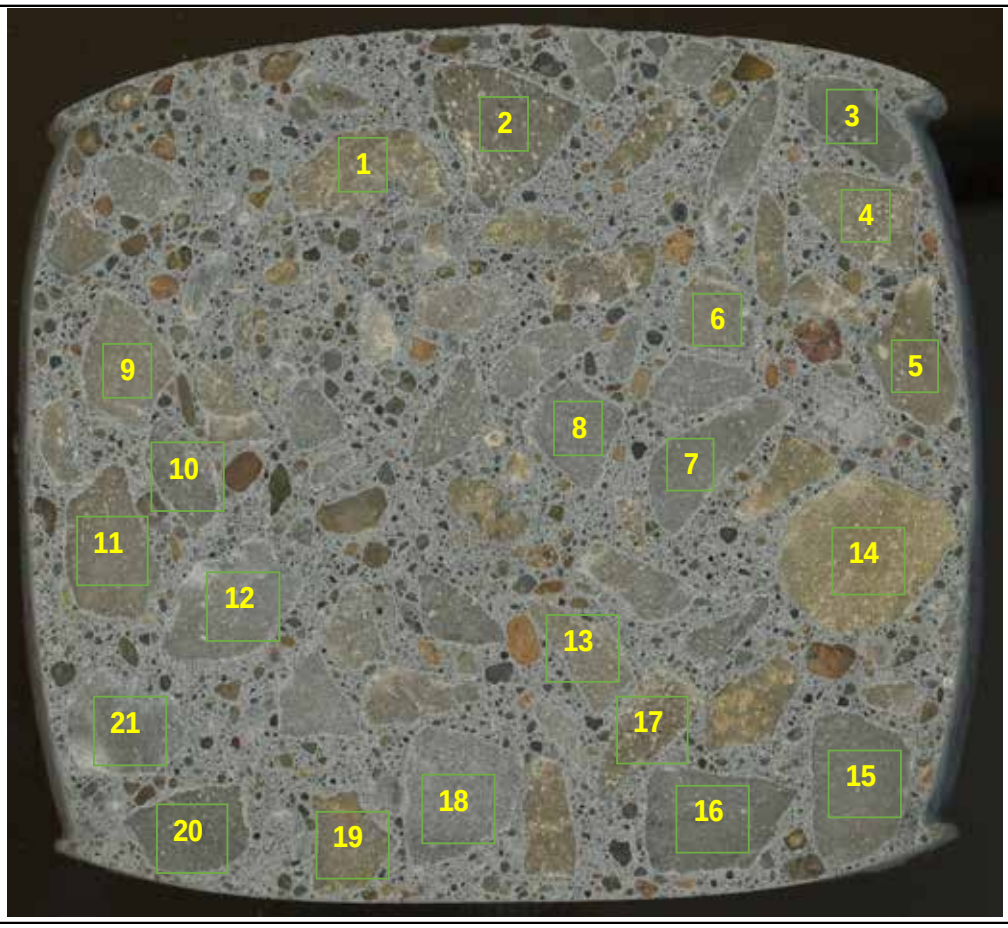


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	3	31	
2	2	17	3	32	
3	2	18	2	33	
4	2	19	2	34	
5	3	20	3	35	
6	2	21	3	36	
7	3	22	2	37	
8	3	23	3	38	
9	2	24		39	
10	2	25		40	
11	3	26		41	
12	2	27		42	
13	3	28		43	
14	3	29		44	
15	2	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	57
Rating 1	0	1	0	# of agg	23
Rating 2	12	2	24	**RATE**	**2.48**
Rating 3	11	3	33		

Sample Name:	2-III-C

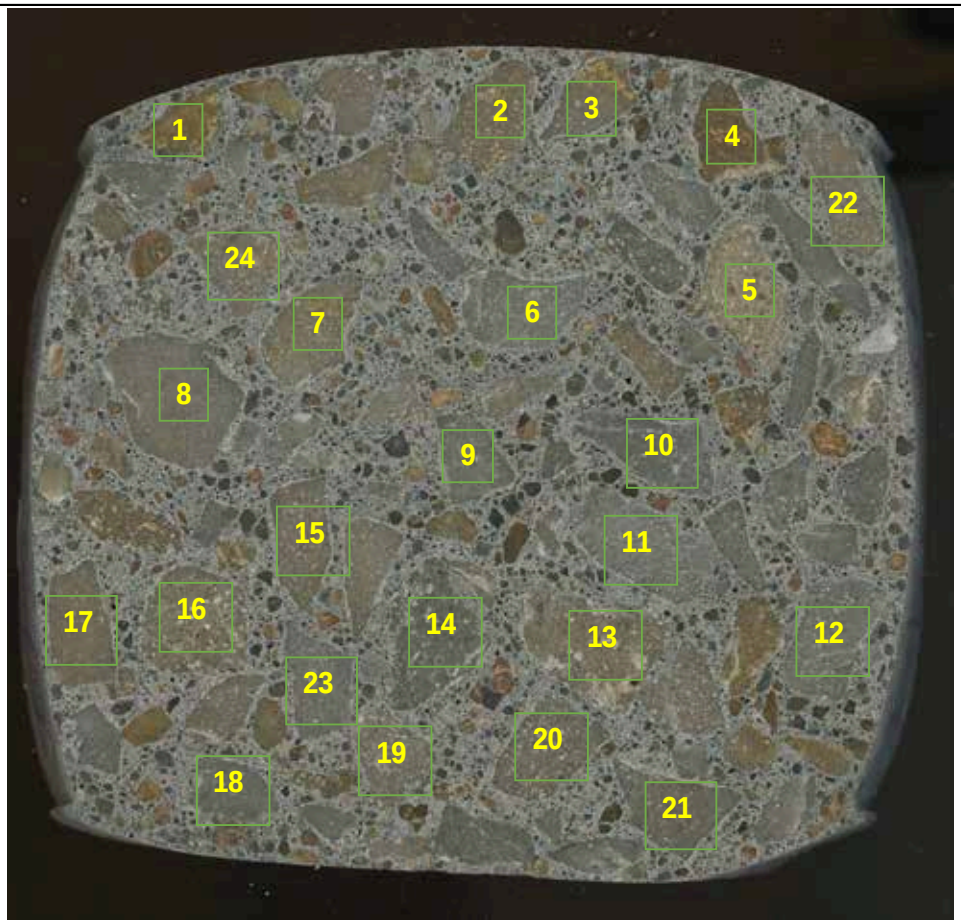


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	2	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	2	35	
6	3	21	3	36	
7	3	22		37	
8	3	23		38	
9	3	24		39	
10	2	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	3	29		44	
15	3	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	60
Rating 1	0	1	0	# of agg	21
Rating 2	3	2	6	**RATE**	**2.86**
Rating 3	18	3	54		

Sample Name:	2-IV-C

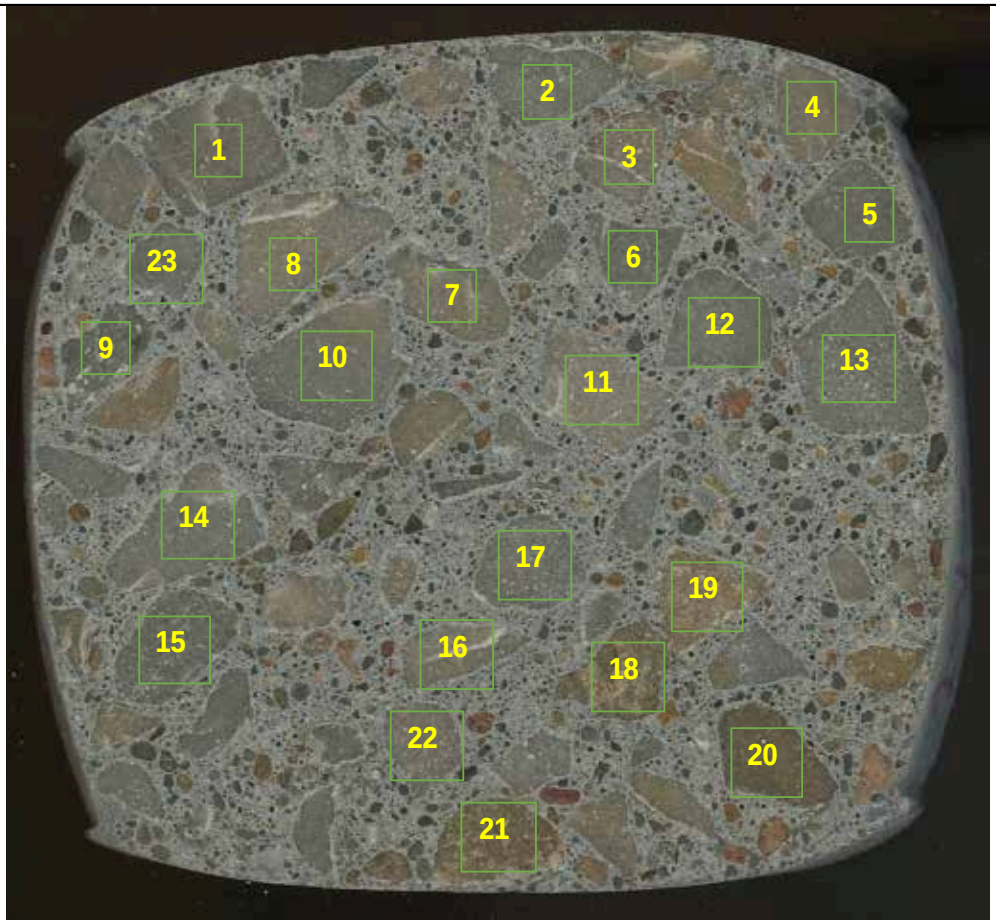


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	2	31	
2	3	17	2	32	
3	3	18	3	33	
4	3	19	3	34	
5	2	20	2	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23	2	38	
9	2	24	3	39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	2	28		43	
14	2	29		44	
15	2	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	63
Rating 1	0	1	0	# of agg	24
Rating 2	9	2	18	**RATE**	**2.63**
Rating 3	15	3	45		

Sample Name:	2-V-C

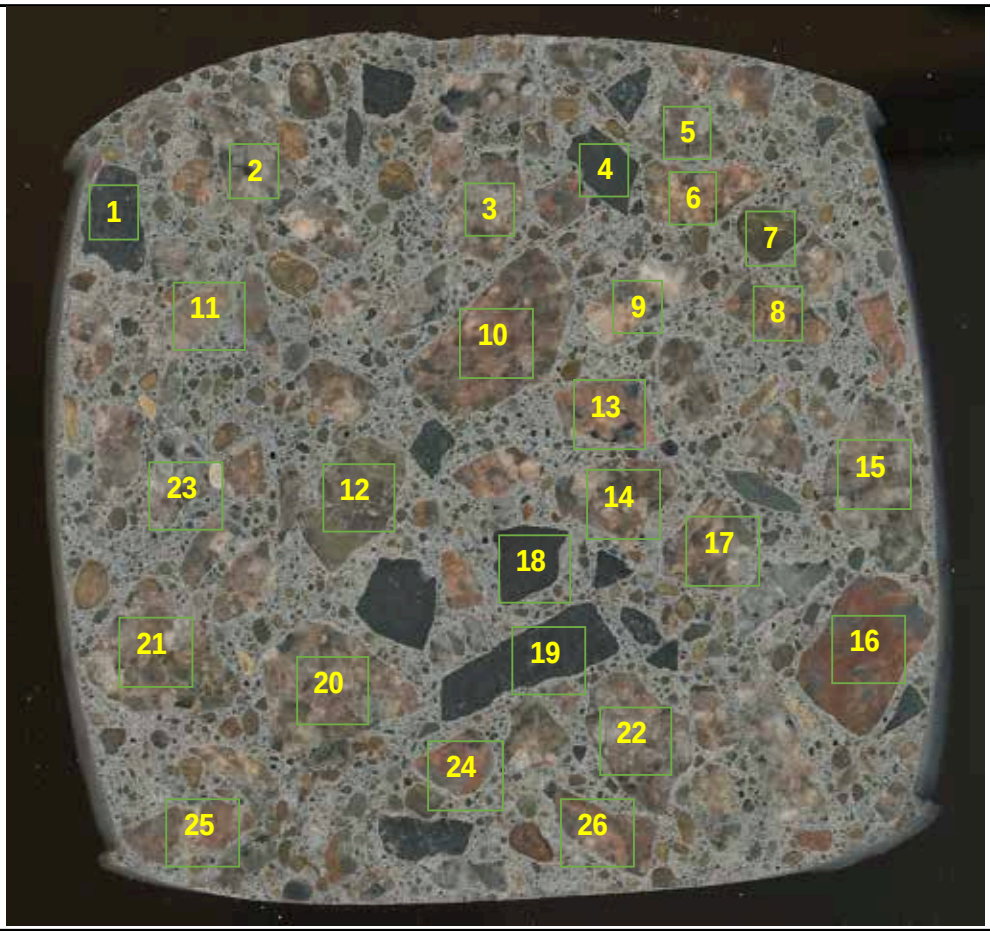


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	2	34	
5	3	20	3	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23	3	38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	2	27		42	
13	2	28		43	
14	3	29		44	
15	3	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	66
Rating 1	0	1	0	# of agg	23
Rating 2	3	2	6	**RATE**	**2.87**
Rating 3	20	3	60		

Sample Name:	3-I-C

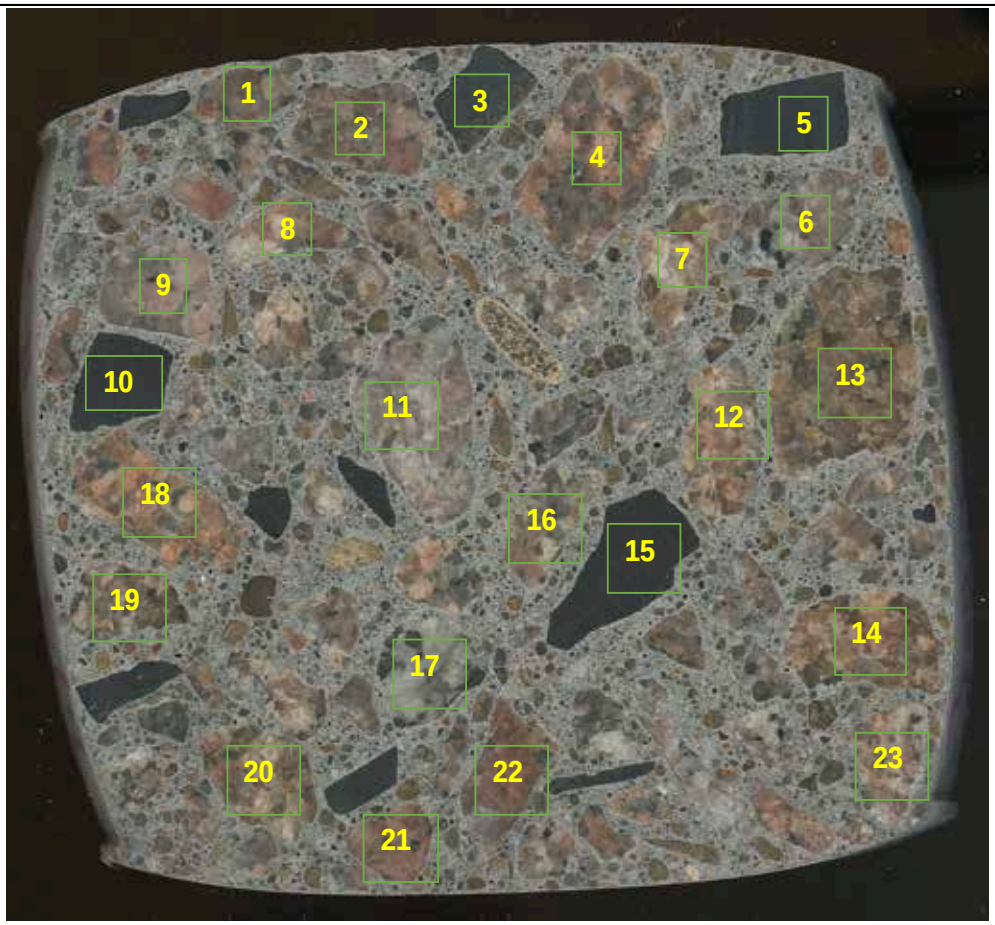


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	2	31	
2	2	17	2	32	
3	2	18	2	33	
4	2	19	2	34	
5	3	20	2	35	
6	2	21	2	36	
7	2	22	3	37	
8	2	23	2	38	
9	2	24	3	39	
10	2	25	2	40	
11	2	26	3	41	
12	2	27		42	
13	3	28		43	
14	2	29		44	
15	3	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	58
Rating 1	0	1	0	# of agg	26
Rating 2	20	2	40	**RATE**	**2.23**
Rating 3	6	3	18		

Sample Name:	3-II-C

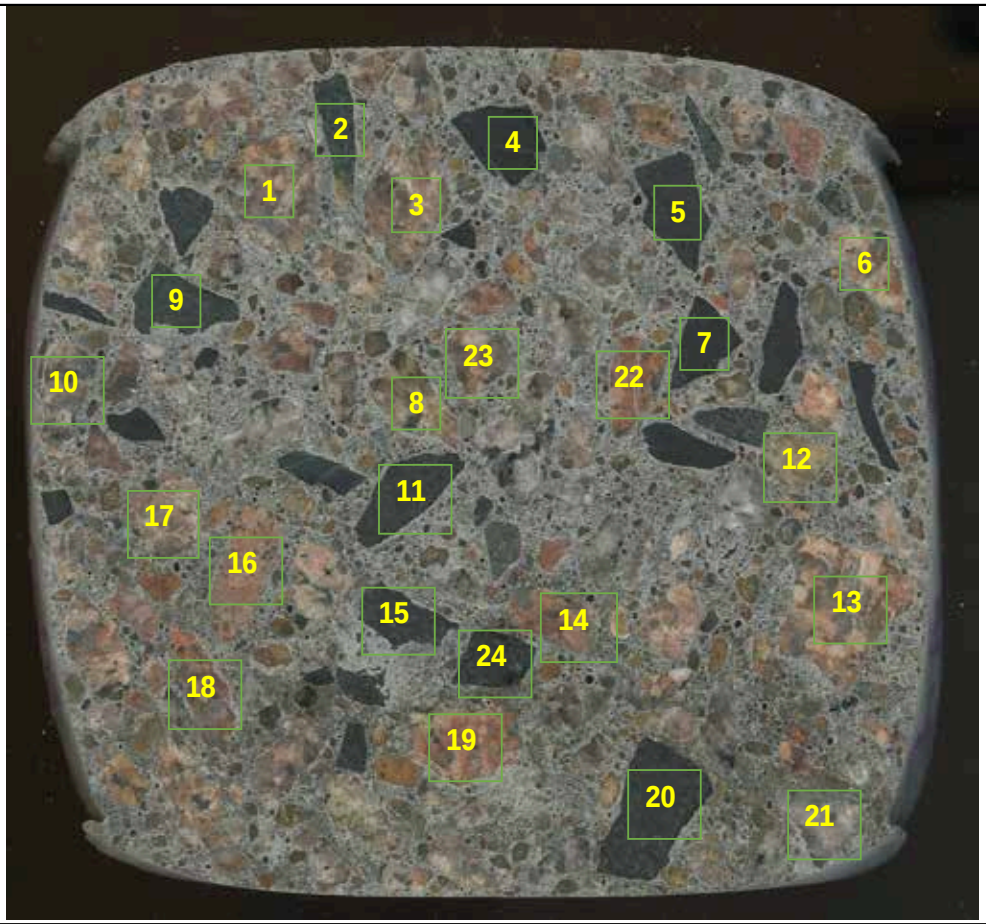


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	3	32	
3	3	18	3	33	
4	3	19	3	34	
5	3	20	3	35	
6	3	21	3	36	
7	3	22	3	37	
8	3	23	3	38	
9	3	24		39	
10	3	25		40	
11	3	26		41	
12	3	27		42	
13	3	28		43	
14	2	29		44	
15	3	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	68
Rating 1	0	1	0	# of agg	23
Rating 2	1	2	2	**RATE**	**2.96**
Rating 3	22	3	66		

Sample Name:	3-III-C

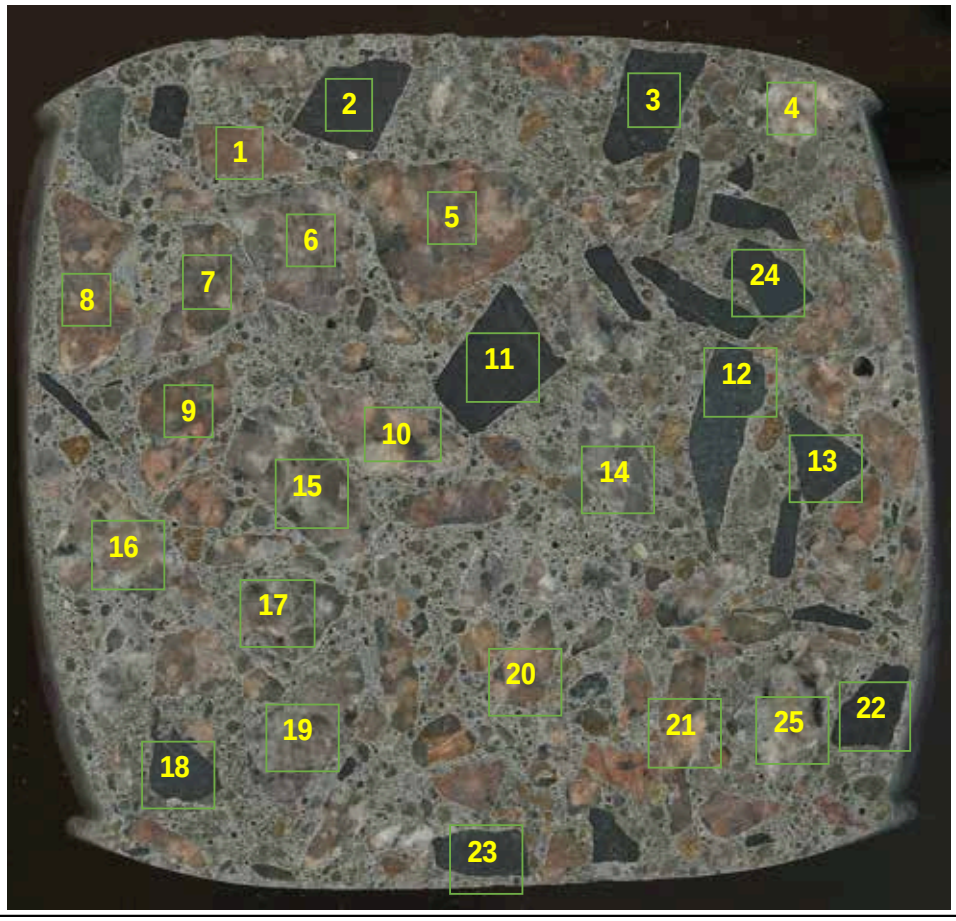


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	2	17	2	32	
3	3	18	3	33	
4	2	19	3	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	2	23	2	38	
9	3	24	2	39	
10	3	25		40	
11	2	26		41	
12	2	27		42	
13	2	28		43	
14	3	29		44	
15	3	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	57
Rating 1	0	1	0	# of agg	24
Rating 2	15	2	30	**RATE**	**2.38**
Rating 3	9	3	27		

Sample Name:	3-IV-C

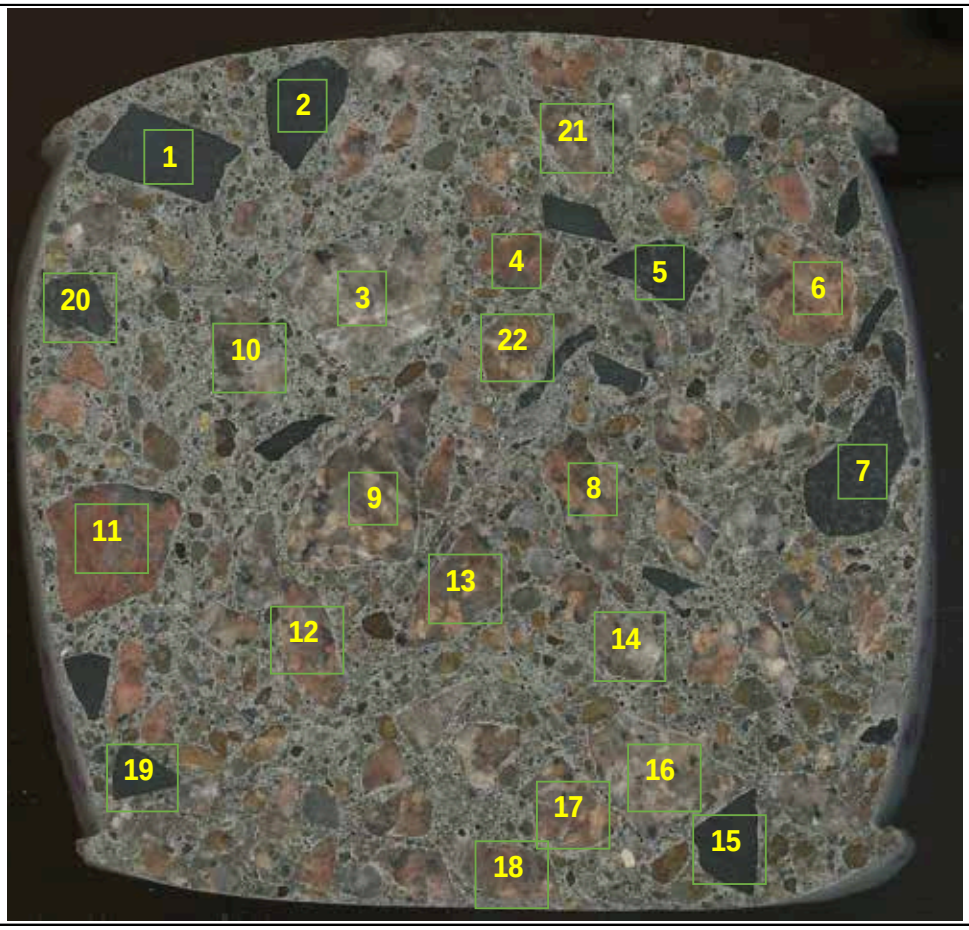


Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	2	16	2	31	
2	2	17	3	32	
3	2	18	2	33	
4	3	19	3	34	
5	2	20	2	35	
6	2	21	2	36	
7	2	22	2	37	
8	3	23	2	38	
9	2	24	2	39	
10	3	25	2	40	
11	2	26		41	
12	2	27		42	
13	2	28		43	
14	3	29		44	
15	2	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	56
Rating 1	0	1	0	# of agg	25
Rating 2	19	2	38	**RATE**	**2.24**
Rating 3	6	3	18		

Sample Name:	3-V-C



Agg. #	Rating	Agg. #	Rating	Agg. #	Rating
1	3	16	3	31	
2	3	17	2	32	
3	3	18	2	33	
4	3	19	2	34	
5	3	20	2	35	
6	3	21	3	36	
7	2	22	3	37	
8	2	23		38	
9	3	24		39	
10	3	25		40	
11	2	26		41	
12	2	27		42	
13	3	28		43	
14	2	29		44	
15	2	30		45	

ANALYSIS

Rating 0	0	0	0	Sum	56
Rating 1	0	1	0	# of agg	22
Rating 2	10	2	20	**RATE**	**2.55**
Rating 3	12	3	36		

Appendix C: Hardened Air Void Analysis Procedure

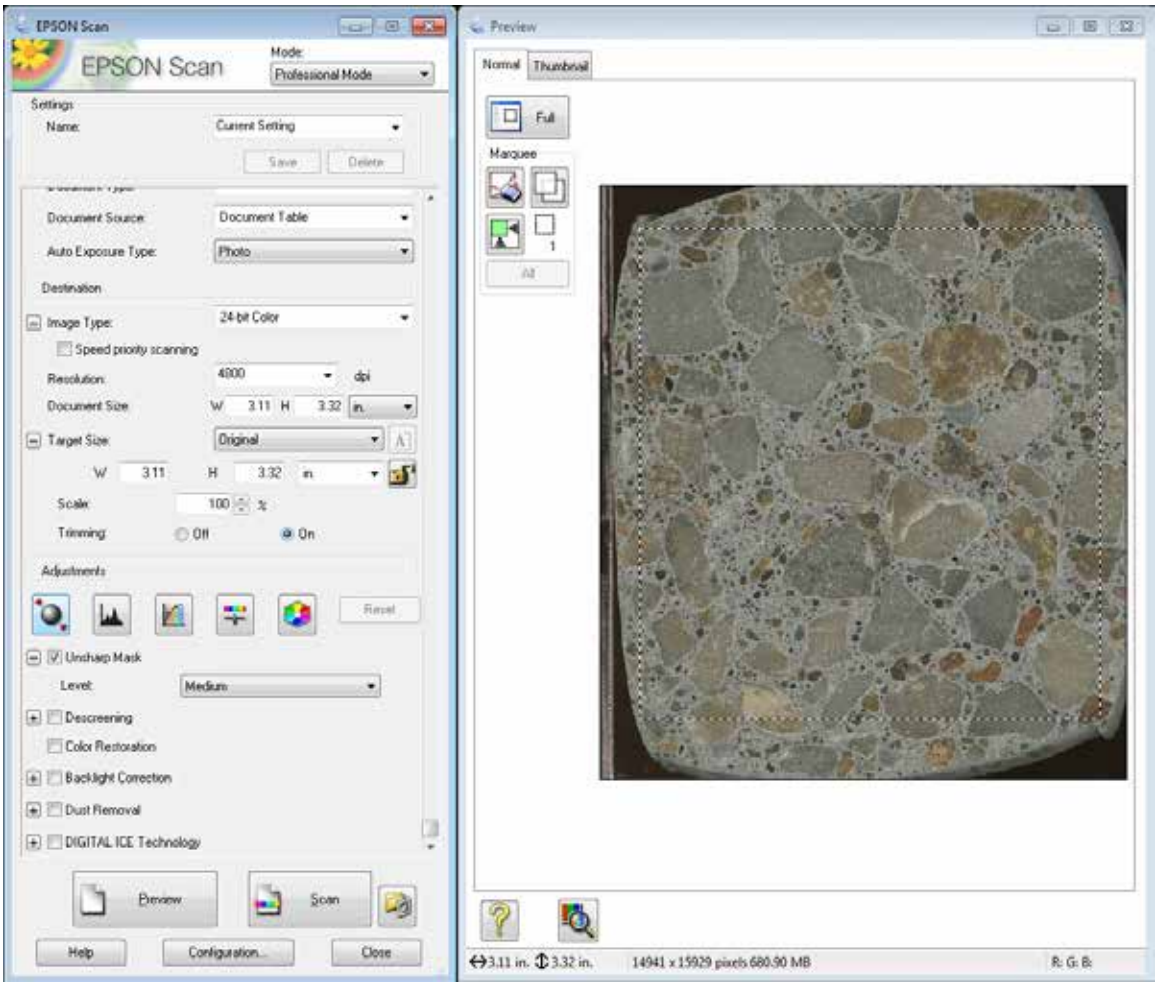
This appendix describes the procedure for air void analysis of hardened concrete that was implemented in this study. Sample polishing is always required prior to hardened void analysis, however the polishing procedure is not presented in this appendix as there are many guidelines available in the literature discussing this topic.

Part A: Material and Equipment Needed

- Flatbed scanner allowing scanning in color (sometimes referred to as the “photo mode”) and in high resolution (minimum of 4800 dpi is recommended)
- The newest version of the scanning software
- Solution of Phenolphthalein (1.0% in 95% Alcohol, Macron Fine Chemicals) in distilled water (1:1)
- Plastic bottle with sprayer (for phenolphthalein application)
- Orange chalk powder (Irwin Strait-Line Marking Chalk)
- Rubber stopper
- Thin microscope slides (1 mm thickens)
- Steel razorblade
- Scanner glass cleaning cloth
- Paper towels
- Adobe Photoshop (or equivalent image processing software)
- K-State Air Void Analyzer software

Part B: Image Scanning

1. All software image enhancement should be disabled. However, functions automatically adjusting scanning exposure can be used. The scanning resolution should be at least 4800 dpi, the minimum recommended color mode is 24-bit. TIFF image format (with no compression) should be used to save images.



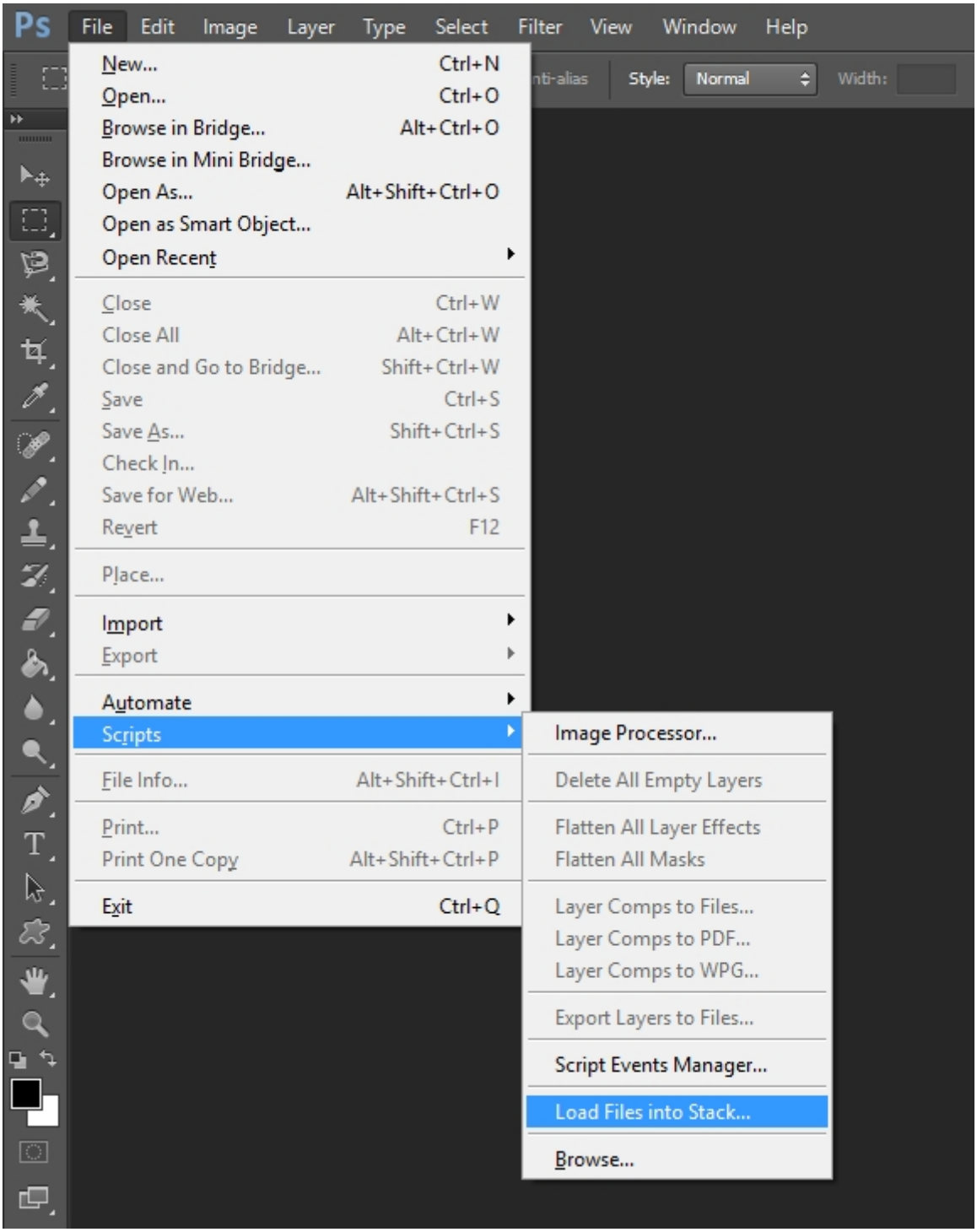
2. In order to make the future image alignment easier, an effort should be made to always place the sample on the same place on the scanning table. The scanning area selection should not be changed.
3. It is not necessary to protect the scanner glass against scratching as long as samples are placed on the scanning table with the upmost care. The scanning table should be cleaned often as the finer dust particles as well as the chalk powder could scratch the glass.
4. The sample should be scanned twice:

(1) First, a dried polished sample should be scanned.

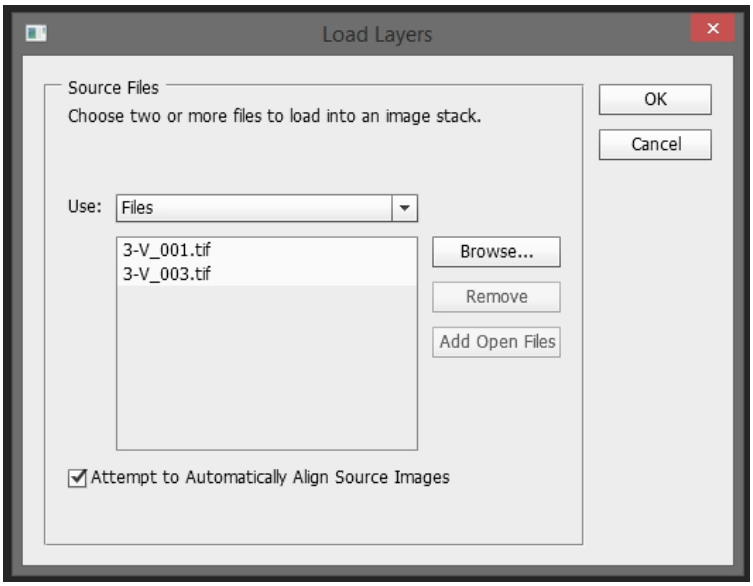
(2) Second, the sample, sprayed with a phenolphthalein solution and the air voids filled with an orange powder, should be scanned. Spray the sample with a phenolphthalein solution. Only a thin layer of solution shall be applied to eliminate excessive amounts of fluid coloring aggregate particles. The sample should be dried using a hairdryer. Finally, fill all air voids with the orange powder. The powder should be uniformly distributed over the sample surface using a microscope slide and then pressed into the air voids using a rubber stopper. This process should be repeated two times to ensure all voids were completely filled. A steel razorblade can be used to remove excess powder from the sample and, if needed, the surface can be dusted with a lightly-oiled laboratory gloved fingertip.

Part C: Image Alignment (using Adobe Photoshop)

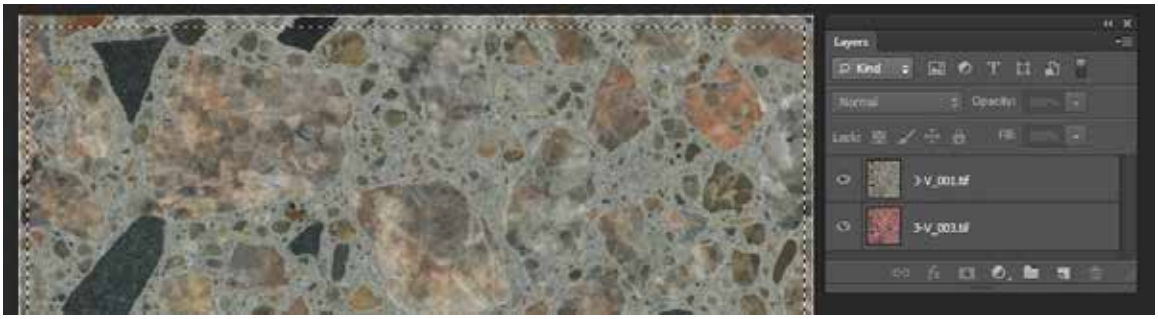
1. The "Load Files into Stack" function of the Adobe Photoshop software program should be used.

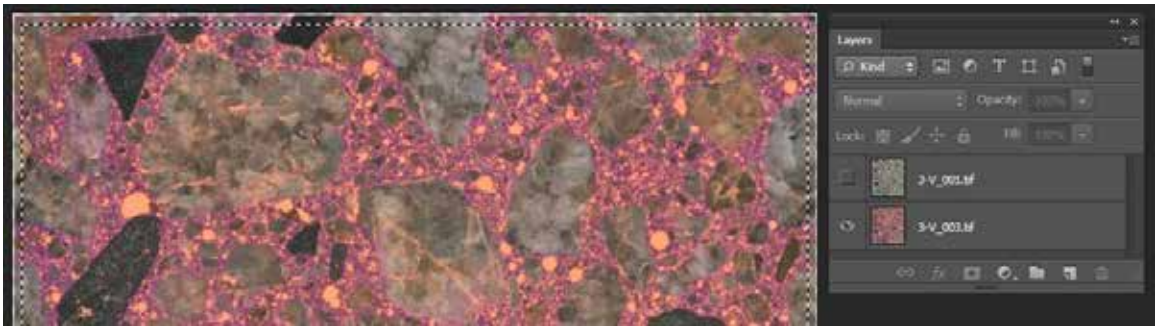


2. In the dialog window of this function, it is important that “Attempt to Automatically Align Source Images” checkbox is checked.



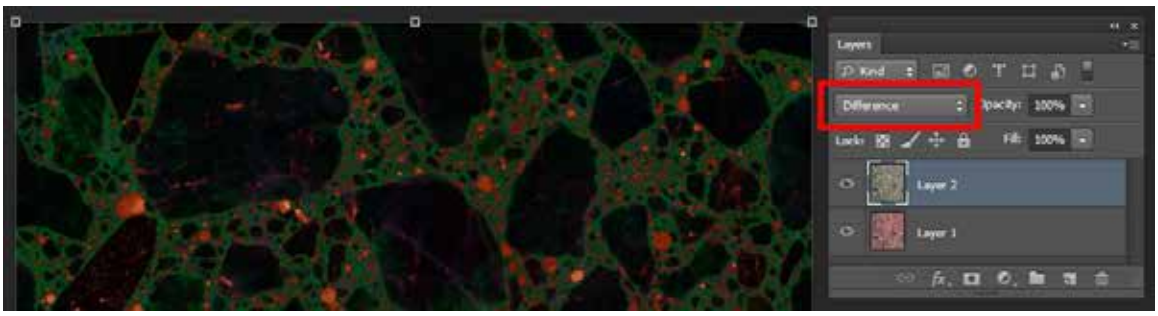
3. Once the aligning process is finished, two layers with aligned images are created. Make a selection containing overlapping areas of both images for every layer and create a new image containing the overlapping (aligned) layers.



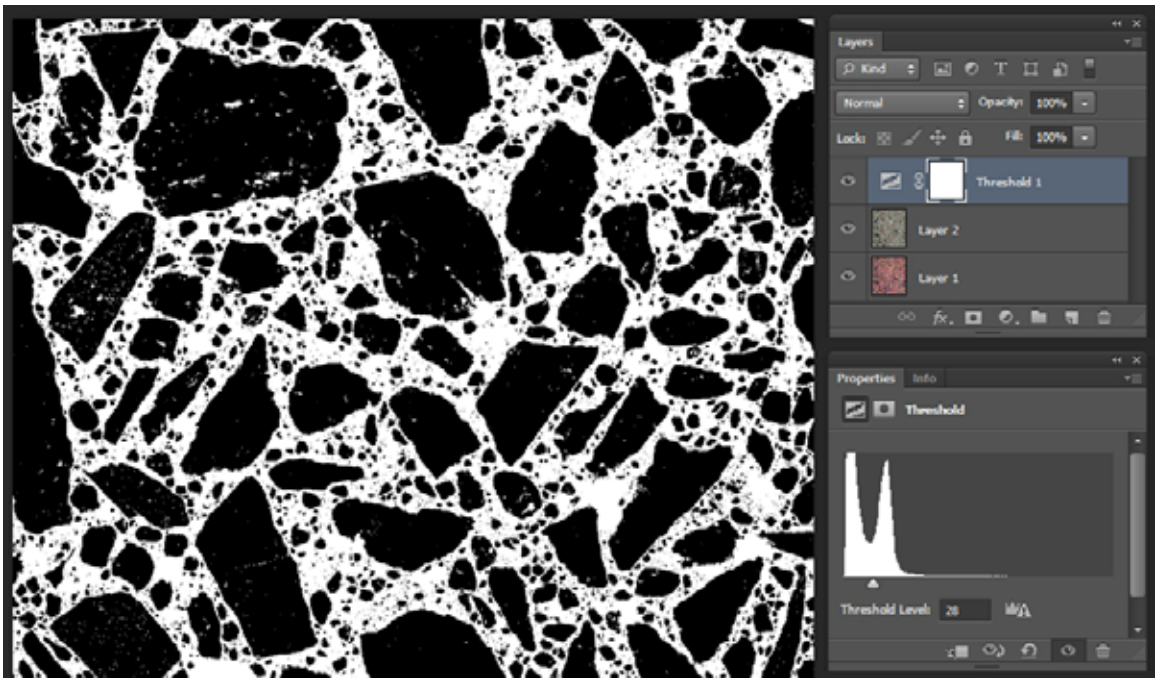


Part D: False Color Image

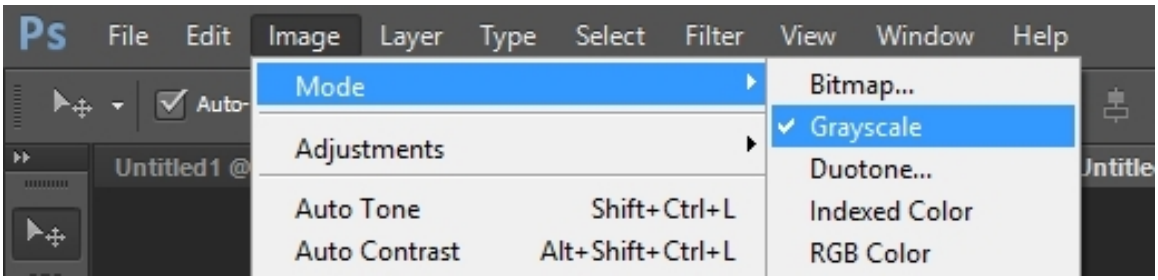
1. In the newly created image with two aligned layers, choose “Difference” in the blending layer drop box.



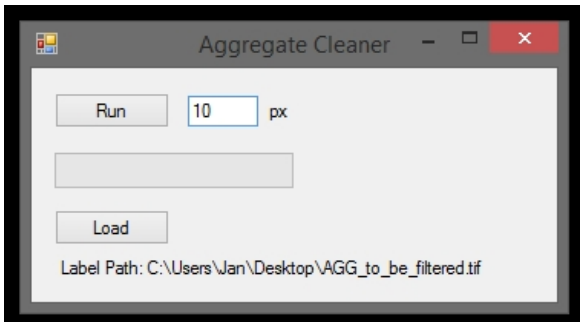
2. Apply the threshold operation on the image (Image à Adjustments à Threshold). The threshold value should be selected so the aggregate particles are detected as accurately as possible. However, it is always better to “underestimate” the aggregate particles as the white spaces in the aggregate will be filled later and the small noise particles will be deleted. If a high threshold value is selected, a lot of noise particles are detected and the cleaning procedure will not be successful. Typically a threshold level corresponding to the valley bottom between two peaks in the image histogram is the appropriate value.



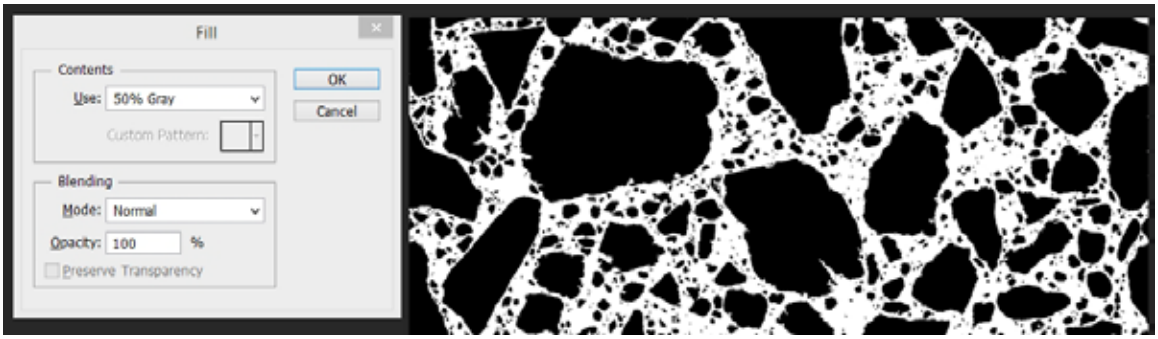
3. Duplicate all layers into a new document and merge them. Change the image mode to "Grayscale" once merged (Image à Mode à Grayscale). Save the image (use the uncompressed TIFF format with discarded layers).



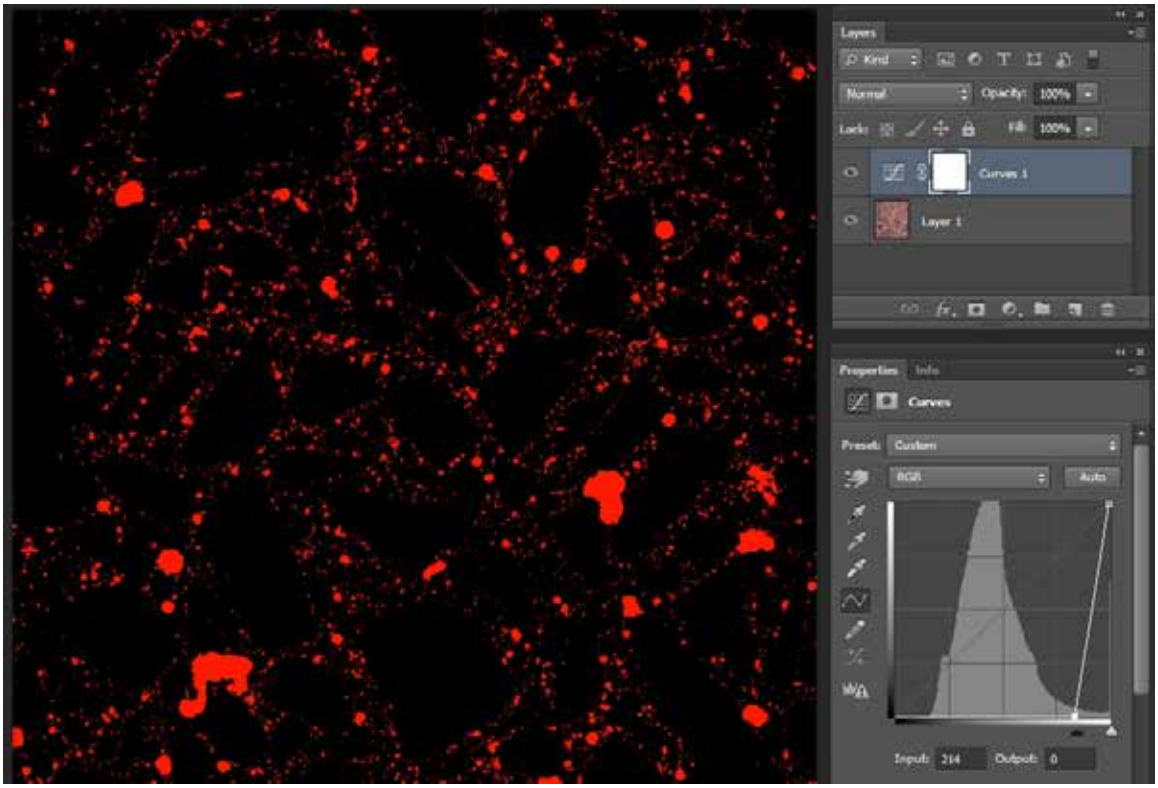
4. Use the "Aggregate Cleaner" module of KSU Void Analyzer to remove the noise particles and fill the air voids inside aggregates. The output image is automatically generated in the program folder (output.tif).



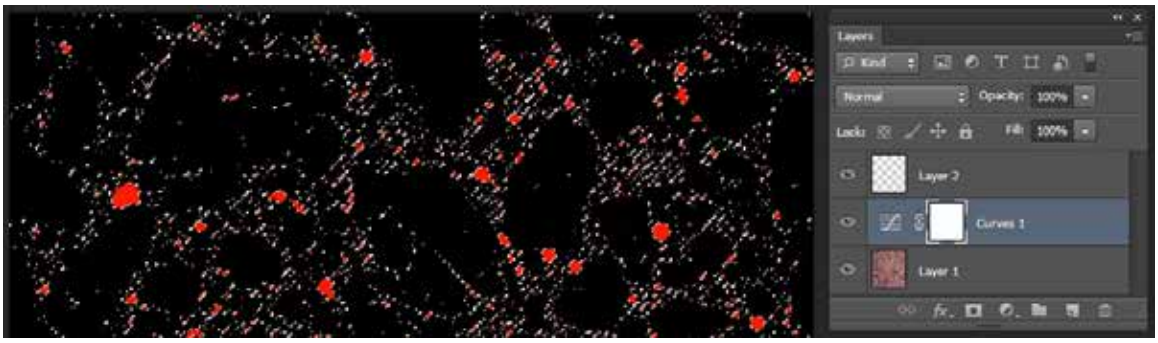
5. Open the output image in Adobe Photoshop and change the color mode once again back to grayscale. Subsequently, use the Magic Wand Tool (keyboard shortcut "W") to select all white areas. Once selected, fill these areas with 50% gray color (Edit à Fill).



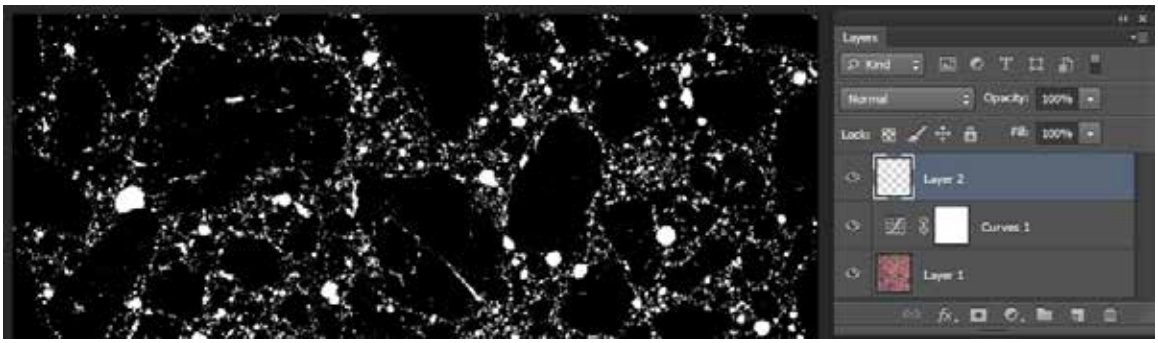
6. Get back to the document from step 2. All layers besides the layer containing the image with the powder pressed into the air voids can be removed. Use the “Curves” function to detect air voids (Image à Adjustments à Curves) on the powdered image. The “Input” value depends on the quality of contrast between the paste and air voids and typically ranges from 185 to 225. Visual comparison of detected voids to the original image needs to be made when choosing the value.



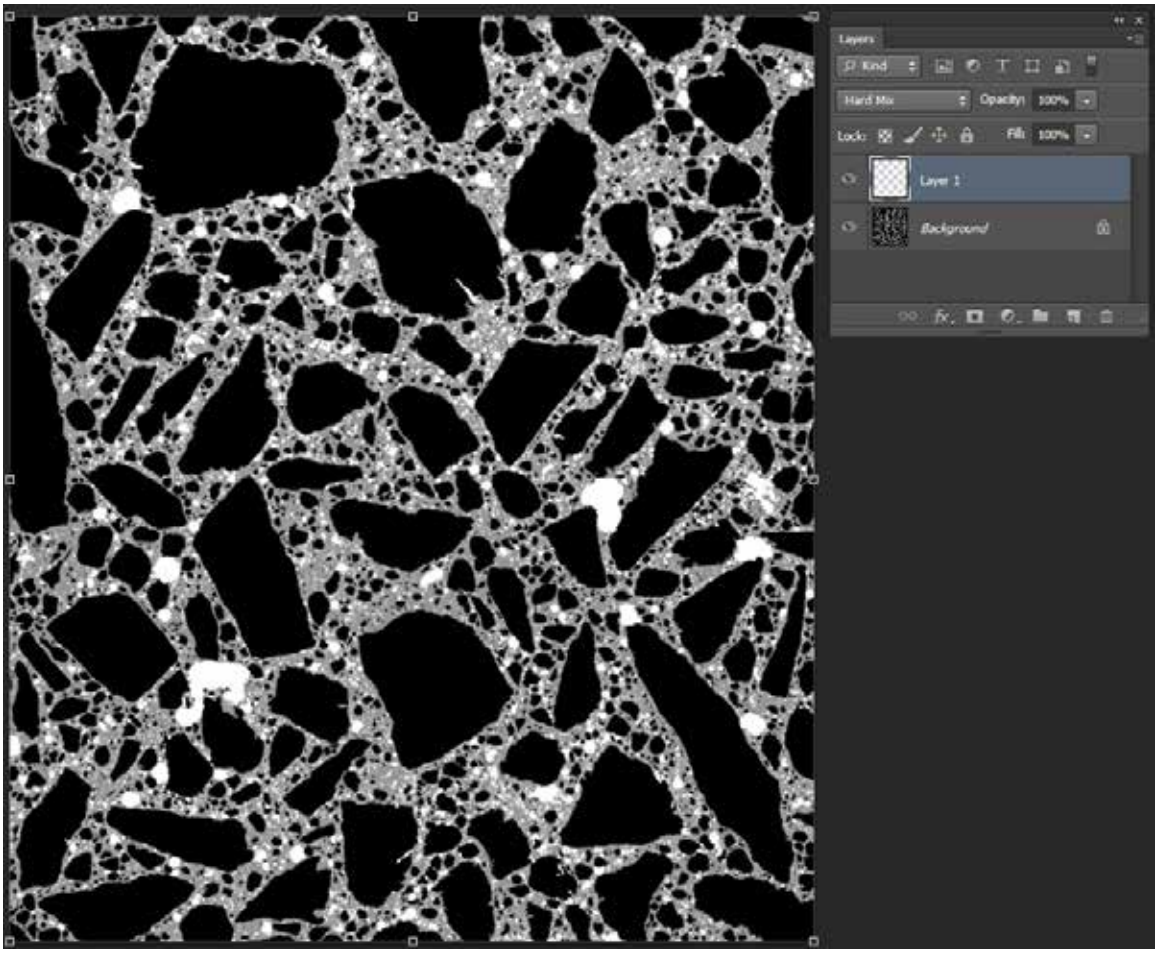
7. Create a new, empty layer and place it on top of all layers. Use the Magic Wand Tool (keyboard shortcut “W”) to color select all black areas (the “curves” layer must be selected).



8. Select the new layer, invert the selection (Ctrl + Shift + I) and fill the selection with white color (Ctrl + Shift + F5 or Edit à Fill). Thus, a new layer containing only the air voids is created.

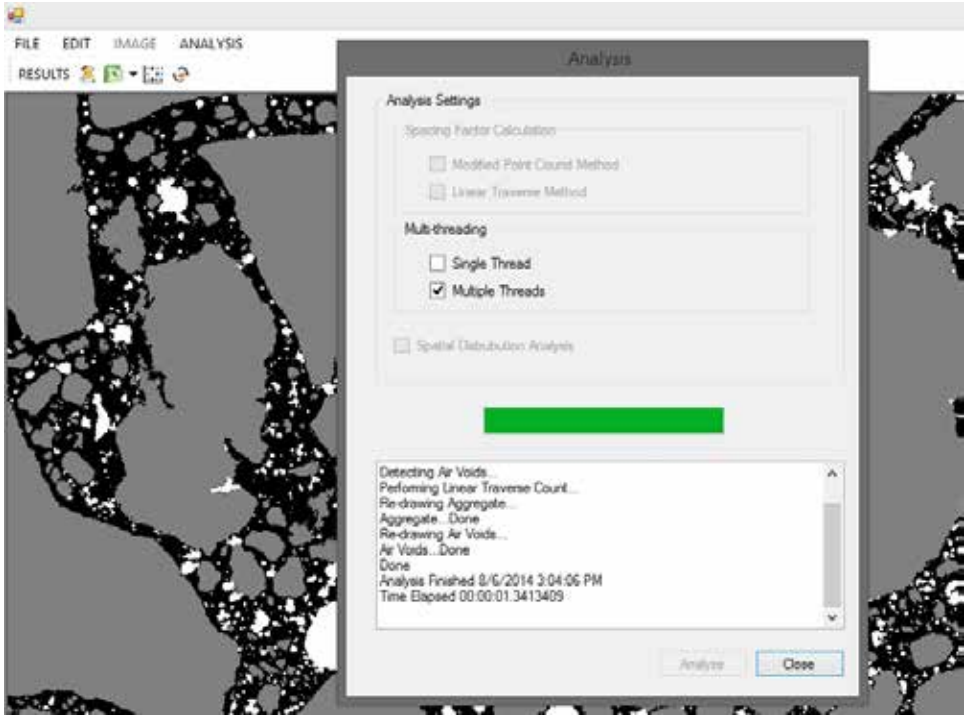


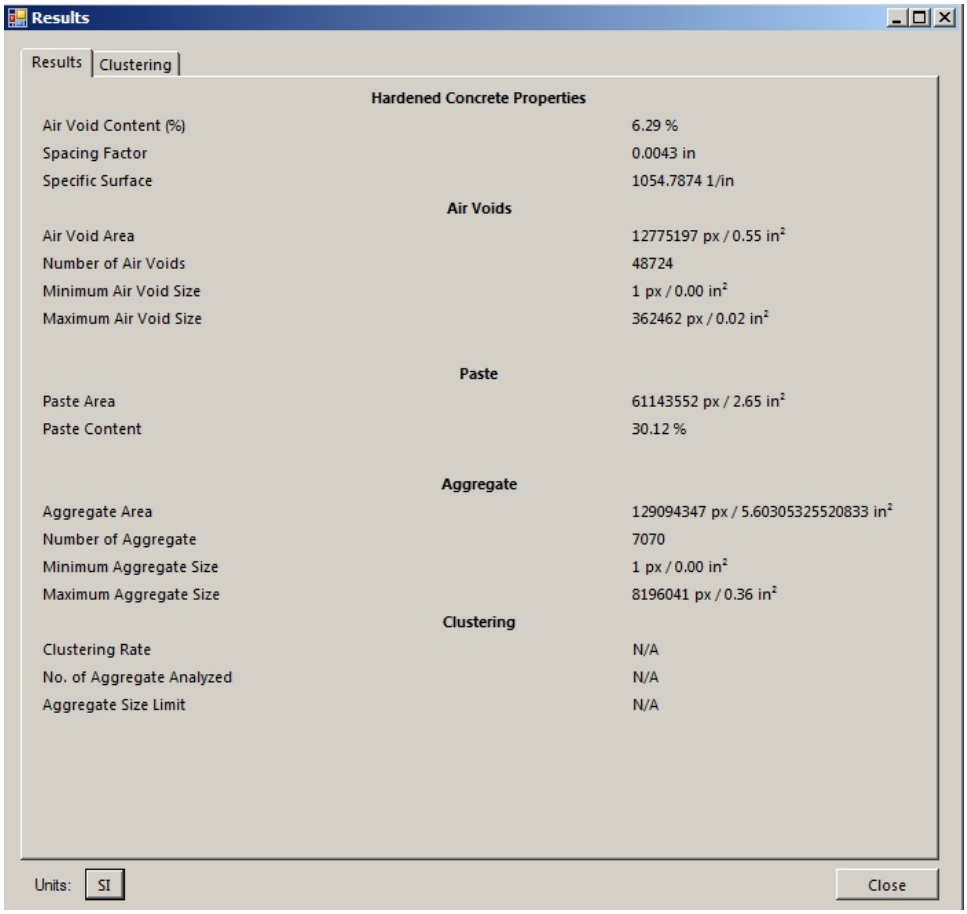
9. Duplicate this layer into the document containing the filtered aggregate image (most probably named output.tif). Select “Hard Mix” in layer blending options drop box. This is the final step as the false color image is generated. Optionally, manual corrections can be performed on this image.



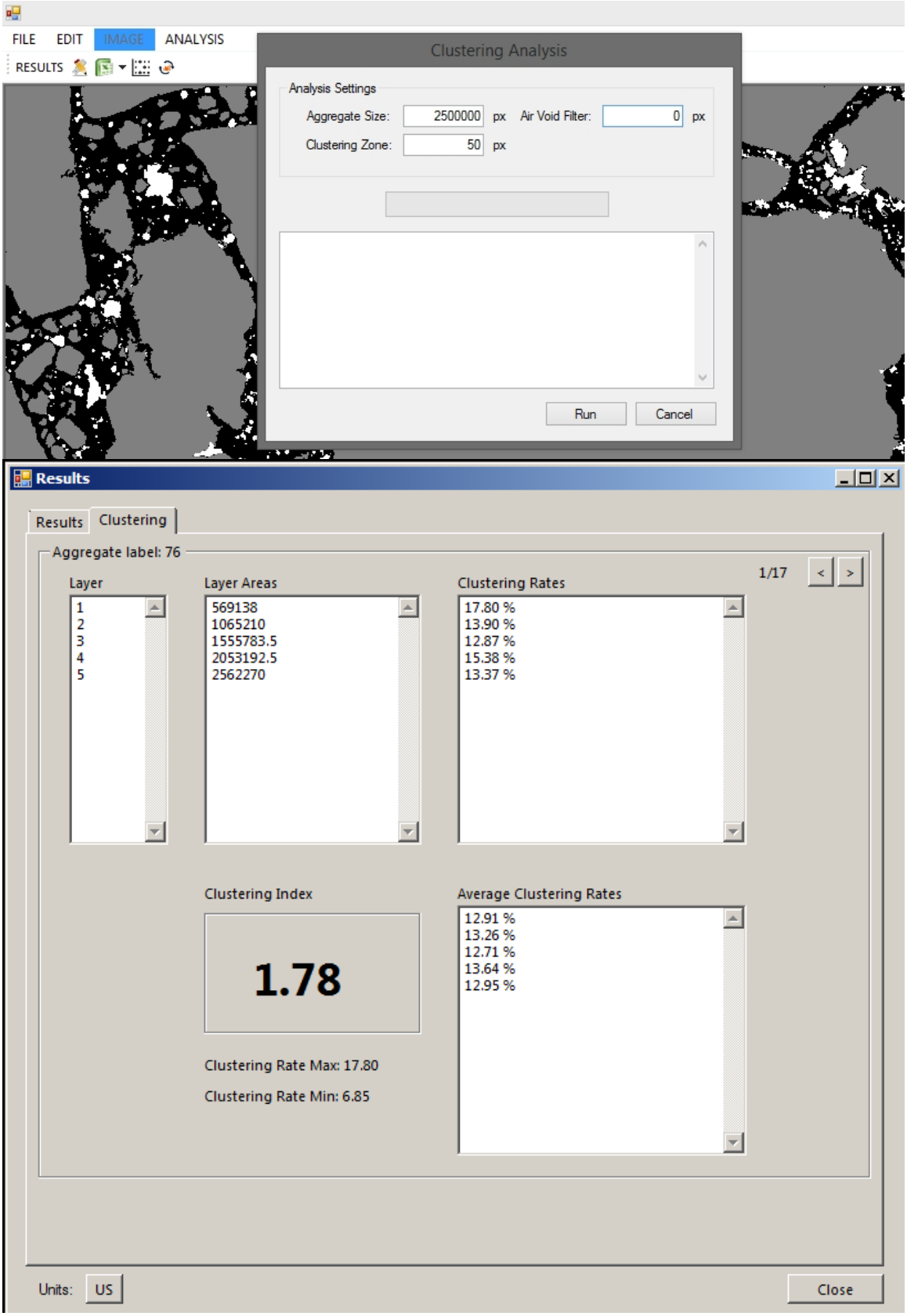
Part E: Analysis

1. The K-State Air Void Analyzer is used to perform the analysis of the false color image. Multiple threads (i.e. multiple processors) or single-thread mode can be selected to perform the analysis. Using multiple threads is naturally faster, however it requires a larger amount of RAM (typically at least 4 GB for images over 700 MB). The software incorporates EmguCV library (version 2.4.9), which is a .Net wrapper to the OpenCV image processing library. During the analysis, three main tasks are executed:
    (1) Air void detection. EmguCV BlobDetector class is utilized to detect all air voids.
    (2) Aggregate detection. An identical algorithm as in the previous task in used, this time aggregate particles are targeted.
    (3) Linear Traverse Count. The linear traverse count as described in ASTM C457 is implemented. The used algorithm iterates through every pixels and the data described in the Section 11.1.2 of ASTM C457 are recorded (total length of traverse, traverse length through air, and traverse length through paste).





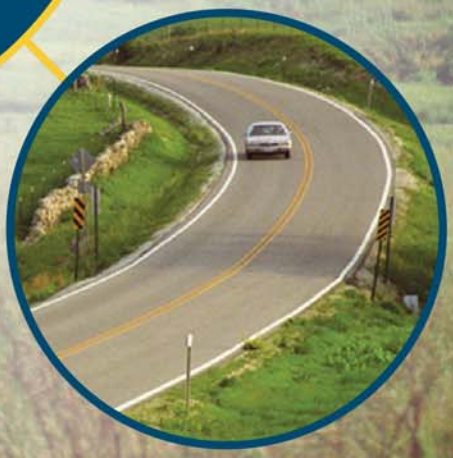
2. If desired, a clustering analysis can be performed as well. Since performing a clustering analysis on every single aggregate particle would be ineffective and computationally expensive, a minimum aggregate size can be specified. Also, the width of the clustering zone can be defined before the analysis is carried out. The width of the clustering zone will influence the results – the larger the zone typically the smaller the clustering index.


FILE
EDIT
IMAGE
ANALYSIS
RESULTS
Clustering Analysis
Analysis Settings
Aggregate Size:
2500000
px
Air Void Filter:
0
px
Clustering Zone:
50
px
Run
Cancel
Results
Results
Clustering
Aggregate label: 76
1/17
Layer
1
2
3
4
5
Layer Areas
569138
1065210
1555783.5
2053192.5
2562270
Clustering Rates
17.80 %
13.90 %
12.87 %
15.38 %
13.37 %
Clustering Index
1.78
Clustering Rate Max: 17.80
Clustering Rate Min: 6.85
Average Clustering Rates
12.91 %
13.26 %
12.71 %
13.64 %
12.95 %
Units:
US
Close

K-TRAN

KANSAS TRANSPORTATION RESEARCH AND NEW-DEVELOPMENT PROGRAM

AD ASTRA PER ASPERA

Kansas

Department of Transportation