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Relationships of HMA In-Place Air Voids, Lift Thickness, and Permeability
Volume Four

Prepared for:

National Cooperative Highway Research Program

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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MIX DESIGN SUMMARY INFORMATION FOR PART 1

Table A.1 Mix Design Summary for 9.5 mm NMAS Granite ARZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Granite ARZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.717

Effective Gravity Solids (Gse): 2.713

Bulk Gravity Solids (Gsb): 2.676

Percent Minus #200: 5.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	5.50	4756.2	126.0	118.0	2.295	2.489	5.01	7.8	18.9	59.0	1.00	86.4
2	5.50	4758.7	125.8	117.9	2.297	2.489	5.01	7.7	18.9	59.2	1.00	86.5
Avg								7.7	18.9	59.1	1.00	86.4
1	6.00	4783.6	126.9	118.1	2.309	2.470	5.51	6.5	18.9	65.5	0.91	87.0
2	6.00	4781.3	126.0	117.6	2.315	2.470	5.51	6.3	18.7	66.4	0.91	87.5
Avg								6.4	18.8	65.9	0.91	87.2
1	6.50	4806.4	126.1	117.7	2.331	2.452	6.01	4.9	18.6	73.4	0.83	88.7
2	6.50	4813.9	126.3	117.6	2.335	2.452	6.01	4.8	18.4	74.2	0.83	88.7
Avg								4.8	18.5	73.8	0.83	88.7
1	7.20	4824.1	126.0	116.6	2.357	2.427	6.72	2.9	18.3	84.3	0.74	89.9
2	7.20	4854.4	126.2	117.2	2.365	2.427	6.72	2.6	18.0	85.8	0.74	90.5
Avg								2.7	18.1	85.0	0.74	90.2

Table A.2 Mix Design Summary for 9.5 mm NMAS Granite BRZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Granite BRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.717

Effective Gravity Solids (Gse): 2.703

Bulk Gravity Solids (Gsb): 2.672

Percent Minus #200: 5.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	4.80	4787.6	129.0	117.3	2.357	2.507	4.38	6.0	16.0	62.6	1.14	85.5
2	4.80	4780.4	128.8	117.1	2.354	2.507	4.38	6.1	16.1	62.0	1.14	85.3
Avg								6.1	16.1	62.3	1.14	85.4
1	5.30	4802.0	128.4	116.5	2.375	2.488	4.88	4.5	15.8	71.3	1.03	86.6
2	5.30	4805.3	128.4	116.4	2.382	2.488	4.88	4.3	15.6	72.5	1.03	86.8
Avg								4.4	15.7	71.9	1.03	86.7
1	5.80	4818.5	128.0	115.8	2.397	2.470	5.38	3.0	15.5	80.9	0.93	87.8
2	5.80	4819.3	128.5	116.0	2.399	2.470	5.38	2.9	15.4	81.4	0.93	87.7
Avg								2.9	15.5	81.1	0.93	87.7

Table A.3 Mix Design Summary for 9.5 mm NMAS Granite TRZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Granite TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22
Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.717
Effective Gravity Solids (Gse): 2.702
Bulk Gravity Solids (Gsb): 2.674

Percent Minus #200: 5.0
Filler Type Added: None
Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	5.30	4760.9	124.0	114.7	2.383	2.487	4.92	4.2	15.6	73.0	1.02	88.6
2	5.30	4760.7	124.1	114.9	2.382	2.487	4.92	4.2	15.6	72.9	1.02	88.7
Avg								4.2	15.6	72.9	1.02	88.6
1	5.80	4782.3	123.6	114.2	2.402	2.469	5.42	2.7	15.4	82.5	0.92	89.9
2	5.80	4791.2	124.0	114.6	2.404	2.469	5.42	2.6	15.3	82.8	0.92	90.0
Avg								2.7	15.3	82.6	0.92	89.9
1	6.30	4802.1	123.7	114.2	2.410	2.451	5.92	1.7	15.5	89.3	0.84	90.8
2	6.30	4819.5	124.0	114.5	2.416	2.451	5.92	1.4	15.3	90.8	0.84	91.0
Avg								1.5	15.4	90.0	0.84	90.9

Table A.4 Mix Design Summary for 19.0 mm NMAS Granite ARZ

Project Name: 9-27 **Compactive Device:** Pine Gyratory Compactor
Mixture ID: 19.0 GRN ARZ **Compactive Effort:** 100 Gyrations

Binder Type: PG 67-22
Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.711
Effective Gravity Solids (Gse): 2.702
Bulk Gravity Solids (Gsb): 2.672

Percent Minus #200 5.1
Filler Type Added: None
Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	4.00	4693.5	120.6	112.7	2.393	2.537	3.58	5.7	14.0	59.5	1.42	88.1
2	4.00	4689.3	119.8	112.2	2.398	2.537	3.58	5.5	13.8	60.5	1.42	88.5
Avg								5.6	13.9	60.0	1.42	88.3
1	4.50	4697.2	120.3	112.2	2.408	2.518	4.09	4.4	13.9	68.7	1.25	89.2
2	4.50	4706.1	121.0	112.8	2.400	2.518	4.09	4.7	14.2	67.2	1.25	88.9
Avg								4.5	14.1	68.0	1.25	89.0
1	5.00	4742.7	120.4	112.1	2.416	2.499	4.59	3.3	14.1	76.4	1.11	90.0
2	5.00	4753.2	121.0	112.9	2.413	2.499	4.59	3.4	14.2	75.9	1.11	90.1
Avg								3.4	14.2	76.2	1.11	90.1

Table A.5 Mix Design Summary for 19.0 mm NMAS Granite BRZ

Project Name: 9-27

Mixture ID: 19 mm NMAS Granite BRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.714

Effective Gravity Solids (Gse): 2.714

Bulk Gravity Solids (Gsb): 2.680

Percent Minus #200: 4.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.50	4782.4	133.2	119.8	2.406	2.567	3.04	6.3	13.4	53.1	1.32	84.3
2	3.50	4749.0	133.3	120.1	2.402	2.567	3.04	6.4	13.5	52.5	1.32	84.3
Avg								6.4	13.46	52.8	1.32	84.3
1	4.00	4762.7	131.1	117.8	2.415	2.547	3.54	5.2	13.5	61.5	1.13	85.2
2	4.00	4774.6	132.5	118.9	2.413	2.547	3.54	5.3	13.6	61.3	1.13	85.0
Avg								5.2	13.55	61.4	1.13	85.1
1	4.50	4761.0	132.9	119.1	2.433	2.528	4.04	3.8	13.3	71.8	0.99	86.2
2	4.50	4805.2	131.8	118.3	2.438	2.528	4.04	3.6	13.1	72.9	0.99	86.6
Avg								3.7	13.2	72.4	0.99	86.4

Table A.6 Mix Design Summary for 19.0 mm NMAS Granite TRZ

Project Name: 9-27

Mixture ID: 19.0 mm NMAS Granite TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.703

Effective Gravity Solids (Gse): 2.697

Bulk Gravity Solids (Gsb): 2.666

Percent Minus #200: 5.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.50	4694.4	121.4	112.3	2.418	2.552	3.08	5.3	12.5	58.0	1.62	87.6
2	3.50	4698.1	122.5	112.9	2.417	2.552	3.08	5.3	12.5	57.8	1.62	87.3
Avg								5.3	12.5	57.9	1.62	87.5
1	4.00	4699.3	122.3	114.3	2.427	2.532	3.58	4.1	12.6	67.1	1.40	89.6
2	4.00	4709.6	121.4	112.1	2.427	2.532	3.58	4.2	12.6	67.0	1.40	88.5
Avg								4.2	12.6	67.0	1.40	89.0
1	4.50	4739.5	121.7	111.7	2.448	2.513	4.08	2.6	12.3	79.0	1.22	89.4
2	4.50	4729.5	121.0	111.2	2.452	2.513	4.08	2.4	12.2	79.9	1.22	89.7
Avg								2.5	12.2	79.5	1.22	89.5

Table A.7 Mix Design Summary for 37.5 mm NMAS Granite ARZ

Project Name: 9-27

Mixture ID: 37.5 mm NMAS Granite ARZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.029

Apparent Gravity Solids (Gsa): 2.714

Effective Gravity Solids (Gse): 2.700

Bulk Gravity Solids (Gsb): 2.685

Percent Minus #200: 3.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.50	4737.8	121.4	114.5	2.389	2.555	3.29	6.5	14.1	54.1	0.91	88.2
2	3.50	4756.8	122.3	115.0	2.392	2.555	3.29	6.4	14.0	54.5	0.91	88.0
Avg								6.4	14.1	54.3	0.91	88.1
1	4.00	4777.9	122.1	114.4	2.410	2.536	3.80	5.0	13.9	64.1	0.79	89.0
2	4.00	4789.0	121.4	114.1	2.412	2.536	3.80	4.9	13.8	64.6	0.79	89.4
Avg								4.9	13.8	64.4	0.79	89.2
1	4.50	4795.4	122.1	114.5	2.429	2.516	4.30	3.5	13.6	74.5	0.70	90.5
2	4.50	4817.2	121.7	114.1	2.437	2.516	4.30	3.1	13.3	76.4	0.70	90.8
Avg								3.3	13.5	75.5	0.70	90.7

Table A.8 Mix Design Summary for 37.5 mm NMAS Granite BRZ

Project Name: 9-27

Mixture ID: 37.5 mm NMAS Granite BRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.713

Effective Gravity Solids (Gse): 2.709

Bulk Gravity Solids (Gsb): 2.685

Percent Minus #200: 3.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.00	4674.9	125.9	114.5	2.460	2.583	2.66	4.8	11.1	57.2	1.13	86.6
2	3.00	4659.9	127.9	116.0	2.463	2.583	2.66	4.6	11.0	57.9	1.13	86.5
Avg								4.7	11.1	57.6	1.13	86.6
1	3.50	4683.8	129.7	116.6	2.460	2.563	3.16	4.0	11.6	65.4	0.95	86.3
2	3.50	4744.7	125.5	114.7	2.460	2.563	3.16	4.0	11.6	65.3	0.95	87.7
Avg								4.0	11.6	65.4	0.95	87.0
1	4.00	4762.1	127.7	114.6	2.472	2.543	3.67	2.8	11.6	75.9	0.82	87.2
2	4.00	4782.2	129.2	116.2	2.482	2.543	3.67	2.4	11.2	78.8	0.82	87.8
Avg								2.6	11.4	77.3	0.82	87.5

Table A.9 Mix Design Summary for 37.5 mm NMAS Granite TRZ

Project Name: 9-27

Mixture ID: 37.5 mm NMAS Granite TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.714

Effective Gravity Solids (Gse): 2.706

Bulk Gravity Solids (Gsb): 2.685

Percent Minus #200: 3.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.00	4788.8	122.6	113.8	2.457	2.580	2.71	4.8	11.2	57.6	1.11	88.4
2	3.00	4764.1	123.4	114.8	2.426	2.580	2.71	6.0	12.4	51.7	1.11	87.5
Avg								5.4	11.8	54.7	1.11	87.9
1	3.50	4730.4	127.5	117.0	2.430	2.560	3.21	5.1	12.7	59.9	0.94	87.1
2	3.50	4791.8	125.7	115.9	2.452	2.560	3.21	4.2	11.9	64.4	0.94	88.3
Avg								4.7	12.3	62.1	0.94	87.7
1	4.00	4767.5	125.2	114.8	2.463	2.541	3.71	3.1	11.9	74.4	0.81	88.9
2	4.00	4811.2	126.8	115.1	2.465	2.541	3.71	3.0	11.9	75.0	0.81	88.1
Avg								3.0	11.9	74.7	0.81	88.5

Table A.10 Mix Design Summary for 9.5 mm NMAS Gravel ARZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Gravel ARZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.654	Percent Minus #200	5.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.629	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.611	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	6.00	4820.4	132.9	122.6	2.251	2.404	5.75	6.4	18.9	66.5	0.87	86.4
2	6.00	4844.3	133.0	122.8	2.256	2.404	5.75	6.2	18.8	67.1	0.87	86.6
Avg								6.3	18.9	66.8	0.87	86.5
1	6.60	4855.7	131.9	121.4	2.284	2.384	6.35	4.2	18.3	77.0	0.79	88.2
2	6.60	4852.8	132.5	121.8	2.282	2.384	6.35	4.3	18.4	76.7	0.79	88.0
Avg								4.2	18.3	76.9	0.79	88.1
1	7.20	4902.3	132.4	121.7	2.303	2.364	6.95	2.6	18.2	85.8	0.72	89.5
2	7.20	4904.1	132.4	121.8	2.304	2.364	6.95	2.5	18.1	86.0	0.72	89.7
Avg								2.6	18.1	85.9	0.72	89.6

Table A.11 Mix Design Summary for 9.5 mm NMAS Gravel BRZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Gravel BRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22	Apparent Gravity Solids (Gsa): 2.653	Percent Minus #200	5.0
Binder Gravity: 1.028	Effective Gravity Solids (Gse): 2.645	Filler Type Added:	None
	Bulk Gravity Solids (Gsb): 2.604	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	5.50	4838.7	134.6	121.6	2.273	2.435	4.92	6.7	17.5	62.0	1.02	84.3
2	5.50	4845.4	134.7	121.7	2.281	2.435	4.92	6.3	17.2	63.3	1.02	84.6
Avg								6.5	17.4	62.7	1.02	84.5
1	6.20	4817.4	133.3	120.3	2.308	2.410	5.62	4.3	16.9	74.8	0.89	86.4
2	6.20	4874.2	134.8	121.3	2.318	2.410	5.62	3.8	16.5	76.9	0.89	86.5
Avg								4.0	16.7	75.8	0.89	86.5
1	6.90	4882.6	133.9	120.3	2.335	2.386	6.33	2.1	16.5	87.1	0.79	87.9
2	6.90	4894.5	134.2	120.5	2.341	2.386	6.33	1.9	16.3	88.3	0.79	88.1
Avg								2.0	16.4	87.7	0.79	88.0

Table A.12 Mix Design Summary for 9.5 mm NMAS Gravel TRZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Gravel TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.653	Percent Minus #200	5.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.649	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.607	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	5.50	4847.4	132.9	121.4	2.288	2.438	4.91	6.1	17.1	64.0	1.02	85.7
2	5.50	4913.2	133.5	122.3	2.306	2.438	4.91	5.4	16.4	67.0	1.02	86.7
Avg								5.8	16.7	65.5	1.02	86.2
1	6.00	4847.3	133.5	122.3	2.325	2.420	5.41	3.9	16.2	75.7	0.92	88.0
2	6.00	4855.4	131.0	119.8	2.323	2.420	5.41	4.0	16.3	75.2	0.92	87.8
Avg								4.0	16.2	75.4	0.92	87.9
1	6.50	4799.1	129.2	117.4	2.342	2.403	5.91	2.5	16.0	84.2	0.85	88.6
2	6.50	4878.3	131.2	119.4	2.340	2.403	5.91	2.6	16.1	83.7	0.85	88.6
Avg								2.6	16.0	83.9	0.85	88.6

Table A.13 Mix Design Summary for 19.0 mm NMAS Gravel ARZ

Project Name: 9-27

Mixture ID: 19.0 mm NMAS Gravel ARZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.644	Percent Minus #200	5.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.634	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.600	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	4.00	4804.8	128.8	119.3	2.316	2.479	3.51	6.6	14.5	54.7	1.43	86.6
2	4.00	4781.4	128.3	118.8	2.312	2.479	3.51	6.7	14.6	54.0	1.43	86.4
Avg								6.6	14.5	54.3	1.43	86.5
1	4.70	4778.4	127.3	117.3	2.344	2.454	4.21	4.5	14.1	68.3	1.19	88.0
2	4.70	4826.5	128.7	118.7	2.340	2.454	4.21	4.6	14.2	67.4	1.19	88.0
Avg								4.5	14.1	67.9	1.19	88.0
1	5.40	4838.0	127.7	117.3	2.370	2.429	4.91	2.4	13.8	82.4	1.02	89.6
2	5.40	4841.4	127.7	117.3	2.370	2.429	4.91	2.4	13.7	82.4	1.02	89.6
Avg								2.4	13.7	82.4	1.02	89.6

Table A.14 Mix Design Summary for 19.0 mm NMAS Gravel BRZ

Project Name: 9-27

Mixture ID: 19 mm NMAS Gravel BRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.644	Percent Minus #200	5.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.640	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.595	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	4.00	4802.4	133.2	119.8	2.355	2.484	3.35	5.2	12.9	59.6	1.49	85.3
2	4.00	4806.8	133.3	120.1	2.349	2.484	3.35	5.4	13.1	58.4	1.49	85.2
Avg								5.3	13.0	59.0	1.49	85.2
1	4.50	4815.3	131.1	117.8	2.378	2.466	3.85	3.6	12.5	71.5	1.30	86.7
2	4.50	4790.3	132.5	118.9	2.357	2.466	3.85	4.4	13.2	66.6	1.30	85.8
Avg								4.0	12.9	69.1	1.30	86.2
1	5.00	4835.1	132.9	119.1	2.380	2.448	4.35	2.8	12.9	78.3	1.15	87.1
2	5.00	4846.8	131.8	118.3	2.387	2.448	4.35	2.5	12.6	80.3	1.15	87.5
Avg								2.6	12.7	79.3	1.15	87.3

Table A.15 Mix Design Summary for 19.0 mm NMAS Gravel TRZ

Project Name: 9-27

Mixture ID: 19 mm NMAS Gravel TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.644

Effective Gravity Solids (Gse): 2.637

Bulk Gravity Solids (Gsb): 2.597

Percent Minus #200: 5.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust / Asphalt	%Gmm @ Ninitial (%)
1	4.00	4843.5	128.8	118.3	2.355	2.481	3.43	5.1	13.0	60.7	1.46	87.2
2	4.00	4847.9	130.0	119.5	2.340	2.481	3.43	5.7	13.5	57.8	1.46	86.7
Avg								5.4	13.2	59.2	1.46	86.9
1	4.50	4869.2	129.5	118.5	2.373	2.463	3.93	3.7	12.7	71.3	1.27	88.2
2	4.50	4848.8	128.4	117.8	2.377	2.463	3.93	3.5	12.6	72.2	1.27	88.5
Avg								3.6	12.7	71.8	1.27	88.4
1	5.00	4897.5	128.5	117.5	2.400	2.445	4.44	1.8	12.2	84.9	1.13	89.8
2	5.00	4890.7	128.8	117.7	2.394	2.445	4.44	2.1	12.4	83.2	1.13	89.5
Avg								2.0	12.3	84.0	1.13	89.6

Table A.16 Mix Design Summary for 37.5 mm NMAS Gravel ARZ

Project Name: 9-27

Mixture ID: 37.5 mm NMAS Gravel ARZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.644	Percent Minus #200	3.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.643	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.608	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.50	4712.0	124.2	115.7	2.354	2.505	2.99	6.0	12.9	53.3	1.00	87.6
2	3.50	4739.0	124.8	116.7	2.352	2.505	2.99	6.1	13.0	52.8	1.00	87.8
Avg								6.1	12.9	53.0	1.00	87.7
1	4.00	4727.0	123.5	115.7	2.353	2.487	3.50	5.4	13.4	59.9	0.86	88.7
2	4.00	4701.4	123.0	114.9	2.374	2.487	3.50	4.5	12.6	64.1	0.86	89.2
Avg								4.9	13.0	62.0	0.86	88.9
1	4.50	4801.8	125.1	116.9	2.380	2.468	4.00	3.6	12.8	72.0	0.75	90.1
2	4.50	4741.2	125.1	116.6	2.371	2.468	4.00	3.9	13.2	70.0	0.75	89.5
Avg								3.8	13.0	71.0	0.75	89.8

Table A.17 Mix Design Summary for 37.5 mm NMAS Gravel BRZ

Project Name: 9-27

Mixture ID: 37.5 mm NMAS Gravel BRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.643	Percent Minus #200	3.0
Binder Gravity:	1.029	Effective Gravity Solids (Gse):	2.638	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.607	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.00	4653.6	129.1	115.5	2.366	2.520	2.55	6.1	12.0	49.0	1.18	84.0
2	3.00	4676.1	128.8	115.2	2.368	2.520	2.55	6.0	11.9	49.2	1.18	84.0
Avg								6.1	11.9	49.1	1.18	84.0
1	3.50	4699.8	129.5	115.5	2.376	2.501	3.05	5.0	12.0	58.5	0.98	84.7
2	3.50	4734.7	131.2	116.9	2.365	2.501	3.05	5.5	12.5	56.3	0.98	84.2
Avg								5.2	12.2	57.4	0.98	84.5
1	4.00	4740.0	128.7	114.7	2.426	2.483	3.55	2.3	10.7	78.6	0.84	87.1
2	4.00	4728.2	128.6	114.9	2.402	2.483	3.55	3.2	11.5	71.9	0.84	86.5
Avg								2.8	11.1	75.2	0.84	86.8

Table A.18 Mix Design Summary for 37.5 mm NMAS Gravel TRZ

Project Name: 9-27

Mixture ID: 37.5 mm NMAS Gravel TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.643	Percent Minus #200	3.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.638	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.607	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.00	4712.9	129.1	115.5	2.357	2.520	2.55	6.5	12.3	47.6	1.17	83.7
2	3.00	4698.7	128.8	115.2	2.382	2.520	2.55	5.5	11.4	52.0	1.17	84.6
Avg								6.0	11.8	49.8	1.17	84.1
1	3.50	4720.6	129.5	115.5	2.373	2.501	3.06	5.1	12.2	58.0	0.98	84.6
2	3.50	4722.1	131.2	116.9	2.367	2.501	3.06	5.3	12.4	56.9	0.98	84.3
Avg								5.2	12.3	57.4	0.98	84.5
1	4.00	4746.2	128.7	114.7	2.404	2.483	3.56	3.2	11.5	72.5	0.84	86.3
2	4.00	4678.2	128.6	114.9	2.383	2.483	3.56	4.0	12.3	67.2	0.84	85.8
Avg								3.6	11.9	69.9	0.84	86.0

Table A.19 Mix Design Summary for 9.5 mm NMAS Limestone ARZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Limestone ARZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.764

Effective Gravity Solids (Gse): 2.750

Bulk Gravity Solids (Gsb): 2.727

Percent Minus #200: 4.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	5.50	4854.5	126.3	115.9	2.388	2.518	5.20	5.2	17.3	70.1	0.77	87.0
2	5.50	4820.9	125.4	115.0	2.391	2.518	5.20	5.0	17.1	70.6	0.77	87.1
Avg								5.1	17.2	70.3	0.77	87.1
1	6.00	4886.7	127.2	116.6	2.389	2.499	5.71	4.4	17.6	75.2	0.70	87.6
2	6.00	4865.7	126.4	115.9	2.394	2.499	5.71	4.2	17.5	76.0	0.70	87.8
Avg								4.3	17.6	75.6	0.70	87.7
1	6.50	4890.9	126.4	115.7	2.404	2.480	6.21	3.0	17.6	82.7	0.64	88.7
2	6.50	4915.0	126.9	116.1	2.408	2.480	6.21	2.9	17.4	83.4	0.64	88.8
Avg								3.0	17.5	83.0	0.64	88.8

Table A.20 Mix Design Summary for 9.5 mm NMAS Limestone BRZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Limestone BRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.761	Percent Minus #200	4.0
Binder Gravity:	1.029	Effective Gravity Solids (Gse):	2.753	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.725	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	4.50	4819.6	127.7	114.3	2.420	2.560	4.14	5.5	15.2	64.0	0.97	84.6
2	4.50	4797.8	127.7	114.4	2.400	2.560	4.14	6.3	15.9	60.7	0.97	84.0
Avg								5.9	15.6	62.3	0.97	84.3
1	5.00	4807.2	127.3	113.9	2.426	2.540	4.64	4.5	15.4	70.8	0.86	85.4
2	5.00	4817.8	127.7	114.0	2.433	2.540	4.64	4.2	15.2	72.3	0.86	85.5
Avg								4.4	15.3	71.6	0.86	85.5
1	5.50	4842.3	127.4	113.5	2.455	2.521	5.14	2.6	14.9	82.4	0.78	86.8
2	5.50	4840.7	127.7	113.9	2.446	2.521	5.14	3.0	15.2	80.4	0.78	86.5
Avg								2.8	15.0	81.4	0.78	86.6

Table A.21 Mix Design Summary for 9.5 mm NMAS Limestonr TRZ

Project Name: 9-27

Mixture ID: 9.5 mm NMAS Limestone TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.761	Percent Minus #200	5.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.742	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.725	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	4.00	4797.0	126.6	113.4	2.430	2.570	3.78	5.5	14.4	62.0	1.32	84.7
2	4.00	4801.5	127.1	114.0	2.415	2.570	3.78	6.0	14.9	59.6	1.32	84.3
Avg								5.8	14.7	60.8	1.32	84.5
1	4.50	4805.0	126.1	112.6	2.445	2.550	4.28	4.1	14.3	71.2	1.17	85.6
2	4.50	4833.4	126.3	113.0	2.450	2.550	4.28	3.9	14.2	72.1	1.17	85.9
Avg								4.0	14.2	71.7	1.17	85.8
1	5.00	4801.3	124.2	110.7	2.491	2.531	4.79	1.6	13.2	88.0	1.04	87.7
2	5.00	4783.9	124.2	110.7	2.484	2.531	4.79	1.9	13.4	86.2	1.04	87.5
Avg								1.7	13.3	87.1	1.04	87.6

Table A.22 Mix Design Summary for 19.0 mm NMAS Limestone ARZ

Project Name: 9-27

Mixture ID: 19.0 mm NMAS Limestone ARZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.754

Effective Gravity Solids (Gse): 2.748

Bulk Gravity Solids (Gsb): 2.702

Percent Minus #200: 4.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.50	4870.9	123.8	114.1	2.446	2.596	2.89	5.8	12.6	54.4	1.39	86.9
2	3.50	4863.8	123.6	113.8	2.438	2.596	2.89	6.1	12.9	52.9	1.39	86.5
Avg								5.9	12.8	53.7	1.39	86.7
1	4.00	4899.6	124.4	114.6	2.452	2.575	3.39	4.8	12.9	62.7	1.18	87.7
2	4.00	4873.8	123.7	114.3	2.460	2.575	3.39	4.5	12.6	64.4	1.18	88.3
Avg								4.6	12.7	63.6	1.18	88.0
1	4.50	4841.3	121.9	112.3	2.473	2.555	3.89	3.2	12.6	74.3	1.03	89.1
2	4.50	4832.3	121.3	111.6	2.486	2.555	3.89	2.7	12.1	77.7	1.03	89.5
Avg								3.0	12.4	76.0	1.03	89.3

Table A.23 Mix Design Summary for 19.0 mm NMAS Limestone BRZ

Project Name: 9-27

Mixture ID: 19 mm NMAS Limestone TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.755	Percent Minus #200	5.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.746	Filler Type Added:	None
		Bulk Gravity Solids (Gsb):	2.706	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.00	4760.1	123.4	110.4	2.475	2.615	2.47	5.3	11.3	52.6	2.03	84.7
2	3.00	4772.9	123.9	111.0	2.484	2.615	2.47	5.0	11.0	54.2	2.03	85.1
Avg								5.2	11.1	53.4	2.03	84.9
1	3.50	4875.3	125.6	112.7	2.504	2.594	2.97	3.5	10.7	67.5	1.68	86.6
2	3.50	4823.3	125.8	112.5	2.489	2.594	2.97	4.1	11.3	63.8	1.68	85.8
Avg								3.8	11.0	65.6	1.68	86.2
1	4.00	4846.9	124.5	111.2	2.519	2.574	3.47	2.2	10.7	79.8	1.44	87.4
2	4.00	4830.1	124.5	110.8	2.525	2.574	3.47	1.9	10.4	81.7	1.44	87.3
Avg								2.0	10.5	80.7	1.44	87.3

Table A.24 Mix Design Summary for 19.0 mm NMAS Limestone TRZ

Project Name: 9-27

Mixture ID: 19 mm NMAS Limestone TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.755

Effective Gravity Solids (Gse): 2.746

Bulk Gravity Solids (Gsb): 2.706

Percent Minus #200: 5.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	3.00	4760.1	123.4	110.4	2.475	2.615	2.47	5.3	11.3	52.6	2.03	84.7
2	3.00	4772.9	123.9	111.0	2.484	2.615	2.47	5.0	11.0	54.2	2.03	85.1
Avg								5.2	11.1	53.4	2.03	84.9
1	3.50	4875.3	125.6	112.7	2.504	2.594	2.97	3.5	10.7	67.5	1.68	86.6
2	3.50	4823.3	125.8	112.5	2.489	2.594	2.97	4.1	11.3	63.8	1.68	85.8
Avg								3.8	11.0	65.6	1.68	86.2
1	4.00	4846.9	124.5	111.2	2.519	2.574	3.47	2.2	10.7	79.8	1.44	87.4
2	4.00	4830.1	124.5	110.8	2.525	2.574	3.47	1.9	10.4	81.7	1.44	87.3
Avg								2.0	10.5	80.7	1.44	87.3

Table A.25 Mix Design Summary for 37.5 mm NMAS Limestone ARZ

Project Name: 9-27

Mixture ID: 37.5 mm NMAS Limestone ARZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22	Apparent Gravity Solids (Gsa): 2.763	Percent Minus #200	3.0
Binder Gravity: 1.028	Effective Gravity Solids (Gse): 2.743	Filler Type Added:	None
	Bulk Gravity Solids (Gsb): 2.736	Fiber Additive:	None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	2.50	4794.4	120.4	112.4	2.436	2.633	2.40	7.5	13.2	43.2	1.25	86.4
2	2.50	4830.4	121.2	113.0	2.457	2.633	2.40	6.7	12.4	46.2	1.25	87.0
Avg								7.1	12.8	44.7	1.25	86.7
1	3.00	4859.0	121.4	113.1	2.473	2.612	2.90	5.3	12.3	56.7	1.03	88.2
2	3.00	4835.1	120.9	112.5	2.472	2.612	2.90	5.4	12.3	56.6	1.03	88.1
Avg								5.3	12.3	56.7	1.03	88.1
1	3.50	4808.5	119.3	110.1	2.519	2.592	3.40	2.8	11.1	74.9	0.88	89.7
2	3.50	4819.2	120.3	111.2	2.508	2.592	3.40	3.2	11.5	72.0	0.88	89.5
Avg								3.0	11.3	73.5	0.88	89.6

Table A.26 Mix Design Summary for 37.5 mm NMAS Limestone BRZ

Project Name: 9-27

Mixture ID: 37.5 mm NMAS Limestone BRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.029

Apparent Gravity Solids (Gsa): 2.762

Effective Gravity Solids (Gse): 2.746

Bulk Gravity Solids (Gsb): 2.738

Percent Minus #200: 3.0

Filler Type Added: None

Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	2.00	4770.6	126.6	114.1	2.480	2.657	1.89	6.7	11.2	40.7	1.58	84.1
2	2.00	4792.3	127.0	115.0	2.468	2.657	1.89	7.1	11.7	38.9	1.58	84.1
Avg								6.9	11.4	39.8	1.58	84.1
1	2.50	4773.5	126.6	112.9	2.504	2.636	2.40	5.0	10.8	53.9	1.25	84.7
2	2.50	4736.2	123.1	111.5	2.501	2.636	2.40	5.1	11.0	53.1	1.25	85.9
Avg								5.1	10.9	53.5	1.25	85.3
1	3.00	4776.4	124.0	111.2	2.539	2.615	2.90	2.9	10.0	71.1	1.04	87.1
2	3.00	4777.4	125.9	112.9	2.532	2.615	2.90	3.2	10.3	69.2	1.04	86.8
Avg								3.0	10.2	70.1	1.04	86.9

Table A.27 Mix Design Summary for 37.5 mm NMAS Limestone TRZ

Project Name: 9-27

Mixture ID: 37.5mm NMAS Limestone TRZ

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 100 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.763	Percent Minus #200: 3.0
Binder Gravity:	1.028	Effective Gravity Solids (Gse):	2.749	Filler Type Added: None
		Bulk Gravity Solids (Gsb):	2.737	Fiber Additive: None

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	Dust Asphalt	%Gmm @ Ninitial (%)
1	2.50	4834.9	122.4	112.0	2.505	2.639	2.33	5.1	10.8	52.8	1.29	86.9
2	2.50	4687.3	122.4	112.0	2.516	2.639	2.33	4.6	10.4	55.1	1.29	87.2
Avg								4.9	10.6	53.9	1.29	87.1
1	3.00	4820.0	121.2	110.7	2.530	2.618	2.83	3.3	10.3	67.6	1.06	88.3
2	3.00	4813.2	121.5	111.2	2.513	2.618	2.83	4.0	10.9	63.3	1.06	87.9
Avg								3.7	10.6	65.5	1.06	88.1
1	3.50	4895.9	124.0	112.7	2.532	2.597	3.33	2.5	10.7	76.6	0.90	88.6
2	3.50	4927.6	124.1	113.0	2.536	2.597	3.33	2.4	10.6	77.7	0.90	88.9
Avg								2.4	10.6	77.1	0.90	88.8

Table A.28 Mix Design Summary for 9.5 mm NMAS Granite SMA

Project Name: 9-27

Mixture ID: 9.5 mm Granite SMA

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 75 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.687

Effective Gravity Solids (Gse): 2.687

Bulk Gravity Solids (Gsb): 2.640

Percent Minus #200: 9.0

Filler Type Added: Marble Dust

Fiber Additive: Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA_{drc} (%)
1	6.20	4596.3	134.6	119.1	2.254	2.443	5.55	7.7	19.9	61.1	32.6	
2	6.20	4662.2	135.1	119.5	2.274	2.443	5.55	6.9	19.2	64.0	32.0	
3	6.20	4665.9	134.8	119.1	2.282	2.443	5.55	6.6	19.5	62.6	31.8	
								7.1	19.5	62.6	32.1	41.9
1	6.90	4681.3	133.8	117.9	2.305	2.418	6.25	4.7	18.7	75.0	31.1	
2	6.90	4678.6	134.0	118.1	2.303	2.418	6.25	4.8	18.8	74.6	31.2	
3	6.90	4677.5	134.3	118.5	2.295	2.418	6.25	5.1	18.7	74.8	31.4	
								4.8	18.7	74.8	31.2	41.9
1	7.60	4678.3	132.8	117.3	2.319	2.394	6.96	3.1	18.8	83.4	30.7	
2	7.60	4772.6	134.7	118.7	2.322	2.394	6.96	3.0	18.7	83.9	30.6	
3	7.60	4700.3	133.8	118.0	2.318	2.394	6.96	3.1	18.8	83.7	30.7	
								3.1	18.8	83.7	30.7	41.9

Table A.29 Mix Design Summary for 12.5 mm NMAS Granite SMA

Project Name: 9-27

Mixture ID: 12.5 mm GRANITE SMA

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 75 Gyrations

Binder Type: PG 67 - 22	Apparent Gravity Solids (Gsa):	2.713	Percent Minus #200: 8.0
Binder Gravity: 1.029	Effective Gravity Solids (Gse):	2.692	Filler Type Added: Marble Dust
	Bulk Gravity Solids (Gsb):	2.679	Fiber Additive: Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA	VCA_{drc}
1	6.20	4663.6	134.4	117.9	2.327	2.447	6.02	4.9	18.5	73.5	30.6	
2	6.20	4668.5	133.8	117.3	2.324	2.447	6.02	5.0	18.6	73.0	30.7	
Avg	6.20	4676.0	133.9	117.2	2.335	2.447	6.02	4.6	18.2	73.3	30.3	
								4.8	18.5	73.3	30.5	42.7
1	6.70	4653.6	134.5	118.2	2.324	2.429	6.52	4.3	19.1	77.3	30.7	
2	6.70	4662.3	135.5	120.9	2.333	2.429	6.52	4.0	18.8	78.8	30.4	
Avg	6.70	4675.4	133.2	117.4	2.343	2.429	6.52	3.5	18.4	78.1	30.1	
								3.9	18.7	78.1	30.4	42.7
1	7.20	4636.4	133.0	117.2	2.331	2.411	7.02	3.3	19.2	82.7	30.4	
2	7.20	4666.9	133.6	117.4	2.342	2.411	7.02	2.9	18.9	84.7	30.1	
Avg	7.20	4675.6	133.7	118.2	2.338	2.411	7.02	3.1	19.0	83.7	30.3	
								3.1	19.0	83.7	30.3	42.7

Table A.30 Mix Design Summary for 19.0 mm NMAS GraniteSMA

Project Name: 9-27

Mixture ID: 19mm Granite SMA

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 75 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.714	Percent Minus #200	8.0
Binder Gravity:	1.029	Effective Gravity Solids (Gse):	2.714	Filler Type Added:	Marble Dust
		Bulk Gravity Solids (Gsb):	2.677	Fiber Additive:	Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA	VCA_{drc}
1	6.20	4615.4	132.8	116.7	2.359	2.464	5.71	4.3	17.3	75.5	29.6	
2	6.20	4589.7	132.7	115.9	2.357	2.464	5.71	4.4	17.4	75.0	29.6	
3	6.20	4613.0	134.1	118.4	2.343	2.464	5.71	4.9	17.9	72.7	30.0	
Avg								4.5	17.6	74.4	29.7	42.0
1	6.70	4596.8	133.6	116.5	2.357	2.446	6.21	3.6	17.8	79.8	29.6	
2	6.70	4622.6	132.1	115.9	2.363	2.446	6.21	3.4	17.6	80.8	29.4	
	6.70	4617.4	132.8	115.9	2.357	2.446	6.21	3.6	17.9	79.7	29.6	
Avg								3.5	17.8	80.1	29.6	42.0
1	7.20	4542.2	129.6	115.0	2.362	2.428	6.72	2.7	18.1	85.1	29.5	
2	7.20	4616.8	131.9	115.3	2.366	2.428	6.72	2.6	18.0	85.8	29.4	
	7.20	4630.8	132.6	115.5	2.356	2.428	6.72	3.0	18.3	83.8	29.7	
Avg								2.7	18.2	84.9	29.5	42.0

Table A.31 Mix Design Summary for 9.5 mm NMAS Gravel SMA

Project Name: 9-27

Mixture ID: 9.5 mm Gravel SMA

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 75 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.642

Effective Gravity Solids (Gse): 2.637

Bulk Gravity Solids (Gsb): 2.582

Percent Minus #200: 9.0

Filler Type Added: Marble Dust

Fiber Additive: Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA	VCA_{drc}
1	6.20	4660.5	135.9	121.1	2.236	2.404	5.42	7.0	18.8	62.9	31.5	
2	6.20	4637.6	136.3	121.0	2.231	2.404	5.42	7.2	19.0	62.1	31.6	
	6.20	4681.3	136.0	120.9	2.244	2.404	5.42	6.6	18.5	64.1	31.2	
Avg								6.9	18.7	63.0	31.4	41.8
1	6.90	4689.4	135.8	121.2	2.250	2.380	6.13	5.4	18.9	71.1	31.0	
2	6.90	4705.4	136.2	121.2	2.257	2.380	6.13	5.2	18.6	72.2	30.8	
	6.90	4702.8	136.4	121.3	2.255	2.380	6.13	5.3	18.7	71.8	30.9	
Avg								5.3	18.7	71.7	30.9	41.8
1	7.60	4752.1	136.5	121.4	2.275	2.357	6.84	3.5	18.6	81.4	30.3	
2	7.60	4727.8	135.8	120.8	2.275	2.357	6.84	3.5	18.6	81.4	30.3	
	7.60	4713.8	134.8	120.0	2.284	2.357	6.84	3.1	18.3	83.1	30.0	
Avg								3.3	18.5	82.0	30.2	41.8

Table A.32 Mix Design Summary for 12.5 mm NMAS Gravel SMA

Project Name: 9-27

Mixture ID: 12.5 mm NMAS Gravel SMA

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 75 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.028

Apparent Gravity Solids (Gsa): 2.636

Effective Gravity Solids (Gse): 2.634

Bulk Gravity Solids (Gsb): 2.594

Percent Minus #200: 9.0

Filler Type Added: Marble Dust

Fiber Additive: Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA	VCAdrc
1	6.00	4612.9	137.6	121.5	2.258	2.409	5.43	6.2	18.2	65.7	32.1	
2	6.00	4655.3	137.2	120.8	2.285	2.409	5.43	5.1	17.2	70.2	31.3	
	6.00	4629.5	137.1	121.1	2.270	2.409	5.43	5.8	17.8	67.5	31.8	
Avg								5.7	17.7	67.8	31.7	42.1
1	6.50	4654.9	135.9	119.9	2.300	2.391	5.93	3.8	17.1	77.7	30.8	
2	6.50	4626.6	136.9	120.3	2.283	2.391	5.93	4.5	17.7	74.4	31.3	
	6.50	4644.7	137.0	120.2	2.293	2.391	5.93	4.1	17.4	76.2	31.1	
Avg								4.2	17.4	76.1	31.1	42.1
1	7.00	4647.8	136.2	120.0	2.279	2.375	6.44	4.0	18.3	77.9	31.5	
2	7.00	4680.3	137.8	121.6	2.288	2.375	6.44	3.6	18.0	79.8	31.2	
	7.00	4579.1	135.1	118.8	2.279	2.375	6.44	4.0	18.3	77.9	31.5	
Avg								3.9	18.2	78.6	31.4	42.1

Table A.33 Mix Design Summary for 19.0 mm NMAS Gravel SMA

Project Name: 9-27

Mixture ID: 19.0 mm NMAS Gravel SMA

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 75 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.029

Apparent Gravity Solids (Gsa): 2.638

Effective Gravity Solids (Gse): 2.626

Bulk Gravity Solids (Gsb): 2.587

Percent Minus #200: 8.0

Filler Type Added: Marble Dust

Fiber Additive: Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA	VCA_{drc}
1	6.20	4518.8	133.9	118.4	2.268	2.396	5.65	5.3	17.8	70.0	29.8	
2	6.20	4547.6	134.2	119.0	2.277	2.396	5.65	5.0	17.5	71.6	29.5	
3	6.20	4555.7	134.3	119.1	2.277	2.396	5.65	5.0	17.5	71.6	29.5	
Avg								5.1	17.6	71.0	29.6	42.0
1	6.70	4523.1	133.3	118.0	2.273	2.379	6.15	4.4	18.0	75.4	29.6	
2	6.70	4527.9	133.9	117.6	2.265	2.379	6.15	4.8	18.3	73.9	29.9	
	6.70	4540.0	134.2	118.6	2.283	2.379	6.15	4.0	17.7	77.2	29.4	
Avg								4.4	18.0	75.5	29.6	42.0
1	7.20	4572.5	133.6	117.9	2.291	2.362	6.65	3.0	17.8	83.0	29.1	
2	7.20	4525.8	132.8	117.0	2.295	2.362	6.65	2.8	17.7	84.0	29.0	
	7.20	4552.2	133.4	117.8	2.285	2.362	6.65	3.3	18.0	81.9	29.3	
Avg								3.0	17.9	83.0	29.1	42.0

Table A.34 Mix Design Summary for 9.5 mm NMAS Limestone SMA

Project Name: 9-27

Compactive Device: Pine Gyratory Compactor

Mixture ID: 9.5 mm Limestone SMA

Compactive Effort: 75 Gyrations

Binder Type:	PG 67 - 22	Apparent Gravity Solids (Gsa):	2.744	Percent Minus #200	9.0
Binder Gravity:	1.029	Effective Gravity Solids (Gse):	2.744	Filler Type Added:	Marble Dust
		Bulk Gravity Solids (Gsb):	2.710	Fiber Additive:	Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA	VCA_{drc}
1	6.10	4757.8	130.4	115.9	2.379	2.491	5.66	4.5	17.5	74.6	31.0	
2	6.10	4742.5	130.8	116.2	2.374	2.491	5.66	4.7	17.7	73.6	31.1	
3	6.10	4756.1	130.3	115.8	2.385	2.491	5.66	4.3	17.6	74.1	30.8	
AVG								4.5	17.6	74.1	31.0	38.4
1	6.60	4776.3	128.0	114.6	2.405	2.472	6.16	2.7	17.1	84.1	30.2	
2	6.60	4767.4	128.0	114.5	2.405	2.472	6.16	2.7	17.1	84.2	30.2	
3	6.60	4771.6	127.8	114.6	2.407	2.472	6.16	2.6	17.1	84.2	30.2	
AVG								2.7	17.1	84.2	30.2	38.4
1	7.10	4783.6	128.0	114.8	2.404	2.454	6.66	2.0	17.6	88.4	30.3	
2	7.10	4778.2	127.9	114.7	2.402	2.454	6.66	2.1	17.6	88.2	30.3	
3	7.10	4776.0	127.8	114.6	2.404	2.454	6.66	2.0	17.6	88.3	30.3	
AVG								2.1	17.6	88.3	30.3	38.4

Table A.35 Mix Design Summary for 12.5 mm NMAS Limestone SMA

Project Name: 9-27

Mixture ID: 12.5 mm Limestone SMA

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 75 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.029

Apparent Gravity Solids (Gsa): 2.750

Effective Gravity Solids (Gse): 2.738

Bulk Gravity Solids (Gsb): 2.705

Percent Minus #200: 9.0

Filler Type Added: Marble Dust

Fiber Additive: Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA	VCA_{drc}
1	6.10	4694.4	133.3	118.4	2.306	2.486	5.67	7.2	19.9	63.7	32.1	
2	6.10	4727.7	133.3	118.3	2.317	2.486	5.67	6.8	19.6	65.2	31.8	
3	6.10	4712.1	133.4	118.2	2.324	2.486	5.67	6.5	19.8	64.4	31.6	
								6.9	19.8	64.4	31.9	38.9
1	6.70	4693.0	132.5	117.6	2.330	2.464	6.27	5.5	19.6	72.2	31.5	
2	6.70	4679.0	131.4	116.7	2.315	2.464	6.27	6.1	19.6	72.2	31.9	
3	6.70	4715.3	133.2	118.8	2.314	2.464	6.27	6.1	19.6	72.2	31.9	
Avg								5.8	19.6	72.2	31.7	38.9
1	7.20	4746.9	132.9	118.4	2.342	2.446	6.77	4.3	19.7	78.3	31.1	
2	7.20	4736.8	132.2	118.0	2.341	2.446	6.77	4.3	19.7	78.3	31.1	
3	7.20	4695.6	131.6	116.7	2.346	2.446	6.77	4.1	19.7	78.3	31.0	
								4.2	19.7	78.3	31.1	38.9

Table A.36 Mix Design Summary for 19.0 mm NMAS Limestone SMA

Project Name: 9-27

Mixture ID: 19.0 mm LimestoneSMA

Compactive Device: Pine Gyratory Compactor

Compactive Effort: 75 Gyrations

Binder Type: PG 67 - 22

Binder Gravity: 1.029

Apparent Gravity Solids (Gsa): 2.749

Effective Gravity Solids (Gse): 2.746

Bulk Gravity Solids (Gsb): 2.714

Percent Minus #200 8.0

Filler Type Added: Marble Dust

Fiber Additive: Cellulose

Sample Number (#)	Asphalt Content (%)	Dry Weight (grams)	Height @ Nintial (mm)	Height @ Ndesign (mm)	Bulk Gravity (g/cm^3)	Rice Gravity (g/cm^3)	Effective Asphalt (%)	VTM (%)	VMA (%)	VFA (%)	VCA (%)	VCA_{drc} (%)
1	5.60	4665.3	130.3	114.5	2.402	2.511	5.19	4.4	16.5	73.5	29.6	
2	5.60	4673.6	130.8	115.0	2.409	2.511	5.19	4.1	16.2	74.9	29.4	
3	5.60	4685.0	130.4	115.2	2.375	2.511	5.19	5.4	17.4	68.8	30.4	
Avg								4.6	16.7	72.4	29.8	40.3
1	6.10	4671.3	129.7	114.2	2.407	2.492	5.69	3.4	16.7	79.5	29.5	
2	6.10	4671.1	128.8	114.3	2.415	2.492	5.69	3.1	16.5	81.1	29.3	
3	6.10	4673.1	130.6	115.8	2.389	2.492	5.69	4.2	17.4	76.1	30.0	
Avg								3.6	16.9	78.9	29.6	40.3
1	6.60	4678.3	131.1	115.3	2.406	2.474	6.19	2.7	17.2	84.2	29.5	
2	6.60	4634.8	130.2	114.7	2.392	2.474	6.19	3.3	17.7	81.4	29.9	
3	6.60	4649.1	129.4	114.4	2.409	2.474	6.19	2.6	17.1	84.7	29.4	
Avg								2.9	17.3	83.4	29.6	40.3

APPENDIX B

(LIFT THICKNESS VERSUS DENSITY DATA USING GYRATORY COMPACTOR)

Table B.1 Data for T/NMAS Versus Air Voids for Granite Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
9.5	ARZ	1	2:1	20.8	11.7	12.6	0.8
9.5	ARZ	2	2:1	20.3	10.2	11.0	0.4
9.5	ARZ	3	2:1	20.5	11.1	12.2	0.8
9.5	ARZ	1	3:1	30.2	9.6	10.1	0.4
9.5	ARZ	2	3:1	29.9	9.5	10.2	0.4
9.5	ARZ	3	3:1	27.9	8.3	8.7	0.3
9.5	ARZ	1	4:1	38.1	5.9	6.2	0.1
9.5	ARZ	2	4:1	38.1	6.2	6.6	0.1
9.5	ARZ	3	4:1	37.9	5.7	5.8	0.1
9.5	ARZ	1	8:1	74.8	4.1	4.1	0.0
9.5	ARZ	2	8:1	75.2	4.2	4.3	0.0
9.5	ARZ	3	8:1	75.3	4.2	4.1	0.0
9.5	BRZ	1	2:1	20.9	12.4	15.2	4.7
9.5	BRZ	2	2:1	20.8	12.4	15.1	4.6
9.5	BRZ	3	2:1	21.0	12.8	14.9	4.7
9.5	BRZ	1	3:1	30.3	8.1	9.6	0.9
9.5	BRZ	2	3:1	30.2	8.5	10.4	1.3
9.5	BRZ	3	3:1	29.9	8.6	10.0	1.1
9.5	BRZ	1	4:1	40.0	6.4	7.7	0.4
9.5	BRZ	2	4:1	40.3	7.4	8.6	0.6
9.5	BRZ	3	4:1	39.8	6.7	7.6	0.4
9.5	BRZ	1	8:1	76.6	4.8	5.3	0.2
9.5	BRZ	2	8:1	77.0	4.6	5.0	0.2
9.5	BRZ	3	8:1	76.4	4.3	4.3	0.1
9.5	TRZ	1	2:1	21.2	14.8	15.9	3.2
9.5	TRZ	2	2:1	21.9	14.9	16.6	3.0
9.5	TRZ	3	2:1	21.1	14.0	15.5	3.1
9.5	TRZ	1	3:1	31.0	11.1	12.3	1.6
9.5	TRZ	2	3:1	31.0	11.4	12.6	1.4
9.5	TRZ	3	3:1	31.0	11.3	12.4	1.4
9.5	TRZ	1	4:1	40.2	8.6	9.2	0.6
9.5	TRZ	2	4:1	41.0	9.9	10.9	0.9
9.5	TRZ	3	4:1	40.4	8.7	9.8	1.2
9.5	TRZ	1	8:1	75.7	4.6	5.1	0.2
9.5	TRZ	2	8:1	75.8	4.7	5.0	0.2
9.5	TRZ	3	8:1	75.4	4.3	5.1	0.2
9.5	SMA	1	2:1	21.7	11.7	18.7	7.2
9.5	SMA	2	2:1	22.0	11.0	18.4	6.8
9.5	SMA	3	2:1	22.0	10.9	17.6	6.0
9.5	SMA	1	3:1	30.8	10.0	13.2	4.3
9.5	SMA	2	3:1	30.8	10.5	14.3	5.5
9.5	SMA	3	3:1	31.0	10.2	15.0	5.4
9.5	SMA	1	4:1	39.4	9.2	11.9	3.4
9.5	SMA	2	4:1	39.2	8.6	10.7	2.6
9.5	SMA	3	4:1	39.7	10.1	12.2	3.8
9.5	SMA	1	8:1	78.2	5.0	6.0	0.8
9.5	SMA	2	8:1	77.7	4.7	5.7	0.7
9.5	SMA	3	8:1	77.3	4.6	5.5	0.6

Table B.1 (Continued) Data for T/NMAS Versus Air Voids for Granite Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
12.5	SMA	1	2:1	26.6	10.1	18.6	6.0
12.5	SMA	2	2:1	26.3	9.1	16.4	5.0
12.5	SMA	3	2:1	27.1	8.5	17.8	4.7
12.5	SMA	1	3:1	38.7	8.4	15.6	4.8
12.5	SMA	2	3:1	40.2	8.5	14.5	5.5
12.5	SMA	3	3:1	38.5	8.9	15.1	5.0
12.5	SMA	1	4:1	52.0	8.3	12.6	4.2
12.5	SMA	2	4:1	52.7	7.8	13.1	4.0
12.5	SMA	3	4:1	52.3	7.9	13.0	4.0
12.5	SMA	1	6:1	75.9	5.5	7.6	1.5
12.5	SMA	2	6:1	76.3	6.4	8.3	1.8
12.5	SMA	3	6:1	76.7	6.8	9.4	2.0
19	SMA	1	2:1	39.7	6.5	13.8	3.2
19	SMA	2	2:1	39.3	7.0	13.4	3.8
19	SMA	3	2:1	38.6	6.8	11.8	3.3
19	SMA	1	3:1	59.1	6.8	9.9	2.3
19	SMA	2	3:1	58.8	5.6	11.2	1.6
19	SMA	3	3:1	58.5	5.9	11.6	2.0
19	SMA	1	4:1	77.4	4.7	7.7	0.8
19	SMA	2	4:1	77.8	4.8	7.5	1.0
19	SMA	3	4:1	77.7	4.8	7.3	0.6
19	ARZ	1	2:1	39.6	6.1	6.6	0.2
19	ARZ	2	2:1	39.8	7.2	7.9	0.6
19	ARZ	3	2:1	39.4	5.6	6.1	0.3
19	ARZ	1	3:1	58.5	4.3	4.7	0.3
19	ARZ	2	3:1	58.3	4.4	4.9	0.1
19	ARZ	3	3:1	58.2	4.1	4.3	0.1
19	ARZ	1	4:1	77.6	4.4	4.7	0.2
19	ARZ	2	4:1	77.2	3.9	4.1	0.2
19	ARZ	3	4:1	76.0	4.1	4.4	0.2
19	BRZ	1	2:1	40.6	8.1	10.8	2.6
19	BRZ	2	2:1	41.0	8.8	11.9	2.8
19	BRZ	3	2:1	40.5	8.8	11.2	2.7
19	BRZ	1	3:1	59.0	6.9	8.5	1.4
19	BRZ	2	3:1	59.1	6.2	8.2	1.2
19	BRZ	3	3:1	58.9	6.2	8.0	1.1
19	BRZ	1	4:1	77.1	5.2	5.8	0.8
19	BRZ	2	4:1	77.8	5.5	6.5	1.0
19	BRZ	3	4:1	77.6	5.5	6.3	0.7

Table B.1 (Continued) Data for T/NMAS Versus Air Voids for Granite Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
19	TRZ	1	2:1	40.0	6.6	7.7	1.0
19	TRZ	2	2:1	39.4	6.2	7.2	0.7
19	TRZ	3	2:1	39.8	6.8	7.9	0.9
19	TRZ	1	3:1	58.8	4.6	5.4	0.5
19	TRZ	2	3:1	58.6	5.1	5.9	0.7
19	TRZ	3	3:1	58.5	5.0	5.6	0.7
19	TRZ	1	4:1	77.7	4.4	4.9	0.8
19	TRZ	2	4:1	77.1	3.9	4.6	0.3
19	TRZ	3	4:1	77.2	4.1	4.7	0.4
37.5	ARZ	1	2:1	73.4	4.1	4.9	0.8
37.5	ARZ	2	2:1	73.6	4.8	5.9	1.0
37.5	ARZ	3	2:1	73.9	5.0	6.0	0.7
37.5	ARZ	1	2.5:1	93.5	4.6	5.4	0.9
37.5	ARZ	2	2.5:1	93.0	4.1	5.2	0.6
37.5	ARZ	3	2.5:1	93.8	4.4	5.1	0.8
37.5	ARZ	1	3:1	113.4	4.1	5.0	0.6
37.5	ARZ	2	3:1	114.0	3.9	4.7	0.8
37.5	ARZ	3	3:1	111.2	4.0	4.7	0.7
37.5	BRZ	1	2:1	77.6	6.0	9.3	2.3
37.5	BRZ	2	2:1	76.6	6.1	9.0	2.7
37.5	BRZ	3	2:1	78.0	5.2	9.1	2.3
37.5	BRZ	1	2.5:1	95.1	5.5	7.0	2.3
37.5	BRZ	2	2.5:1	94.7	4.5	6.3	1.6
37.5	BRZ	3	2.5:1	94.9	5.2	6.7	1.7
37.5	BRZ	1	3:1	112.1	5.0	5.7	1.7
37.5	BRZ	2	3:1	112.1	4.5	5.6	1.2
37.5	BRZ	3	3:1	112.6	4.5	5.5	1.2
37.5	TRZ	1	2:1	74.8	5.7	7.4	1.8
37.5	TRZ	2	2:1	75.7	5.9	8.3	2.0
37.5	TRZ	3	2:1	74.5	6.1	7.6	1.5
37.5	TRZ	1	2.5:1	93.8	4.0	6.3	1.1
37.5	TRZ	2	2.5:1	92.6	5.0	5.1	1.5
37.5	TRZ	3	2.5:1	93.0	3.8	4.9	0.8
37.5	TRZ	1	3:1	113.4	4.0	5.1	1.0
37.5	TRZ	2	3:1	112.1	4.0	4.9	1.0
37.5	TRZ	3	3:1	111.2	3.9	3.9	1.0

Table B.2 Data for T/NMAS Versus Air Voids for Limestone Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
9.5	ARZ	1	2:1	21.2	13.3	14.0	1.2
9.5	ARZ	2	2:1	20.7	12.3	12.9	1.1
9.5	ARZ	3	2:1	20.7	11.2	12.2	1.5
9.5	ARZ	1	3:1	29.6	8.4	8.9	0.6
9.5	ARZ	2	3:1	29.2	7.6	8.0	0.4
9.5	ARZ	3	3:1	29.5	8.0	8.2	0.4
9.5	ARZ	1	4:1	38.3	6.2	6.7	0.2
9.5	ARZ	2	4:1	38.3	6.4	6.8	0.2
9.5	ARZ	3	4:1	37.9	6.4	6.7	0.2
9.5	ARZ	1	8:1	77.9	3.9	4.4	0.1
9.5	ARZ	2	8:1	75.1	3.6	4.0	0.1
9.5	ARZ	3	8:1	75.2	3.9	4.1	0.1
9.5	BRZ	1	2:1	21.4	13.0	15.3	6.8
9.5	BRZ	2	2:1	21.7	13.5	16.3	6.6
9.5	BRZ	3	2:1	21.6	12.8	15.6	5.7
9.5	BRZ	1	3:1	30.7	10.5	12.0	2.7
9.5	BRZ	2	3:1	30.1	9.7	11.7	2.3
9.5	BRZ	3	3:1	31.0	10.1	12.1	2.7
9.5	BRZ	1	4:1	39.5	7.8	9.3	1.0
9.5	BRZ	2	4:1	38.8	7.7	9.4	0.6
9.5	BRZ	3	4:1	39.2	7.1	8.5	0.9
9.5	BRZ	1	8:1	76.7	4.6	5.6	0.2
9.5	BRZ	2	8:1	77.3	5.9	7.1	0.3
9.5	BRZ	3	8:1	76.4	4.9	5.8	0.3
9.5	TRZ	1	2:1	22.0	15.5	18.3	5.2
9.5	TRZ	2	2:1	21.8	15.0	17.4	4.6
9.5	TRZ	3	2:1	22.0	15.7	18.2	5.1
9.5	TRZ	1	3:1	30.7	10.4	12.1	1.5
9.5	TRZ	2	3:1	31.0	11.5	13.3	2.4
9.5	TRZ	3	3:1	30.9	10.9	12.3	2.0
9.5	TRZ	1	4:1	40.0	8.7	9.8	0.9
9.5	TRZ	2	4:1	39.6	8.6	9.8	1.0
9.5	TRZ	3	4:1	39.7	8.8	9.9	0.9
9.5	TRZ	1	8:1	78.2	4.4	5.2	0.2
9.5	TRZ	2	8:1	77.7	4.4	6.1	0.2
9.5	TRZ	3	8:1	77.6	4.1	4.7	0.2
9.5	SMA	1	2:1	20.3	10.7	17.6	6.6
9.5	SMA	2	2:1	21.6	11.3	17.6	6.6
9.5	SMA	3	2:1	21.7	10.5	16.6	6.0
9.5	SMA	1	3:1	29.7	9.7	12.9	4.0
9.5	SMA	2	3:1	30.0	9.6	12.7	4.4
9.5	SMA	3	3:1	29.8	10.9	14.0	5.0
9.5	SMA	1	4:1	38.9	8.3	10.5	2.2
9.5	SMA	2	4:1	37.4	8.8	11.4	3.1
9.5	SMA	3	4:1	39.2	8.1	10.1	2.2
9.5	SMA	1	8:1	76.8	5.2	6.4	0.9
9.5	SMA	2	8:1	77.5	5.1	6.3	0.6
9.5	SMA	3	8:1	77.4	5.8	6.8	0.7

Table B.2 (Continued) Data for T/NMAS Versus Air Voids for Limestone Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
12.5	SMA	1	2:1	25.4	10.2	17.4	6.6
12.5	SMA	2	2:1	25.6	10.6	16.4	6.8
12.5	SMA	3	2:1	25.1	11.8	16.8	7.1
12.5	SMA	1	3:1	36.8	8.3	11.2	3.2
12.5	SMA	2	3:1	37.7	8.7	11.1	4.6
12.5	SMA	3	3:1	37.5	7.4	10.1	3.4
12.5	SMA	1	4:1	48.3	8.0	10.2	2.8
12.5	SMA	2	4:1	49.8	6.8	8.7	2.1
12.5	SMA	3	4:1	49.2	6.4	8.3	1.7
12.5	SMA	1	6:1	78.0	6.6	7.5	0.9
12.5	SMA	2	6:1	77.0	6.7	8.0	1.3
12.5	SMA	3	6:1	76.2	6.4	7.4	1.1
19	SMA	1	2:1	41.0	7.7	16.4	4.9
19	SMA	2	2:1	38.0	8.1	16.2	4.9
19	SMA	3	2:1	36.6	8.2	15.9	3.9
19	SMA	1	3:1	58.8	6.4	9.0	2.6
19	SMA	2	3:1	59.4	7.1	10.2	2.9
19	SMA	3	3:1	58.8	6.4	9.3	2.4
19	SMA	1	4:1	77.5	4.6	6.5	1.3
19	SMA	2	4:1	77.8	4.5	6.7	1.2
19	SMA	3	4:1	78.3	5.4	7.3	1.6
19	ARZ	1	2:1	38.6	9.6	10.5	1.3
19	ARZ	2	2:1	40.0	9.1	9.9	0.7
19	ARZ	3	2:1	40.5	9.6	10.4	0.8
19	ARZ	1	3:1	56.3	6.8	7.4	0.8
19	ARZ	2	3:1	56.6	5.4	5.8	0.2
19	ARZ	3	3:1	56.6	4.8	5.2	0.2
19	ARZ	1	4:1	75.0	3.9	4.2	0.1
19	ARZ	2	4:1	75.4	4.2	4.7	0.2
19	ARZ	3	4:1	75.2	3.9	4.2	0.2
19	BRZ	1	2:1	40.6	8.3	10.5	3.1
19	BRZ	2	2:1	40.1	9.0	10.9	3.9
19	BRZ	3	2:1	39.6	9.5	11.6	2.7
19	BRZ	1	3:1	57.9	5.6	6.6	1.2
19	BRZ	2	3:1	56.3	5.1	6.3	0.6
19	BRZ	3	3:1	57.2	5.1	6.1	0.7
19	BRZ	1	4:1	75.6	4.0	5.3	0.5
19	BRZ	2	4:1	75.4	3.8	4.8	0.4
19	BRZ	3	4:1	76.1	4.2	5.2	0.6

Table B.2 (Continued) Data for T/NMAS Versus Air Voids for Limestone Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
19	TRZ	1	2:1	38.9	10.1	12.7	4.0
19	TRZ	2	2:1	39.3	10.7	13.6	5.0
19	TRZ	3	2:1	38.7	11.0	13.8	4.5
19	TRZ	1	3:1	56.6	6.8	8.0	1.2
19	TRZ	2	3:1	56.5	7.0	8.5	1.5
19	TRZ	3	3:1	56.4	6.3	7.6	1.3
19	TRZ	1	4:1	75.9	5.3	6.4	1.1
19	TRZ	2	4:1	76.0	4.5	5.6	0.7
19	TRZ	3	4:1	75.8	4.5	5.1	0.6
37.5	ARZ	1	2:1	72.0	4.6	4.8	0.6
37.5	ARZ	2	2:1	72.5	4.5	5.0	0.8
37.5	ARZ	3	2:1	72.4	4.5	4.9	0.8
37.5	ARZ	1	2.5:1	91.5	4.6	4.2	0.7
37.5	ARZ	2	2.5:1	91.8	4.3	4.3	0.9
37.5	ARZ	3	2.5:1	91.4	4.5	4.3	0.7
37.5	ARZ	1	3:1	112.6	4.5	4.3	0.6
37.5	ARZ	2	3:1	112.9	4.4	4.4	0.7
37.5	ARZ	3	3:1	112.7	4.3	4.4	0.7
37.5	BRZ	1	2:1	76.2	4.3	8.8	1.5
37.5	BRZ	2	2:1	74.9	5.1	7.5	1.5
37.5	BRZ	3	2:1	74.1	4.7	7.1	1.6
37.5	BRZ	1	2.5:1	92.6	4.6	6.0	1.4
37.5	BRZ	2	2.5:1	93.3	4.3	6.8	1.3
37.5	BRZ	3	2.5:1	93.1	4.5	6.1	1.2
37.5	BRZ	1	3:1	112.2	4.9	6.2	1.5
37.5	BRZ	2	3:1	113.4	4.8	6.8	1.4
37.5	BRZ	3	3:1	111.8	4.6	5.8	1.3
37.5	TRZ	1	2:1	74.1	5.1	6.4	1.3
37.5	TRZ	2	2:1	73.7	4.4	5.6	1.2
37.5	TRZ	3	2:1	72.7	4.6	5.4	1.1
37.5	TRZ	1	2.5:1	92.5	4.2	5.1	1.2
37.5	TRZ	2	2.5:1	91.1	4.0	4.7	1.1
37.5	TRZ	3	2.5:1	92.6	4.0	4.9	1.1
37.5	TRZ	1	3:1	112.6	4.0	5.3	1.2
37.5	TRZ	2	3:1	111.4	3.6	3.9	0.7
37.5	TRZ	3	3:1	114.7	4.1	5.9	1.2

Table B.3 Data for T/NMAS Versus Air Voids for Gravel Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
9.5	ARZ	1	2:1	20.2	12.1	13.0	0.6
9.5	ARZ	2	2:1	20.6	11.5	12.4	0.7
9.5	ARZ	3	2:1	20.6	11.0	11.6	0.7
9.5	ARZ	1	3:1	29.1	7.9	8.3	0.4
9.5	ARZ	2	3:1	29.1	7.7	8.1	0.3
9.5	ARZ	3	3:1	29.2	7.9	8.1	0.4
9.5	ARZ	1	4:1	37.9	5.9	6.3	0.2
9.5	ARZ	2	4:1	37.5	5.9	6.2	0.2
9.5	ARZ	3	4:1	37.5	5.4	5.8	0.1
9.5	ARZ	1	8:1	74.0	3.8	3.9	0.1
9.5	ARZ	2	8:1	74.0	4.4	4.4	0.1
9.5	ARZ	3	8:1	73.8	3.9	3.8	0.1
9.5	BRZ	1	2:1	21.3	12.6	18.7	4.1
9.5	BRZ	2	2:1	21.1	14.1	16.9	4.5
9.5	BRZ	3	2:1	21.5	11.7	18.9	3.6
9.5	BRZ	1	3:1	29.9	8.4	9.4	1.1
9.5	BRZ	2	3:1	29.9	8.6	10.2	1.6
9.5	BRZ	3	3:1	29.2	8.5	9.6	1.2
9.5	BRZ	1	4:1	38.5	6.4	7.5	0.5
9.5	BRZ	2	4:1	39.1	6.9	8.3	0.6
9.5	BRZ	3	4:1	38.6	6.5	7.4	0.6
9.5	BRZ	1	8:1	74.0	3.4	4.3	0.1
9.5	BRZ	2	8:1	74.2	3.4	4.4	0.2
9.5	BRZ	3	8:1	74.0	3.2	4.2	0.1
9.5	TRZ	1	2:1	20.7	11.9	13.4	1.6
9.5	TRZ	2	2:1	20.9	12.4	13.7	2.1
9.5	TRZ	3	2:1	20.9	11.7	13.1	1.5
9.5	TRZ	1	3:1	30.0	8.6	8.7	0.6
9.5	TRZ	2	3:1	30.0	8.5	9.3	0.8
9.5	TRZ	3	3:1	29.6	7.6	8.2	0.4
9.5	TRZ	1	4:1	38.9	6.0	6.5	0.2
9.5	TRZ	2	4:1	38.9	6.5	7.1	0.3
9.5	TRZ	3	4:1	38.9	6.3	7.4	0.2
9.5	TRZ	1	8:1	76.2	3.8	4.1	0.1
9.5	TRZ	2	8:1	76.7	4.3	4.9	0.1
9.5	TRZ	3	8:1	76.3	4.2	4.4	0.1
9.5	SMA	1	2:1	20.1	10.6	18.7	5.7
9.5	SMA	2	2:1	22.0	11.0	19.2	6.4
9.5	SMA	3	2:1	21.1	10.5	20.3	5.8
9.5	SMA	1	3:1	30.0	10.2	14.6	4.8
9.5	SMA	2	3:1	30.4	10.9	15.3	5.5
9.5	SMA	3	3:1	30.4	10.2	15.1	5.1
9.5	SMA	1	4:1	38.8	9.2	12.5	3.7
9.5	SMA	2	4:1	38.1	9.6	12.3	3.4
9.5	SMA	3	4:1	38.0	9.2	12.3	3.5
9.5	SMA	1	8:1	77.8	6.1	7.4	1.1
9.5	SMA	2	8:1	77.2	5.9	6.7	1.0
9.5	SMA	3	8:1	77.3	5.3	6.3	0.7

Table B.3 (Continued) Data for T/NMAS Versus Air Voids for Gravel Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
12.5	SMA	1	2:1	27.5	8.0	17.8	4.9
12.5	SMA	2	2:1	27.0	8.5	18.3	5.2
12.5	SMA	3	2:1	27.2	8.2	16.8	4.8
12.5	SMA	1	3:1	38.9	7.8	13.1	3.8
12.5	SMA	2	3:1	38.1	8.5	13.6	3.9
12.5	SMA	3	3:1	38.4	7.9	14.2	4.5
12.5	SMA	1	4:1	52.8	7.0	10.6	3.2
12.5	SMA	2	4:1	52.4	7.8	11.5	3.9
12.5	SMA	3	4:1	53.0	8.4	12.6	4.2
12.5	SMA	1	6:1	76.7	6.0	7.7	1.6
12.5	SMA	2	6:1	77.1	5.6	7.5	1.6
12.5	SMA	3	6:1	76.9	6.0	7.9	1.9
19	SMA	1	2:1	38.9	6.6	12.3	3.0
19	SMA	2	2:1	40.2	7.3	14.1	4.0
19	SMA	3	2:1	38.5	7.1	13.3	4.5
19	SMA	1	3:1	57.1	5.1	8.2	1.7
19	SMA	2	3:1	57.3	5.6	8.0	1.4
19	SMA	3	3:1	59.0	6.4	7.8	3.1
19	SMA	1	4:1	77.6	5.6	8.2	2.2
19	SMA	2	4:1	77.8	4.8	7.7	1.7
19	SMA	3	4:1	77.7	6.0	8.5	1.6
19	ARZ	1	2:1	39.7	7.6	8.2	0.6
19	ARZ	2	2:1	39.0	6.8	7.5	0.2
19	ARZ	3	2:1	38.0	7.9	8.9	1.3
19	ARZ	1	3:1	57.1	4.4	4.9	0.2
19	ARZ	2	3:1	57.2	4.8	5.1	0.1
19	ARZ	3	3:1	56.9	4.3	4.6	0.1
19	ARZ	1	4:1	75.1	3.6	3.9	0.1
19	ARZ	2	4:1	75.5	3.6	3.9	0.1
19	ARZ	3	4:1	75.9	4.0	4.3	0.1
19	BRZ	1	2:1	41.2	8.1	10.8	2.8
19	BRZ	2	2:1	40.3	8.0	9.3	2.4
19	BRZ	3	2:1	40.3	7.7	9.7	2.5
19	BRZ	1	3:1	57.7	4.2	5.2	0.6
19	BRZ	2	3:1	58.1	4.6	5.7	0.6
19	BRZ	3	3:1	58.4	4.6	5.8	0.6
19	BRZ	1	4:1	75.5	2.9	3.8	0.2
19	BRZ	2	4:1	75.5	3.3	4.1	0.3
19	BRZ	3	4:1	76.2	3.3	4.0	0.3

Table B.3 (Continued) Data for T/NMAS Versus Air Voids for Gravel Mixes

NMAS	Gradation	Replicate	t/NMAS	Thickness, mm	Voids SSD, %	Voids Corelok, %	Water Abs., %
19	TRZ	1	2:1	39.7	7.9	9.4	2.3
19	TRZ	2	2:1	39.9	7.2	9.5	1.5
19	TRZ	3	2:1	39.5	8.3	10.4	2.5
19	TRZ	1	3:1	57.4	5.0	5.7	0.6
19	TRZ	2	3:1	57.3	4.3	4.9	0.4
19	TRZ	3	3:1	57.0	4.0	4.5	0.4
19	TRZ	1	4:1	76.1	3.1	3.4	0.3
19	TRZ	2	4:1	75.9	3.4	3.8	0.3
19	TRZ	3	4:1	75.8	3.2	2.9	0.2
37.5	ARZ	1	2:1	72.0	4.4	5.0	0.5
37.5	ARZ	2	2:1	72.3	5.3	5.8	0.5
37.5	ARZ	3	2:1	72.0	4.4	4.8	0.6
37.5	ARZ	1	2.5:1	90.8	3.6	3.6	0.2
37.5	ARZ	2	2.5:1	91.0	4.2	4.6	0.4
37.5	ARZ	3	2.5:1	91.4	4.8	5.1	0.9
37.5	ARZ	1	3:1	110.6	3.5	3.7	0.2
37.5	ARZ	2	3:1	112.1	5.2	5.5	0.8
37.5	ARZ	3	3:1	111.0	3.8	4.8	0.3
37.5	BRZ	1	2:1	74.1	5.0	7.3	1.9
37.5	BRZ	2	2:1	73.6	5.3	7.0	2.0
37.5	BRZ	3	2:1	73.8	5.0	7.5	2.2
37.5	BRZ	1	2.5:1	93.4	4.7	7.0	1.6
37.5	BRZ	2	2.5:1	92.0	4.6	5.7	1.9
37.5	BRZ	3	2.5:1	93.5	4.6	7.0	1.8
37.5	BRZ	1	3:1	111.8	4.8	5.8	1.9
37.5	BRZ	2	3:1	111.7	4.4	5.6	1.2
37.5	BRZ	3	3:1	111.4	4.1	5.2	1.0
37.5	TRZ	1	2:1	73.7	4.2	5.4	1.2
37.5	TRZ	2	2:1	73.1	3.7	4.8	0.7
37.5	TRZ	3	2:1	73.8	4.5	5.4	1.3
37.5	TRZ	1	2.5:1	91.6	3.4	4.0	0.9
37.5	TRZ	2	2.5:1	92.7	4.0	4.6	1.0
37.5	TRZ	3	2.5:1	92.2	3.4	4.2	0.8
37.5	TRZ	1	3:1	112.0	3.5	4.4	0.8
37.5	TRZ	2	3:1	112.3	3.5	4.3	0.7
37.5	TRZ	3	3:1	110.1	3.2	3.7	0.6

APPENDIX C

(LIFT THICKNESS VERSUS DENSITY DATA USING VIBRATORY COMPACTOR)

Table C.1 Data for T/NMAS Versus Air Voids for Granite Mixes

NMAS	Gradation	Compact. Time, sec.	Replicate	Target t/NMAS	Thickness, mm	Actual t/NMAS	Voids SSD, %	Voids Corelok, %	Water Abs., %
9.5	ARZ	30	1	2.0	19.3	2.0	6.4	6.8	0.2
9.5	ARZ	30	2	2.0	19.5	2.0	6.2	6.1	0.2
9.5	ARZ	60	1	2.0	18.7	2.0	4.8	4.9	0.3
9.5	ARZ	60	2	2.0	18.3	1.9	3.3	4.5	0.2
9.5	ARZ	90	1	2.0	18.3	1.9	4.2	4.3	0.3
9.5	ARZ	90	2	2.0	18.7	2.0	3.4	4.8	0.3
9.5	ARZ	30	1	3.0	28.6	3.0	5.1	6.1	0.2
9.5	ARZ	30	2	3.0	28.9	3.0	5.0	6.2	0.2
9.5	ARZ	60	1	3.0	28.7	3.0	5.4	5.1	0.1
9.5	ARZ	60	2	3.0	28.1	3.0	5.2	5.2	0.2
9.5	ARZ	90	1	3.0	29.2	3.1	4.7	3.7	0.2
9.5	ARZ	90	2	3.0	28.4	3.0	2.8	3.3	0.1
9.5	ARZ	30	1	4.0	38.6	4.1	5.4	5.0	0.2
9.5	ARZ	30	2	4.0	38.7	4.1	5.7	5.4	0.2
9.5	ARZ	60	1	4.0	38.4	4.0	4.7	4.3	0.1
9.5	ARZ	60	2	4.0	37.9	4.0	3.5	4.1	0.2
9.5	ARZ	90	1	4.0	37.3	3.9	3.6	3.1	0.1
9.5	ARZ	90	2	4.0	37.9	4.0	3.9	3.7	0.1
9.5	BRZ	30	1	2.0	20.8	2.2	9.5	11.2	2.0
9.5	BRZ	30	2	2.0	20.6	2.2	8.7	10.8	1.8
9.5	BRZ	60	1	2.0	20.5	2.2	7.1	8.2	1.0
9.5	BRZ	60	2	2.0	20.0	2.1	5.8	8.2	0.8
9.5	BRZ	90	1	2.0	20.0	2.1	5.3	6.4	0.6
9.5	BRZ	90	2	2.0	19.9	2.1	6.0	7.1	0.6
9.5	BRZ	30	1	3.0	30.3	3.2	7.9	9.9	1.8
9.5	BRZ	30	2	3.0	30.5	3.2	9.1	10.4	1.6
9.5	BRZ	60	1	3.0	29.8	3.1	8.0	9.0	0.9
9.5	BRZ	60	2	3.0	29.4	3.1	7.0	8.7	0.6
9.5	BRZ	90	1	3.0	29.1	3.1	6.1	6.8	0.4
9.5	BRZ	90	2	3.0	29.4	3.1	6.7	7.4	0.4
9.5	BRZ	30	1	4.0	40.8	4.3	8.7	9.4	1.8
9.5	BRZ	30	2	4.0	40.5	4.3	8.3	9.0	1.1
9.5	BRZ	60	1	4.0	40.6	4.3	8.2	8.3	0.9
9.5	BRZ	60	2	4.0	40.1	4.2	7.2	7.9	0.8
9.5	BRZ	90	1	4.0	39.2	4.1	5.7	6.2	0.3
9.5	BRZ	90	2	4.0	39.4	4.1	6.3	6.8	0.3

Table C.1 (Continued) Data for T/NMAS Versus Air Voids for Granite Mixes

NMAS	Gradation	Compact. Time, sec.	Replicate	Target t/NMAS	Thickness, mm	Actual t/NMAS	Voids SSD, %	Voids Corelok, %	Water Abs., %
9.5	SMA	30	1	2.0	19.3	2.0	7.1	10.5	1.9
9.5	SMA	30	2	2.0	18.8	2.0	6.4	11.0	2.0
9.5	SMA	60	1	2.0	19.3	2.0	6.8	9.4	2.1
9.5	SMA	60	2	2.0	19.0	2.0	6.5	9.1	2.1
9.5	SMA	90	1	2.0	18.2	1.9	4.9	5.8	0.9
9.5	SMA	90	2	2.0	18.9	2.0	5.4	6.3	0.9
9.5	SMA	30	1	3.0	30.3	3.2	8.7	10.5	2.6
9.5	SMA	30	2	3.0	30.4	3.2	8.4	10.3	2.4
9.5	SMA	60	1	3.0	29.0	3.0	5.5	7.0	1.5
9.5	SMA	60	2	3.0	29.0	3.0	5.4	6.9	1.5
9.5	SMA	90	1	3.0	28.0	2.9	3.0	4.3	0.3
9.5	SMA	90	2	3.0	28.2	3.0	3.8	4.7	0.6
9.5	SMA	30	1	4.0	40.7	4.3	8.3	9.9	1.8
9.5	SMA	30	2	4.0	40.9	4.3	9.0	10.5	1.9
9.5	SMA	60	1	4.0	39.1	4.1	5.0	5.7	0.5
9.5	SMA	60	2	4.0	39.5	4.2	5.6	6.3	0.6
9.5	SMA	90	1	4.0	38.0	4.0	3.8	4.5	0.6
9.5	SMA	90	2	4.0	38.2	4.0	3.6	4.4	0.5
12.5	SMA	30	1	2.0	26.6	2.1	7.4	12.4	3.2
12.5	SMA	30	2	2.0	26.3	2.1	7.5	12.6	3.2
12.5	SMA	60	1	2.0	25.2	2.0	6.0	9.2	1.4
12.5	SMA	60	2	2.0	25.3	2.0	5.4	8.8	1.3
12.5	SMA	90	1	2.0	24.4	2.0	5.3	7.3	1.0
12.5	SMA	90	2	2.0	24.4	2.0	4.6	6.5	0.6
12.5	SMA	30	1	3.0	39.4	3.1	7.6	10.7	2.2
12.5	SMA	30	2	3.0	38.8	3.1	7.8	10.9	2.9
12.5	SMA	60	1	3.0	37.9	3.0	4.6	7.3	0.6
12.5	SMA	60	2	3.0	37.2	3.0	4.5	7.2	0.5
12.5	SMA	90	1	3.0	36.9	3.0	3.9	4.7	0.5
12.5	SMA	90	2	3.0	37.1	3.0	4.6	5.4	0.6
12.5	SMA	30	1	4.0	51.0	4.1	7.8	11.0	2.6
12.5	SMA	30	2	4.0	50.9	4.1	7.9	10.5	1.8
12.5	SMA	60	1	4.0	51.7	4.1	6.7	8.8	1.3
12.5	SMA	60	2	4.0	49.3	3.9	7.8	8.6	2.6
12.5	SMA	90	1	4.0	51.1	4.1	6.4	7.6	1.3
12.5	SMA	90	2	4.0	51.8	4.1	7.1	8.3	1.3

Table C.1 (Continued) Data for T/NMAS Versus Air Voids for Granite Mixes

NMAS	Gradation	Compact. Time, sec.	Replicate	Target t/NMAS	Thickness, mm	Actual t/NMAS	Voids SSD, %	Voids Corelok, %	Water Abs., %
19	ARZ	30	1	2.0	40.4	2.1	7.7	9.3	3.0
19	ARZ	30	2	2.0	40.1	2.1	8.6	8.9	1.4
19	ARZ	60	1	2.0	39.6	2.1	7.0	7.1	1.2
19	ARZ	60	2	2.0	39.5	2.1	7.3	7.4	1.2
19	ARZ	90	1	2.0	39.1	2.1	5.9	5.7	0.9
19	ARZ	90	2	2.0	38.8	2.0	5.1	5.1	0.3
19	ARZ	30	1	3.0	59.4	3.1	6.4	6.6	0.6
19	ARZ	30	2	3.0	59.6	3.1	7.0	7.2	0.6
19	ARZ	60	1	3.0	59.2	3.1	5.8	6.0	1.0
19	ARZ	60	2	3.0	58.2	3.1	4.5	5.5	0.7
19	ARZ	90	1	3.0	58.5	3.1	5.4	5.0	0.6
19	ARZ	90	2	3.0	57.8	3.0	4.8	4.6	0.7
19	ARZ	30	1	4.0	76.9	4.0	8.0	7.6	1.5
19	ARZ	30	2	4.0	78.3	4.1	8.7	8.3	1.5
19	ARZ	60	1	4.0	76.6	4.0	6.1	6.1	1.1
19	ARZ	60	2	4.0	76.3	4.0	6.7	6.5	0.9
19	ARZ	90	1	4.0	74.1	3.9	3.7	3.9	0.4
19	ARZ	90	2	4.0	74.3	3.9	4.0	5.1	0.5
19	BRZ	30	1	2.0	41.0	2.2	8.2	10.6	1.8
19	BRZ	30	2	2.0	40.8	2.1	7.6	10.3	1.7
19	BRZ	60	1	2.0	40.7	2.1	7.7	9.7	1.2
19	BRZ	60	2	2.0	40.8	2.1	7.3	9.6	1.2
19	BRZ	90	1	2.0	38.6	2.0	5.6	7.5	0.6
19	BRZ	90	2	2.0	39.9	2.1	6.1	8.0	0.6
19	BRZ	30	1	3.0	58.4	3.1	8.0	10.9	1.6
19	BRZ	30	2	3.0	58.9	3.1	8.2	11.9	1.5
19	BRZ	60	1	3.0	57.2	3.0	6.0	9.7	0.8
19	BRZ	60	2	3.0	57.1	3.0	6.3	9.3	0.8
19	BRZ	90	1	3.0	56.5	3.0	6.3	7.3	0.9
19	BRZ	90	2	3.0	56.3	3.0	5.2	7.2	0.5
19	BRZ	30	1	4.0	77.5	4.1	9.2	11.2	2.1
19	BRZ	30	2	4.0	77.3	4.1	9.0	10.7	2.2
19	BRZ	60	1	4.0	76.8	4.0	6.3	8.8	0.8
19	BRZ	60	2	4.0	78.0	4.1	6.6	9.0	1.2
19	BRZ	90	1	4.0	75.5	4.0	5.8	6.8	0.8
19	BRZ	90	2	4.0	75.6	4.0	5.7	6.7	0.8

Table C.1 (Continued) Data for T/NMAS Versus Air Voids for Granite Mixes

NMAS	Gradation	Compact. Time, sec.	Replicate	Target t/NMAS	Thickness, mm	Actual t/NMAS	Voids SSD, %	Voids Corelok, %	Water Abs., %
19	SMA	30	1	2.0	40.2	2.1	6.7	11.6	1.8
19	SMA	30	2	2.0	40.8	2.1	6.3	12.1	2.5
19	SMA	60	1	2.0	38.7	2.0	5.6	7.7	0.9
19	SMA	60	2	2.0	38.2	2.0	5.5	7.6	0.9
19	SMA	90	1	2.0	37.5	2.0	4.2	5.3	0.7
19	SMA	90	2	2.0	37.5	2.0	4.9	6.0	0.7
19	SMA	30	1	3.0	59.2	3.1	7.2	11.6	1.9
19	SMA	30	2	3.0	58.1	3.1	7.2	11.0	2.0
19	SMA	60	1	3.0	56.5	3.0	5.1	7.3	0.8
19	SMA	60	2	3.0	56.4	3.0	5.4	7.6	0.8
19	SMA	90	1	3.0	55.9	2.9	4.8	6.0	0.5
19	SMA	90	2	3.0	55.7	2.9	4.5	5.7	0.5
19	SMA	30	1	4.0	75.1	4.0	6.6	9.9	1.1
19	SMA	30	2	4.0	72.8	3.8	5.7	10.6	1.2
19	SMA	60	1	4.0	77.1	4.1	5.1	8.1	0.6
19	SMA	60	2	4.0	75.8	4.0	6.1	8.2	1.1
19	SMA	90	1	4.0	76.9	4.0	6.0	6.9	1.0
19	SMA	90	2	4.0	75.8	4.0	5.4	6.8	0.6

Table C.2 Data for T/NMAS Versus Air Voids for Limestone Mixes

NMAS	Gradation	Compact. Time, sec.	Replicate	Target t/NMAS	Thickness, mm	Actual t/NMAS	Voids SSD, %	Voids Corelok, %	Water Abs., %
9.5	ARZ	30	1	2.0	19.6	2.1	7.9	8.5	0.3
9.5	ARZ	30	2	2.0	19.4	2.0	7.6	7.8	0.3
9.5	ARZ	60	1	2.0	19.2	2.0	7.4	7.3	0.3
9.5	ARZ	60	2	2.0	19.5	2.1	7.9	7.8	0.4
9.5	ARZ	90	1	2.0	18.9	2.0	6.1	7.1	0.2
9.5	ARZ	90	2	2.0	18.8	2.0	5.3	6.9	0.1
9.5	ARZ	30	1	3.0	29.5	3.1	7.8	8.5	0.2
9.5	ARZ	30	2	3.0	29.9	3.1	8.7	8.7	0.3
9.5	ARZ	60	1	3.0	29.4	3.1	6.9	6.9	0.2
9.5	ARZ	60	2	3.0	29.6	3.1	7.2	7.2	0.2
9.5	ARZ	90	1	3.0	29.1	3.1	6.5	6.8	0.2
9.5	ARZ	90	2	3.0	29.1	3.1	6.3	6.5	0.1
9.5	ARZ	30	1	4.0	38.9	4.1	6.2	6.0	0.2
9.5	ARZ	30	2	4.0	39.0	4.1	6.6	8.4	0.2
9.5	ARZ	60	1	4.0	38.7	4.1	6.0	6.0	0.2
9.5	ARZ	60	2	4.0	38.8	4.1	6.3	6.3	0.2
9.5	ARZ	90	1	4.0	38.0	4.0	3.8	3.7	0.2
9.5	ARZ	90	2	4.0	39.0	4.1	4.0	4.4	0.1
9.5	BRZ	30	1	2.0	19.7	2.1	7.5	9.3	1.0
9.5	BRZ	30	2	2.0	19.5	2.1	7.1	8.3	0.8
9.5	BRZ	60	1	2.0	18.6	2.0	5.5	6.7	0.8
9.5	BRZ	60	2	2.0	19.2	2.0	6.6	7.8	1.0
9.5	BRZ	90	1	2.0	18.8	2.0	5.2	6.7	0.7
9.5	BRZ	90	2	2.0	18.9	2.0	5.5	6.4	0.8
9.5	BRZ	30	1	3.0	28.4	3.0	8.4	9.1	0.7
9.5	BRZ	30	2	3.0	28.2	3.0	8.2	8.8	0.5
9.5	BRZ	60	1	3.0	27.7	2.9	6.9	7.3	0.9
9.5	BRZ	60	2	3.0	28.2	3.0	7.0	7.4	0.9
9.5	BRZ	90	1	3.0	27.3	2.9	5.2	5.9	0.2
9.5	BRZ	90	2	3.0	27.1	2.9	4.5	5.5	0.3
9.5	BRZ	30	1	4.0	39.8	4.2	7.9	8.1	0.5
9.5	BRZ	30	2	4.0	39.6	4.2	7.7	8.1	0.5
9.5	BRZ	60	1	4.0	38.5	4.1	6.4	7.5	0.3
9.5	BRZ	60	2	4.0	39.5	4.2	7.0	8.1	0.3
9.5	BRZ	90	1	4.0	38.8	4.1	5.0	5.3	0.3
9.5	BRZ	90	2	4.0	38.8	4.1	5.0	5.1	0.4

Table C.2 (Continued) Data for T/NMAS Versus Air Voids for Limestone Mixes

NMAS	Gradation	Compact. Time, sec.	Replicate	Target t/NMAS	Thickness, mm	Actual t/NMAS	Voids SSD, %	Voids Corelok, %	Water Abs., %
9.5	SMA	30	1	2.0	19.0	2.0	6.4	9.6	1.6
9.5	SMA	30	2	2.0	19.3	2.0	6.4	9.6	1.6
9.5	SMA	60	1	2.0	18.3	1.9	5.7	6.2	1.1
9.5	SMA	60	2	2.0	18.3	1.9	4.8	5.3	0.8
9.5	SMA	90	1	2.0	18.1	1.9	3.2	3.9	0.7
9.5	SMA	90	2	2.0	18.1	1.9	2.6	2.8	0.6
9.5	SMA	30	1	3.0	29.8	3.1	6.9	8.9	1.0
9.5	SMA	30	2	3.0	29.6	3.1	6.2	8.2	0.9
9.5	SMA	60	1	3.0	29.0	3.0	5.1	6.0	0.7
9.5	SMA	60	2	3.0	28.6	3.0	5.1	5.9	0.7
9.5	SMA	90	1	3.0	28.2	3.0	3.4	3.5	0.4
9.5	SMA	90	2	3.0	28.3	3.0	3.6	4.1	0.5
9.5	SMA	30	1	4.0	39.4	4.2	6.5	8.1	1.1
9.5	SMA	30	2	4.0	39.5	4.2	6.7	8.3	1.2
9.5	SMA	60	1	4.0	38.1	4.0	4.0	4.5	0.5
9.5	SMA	60	2	4.0	38.3	4.0	4.9	5.4	0.6
9.5	SMA	90	1	4.0	37.7	4.0	4.4	4.3	0.5
9.5	SMA	90	2	4.0	37.9	4.0	4.6	5.1	0.6
12.5	SMA	30	1	2.0	24.9	2.0	6.3	8.6	1.4
12.5	SMA	30	2	2.0	25.2	2.0	5.5	7.7	1.2
12.5	SMA	60	1	2.0	25.2	2.0	6.4	8.3	1.0
12.5	SMA	60	2	2.0	25.0	2.0	5.0	6.9	1.0
12.5	SMA	90	1	2.0	24.7	2.0	6.2	7.5	0.8
12.5	SMA	90	2	2.0	24.4	1.9	5.4	7.0	0.8
12.5	SMA	30	1	3.0	38.7	3.1	6.8	7.6	0.9
12.5	SMA	30	2	3.0	38.6	3.1	6.8	7.7	1.0
12.5	SMA	60	1	3.0	37.6	3.0	3.6	4.6	0.6
12.5	SMA	60	2	3.0	37.3	3.0	3.5	4.1	0.3
12.5	SMA	90	1	3.0	36.3	2.9	3.0	3.6	0.3
12.5	SMA	90	2	3.0	36.1	2.9	2.8	2.8	0.3
12.5	SMA	30	1	4.0	52.4	4.2	7.3	8.6	1.1
12.5	SMA	30	2	4.0	52.3	4.2	7.5	8.6	1.0
12.5	SMA	60	1	4.0	51.7	4.1	6.5	7.1	0.8
12.5	SMA	60	2	4.0	51.1	4.1	6.2	6.8	0.7
12.5	SMA	90	1	4.0	50.0	4.0	3.8	3.8	0.3
12.5	SMA	90	2	4.0	49.1	3.9	3.7	3.4	0.4

Table C.2 (Continued) Data for T/NMAS Versus Air Voids for Limestone Mixes

NMAS	Gradation	Compact. Time, sec.	Replicate	Target t/NMAS	Thickness, mm	Actual t/NMAS	Voids SSD, %	Voids Corelok, %	Water Abs., %
19	ARZ	30	1	2.0	39.8	2.1	7.8	8.0	0.3
19	ARZ	30	2	2.0	39.8	2.1	7.7	7.8	0.4
19	ARZ	60	1	2.0	39.6	2.1	7.2	7.7	0.4
19	ARZ	60	2	2.0	39.4	2.1	6.7	7.1	0.3
19	ARZ	90	1	2.0	38.0	2.0	4.8	4.9	0.2
19	ARZ	90	2	2.0	37.8	2.0	4.0	3.9	0.2
19	ARZ	30	1	3.0	59.8	3.1	8.7	8.7	1.0
19	ARZ	30	2	3.0	59.2	3.1	7.8	7.6	0.8
19	ARZ	60	1	3.0	59.3	3.1	6.6	6.4	0.4
19	ARZ	60	2	3.0	59.9	3.2	7.6	7.1	0.7
19	ARZ	90	1	3.0	57.6	3.0	5.7	5.2	0.2
19	ARZ	90	2	3.0	58.6	3.1	6.2	6.1	0.4
19	ARZ	30	1	4.0	76.6	4.0	8.0	8.0	1.2
19	ARZ	30	2	4.0	77.4	4.1	8.5	8.4	1.0
19	ARZ	60	1	4.0	74.3	3.9	5.7	5.7	0.5
19	ARZ	60	2	4.0	75.6	4.0	6.5	6.5	0.8
19	ARZ	90	1	4.0	75.0	3.9	5.8	5.4	0.5
19	ARZ	90	2	4.0	75.1	4.0	5.6	5.4	0.4
19	BRZ	30	1	2.0	39.5	2.1	8.0	9.6	1.0
19	BRZ	30	2	2.0	39.3	2.1	7.8	9.6	1.1
19	BRZ	60	1	2.0	38.1	2.0	5.7	7.2	0.6
19	BRZ	60	2	2.0	38.9	2.0	6.7	8.1	0.7
19	BRZ	90	1	2.0	38.0	2.0	4.1	5.5	0.3
19	BRZ	90	2	2.0	38.0	2.0	3.1	4.2	0.3
19	BRZ	30	1	3.0	59.6	3.1	7.2	8.8	1.1
19	BRZ	30	2	3.0	59.5	3.1	7.6	8.8	0.9
19	BRZ	60	1	3.0	58.2	3.1	5.5	6.6	0.5
19	BRZ	60	2	3.0	58.5	3.1	6.4	7.5	0.6
19	BRZ	90	1	3.0	58.4	3.1	4.7	5.3	0.2
19	BRZ	90	2	3.0	57.7	3.0	4.0	5.0	0.2
19	BRZ	30	1	4.0	76.1	4.0	7.5	8.4	0.7
19	BRZ	30	2	4.0	76.5	4.0	8.1	8.6	0.9
19	BRZ	60	1	4.0	75.3	4.0	6.3	7.0	0.5
19	BRZ	60	2	4.0	75.2	4.0	6.0	6.7	0.4
19	BRZ	90	1	4.0	74.4	3.9	5.8	6.3	0.3
19	BRZ	90	2	4.0	74.2	3.9	6.3	7.0	0.5

Table C.2 (Continued) Data for T/NMAS Versus Air Voids for Limestone Mixes

NMAS	Gradation	Compact. Time, sec.	Replicate	Target t/NMAS	Thickness, mm	Actual t/NMAS	Voids SSD, %	Voids Corelok, %	Water Abs., %
19	SMA	30	1	2.0	36.3	1.9	4.2	6.6	0.6
19	SMA	30	2	2.0	37.1	2.0	4.6	6.7	0.7
19	SMA	60	1	2.0	37.2	2.0	4.4	6.3	1.2
19	SMA	60	2	2.0	37.1	2.0	4.6	6.5	1.2
19	SMA	90	1	2.0	37.8	2.0	4.1	5.1	0.8
19	SMA	90	2	2.0	37.1	2.0	3.2	4.6	0.5
19	SMA	30	1	3.0	59.3	3.1	6.2	9.2	1.2
19	SMA	30	2	3.0	59.8	3.1	7.1	10.2	1.9
19	SMA	60	1	3.0	57.6	3.0	5.1	7.3	0.5
19	SMA	60	2	3.0	58.2	3.1	5.5	7.7	0.7
19	SMA	90	1	3.0	58.3	3.1	5.6	7.7	0.8
19	SMA	90	2	3.0	57.5	3.0	5.1	6.6	0.5
19	SMA	30	1	4.0	77.6	4.1	7.5	10.2	1.7
19	SMA	30	2	4.0	77.2	4.1	7.1	9.7	1.9
19	SMA	60	1	4.0	74.8	3.9	5.0	6.1	0.6
19	SMA	60	2	4.0	75.5	4.0	5.4	6.5	0.6
19	SMA	90	1	4.0	73.7	3.9	4.7	5.8	0.6
19	SMA	90	2	4.0	74.0	3.9	5.0	6.3	0.6

APPENDIX D

(LIFT THICKNESS VERSUS PERMEABILITY DATA)

Table D.1 Data for T/NMAS Versus Permeability for Granite Mixes Using Gyratory Compactor

NMAS	Gradation	Replicate	T/NMAS	Thickness, mm	Air Voids (Corelok),%	Permeability, 10^{-5} cm/sec
9.5	ARZ	1	2.0	20.4	13.0	-
9.5	ARZ	2	2.0	19.1	11.9	-
9.5	ARZ	3	2.0	20.5	12.2	-
9.5	ARZ	1	3.0	29.3	9.5	-
9.5	ARZ	2	3.0	28.5	10.1	-
9.5	ARZ	3	3.0	27.9	8.7	-
9.5	ARZ	1	4.0	37.7	6.2	1
9.5	ARZ	2	4.0	37.8	6.6	1
9.5	ARZ	3	4.0	37.7	5.9	-
9.5	BRZ	1	2.0	21.1	17.1	-
9.5	BRZ	2	2.0	20.6	14.6	-
9.5	BRZ	3	2.0	21.0	16.7	-
9.5	BRZ	1	3.0	29.5	10.7	-
9.5	BRZ	2	3.0	29.2	11.5	-
9.5	BRZ	3	3.0	29.1	10.2	-
9.5	BRZ	1	4.0	39.8	7.7	26
9.5	BRZ	2	4.0	39.7	7.6	40
9.5	BRZ	3	4.0	39.0	8.6	-
9.5	SMA	1	2.0	20.8	18.2	-
9.5	SMA	2	2.0	21.7	18.0	-
9.5	SMA	3	2.0	21.5	18.6	-
9.5	SMA	1	3.0	29.5	12.3	-
9.5	SMA	2	3.0	30.4	13.3	-
9.5	SMA	3	3.0	29.6	12.8	-
9.5	SMA	1	4.0	38.5	9.9	-
9.5	SMA	2	4.0	39.1	9.6	-
9.5	SMA	3	4.0	38.4	9.1	-
12.5	SMA	1	2.0	25.8	17.1	-
12.5	SMA	2	2.0	25.2	15.7	-
12.5	SMA	3	2.0	26.0	17.4	-
12.5	SMA	1	3.0	37.5	15.1	-
12.5	SMA	2	3.0	37.5	13.6	-
12.5	SMA	3	3.0	37.5	14.3	-
12.5	SMA	1	4.0	50.0	10.1	-
12.5	SMA	2	4.0	50.0	10.5	-
12.5	SMA	3	4.0	50.0	11.2	-

- No specimens achieve 7 ± 1.0 % air voids

Table D.1 (Continued) Data for T/NMAS Versus Permeability for Granite Mixes Using Gyratory Compactor

NMAS	Gradation	Replicate	T/NMAS	Thickness, mm	Air Voids (Corelok),%	Permeability, 10^{-5} cm/sec
19	ARZ	1	2.0	39.6	6.6	40
19	ARZ	2	2.0	39.8	7.9	117
19	ARZ	3	2.0	39.5	6.1	17
19	ARZ	1	3.0	56.6	7.9	0
19	ARZ	2	3.0	56.8	7.4	1
19	ARZ	3	3.0	57.0	8.0	2
19	ARZ	1	4.0	75.7	6.9	7
19	ARZ	2	4.0	75.5	7.1	14
19	ARZ	3	4.0	75.7	7.3	14
19	BRZ	1	2.0	38.9	9.7	-
19	BRZ	2	2.0	38.7	10.3	-
19	BRZ	3	2.0	39.0	10.1	-
19	BRZ	1	3.0	57.0	8.3	-
19	BRZ	2	3.0	57.0	8.5	-
19	BRZ	3	3.0	57.0	8.2	-
19	BRZ	1	4.0	76.6	5.9	-
19	BRZ	2	4.0	77.4	6.5	303
19	BRZ	3	4.0	77.3	6.3	251
19	SMA	1	2.0	39.1	12.8	-
19	SMA	2	2.0	38.0	10.7	-
19	SMA	3	2.0	38.7	11.8	-
19	SMA	1	3.0	57.0	8.5	-
19	SMA	2	3.0	57.0	8.5	-
19	SMA	3	3.0	57.0	8.6	-
19	SMA	1	4.0	76.9	7.7	425
19	SMA	2	4.0	77.1	7.5	559
19	SMA	3	4.0	77.0	7.3	49

- No specimens achieve 7 ± 1.0 % air voids

Table D.2 Data for T/NMAS Versus Permeability for Limestone Mixes Using Gyratory Compactor

NMAS	Gradation	Replicate	T/NMAS	Thickness, mm	Air Voids (Corelok),%	Permeability, 10^{-5} cm/sec
9.5	ARZ	1	2	20.8	14.7	-
9.5	ARZ	2	2	20.4	13.0	-
9.5	ARZ	3	2	20.6	13.0	-
9.5	ARZ	1	3	29.7	9.7	-
9.5	ARZ	2	3	29.8	9.9	-
9.5	ARZ	3	3	29.4	8.6	-
9.5	ARZ	1	4	38.1	6.7	3
9.5	ARZ	2	4	38.1	6.8	4
9.5	ARZ	3	4	37.9	6.7	3
9.5	BRZ	1	2	20.9	15.3	-
9.5	BRZ	2	2	20.8	14.2	-
9.5	BRZ	3	2	20.6	14.6	-
9.5	BRZ	1	3	28.7	12.3	-
9.5	BRZ	2	3	28.7	11.5	-
9.5	BRZ	3	3	28.7	12.5	-
9.5	BRZ	1	4	37.5	7.5	33
9.5	BRZ	2	4	37.4	7.3	19
9.5	BRZ	3	4	37.5	6.8	7
9.5	SMA	1	2	20.2	15.6	-
9.5	SMA	2	2	20.2	15.6	-
9.5	SMA	3	2	19.6	12.0	-
9.5	SMA	1	3	29.4	10.0	-
9.5	SMA	2	3	29.8	12.9	-
9.5	SMA	3	3	29.1	8.5	-
9.5	SMA	1	4	38.0	7.9	-
9.5	SMA	2	4	38.0	8.6	-
9.5	SMA	3	4	38.0	8.9	-
12.5	SMA	1	2	27.0	17.1	-
12.5	SMA	2	2	26.3	15.7	-
12.5	SMA	3	2	27.2	17.4	-
12.5	SMA	1	3	38.7	15.1	-
12.5	SMA	2	3	39.1	13.6	-
12.5	SMA	3	3	39.0	14.3	-
12.5	SMA	1	4	50.6	10.1	-
12.5	SMA	2	4	51.2	10.5	-
12.5	SMA	3	4	50.3	11.2	-

- No specimens achieve 7 ± 1.0 % air voids

Table D.2 (Continued) Data for T/NMAS Versus Permeability for Limestone Mixes Using Gyratory Compactor

NMAS	Gradation	Replicate	T/NMAS	Thickness, mm	Air Voids (Corelok),%	Permeability, 10^{-5} cm/sec
19	ARZ	1	2	38.0	10.5	-
19	ARZ	2	2	38.8	10.6	-
19	ARZ	3	2	38.8	10.3	-
19	ARZ	1	3	56.6	6.8	4
19	ARZ	2	3	56.9	7.1	4
19	ARZ	3	3	56.8	8.4	-
19	ARZ	1	4	77.0	6.5	1
19	ARZ	2	4	74.8	7.0	6
19	ARZ	3	4	77.2	7.2	4
19	BRZ	1	2	38.1	8.9	-
19	BRZ	2	2	38.0	9.0	-
19	BRZ	3	2	38.0	11.0	-
19	BRZ	1	3	57.6	6.6	225
19	BRZ	2	3	56.3	6.3	21
19	BRZ	3	3	56.9	6.1	80
19	BRZ	1	4	75.7	7.6	118
19	BRZ	2	4	76.1	7.7	177
19	BRZ	3	4	76.0	9.2	-
19	SMA	1	2	38.0	14.6	-
19	SMA	2	2	38.0	14.6	-
19	SMA	3	2	38.0	13.9	-
19	SMA	1	3	57.0	8.2	-
19	SMA	2	3	57.0	8.0	-
19	SMA	3	3	57.0	8.6	-
19	SMA	1	4	76.7	6.5	2
19	SMA	2	4	76.9	6.7	264
19	SMA	3	4	77.8	7.3	82

- No specimens achieve 7 ± 1.0 % air voids

Table D.3 Data for T/NMAS Versus Permeability for Granite Mixes Using Vibratory Compactor

NMAS	Gradation	T/NMAS	Replicate	Thickness, mm	Air Voids (Corelok), %	Permeability, 10x-5 cm/sec
9.5	ARZ	2	1	19.1	6.8	31
9.5	ARZ	2	2	19.8	6.0	5
9.5	ARZ	3	1	29.3	6.0	1
9.5	ARZ	3	2	28.7	6.1	4
9.5	ARZ	4	1	39.5	7.7	10
9.5	ARZ	4	2	39.2	7.3	10
9.5	BRZ	2	1	20.3	7.1	0
9.5	BRZ	2	2	19.6	8.0	87
9.5	BRZ	3	1	29.8	8.0	2
9.5	BRZ	3	2	29.5	7.4	0
9.5	BRZ	4	1	39.8	8.0	2
9.5	BRZ	4	2	39.6	7.9	0
9.5	SMA	2	1	18.6	7.0	301
9.5	SMA	2	2	18.4	7.0	174
9.5	SMA	3	1	28.8	6.9	103
9.5	SMA	3	2	28.7	6.9	0
9.5	SMA	4	1	39.4	7.5	0
9.5	SMA	4	2	39.2	7.8	78
12.5	SMA	2	1	24.3	7.8	470
12.5	SMA	2	2	25.1	6.7	226
12.5	SMA	3	1	38.3	6.1	0
12.5	SMA	3	2	38.1	6.0	0
12.5	SMA	4	1	50.9	6.4	0
12.5	SMA	4	2	51.5	7.5	107
19	ARZ	2	1	39.1	6.9	0
19	ARZ	2	2	40.6	7.6	0
19	ARZ	3	1	59.7	6.1	0
19	ARZ	3	2	59.7	6.0	0
19	ARZ	4	1	77.9	6.7	0
19	ARZ	4	2	77.1	6.7	0
19	BRZ	2	1	39.7	6.0	0
19	BRZ	2	2	39.4	7.9	130
19	BRZ	3	1	59.9	7.0	0
19	BRZ	3	2	59.8	7.9	174
19	BRZ	4	1	75.6	7.2	86
19	BRZ	4	2	75.0	7.1	0
19	SMA	2	1	39.1	6.9	0
19	SMA	2	2	38.8	7.9	0
19	SMA	3	1	56.4	6.6	0
19	SMA	3	2	56.2	7.9	49
19	SMA	4	1	77.0	8.0	0
19	SMA	4	2	76.6	7.0	0

Table D.4 Data for T/NMAS Versus Permeability for Limestone Mixes Using Vibratory Compactor

NMAS	Gradation	Replicate	T/NMAS	Thickness, mm	Air Voids (Corelok), %	Permeability, $10x^{-5}$ cm/sec
9.5	ARZ	1	2	19.5	8.0	15
9.5	ARZ	2	2	19.5	8.0	9
9.5	ARZ	1	3	29.6	7.4	23
9.5	ARZ	2	3	29.4	7.5	32
9.5	ARZ	1	4	39.4	6.3	6
9.5	ARZ	2	4	38.6	7.1	23
9.5	BRZ	1	2	19.7	6.4	0
9.5	BRZ	2	2	18.1	7.0	122
9.5	BRZ	1	3	28.4	6.4	0
9.5	BRZ	2	3	26.4	7.5	54
9.5	BRZ	1	4	38.2	7.2	0
9.5	BRZ	2	4	38.0	7.0	0
9.5	SMA	1	2	19.5	6.3	165
9.5	SMA	2	2	18.1	6.0	51
9.5	SMA	1	3	29.7	7.7	134
9.5	SMA	2	3	29.9	6.3	18
9.5	SMA	1	4	39.4	6.4	12
9.5	SMA	2	4	39.5	7.4	0
12.5	SMA	1	2	24.3	6.5	0
12.5	SMA	2	2	24.7	6.5	87
12.5	SMA	1	3	37.6	6.1	0
12.5	SMA	2	3	38.4	6.2	4
12.5	SMA	1	4	50.9	6.0	11
12.5	SMA	2	4	51.4	6.8	8
19	ARZ	1	2	38.9	8.0	27
19	ARZ	2	2	39.7	6.8	47
19	ARZ	1	3	59.4	7.9	25
19	ARZ	2	3	58.4	7.8	18
19	ARZ	1	4	76.3	7.1	12
19	ARZ	2	4	75.6	6.2	11
19	BRZ	1	2	38.4	6.9	0
19	BRZ	2	2	38.2	6.0	0
19	BRZ	1	3	57.8	6.1	0
19	BRZ	2	3	58.8	6.0	19
19	BRZ	1	4	74.6	6.1	0
19	BRZ	2	4	75.1	6.6	0
19	SMA	1	2	36.8	6.1	0
19	SMA	2	2	37.0	6.0	0
19	SMA	1	3	57.7	6.9	0
19	SMA	2	3	57.0	6.1	0
19	SMA	1	4	75.8	6.0	0
19	SMA	2	4	75.3	6.5	0

APPENDIX E

(FACTORS AFFENCTING PERMEABILITY DATA USING FIELD CORE SAMPLES)

Table E.1 Permeability Data for Core Samples

Site	NMAS	Gradation	N_{des}	Core No.	Height (cm)	Voids SSD (%)	Voids Corelok (%)	Water Abs. (%)	VMA Corelok (%)	Permeability ($x 10^{-5}$ cm/sec)
Project 1	9.5	C	86	1	32.8	8.78	8.80	0.40	19.4	69
Project 1	9.5	C	86	2	36.9	7.41	7.26	0.21	18.0	16
Project 1	9.5	C	86	3	35.8	7.51	7.75	0.26	18.5	9
Project 1	9.5	C	86	4	32.3	7.74	7.69	0.31	18.8	31
Project 1	9.5	C	86	5	31.3	9.77	9.53	0.60	20.4	249
Project 1	9.5	C	86	6	36.9	7.33	7.41	0.34	18.5	69
Project 2	9.5	C	90	1	43.1	9.14	11.17	0.90	*	343
Project 2	9.5	C	90	2	33.7	10.35	11.40	0.69	*	612
Project 2	9.5	C	90	3	44.1	10.71	12.66	1.65	*	880
Project 2	9.5	C	90	4	42.7	10.70	11.83	1.58	*	849
Project 2	9.5	C	90	5	43.4	7.87	10.05	0.59	*	90
Project 2	9.5	C	90	6	41.3	6.51	9.54	0.33	*	10
Project 2	9.5	C	90	7	42.0	10.43	13.13	1.56	*	768
Project 2	9.5	C	90	8	44.2	10.37	12.49	3.23	*	583
Project 2	9.5	C	90	9	37.5	9.05	10.52	0.54	*	239
Project 2	9.5	C	90	10	32.6	9.35	14.76	0.55	*	303
Project 3	9.5	C	90	1	44.8	8.40	9.50	0.60	18.7	63
Project 3	9.5	C	90	2	43.9	8.64	10.13	0.98	19.3	220
Project 3	9.5	C	90	3	46.7	8.15	9.70	0.66	18.9	112
Project 3	9.5	C	90	4	45.3	9.53	11.28	2.13	20.9	389
Project 3	9.5	C	90	5	45.8	8.76	11.05	1.19	20.7	209
Project 3	9.5	C	90	6	42.7	8.23	8.31	0.57	18.3	196
Project 3	9.5	C	90	7	38.9	9.23	11.64	0.59	20.4	129
Project 3	9.5	C	90	8	46.0	10.41	11.21	1.01	20.0	286
Project 3	9.5	C	90	9	46.2	10.61	13.23	1.56	21.8	319
Project 4	9.5	C	105	1	54.2	9.45	11.28	1.34	19.7	371
Project 4	9.5	C	105	2	50.7	9.41	10.71	1.41	19.2	494
Project 4	9.5	C	105	3	45.5	9.00	11.29	1.32	19.8	377
Project 4	9.5	C	105	4	43.5	7.38	9.29	0.64	18.3	79
Project 4	9.5	C	105	5	42.3	8.81	10.70	0.61	19.6	255
Project 4	9.5	C	105	6	38.7	8.48	10.47	0.48	19.4	206
Project 4	9.5	C	105	7	45.7	8.32	9.61	1.00	18.6	230
Project 4	9.5	C	105	8	44.9	7.06	8.16	0.69	17.3	102
Project 4	9.5	C	105	9	45.9	6.83	7.77	0.78	16.9	60
Project 5	9.5	C	50	1	47.7	15.97	16.87	3.49	26.5	1576
Project 5	9.5	C	50	2	35.5	14.98	14.75	0.94	24.6	983
Project 5	9.5	C	50	3	31.6	14.55	14.84	0.89	24.7	881
Project 5	9.5	C	50	4	27.2	19.82	21.12	2.05	31.0	3605
Project 5	9.5	C	50	5	28.9	15.40	15.60	1.32	26.2	3866
Project 5	9.5	C	50	6	16.4	17.28	18.85	1.38	29.0	2276
Project 6	9.5	C	100	1	37.1	8.81	9.06	0.41	18.6	166
Project 6	9.5	C	100	2	35.6	8.76	8.90	0.42	18.4	136
Project 6	9.5	C	100	3	29.3	8.42	8.69	0.43	18.2	73
Project 6	9.5	C	100	4	31.8	7.52	7.76	0.42	18.0	36
Project 6	9.5	C	100	5	37.0	8.32	8.40	0.37	18.6	124
Project 6	9.5	C	100	6	32.6	8.55	8.92	0.48	19.0	115

Table E.1 (Continued) Permeability Data for Core Samples

Site	NMAS	Gradation	N_{des}	Core #.	Height (cm)	Voids SSD (%)	Voids Corelok (%)	Water Abs. (%)	VMA Corelok (%)	Permeability (x 10^{-5} cm/sec)
Project 7	9.5	C	125	1	39.0	6.8	7.0	0.32	*	11
Project 7	9.5	C	125	2	36.6	5.1	5.3	0.17	*	6
Project 7	9.5	C	125	3	39.0	7.9	8.3	0.42	*	57
Project 7	9.5	C	125	4	23.8	8.7	9.2	0.31	*	46
Project 7	9.5	C	125	5	32.0	8.8	10.0	0.45	*	318
Project 7	9.5	C	125	6	38.8	8.3	8.9	0.41	*	342
Project 8	9.5	C	100	1	50.7	12.2	13.5	2.2	23.0	1619
Project 8	9.5	C	100	2	49.0	10.9	12.6	1.9	22.2	1152
Project 8	9.5	C	100	3	52.8	11.3	12.0	1.9	21.7	772
Project 8	9.5	C	100	4	44.1	10.1	11.0	1.5	20.7	535
Project 8	9.5	C	100	5	43.1	10.6	12.8	2.5	22.3	667
Project 8	9.5	C	100	6	41.0	9.3	10.7	1.3	20.4	360
Project 8	9.5	C	100	7	34.2	9.4	9.8	0.7	19.5	215
Project 8	9.5	C	100	8	36.0	7.0	8.0	0.3	17.9	23
Project 8	9.5	C	100	9	46.2	8.5	9.9	0.8	19.6	108
Project 9	9.5	C	100	1	27.4	12.6	13.4	0.9	22.3	998
Project 9	9.5	C	100	2	25.5	9.0	9.8	0.6	19.1	157
Project 9	9.5	C	100	3	23.9	9.4	10.2	0.7	19.4	142
Project 9	9.5	C	100	4	23.6	9.5	10.1	0.9	19.8	321
Project 9	9.5	C	100	5	18.1	9.2	10.0	0.7	19.7	356
Project 9	9.5	C	100	6	18.9	8.0	8.9	0.4	18.7	108
Project 9	9.5	C	100	7	20.8	9.0	10.0	0.7	20.0	314
Project 9	9.5	C	100	8	21.4	9.6	10.1	0.5	20.0	290
Project 9	9.5	C	100	9	21.3	11.3	11.4	0.9	21.2	362
Project 10	9.5	F	75	1	39.9	7.4	7.7	0.2	19.2	2
Project 10	9.5	F	75	2	44.5	5.5	5.7	0.1	17.4	1
Project 10	9.5	F	75	3	42.0	7.8	7.6	0.1	19.1	3
Project 10	9.5	F	75	4	37.2	7.1	7.0	0.2	18.5	7
Project 10	9.5	F	75	5	39.1	7.8	8.6	0.2	19.9	16
Project 11	9.5	F	75	1	32.7	10.4	10.8	0.4	*	200
Project 11	9.5	F	75	2	36.5	9.6	10.1	0.4	*	114
Project 11	9.5	F	75	3	32.9	9.4	9.8	0.4	*	108
Project 11	9.5	F	75	4	34.3	8.3	9.1	0.3	*	65
Project 11	9.5	F	75	5	29.9	12.5	13.4	0.7	*	695
Project 11	9.5	F	75	6	28.8	11.3	12.0	0.5	*	511
Project 11	9.5	F	75	7	28.7	12.6	16.5	0.8	*	1631
Project 11	9.5	F	75	8	31.1	9.5	9.4	0.2	*	53
Project 11	9.5	F	75	9	36.4	10.1	10.4	0.3	*	91
Project 12	12.5	C	106	1	40.6	11.6	12.6	1.3	24.0	275
Project 12	12.5	C	106	2	39.1	11.7	13.5	2.1	24.9	632
Project 13	12.5	C	100	1	41.0	13.5	19.6	3.5	27.1	8485
Project 13	12.5	C	100	2	41.7	14.1	21.3	2.6	28.7	12800
Project 13	12.5	C	100	3	48.1	11.3	15.4	2.3	23.7	3393
Project 13	12.5	C	100	4	42.0	12.0	14.4	2.2	22.6	2252
Project 13	12.5	C	100	5	39.0	11.4	13.6	1.3	21.9	1352

Table E.1 (Continued) Permeability Data for Core Samples

Site	NMAS	Gradation	N_{des}	Core #.	Height (cm)	Voids SSD (%)	Voids Corelok (%)	Water Abs. (%)	VMA Corelok (%)	Permeability ($x 10^{-5}$ cm/sec)
Project 14	12.5	C	100	1	30.1	11.6	13.7	0.8	23.9	840
Project 14	12.5	C	100	2	32.4	10.9	12.5	1.2	22.7	333
Project 14	12.5	C	100	3	29.9	11.4	13.3	0.7	23.5	752
Project 14	12.5	C	100	4	51.8	8.7	10.3	0.9	20.3	23
Project 14	12.5	C	100	5	45.2	10.1	11.6	0.9	21.5	324
Project 14	12.5	C	100	6	38.7	10.8	12.2	0.4	22.0	247
Project 15	12.5	C	75	1	36.0	8.0	8.5	0.3	18.3	13
Project 15	12.5	C	75	2	32.7	8.6	10.1	0.4	19.7	24
Project 15	12.5	C	75	3	35.7	12.3	14.2	1.0	23.4	213
Project 15	12.5	C	75	4	33.1	10.0	11.3	0.4	20.6	28
Project 15	12.5	C	75	5	30.3	9.7	10.9	0.3	20.3	226
Project 15	12.5	C	75	6	29.4	10.9	12.1	0.6	21.3	483
Project 15	12.5	C	75	7	33.7	9.2	11.0	0.3	20.3	32
Project 15	12.5	C	75	8	34.1	12.8	14.2	0.8	23.2	935
Project 15	12.5	C	75	9	38.7	12.3	13.3	1.1	22.4	560
Project 16	12.5	C	125	1	54.6	8.3	9.8	2.3	18.9	463
Project 16	12.5	C	125	2	55.5	6.0	7.3	1.1	16.6	48
Project 16	12.5	C	125	3	54.5	8.6	9.8	2.9	18.9	569
Project 16	12.5	C	125	4	51.9	8.1	9.5	2.1	18.9	340
Project 16	12.5	C	125	5	53.2	8.3	9.3	2.4	18.7	481
Project 16	12.5	C	125	6	54.1	8.0	9.0	2.8	18.4	256
Project 16	12.5	C	125	7	53.3	8.4	10.2	2.7	19.3	295
Project 16	12.5	C	125	8	52.4	8.7	9.6	2.2	18.7	451
Project 16	12.5	C	125	9	52.4	8.3	9.2	1.2	18.4	206
Project 17	12.5	C	125	1	55.8	11.3	12.3	3.4	18.5	1934
Project 17	12.5	C	125	2	44.5	11.7	13.3	2.6	19.5	3063
Project 17	12.5	C	125	3	46.7	10.3	11.4	2.7	17.7	812
Project 17	12.5	C	125	4	52.6	11.9	13.0	3.5	19.7	3639
Project 17	12.5	C	125	5	51.9	12.1	13.5	4.4	20.2	3584
Project 17	12.5	C	125	6	54.3	10.4	11.6	3.1	18.4	1245
Project 18	12.5	C	125	1	51.8	9.4	10.1	1.4	20.2	399
Project 18	12.5	C	125	2	52.9	8.7	9.5	1.2	19.7	226
Project 18	12.5	C	125	3	49.3	8.2	8.7	0.8	19.0	84
Project 18	12.5	C	125	4	53.9	9.6	12.3	1.7	21.9	392
Project 18	12.5	C	125	5	55.4	8.0	8.8	0.8	18.8	37
Project 18	12.5	C	125	6	53.4	9.0	10.1	1.2	19.9	291
Project 19	12.5	C	125	1	57.7	10.1	13.9	1.1	24.1	485
Project 19	12.5	C	125	2	56.8	9.3	10.3	1.4	21.0	231
Project 19	12.5	C	125	3	66.1	9.6	10.5	1.1	21.2	252
Project 19	12.5	C	125	4	57.8	10.3	11.0	1.2	22.1	453
Project 19	12.5	C	125	5	52.2	9.9	10.9	1.1	22.0	523
Project 19	12.5	C	125	6	49.6	8.2	9.1	0.9	20.5	164
Project 19	12.5	C	125	7	58.7	9.8	10.7	1.5	21.6	510
Project 19	12.5	C	125	8	57.1	9.9	10.9	1.3	21.8	396
Project 19	12.5	C	125	9	55.2	9.5	10.2	0.9	21.1	235

Table E.1 (Continued) Permeability Data for Core Samples

Site	NMAS	Gradation	N_{des}	Core #.	Height (cm)	Voids SSD (%)	Voids Corelok (%)	Water Abs. (%)	VMA Corelok (%)	Permeability (x 10^{-5} cm/sec)
Project 20	12.5	C	109	1	58.3	6.4	6.8	0.2	17.0	19
Project 20	12.5	C	109	2	49.8	7.3	7.4	0.3	17.5	59
Project 20	12.5	C	109	3	47.9	7.6	11.1	0.3	20.9	88
Project 20	12.5	C	109	4	50.6	6.8	7.1	0.1	17.0	5
Project 20	12.5	C	109	5	43.9	6.5	6.6	0.3	16.6	8
Project 20	12.5	C	109	6	53.1	6.7	7.5	0.3	17.4	53
Project 21	12.5	C	86	1	61.8	6.5	7.9	1.5	17.8	36
Project 21	12.5	C	86	2	62.0	6.1	7.3	1.3	17.2	36
Project 21	12.5	C	86	3	61.4	5.5	6.5	1.1	16.5	28
Project 21	12.5	C	86	4	46.3	6.5	6.6	0.4	16.8	195
Project 21	12.5	C	86	5	54.7	6.5	7.3	1.3	17.4	172
Project 21	12.5	C	86	6	33.6	5.4	5.5	0.2	15.8	48
Project 21	12.5	C	86	7	39.4	6.7	7.3	0.3	17.0	119
Project 21	12.5	C	86	8	34.8	6.4	7.0	0.1	16.7	48
Project 21	12.5	C	86	9	34.8	7.1	7.4	0.3	17.0	148
Project 22	12.5	C	100	1	44.0	3.8	6.9	0.1	*	1
Project 22	12.5	C	100	2	47.1	5.1	5.6	0.2	*	1
Project 22	12.5	C	100	3	37.0	6.0	5.9	0.2	*	1
Project 22	12.5	C	100	4	37.5	4.9	4.8	0.2	*	4
Project 22	12.5	C	100	5	56.6	5.2	5.5	0.3	*	1
Project 22	12.5	C	100	6	43.7	4.1	4.5	0.1	*	1
Project 22	12.5	C	100	7	42.0	5.0	5.1	0.2	*	1
Project 22	12.5	C	100	8	54.3	6.2	6.5	0.3	*	1
Project 22	12.5	C	100	9	35.0	7.0	7.0	0.2	*	7
Project 23	12.5	C	125	1	52.8	8.4	10.6	0.5	*	396
Project 23	12.5	C	125	2	54.2	9.8	11.9	0.9	*	1574
Project 23	12.5	C	125	3	49.6	4.8	5.8	0.1	*	1
Project 23	12.5	C	125	4	52.2	7.6	9.6	0.3	*	94
Project 23	12.5	C	125	5	50.4	6.9	9.1	0.3	*	120
Project 23	12.5	C	125	6	52.2	6.4	7.5	0.2	*	18
Project 23	12.5	C	125	7	48.8	7.8	10.0	0.3	*	111
Project 23	12.5	C	125	8	50.9	6.6	8.4	0.3	*	2
Project 23	12.5	C	125	9	48.6	7.8	9.0	0.4	*	20
Project 24	12.5	C	100	1	67.2	10.4	11.4	1.3	22.0	166
Project 24	12.5	C	100	2	65.5	9.0	9.2	0.6	20.1	29
Project 24	12.5	C	100	3	64.8	6.6	7.6	0.3	18.7	1
Project 24	12.5	C	100	4	90.4	9.2	10.1	2.5	20.4	3
Project 24	12.5	C	100	5	93.2	8.9	9.7	2.1	20.0	1
Project 24	12.5	C	100	6	93.9	9.6	10.0	2.0	20.3	80
Project 24	12.5	C	100	7	84.2	8.4	8.7	0.8	19.7	86
Project 24	12.5	C	100	8	78.8	8.3	8.6	1.1	19.6	137
Project 24	12.5	C	100	9	71.4	7.5	8.2	0.6	19.3	24

Table E.1 (Continued) Permeability Data for Core Samples

Site	NMAS	Gradation	N_{des}	Core #.	Height (cm)	Voids SSD (%)	Voids Corelok (%)	Water Abs. (%)	VMA Corelok (%)	Permeability (x 10^{-5} cm/sec)
Project 25	12.5	C	125	1	49.4	7.3	9.0	0.6	18.7	16
Project 25	12.5	C	125	2	46.5	6.1	7.8	0.3	17.6	1
Project 25	12.5	C	125	3	47.2	6.5	8.3	0.2	18.1	10
Project 25	12.5	C	125	4	50.5	7.0	8.5	0.4	18.6	83
Project 25	12.5	C	125	5	48.8	7.0	8.5	0.4	18.5	52
Project 25	12.5	C	125	6	50.6	6.9	8.1	0.4	18.2	48
Project 25	12.5	C	125	7	47.6	6.0	7.5	0.2	17.7	22
Project 25	12.5	C	125	8	47.5	5.7	6.9	0.1	17.1	1
Project 25	12.5	C	125	9	47.3	6.2	8.2	0.2	18.3	32
Project 26	12.5	C	100	1	39.0	7.3	7.2	0.1	17.1	14
Project 26	12.5	C	100	2	40.9	8.5	8.8	0.1	18.4	26
Project 26	12.5	C	100	3	36.5	8.8	8.7	0.3	18.4	27
Project 26	12.5	C	100	4	35.7	5.9	5.8	0.1	16.0	6
Project 26	12.5	C	100	5	33.7	6.5	6.5	0.1	16.6	16
Project 26	12.5	C	100	6	35.6	7.7	7.4	0.2	17.4	55
Project 26	12.5	C	100	7	29.5	7.8	7.7	0.2	18.1	119
Project 26	12.5	C	100	8	37.8	8.8	9.0	0.2	19.2	61
Project 26	12.5	C	100	9	38.1	8.2	7.8	0.1	18.1	66
Project 27	12.5	F	86	1	53.2	3.7	4.2	0.2	16.2	1
Project 27	12.5	F	86	2	51.4	5.2	5.6	0.1	17.4	4
Project 27	12.5	F	86	3	53.1	5.1	5.6	0.1	17.4	15
Project 27	12.5	F	86	4	45.5	5.2	6.8	0.1	17.8	4
Project 27	12.5	F	86	5	45.7	5.6	6.8	0.2	17.8	1
Project 27	12.5	F	86	6	50.5	6.2	6.6	0.2	17.6	18
Project 27	12.5	F	86	7	57.0	6.4	7.4	0.2	18.3	24
Project 27	12.5	F	86	8	61.3	5.4	6.0	0.1	17.1	2
Project 27	12.5	F	86	9	62.3	5.3	6.5	0.1	17.5	9
Project 28	12.5	F	86	1	32.9	6.9	7.2	0.8	18.0	44
Project 28	12.5	F	86	2	31.8	8.3	8.7	0.8	19.3	125
Project 28	12.5	F	86	3	39.4	7.3	7.6	0.3	18.3	48
Project 28	12.5	F	86	4	50.5	9.0	9.5	0.9	19.7	143
Project 28	12.5	F	86	5	50.8	9.1	9.7	0.9	19.8	150
Project 28	12.5	F	86	6	50.2	8.7	9.1	0.5	19.3	127
Project 28	12.5	F	86	7	49.1	9.3	9.7	1.0	19.8	242
Project 28	12.5	F	86	8	47.9	9.2	9.6	0.9	19.7	172
Project 28	12.5	F	86	9	46.2	9.3	10.1	0.7	20.2	148
Project 29	12.5	F	125	1	26.7	8.9	9.0	0.3	18.4	40
Project 29	12.5	F	125	2	37.5	9.7	9.4	0.2	18.7	54
Project 29	12.5	F	125	3	35.1	12.2	12.0	0.2	21.1	81
Project 29	12.5	F	125	4	41.9	8.7	9.0	0.3	18.5	52
Project 29	12.5	F	125	5	38.7	11.1	11.5	0.4	20.7	149
Project 29	12.5	F	125	6	40.0	11.0	11.0	0.1	20.2	71
Project 29	12.5	F	125	7	60.5	10.8	10.6	0.3	19.6	132
Project 29	12.5	F	125	8	66.1	10.5	10.8	0.3	19.7	107
Project 29	12.5	F	125	9	66.0	9.7	10.1	0.3	19.1	88
Project 30	12.5	F	68	1	47.5	8.1	8.7	0.3	25.4	25
Project 30	12.5	F	68	2	38.4	7.0	7.1	0.3	24.4	4
Project 30	12.5	F	68	3	38.2	9.4	9.2	0.2	26.1	35
Project 30	12.5	F	68	4	34.9	8.1	8.1	0.3	25.2	11

Table E.1 (Continued) Permeability Data for Core Samples

Site	NMAS	Gradation	N_{des}	Core #.	Height (cm)	Voids SSD (%)	Voids Corelok (%)	Water Abs. (%)	VMA Corelok (%)	Permeability (x 10^{-5} cm/sec)
Project 31	12.5	F	76	1	56.4	9.8	11.1	0.4	*	163
Project 31	12.5	F	76	2	55.3	10.0	10.9	0.4	*	212
Project 31	12.5	F	76	3	52.6	9.7	10.3	0.2	*	137
Project 31	12.5	F	76	4	53.1	7.1	7.9	0.2	*	76
Project 31	12.5	F	76	5	51.8	9.1	9.6	1.0	*	116
Project 31	12.5	F	76	6	51.5	9.9	10.9	0.9	*	107
Project 31	12.5	F	76	7	47.6	8.7	9.7	0.4	*	103
Project 31	12.5	F	76	8	46.3	8.7	9.9	0.4	*	61
Project 31	12.5	F	76	9	46.3	10.2	12.3	0.6	*	141
Project 32	12.5	F	109	1	64.4	8.2	8.7	0.5	*	3
Project 32	12.5	F	109	2	59.1	8.1	8.9	0.5	*	37
Project 32	12.5	F	109	3	64.1	7.7	7.6	0.4	*	5
Project 32	12.5	F	109	4	52.4	7.9	7.9	0.3	*	20
Project 32	12.5	F	109	5	51.3	7.9	7.7	0.4	*	38
Project 32	12.5	F	109	6	52.6	7.1	7.3	0.5	*	218
Project 32	12.5	F	109	7	51.9	8.1	8.6	0.3	*	125
Project 32	12.5	F	109	8	49.6	8.7	9.0	0.5	*	160
Project 32	12.5	F	109	9	51.8	7.7	7.9	0.4	*	97
Project 33	12.5	F	100	1	35.6	9.9	11.1	1.0	21.0	326
Project 33	12.5	F	100	2	34.2	11.1	12.3	1.1	22.0	590
Project 33	12.5	F	100	3	34.9	12.6	13.2	1.2	22.9	797
Project 33	12.5	F	100	4	32.4	10.5	11.2	0.8	20.8	381
Project 33	12.5	F	100	5	31.6	10.7	11.7	0.9	21.3	337
Project 33	12.5	F	100	6	31.5	8.9	9.5	0.7	19.4	175
Project 33	12.5	F	100	7	32.5	7.3	8.3	0.4	18.3	45
Project 33	12.5	F	100	8	39.6	6.7	6.9	0.3	17.1	28
Project 33	12.5	F	100	9	41.0	8.6	9.5	0.8	19.4	182
Project 34	12.5	F	75	1	32.3	8.4	8.2	0.4	17.5	95
Project 34	12.5	F	75	2	32.0	7.7	7.3	0.2	16.7	27
Project 34	12.5	F	75	3	41.4	9.2	9.2	0.4	18.4	121
Project 34	12.5	F	75	4	46.5	6.3	6.8	0.5	16.6	64
Project 34	12.5	F	75	5	46.7	6.1	6.5	0.3	16.3	33
Project 34	12.5	F	75	6	52.5	8.2	8.6	0.9	18.2	156
Project 34	12.5	F	75	7	26.2	10.5	10.3	0.5	19.5	235
Project 34	12.5	F	75	8	22.5	10.5	10.3	0.3	19.5	252
Project 34	12.5	F	75	9	47.8	9.4	9.6	0.6	18.8	313
Project 35	19	F	95	1	47.5	7.9	7.8	0.2	17.0	2
Project 35	19	F	95	2	36.8	7.2	7.2	0.0	16.4	2
Project 35	19	F	95	3	37.3	10.7	10.1	0.4	19.1	29
Project 35	19	F	95	4	33.2	7.8	9.3	0.5	18.9	8
Project 35	19	F	95	5	17.7	8.4	8.2	0.6	17.9	9
Project 35	19	F	95	6	25.6	8.3	7.8	0.6	17.5	20

Table E.1 (Continued) Permeability Data for Core Samples

Site	NMAS	Gradation	N_{des}	Core #.	Height (cm)	Voids SSD (%)	Voids Corelok (%)	Water Abs. (%)	VMA Corelok (%)	Permeability (10^{-5} cm/sec)
Project 36	19	F	68	1	48.1	8.6	8.7	0.2	17.8	73
Project 36	19	F	68	2	51.9	9.5	9.0	0.3	18.0	132
Project 36	19	F	68	3	49.0	9.4	9.1	0.3	18.1	120
Project 36	19	F	68	4	57.8	4.2	3.5	0.1	13.6	1
Project 36	19	F	68	5	51.2	5.3	5.0	0.1	15.0	2
Project 36	19	F	68	6	32.9	6.9	6.7	0.1	16.5	15
Project 36	19	F	68	7	58.6	5.2	5.4	0.1	14.8	1
Project 36	19	F	68	8	59.1	5.2	5.3	0.1	14.7	1
Project 36	19	F	68	9	37.6	5.2	5.3	0.1	14.7	1
Project 37	19	F	96	1	47.9	7.2	7.2	0.1	17.0	9
Project 37	19	F	96	2	48.3	6.2	6.4	0.1	16.3	14
Project 37	19	F	96	3	51.2	6.2	6.2	0.1	16.2	4
Project 37	19	F	96	4	40.4	7.2	7.0	0.2	16.9	17
Project 37	19	F	96	5	49.8	7.1	7.1	0.2	16.9	11
Project 37	19	F	96	6	48.3	7.1	7.1	0.1	16.9	15
Project 37	19	F	96	7	48.6	7.1	7.0	0.1	16.7	11
Project 37	19	F	96	8	51.0	6.7	6.8	0.1	16.5	8
Project 37	19	F	96	9	52.7	7.6	7.9	0.2	17.5	21

Table E. 2 Information on Mix Gradation

Site	NMAS	Gradation	Percent Passing on Sieve										Coarse
			19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	0.6 mm	0.3 mm	0.15 mm	0.075 mm	Agg. Ratio
Project 1	9.5	C	100.0	99.7	96.7	63.1	39.1	27.3	19.0	9.0	5.2	3.8	2.7
Project 2	9.5	C	100.0	100.0	99.8	58.9	30.8	21.4	16.1	9.0	6.2	5.1	3.7
Project 3	9.5	C	100.0	97.0	90.4	53.2	32.1	19.7	12.6	8.7	6.7	5.2	4.1
Project 4	9.5	C	100.0	100.0	98.2	58.1	31.2	19.7	12.8	7.8	5.9	5.2	4.1
Project 5	9.5	C	100.0	99.6	94.0	64.9	39.6	27.1	19.0	12.5	9.0	6.4	2.7
Project 6	9.5	C	100.0	100.0	96.7	60.9	30.0	17.8	12.7	9.6	7.0	4.9	4.6
Project 7	9.5	C	100.0	99.9	98.7	71.4	37.5	21.8	14.6	10.0	7.0	5.6	3.6
Project 8	9.5	C	100.0	99.8	92.1	58.1	38.7	24.5	15.8	10.2	7.0	5.2	3.1
Project 9	9.5	C	100.0	99.9	89.8	51.8	35.3	22.1	14.7	9.9	7.2	5.3	3.5
Project 10	9.5	F	100.0	99.9	99.1	82.0	58.0	38.6	25.7	15.3	8.6	5.2	1.6
Project 11	9.5	F	100.0	100.0	99.8	81.5	57.9	42.1	30.2	16.5	7.9	4.6	1.4
Project 12	12.5	C	100.0	95.4	80.1	46.3	31.5	24.2	17.9	11.2	7.0	4.8	2.2
Project 13	12.5	C	100.0	98.4	90.8	47.0	27.2	19.9	15.5	10.8	7.2	5.1	2.7
Project 14	12.5	C	100.0	91.2	77.4	47.8	31.5	22.5	14.0	6.7	4.2	2.7	2.2
Project 15	12.5	C	100.0	97.3	88.0	55.4	37.3	28.9	21.1	11.7	6.7	4.7	1.7
Project 16	12.5	C	100.0	94.8	76.6	42.8	26.5	18.8	14.9	12.5	8.8	5.6	2.8
Project 17	12.5	C	100.0	93.2	83.9	40.4	26.4	20.0	16.0	11.8	8.1	5.8	2.8
Project 18	12.5	C	99.9	94.9	83.8	48.2	28.9	19.2	14.3	11.4	9.5	6.1	2.5
Project 19	12.5	C	100.0	95.0	84.0	55.0	37.0	25.0	18.0	11.0	7.0	4.6	1.7
Project 20	12.5	C	100.0	94.0	81.3	59.5	37.9	26.2	18.7	13.1	8.2	4.9	1.6
Project 21	12.5	C	100.0	98.6	86.7	50.0	31.3	23.9	18.3	12.5	8.2	5.2	2.2
Project 22	12.5	C	100.0	97.1	87.3	54.5	37.3	29.9	24.0	16.4	9.1	5.3	1.7
Project 23	12.5	C	99.9	96.5	83.2	48.4	26.5	15.7	10.3	7.5	6.3	5.1	2.8
Project 24	12.5	C	100.0	98.7	88.6	56.1	36.2	24.0	17.5	13.5	11.3	9.4	1.8
Project 25	12.5	C	100.0	98.6	90.3	56.2	30.6	19.2	13.5	10.3	8.5	7.1	2.3
Project 25	12.5	C	100.0	98.6	90.3	56.2	30.6	19.2	13.5	10.3	8.5	7.1	2.3
Project 26	12.5	C	100.0	97.7	90.1	62.4	42.4	29.0	18.5	9.2	4.8	3.2	1.4

Table E. 2 (Continued) Information on Mix Gradation

Site	NMAS	Gradation	Percent Passing on Sieve										Coarse
			19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	0.6 mm	0.3 mm	0.15 mm	0.075 mm	Agg. Ratio
Project 27	12.5	F	100.0	96.4	87.6	63.3	44.7	33.0	24.3	16.2	10.2	6.4	1.2
Project 28	12.5	F	100.0	96.0	85.8	60.5	40.4	28.3	19.4	11.8	7.0	4.3	1.5
Project 29	12.5	F	100.0	95.5	84.6	55.3	41.7	33.0	24.4	16.2	9.4	5.5	1.4
Project 30	12.5	F	99.8	94.0	88.2	76.4	51.4	29.8	18.0	9.3	5.4	3.9	0.9
Project 31	12.5	F	99.6	93.3	87.5	77.6	55.5	34.4	20.6	9.4	4.6	2.9	0.8
Project 32	12.5	F	99.2	94.8	89.2	70.6	48.6	33.5	23.2	14.9	9.7	6.1	1.1
Project 33	12.5	F	100.0	96.2	81.8	53.0	40.9	31.2	23.3	10.4	4.9	3.7	1.4
Project 34	12.5	F	100.0	99.1	88.7	61.5	43.5	29.5	20.4	13.1	7.4	4.7	1.3
Project 35	19	F	99.6	88.5	80.1	69.0	52.3	39.2	26.9	16.1	9.7	6.0	0.4
Project 36	19	F	100.0	87.0	74.6	57.2	41.8	31.3	23.8	16.9	10.9	7.3	0.7
Project 37	19	F	99.9	94.5	87.8	70.6	49.5	33.3	23.5	13.9	7.7	5.1	0.4

TASK 3 – PART 3

APPENDIX A
INFORMATION ON 40 SAMPLES FOR
SATURATION TIME EXPERIMENT

Table A.1 Information on 40 Samples for Time Experiment

				Masses												
Agg.	NMAS	Grad.	Gyr.	Dry (g)	Sub., 6 sec (g)	SSD, 6 sec (g)	Sub., 10 sec	SSD, 10 sec	Sub., 15 sec	SSD, 15 sec	Sub., 20 sec	SSD, 20 sec	Sub., 30 sec	SSD, 30 sec	Sub., 60 sec	SSD, 60 sec
Granite	9.5	ARZ	15	4419.6	2440.5	4438.4	2443.0	4440.5	2445.3	4441.2	2445.5	4442.8	2446.7	4443.7	2448.0	4444.5
Granite	9.5	BRZ	15	4499.5	2543.9	4575.2	2552.7	4581.7	2551.0	4578.0	2549.9	4577.1	2547.7	4571.5	2545.4	4568.3
Granite	9.5	SMA	15	4346.0	2398.0	4414.2	2394.5	4408.8	2391.0	4404.4	2389.7	4401.8	2389.5	4399.4	2386.1	4398.4
Granite	9.5	TRZ	15	4487.9	2529.5	4528.2	2531.4	4528.7	2532.3	4529.0	2533.8	4528.8	2535.0	4528.5	2534.9	4527.8
Granite	9.5	BRZ	50	4697.0	2701.2	4727.8	2701.5	4727.2	2701.6	4726.5	2700.8	4725.3	2701.2	4724.7	2700.7	4724.4
Granite	9.5	SMA	50	4539.1	2570.0	4555.2	2571.6	4554.0	2571.9	4552.7	2571.1	4551.8	2571.5	4551.7	2570.4	4550.4
Granite	9.5	TRZ	50	4692.9	2689.4	4709.0	2690.2	4710.9	2690.9	4711.9	2690.9	4712.3	2692.6	4713.6	2694.0	4713.8
Granite	9.5	ARZ	125	4803.9	2756.2	4805.3	2753.7	4805.8	2755.1	4805.8	2756.0	4806.1	2755.9	4806.4	2755.2	4806.4
Granite	9.5	BRZ	125	4849.3	2823.9	4862.6	2824.7	4861.4	2825.3	4861.4	2825.3	4860.1	2823.4	4860.4	2825.6	4859.8
Granite	12.5	SMA	15	4382.0	2447.4	4438.3	2447.7	4425.2	2441.9	4419.0	2442.3	4416.5	2443.6	4419.5	2445.4	4411.4
Granite	12.5	SMA	50	4562.8	2605.1	4592.6	2602.5	4590.3	2601.0	4587.3	2602.5	4585.4	2604.0	4583.8	2602.0	4584.4
Granite	19.0	BRZ	15	4586.9	2627.3	4638.3	2621.4	4633.6	2620.6	4629.6	2623.9	4630.0	2620.7	4626.9	2620.9	4623.9
Granite	19.0	SMA	15	4398.2	2499.3	4479.6	2500.9	4462.7	2498.7	4463.7	2499.6	4459.6	2502.0	4451.7	2499.1	4452.1
Granite	19.0	BRZ	50	4784.6	2797.4	4810.9	2800.5	4808.3	2800.0	4806.9	2798.6	4805.0	2799.0	4805.1	2798.5	4803.7
Granite	19.0	ARZ	125	4889.6	2867.7	4901.6	2868.5	4900.3	2867.7	4899.5	2866.5	4900.0	2867.2	4898.0	2867.8	4899.8
Granite	19.0	SMA	125	4752.3	2784.4	4762.5	2783.2	4760.6	2782.9	4762.1	2783.2	4760.0	2784.4	4760.0	2784.3	4759.3
Granite	37.5	BRZ	15	4397.4	2595.4	4467.8	2597.2	4468.6	2596.6	4453.3	2585.0	4452.6	2586.2	4437.8	2585.4	4430.8
Granite	37.5	BRZ	50	4735.4	2811.6	4792.7	2808.0	4790.0	2808.4	4787.0	2812.8	4782.6	2809.9	4779.8	2810.9	4780.2
Granite	37.5	TRZ	125	4967.6	2958.6	5000.2	2960.5	5003.3	2962.0	5003.5	2964.2	5002.5	2962.3	5005.8	2963.9	5002.4
Limestone	9.5	ARZ	15	4517.5	2539.9	4542.9	2552.0	4553.2	2557.7	4557.5	2562.0	4560.4	2565.2	4562.5	2567.7	4564.8
Limestone	9.5	BRZ	15	4590.2	2612.0	4674.3	2616.8	4674.4	2618.8	4673.1	2618.6	4674.2	2616.8	4669.7	2614.2	4665.2
Limestone	9.5	SMA	15	4462.5	2517.4	4525.1	2518.7	4521.0	2517.5	4517.1	2512.4	4511.8	2514.3	4513.7	2512.4	4512.6
Limestone	9.5	TRZ	15	4619.1	2662.0	4685.3	2676.8	4697.4	2676.2	4696.3	2674.9	4695.0	2674.8	4693.2	2673.8	4689.4
Limestone	9.5	BRZ	50	4795.4	2781.1	4826.8	2784.2	4828.1	2786.0	4828.1	2786.7	4827.9	2784.9	4828.5	2786.4	4827.3
Limestone	9.5	TRZ	50	4825.3	2839.8	4850.1	2839.4	4850.3	2839.4	4851.6	2840.9	4851.7	2840.2	4851.3	2840.4	4851.1
Limestone	9.5	ARZ	125	4872.9	2849.2	4875.6	2849.9	4875.8	2848.8	4876.2	2850.2	4876.0	2851.3	4876.8	2850.5	4876.8
Limestone	9.5	BRZ	125	4953.7	2932.7	4967.2	2931.7	4965.7	2933.4	4965.0	2931.4	4965.4	2932.1	4964.2	2931.1	4964.4
Limestone	9.5	SMA	125	4829.5	2869.8	4831.7	2870.8	4832.0	2871.6	4832.4	2872.2	4832.3	2871.2	4831.8	2871.7	4831.7
Limestone	12.5	SMA	15	4392.6	2461.6	4438.4	2461.9	4434.2	2461.4	4431.4	2462.1	4432.6	2458.0	4427.5	2458.2	4426.3
Limestone	12.5	SMA	50	4588.0	2631.7	4600.1	2631.4	4598.3	2632.8	4597.8	2633.0	4597.2	2634.2	4596.0	2634.5	4595.7
Limestone	19.0	ARZ	15	4650.2	2696.2	4688.2	2698.1	4690.5	2699.9	4691.7	2702.0	4692.4	2703.0	4693.2	2703.8	4692.8
Limestone	19.0	BRZ	15	4601.5	2639.1	4669.2	2637.4	4664.6	2636.6	4660.9	2635.5	4657.8	2635.5	4654.6	2632.6	4652.7
Limestone	19.0	SMA	15	4409.3	2539.4	4474.8	2530.1	4471.8	2530.2	4465.1	2526.2	4458.9	2533.4	4461.3	2528.2	4456.7
Limestone	19.0	SMA	50	4662.1	2724.1	4679.0	2722.2	4677.9	2722.4	4677.1	2722.5	4675.3	2722.3	4673.4	2721.9	4674.3
Limestone	19.0	ARZ	125	5014.9	2996.4	5020.3	2996.8	5020.4	2997.6	5021.2	2997.3	5020.8	2997.7	5020.5	2998.3	5020.5
Limestone	19.0	BRZ	125	4963.1	2964.4	4975.2	2965.7	4976.1	2967.4	4974.0	2966.2	4974.7	2964.8	4976.6	2967.4	4973.6
Limestone	37.5	TRZ	50	4904.4	2953.6	4959.8	2950.5	4957.7	2951.7	4955.4	2950.6	4951.2	2949.9	4950.3	2953.3	4942.0
Limestone	37.5	ARZ	125	5074.1	3059.9	5092.2	3057.5	5092.0	3057.1	5092.1	3059.1	5090.9	3057.3	5090.0	3056.9	5089.1
Limestone	37.5	BRZ	125	5041.3	3058.4	5076.3	3061.5	5075.4	3062.5	5070.7	3059.6	5068.9	3060.5	5067.7	3060.1	5067.1
Limestone	37.5	TRZ	125	5085.6	3085.6	5115.5	3087.7	5112.8	3086.2	5111.9	3088.2	5112.6	3087.1	5113.3	3089.3	5109.1

Table A.2 Information on 40 Samples for Time Experiment

Agg.	NMAS	Grad.	Gyr.	G_{mb} at 6 s	G_{mb} at 10 s	G_{mb} at 15 s	G_{mb} at 20 s	G_{mb} at 30 s	G_{mb} at 60 s
Granite	9.5	ARZ	15	2.212	2.213	2.214	2.213	2.213	2.214
Granite	9.5	BRZ	15	2.215	2.218	2.220	2.220	2.223	2.224
Granite	9.5	SMA	15	2.156	2.158	2.159	2.160	2.162	2.160
Granite	9.5	TRZ	15	2.245	2.247	2.248	2.250	2.251	2.252
Granite	9.5	BRZ	50	2.318	2.319	2.320	2.320	2.321	2.321
Granite	9.5	SMA	50	2.286	2.290	2.292	2.292	2.292	2.292
Granite	9.5	TRZ	50	2.324	2.322	2.322	2.322	2.322	2.323
Granite	9.5	ARZ	125	2.344	2.341	2.343	2.343	2.343	2.342
Granite	9.5	BRZ	125	2.379	2.381	2.382	2.383	2.381	2.384
Granite	12.5	SMA	15	2.201	2.216	2.216	2.220	2.218	2.229
Granite	12.5	SMA	50	2.296	2.295	2.297	2.301	2.305	2.302
Granite	19.0	BRZ	15	2.281	2.280	2.283	2.286	2.286	2.290
Granite	19.0	SMA	15	2.221	2.242	2.238	2.244	2.256	2.252
Granite	19.0	BRZ	50	2.376	2.383	2.384	2.385	2.385	2.386
Granite	19.0	ARZ	125	2.404	2.407	2.407	2.405	2.408	2.406
Granite	19.0	SMA	125	2.402	2.403	2.401	2.404	2.405	2.406
Granite	37.5	BRZ	15	2.349	2.350	2.368	2.355	2.375	2.383
Granite	37.5	BRZ	50	2.390	2.389	2.393	2.404	2.404	2.405
Granite	37.5	TRZ	125	2.433	2.432	2.433	2.437	2.431	2.437
Limestone	9.5	ARZ	15	2.255	2.257	2.259	2.261	2.262	2.262
Limestone	9.5	BRZ	15	2.226	2.231	2.234	2.233	2.236	2.238
Limestone	9.5	SMA	15	2.223	2.229	2.232	2.232	2.232	2.231
Limestone	9.5	TRZ	15	2.283	2.286	2.287	2.287	2.288	2.292
Limestone	9.5	BRZ	50	2.344	2.346	2.348	2.349	2.347	2.350
Limestone	9.5	TRZ	50	2.400	2.400	2.398	2.400	2.399	2.400
Limestone	9.5	ARZ	125	2.405	2.405	2.404	2.405	2.406	2.405
Limestone	9.5	BRZ	125	2.435	2.435	2.438	2.435	2.438	2.436
Limestone	9.5	SMA	125	2.462	2.463	2.463	2.464	2.463	2.464
Limestone	12.5	SMA	15	2.222	2.227	2.230	2.229	2.230	2.232
Limestone	12.5	SMA	50	2.331	2.333	2.335	2.336	2.339	2.339
Limestone	19.0	ARZ	15	2.334	2.334	2.335	2.336	2.337	2.338
Limestone	19.0	BRZ	15	2.267	2.270	2.273	2.275	2.279	2.278
Limestone	19.0	SMA	15	2.278	2.271	2.279	2.281	2.287	2.286
Limestone	19.0	SMA	50	2.385	2.384	2.385	2.387	2.389	2.388
Limestone	19.0	ARZ	125	2.478	2.478	2.478	2.478	2.479	2.480
Limestone	19.0	BRZ	125	2.468	2.469	2.473	2.471	2.467	2.474
Limestone	37.5	TRZ	50	2.445	2.443	2.448	2.451	2.452	2.466
Limestone	37.5	ARZ	125	2.497	2.494	2.493	2.497	2.496	2.497
Limestone	37.5	BRZ	125	2.498	2.503	2.510	2.509	2.512	2.512
Limestone	37.5	TRZ	125	2.505	2.511	2.511	2.512	2.510	2.518

Table A.3 Information on 40 Samples for Time Experiment

Agg.	NMAS	Grad.	Gyr.	Absorb. At 6 s	Absorb. At 10 s	Absorb. At 15 s	Absorb. At 20 s	Absorb. At 30 s	Absorb. At 60 s
Granite	9.5	ARZ	15	0.94	1.05	1.08	1.16	1.21	1.25
Granite	9.5	BRZ	15	3.73	4.05	3.87	3.83	3.56	3.40
Granite	9.5	SMA	15	3.38	3.12	2.90	2.77	2.66	2.60
Granite	9.5	TRZ	15	2.02	2.04	2.06	2.05	2.04	2.00
Granite	9.5	BRZ	50	1.52	1.49	1.46	1.40	1.37	1.35
Granite	9.5	SMA	50	0.81	0.75	0.69	0.64	0.64	0.57
Granite	9.5	TRZ	50	0.80	0.89	0.94	0.96	1.02	1.03
Granite	9.5	ARZ	125	0.07	0.09	0.09	0.11	0.12	0.12
Granite	9.5	BRZ	125	0.65	0.59	0.59	0.53	0.54	0.52
Granite	12.5	SMA	15	2.83	2.18	1.87	1.75	1.90	1.50
Granite	12.5	SMA	50	1.50	1.38	1.23	1.14	1.06	1.09
Granite	19.0	BRZ	15	2.56	2.32	2.13	2.15	1.99	1.85
Granite	19.0	SMA	15	4.11	3.29	3.33	3.13	2.74	2.76
Granite	19.0	BRZ	50	1.31	1.18	1.11	1.02	1.02	0.95
Granite	19.0	ARZ	125	0.59	0.53	0.49	0.51	0.41	0.50
Granite	19.0	SMA	125	0.52	0.42	0.50	0.39	0.39	0.35
Granite	37.5	BRZ	15	3.76	3.80	3.01	2.96	2.18	1.81
Granite	37.5	BRZ	50	2.89	2.75	2.61	2.40	2.25	2.27
Granite	37.5	TRZ	125	1.60	1.75	1.76	1.71	1.87	1.71
Limestone	9.5	ARZ	15	1.27	1.78	2.00	2.15	2.25	2.37
Limestone	9.5	BRZ	15	4.08	4.09	4.04	4.09	3.87	3.66
Limestone	9.5	SMA	15	3.12	2.92	2.73	2.47	2.56	2.50
Limestone	9.5	TRZ	15	3.27	3.88	3.82	3.76	3.67	3.49
Limestone	9.5	BRZ	50	1.53	1.60	1.60	1.59	1.62	1.56
Limestone	9.5	TRZ	50	1.23	1.24	1.31	1.31	1.29	1.28
Limestone	9.5	ARZ	125	0.13	0.14	0.16	0.15	0.19	0.19
Limestone	9.5	BRZ	125	0.66	0.59	0.56	0.58	0.52	0.53
Limestone	9.5	SMA	125	0.11	0.13	0.15	0.14	0.12	0.11
Limestone	12.5	SMA	15	2.32	2.11	1.97	2.03	1.77	1.71
Limestone	12.5	SMA	50	0.61	0.52	0.50	0.47	0.41	0.39
Limestone	19.0	ARZ	15	1.91	2.02	2.08	2.12	2.16	2.14
Limestone	19.0	BRZ	15	3.33	3.11	2.93	2.78	2.63	2.53
Limestone	19.0	SMA	15	3.38	3.22	2.88	2.57	2.70	2.46
Limestone	19.0	SMA	50	0.86	0.81	0.77	0.68	0.58	0.62
Limestone	19.0	ARZ	125	0.27	0.27	0.31	0.29	0.28	0.28
Limestone	19.0	BRZ	125	0.60	0.65	0.54	0.58	0.67	0.52
Limestone	37.5	TRZ	50	2.76	2.66	2.55	2.34	2.29	1.89
Limestone	37.5	ARZ	125	0.89	0.88	0.88	0.83	0.78	0.74
Limestone	37.5	BRZ	125	1.73	1.69	1.46	1.37	1.32	1.29
Limestone	37.5	TRZ	125	1.47	1.34	1.30	1.33	1.37	1.16

Table A.4 Information on 40 Samples for Time Experiment

Agg.	NMAS	Grad.	Gyr.	Air Voids at 6 s	Air Voids at 10 s	Air Voids at 15 s	Air Voids at 20 s	Air Voids at 30 s	Air Voids at 60 s
Granite	9.5	ARZ	15	9.52	9.51	9.43	9.50	9.48	9.46
Granite	9.5	BRZ	15	10.97	10.87	10.78	10.79	10.64	10.60
Granite	9.5	SMA	15	16.16	16.08	16.04	15.99	15.90	16.00
Granite	9.5	TRZ	15	9.61	9.54	9.51	9.44	9.37	9.34
Granite	9.5	BRZ	50	6.85	6.80	6.77	6.75	6.70	6.71
Granite	9.5	SMA	50	5.98	5.85	5.78	5.77	5.75	5.74
Granite	9.5	TRZ	50	6.45	6.51	6.52	6.54	6.52	6.46
Granite	9.5	ARZ	125	4.11	4.25	4.19	4.16	4.18	4.21
Granite	9.5	BRZ	125	4.40	4.30	4.27	4.21	4.32	4.18
Granite	12.5	SMA	15	9.53	8.92	8.90	8.77	8.85	8.39
Granite	12.5	SMA	50	5.64	5.66	5.58	5.42	5.27	5.40
Granite	19.0	BRZ	15	9.92	9.97	9.83	9.70	9.70	9.56
Granite	19.0	SMA	15	9.57	8.72	8.87	8.63	8.15	8.31
Granite	19.0	BRZ	50	6.15	5.88	5.84	5.82	5.80	5.76
Granite	19.0	ARZ	125	4.22	4.12	4.12	4.20	4.07	4.13
Granite	19.0	SMA	125	2.18	2.15	2.23	2.12	2.06	2.03
Granite	37.5	BRZ	15	8.65	8.60	7.88	8.42	7.63	7.32
Granite	37.5	BRZ	50	7.03	7.07	6.91	6.50	6.50	6.47
Granite	37.5	TRZ	125	4.80	4.86	4.80	4.65	4.89	4.66
Limestone	9.5	ARZ	15	9.75	9.67	9.60	9.54	9.49	9.48
Limestone	9.5	BRZ	15	12.37	12.17	12.03	12.09	11.97	11.89
Limestone	9.5	SMA	15	10.63	10.39	10.27	10.26	10.26	10.29
Limestone	9.5	TRZ	15	10.61	10.49	10.47	10.47	10.40	10.27
Limestone	9.5	BRZ	50	7.71	7.63	7.55	7.51	7.62	7.49
Limestone	9.5	TRZ	50	6.02	6.05	6.11	6.04	6.06	6.04
Limestone	9.5	ARZ	125	3.77	3.75	3.82	3.74	3.73	3.77
Limestone	9.5	BRZ	125	4.14	4.12	4.00	4.12	4.03	4.08
Limestone	9.5	SMA	125	1.02	0.98	0.96	0.93	0.95	0.92
Limestone	12.5	SMA	15	8.89	8.69	8.58	8.60	8.56	8.49
Limestone	12.5	SMA	50	4.44	4.36	4.27	4.23	4.11	4.08
Limestone	19.0	ARZ	15	9.20	9.22	9.19	9.13	9.12	9.06
Limestone	19.0	BRZ	15	11.01	10.88	10.75	10.66	10.52	10.57
Limestone	19.0	SMA	15	8.72	9.02	8.70	8.60	8.37	8.40
Limestone	19.0	SMA	50	4.45	4.49	4.44	4.35	4.27	4.33
Limestone	19.0	ARZ	125	3.62	3.61	3.61	3.60	3.57	3.54
Limestone	19.0	BRZ	125	3.09	3.07	2.89	2.98	3.14	2.87
Limestone	37.5	TRZ	50	6.91	6.95	6.79	6.65	6.64	6.09
Limestone	37.5	ARZ	125	4.12	4.22	4.25	4.10	4.14	4.11
Limestone	37.5	BRZ	125	4.90	4.71	4.44	4.49	4.39	4.38
Limestone	37.5	TRZ	125	4.59	4.37	4.40	4.34	4.42	4.12

TASK 5

APPENDIX A

Project 1:

Project 1 was evaluated on May 21, 2002 and consisted of the 38.1mm overlay of an existing HMA pavement in the eastbound lane of a two-lane county highway. The mix consisted of a 9.5mm nominal maximum aggregate size fine-graded blend designed at an N_{design} of 65 gyrations resulting in a design asphalt content of 5.8 percent. The asphalt binder that was used was a PG 70-22. A liquid anti-stripping agent was used at a rate of 0.5 percent. The weather conditions during paving were approximately 70°F, overcast, with a light drizzle throughout the day. The design and gradation information are provided in Tables A1 and A2.

The project was located approximately 25 miles from the CMI drum plant. Dump trucks fed the mix to the Ingersoll Rand PF-200 paver. Breakdown and intermediate rolling were both conducted using the same Ingersoll Rand DD90 roller. Breakdown rolling was operated in high amplitude and frequency, with the roller typically making 2 to 3 passes over the mat at a temperature of about 265°F, with the mat being laid at a temperature of about 310°F. Intermediate rolling was performed in static mode with the paver making 2 to 3 passes at a temperature of approximately 210°F. A separate Ingersoll Rand DD90 static steel-wheel roller in static mode performed finish rolling, starting at a pavement temperature of about 170°F, making about 3 passes over the mat.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mixture are provided in Tables A3-A7.

Table A1: Project 1 Mix Design Summary Information	
JMF I.D. Number:	2024-02-13
Date(s) on Project:	5/21/02
Number of Stockpiles Used:	5
- Coarse Aggregate Angularity:	100% 2+ crushed faces
- Fine Aggregate Angularity:	48.6
Percent RAP:	15
Gradation:	9.5mm Fine Graded
$N_{initial}$, N_{design}, N_{max}:	7, 65, NA
Type Asphalt Binder Used:	PG 70-22
Design Asphalt Binder Content:	5.8
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Liquid Adhere HP+
Percent Anti-Strip Used:	0.5
Design Voids in Total Mix:	3.86
Design Voids in Mineral Aggregate:	16.2
Design Voids Filled with Asphalt:	76
Tensile Strength Ratio:	0.84
Dust/Asphalt Ratio:	1.0

Table A2: Design Gradation for Project 1			
Sieve Size	Sieve Size, mm	Recommended Limits from Job Mix	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5	100	100
3/8 in	9.5	90-100	94.5
No. 4	4.75	90 max	64.7
No. 8	2.36	38-67	52.6
No. 16	1.18		39.2
No. 30	0.6		29.6
No. 50	0.3		15.7
No. 100	0.15		8.0
No. 200	0.075	2-10	4.8

Table A3: Results of SGC Compactions **Ndesign = 65**

Project: 1															
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa) 2.771		Eff. Sp. Gr. (Gse): 2.752		Bulk Sp. Gr. (Gsb): 2.732		Mix Description: 9.5mm Fine						Date 9/4/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	5.3	4895.6	2849.0	4900.0	2.387	2.527	82.7	12.3	148.9	5.5	17.3	67.9	5.0	
1	2	5.3	4905.0	2864.7	4913.2	2.394	2.527	83.0	12.3	149.4	5.2	17.0	69.1	5.0	
1	3	5.3	4908.0	2865.7	4916.0	2.394	2.527	83.0	12.3	149.4	5.3	17.0	69.0	5.0	
2	1	5.8	4892.5	2868.1	4894.4	2.414	2.510	83.3	13.6	150.7	3.8	16.7	77.3	5.5	
2	2	5.8	4895.9	2873.5	4898.3	2.418	2.510	83.4	13.6	150.9	3.7	16.6	77.9	5.5	
2	3	5.8	4892.7	2871.5	4895.2	2.418	2.510	83.4	13.6	150.9	3.7	16.6	77.9	5.5	
Input By:													Checked By:		

SSD = Saturated Surface Dry | cc = cubic centimeter | VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density | AC = Asphalt Cement | VFA = Voids Filled With Asphalt Cement
gm = gram | pcf = pounds per cubic foot | VTM = Voids in Total Mix

Table A4: Results of Height Sample SGC Compactions **Ndesign = 65**

Project: 1													Date 9/4/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa) 2.771		Eff. Sp. Gr. (Gse): 2.752		Bulk Sp. Gr. (Gsb): 2.732	Mix Description: 9.5mm Fine					
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	5.3	1628.4	932.4	1631.3	2.330	2.527	12.0	7.8	9.2	8	5.0	
1	2	5.3	1622.4	929.4	1624.7	2.333	2.527	12.0	7.7	8.3	11	5.0	
1	3	5.3	1526.3	871.9	1529.8	2.320	2.527	12.0	8.2	9.9	37	5.0	
1	4	5.3	1524.4	872.0	1528.7	2.321	2.527	12.0	8.1	9.8	52	5.0	
1	5	5.3	1486.5	836.6	1493.3	2.264	2.527	11.7	10.4	11.9	142	5.0	
1	6	5.3	1484.5	832.0	1490.4	2.255	2.527	11.6	10.8	14.8	142	5.0	
1	7	5.3	1446.2	801.3	1453.9	2.216	2.527	11.4	12.3	14.2	521	5.0	
1	8	5.3	1444.1	796.7	1451.6	2.205	2.527	11.4	12.7	14.2	347	5.0	
2	1	5.8	1585.7	914.2	1588.6	2.351	2.510	13.3	6.3	7.2	0	5.5	
2	2	5.8	1590.9	915.6	1592.2	2.351	2.510	13.3	6.3	7.3	0	5.5	
2	3	5.8	1488.7	836.2	1493.3	2.266	2.510	12.8	9.7	10.9	121	5.5	
2	4	5.8	1489.7	835.2	1493.9	2.262	2.510	12.8	9.9	11.3	87	5.5	
2	5	5.8	1467.4	817.2	1473.3	2.237	2.510	12.6	10.9	12.4	238	5.5	
2	6	5.8	1467.5	814.4	1472.2	2.231	2.510	12.6	11.1	16.1	141	5.5	
2	7	5.8	1439.0	790.3	1444.6	2.199	2.510	12.4	12.4	13.7	260	5.5	
2	8	5.8	1435.9	793.1	1444.6	2.204	2.510	12.4	12.2	11.2	388	5.5	
Input By:													

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A5: Gradations and Asphalt Contents per Sublot

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.50	5.11	100.00	100.00	100.00	100.00	0.0	100.00	100.00	100.00	100.00	0.0	100.00	0.00	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.00	100.0
19	3.76	100	100	100	100.0	0.0	100	100	100	100.0	0.0	100.0	0.00	100.0
12.5	3.12	99.7	100	100	99.9	0.2	100	99.6	100	99.9	0.2	99.9	0.02	100.0
9.5	2.75	95.1	97	94.7	95.6	1.2	94.9	94.3	94.4	94.5	0.3	95.1	0.75	94.5
4.75	2.02	68.3	70.9	67.3	68.8	1.9	67.6	66.4	66.6	66.9	0.6	67.9	1.39	64.7
2.36	1.47	51.8	53.5	50.6	52.0	1.5	52.8	51.5	51.8	52.0	0.7	52.0	0.05	52.6
1.18	1.08	38.6	39.4	37.8	38.6	0.8	39.4	38.6	38.9	39.0	0.4	38.8	0.26	39.2
0.6	0.8	30.3	30.7	29.8	30.3	0.5	30.6	30.2	30.3	30.4	0.2	30.3	0.07	29.6
0.3	0.58	17.3	17.5	17.2	17.3	0.2	16.7	16.6	16.7	16.7	0.1	17.0	0.47	15.7
0.15	0.43	9.1	9.2	9.1	9.1	0.1	8.5	8.5	8.6	8.5	0.1	8.8	0.42	8.0
0.075	0.31	5.5	5.6	5.4	5.5	0.1	5.1	5.2	5.2	5.2	0.1	5.3	0.24	4.8
Asphalt Content		**Sample 1**					**Sample 2**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		5.20	5.50	5.20	5.30	0.17	5.70	5.80	5.70	5.73	0.06	5.52	0.31	5.80

Table A6: Coarse Aggregate Properties for Project 1

Test	Salem #8		
Bulk / Apparent Specific Gravit	2.673/2.728		
Absorption, %	1.15		
LA Abrasion, % Loss	15.3		
Flat and Elongated, %			
3 to 1			
5 to 1	2.5		
Coarse Aggregate Flow, %	47.4		
Crushed Content, %			
One Face	100		
Two+ Faces	100		
Data provided by either the agency or determined at NCAT lab			

Table A7: Fine Aggregate Properties for Project 1

Test	Marti #34	S&R #10	BR Sand	Castle Sand	RAP
Bulk / Apparent Specific Gravi	2.825/2.843	2.762/2.847	2.665/2.711	2.618/2.660	2.612/2.669
Absorption, %	0.49	1.57	1.8	0.89	0.51
Fine Aggregate Angularity, %	51.7	46.6	45.3	46.4	45.2
Sand Equivalent	96	85	76	76	86
Data provided by either the agency or determined at NCAT lab					

Project 2

Project 2 was evaluated on May 22, 2002 and consisted of the placement of 63.5mm new hot mix asphalt (HMA) in the construction of a new highway. The mix consisted of a 19.0mm nominal maximum aggregate size limestone/sand/RAP coarse-graded blend designed at an N_{design} of 65 gyrations resulting in a design asphalt content of 5.3 percent. The asphalt binder that was used was a PG 64-22. A liquid anti-stripping agent was used at a rate of 0.5 percent. The weather conditions during paving were approximately 60°F, sunny, with a light wind. The mix design and gradation information are provided in Tables A8 and A9.

The project was located approximately 5 miles from the drum plant. Dump trucks fed the mix to the Ingersoll Rand PF-3200 paver. Breakdown rolling was conducted using an Ingersoll Rand DD110 HF roller, which started compaction when the mat had cooled to a temperature of approximately 260°F. The mat was laid at a temperature of about 300°F. Maximum amplitude and frequency were used during breakdown rolling with the roller making four to five passes over the mat. Finish rolling was started at approximately 185°F and was performed using an Ingersoll Rand DD90 HF roller operating in static mode making four to five passes

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A10-A14.

Table A8: Project 2 Mix Design Summary Information	
JMF I.D. Number:	2025-02-08
Date(s) on Project:	5/22/02
Number of Stockpiles Used:	3
- Coarse Aggregate Angularity:	100% 2+ crushed faces
- Fine Aggregate Angularity:	45.5
Percent RAP:	15
Gradation:	19.0mm Coarse Graded
Ninitial, Ndesign, Nmax:	7, 65, NA
Type Asphalt Binder Used:	PG 64-22
Design Asphalt Binder Content:	5.3
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Liquid Adhere HP+
Percent Anti-Strip Used:	0.5
Design Voids in Total Mix:	4.16
Design Voids in Mineral Aggregate:	16.2
Design Voids Filled with Asphalt:	74
Tensile Strength Ratio:	0.90
Dust/Asphalt Ratio:	1.0

Table A9: Design Gradation for Project 2			
Sieve Size	Sieve Size, mm	Recommended Limits From JMF	Percent Passing
11/2 in.	37.5		100
1 in.	25.0	100	100
¾ in.	19.0	90-100	99.6
½ in.	12.5	90 max	88.9
3/8 in	9.5		76.8
No. 4	4.75		52.2
No. 8	2.36	28-49	30.3
No. 16	1.18		19.3
No. 30	0.6		14.1
No. 50	0.3		8.2
No. 100	0.15		5.9
No. 200	0.075	2-8	4.6

Table A10: Results from SGC Compactions **Ndesign = 65**

Project: 2															
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa) 2.832		Eff. Sp. Gr. (Gse): 2.795		Bulk Sp. Gr. (Gsb): 2.765		Mix Description: 19.0mm Coarse						Date 9/4/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	4.7	4949.2	2947.9	4960.5	2.459	2.593	84.8	11.2	153.4	5.2	15.2	66.1	4.3	
1	2	4.7	4951.1	2970.6	4960.0	2.489	2.593	85.8	11.4	155.3	4.0	14.2	71.7	4.3	
1	3	4.7	4951.1	2966.2	4959.6	2.484	2.593	85.6	11.4	155.0	4.2	14.4	70.7	4.3	
2	1	4.7	4944.7	2958.0	4955.3	2.476	2.580	85.3	11.3	154.5	4.0	14.7	72.4	4.3	
2	2	4.7	4925.5	2938.3	4935.7	2.466	2.580	85.0	11.3	153.9	4.4	15.0	70.5	4.3	
2	3	4.7	4937.3	2946.5	4946.0	2.469	2.580	85.1	11.3	154.1	4.3	14.9	71.2	4.3	
Input By:													Checked By:		

SSD = Saturated Surface Dry   cc = cubic centimeter   VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density   AC = Asphalt Cement   VFA = Voids Filled With Asphalt Cement
gm = gram   pcf = pounds per cubic foot   VTM = Voids in Total Mix

Table A11: Results of Height Sample SGC Compactions **Ndesign = 65**

Project: 2													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.795		Bulk Sp. Gr. (Gsb): 2.765		Mix Description: 19.0mm Coarse				9/4/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	4.7	2456.8	1464.0	2463.4	2.458	2.593	11.2	5.2	6.8	0	4.3	
1	2	4.7	2447.8	1464.0	2452.7	2.476	2.593	11.3	4.5	5.9	0	4.3	
1	3	4.7	2347.6	1395.6	2353.9	2.450	2.593	11.2	5.5	7.0	0	4.3	
1	4	4.7	2339.2	1388.3	2346.1	2.442	2.593	11.2	5.8	7.3	0	4.3	
1	5	4.7	2299.6	1359.7	2311.3	2.417	2.593	11.0	6.8	8.5	0	4.3	
1	6	4.7	2304.9	1361.7	2313.4	2.422	2.593	11.1	6.6	8.4	0	4.3	
1	7	4.7	2261.2	1324.6	2280.0	2.367	2.593	10.8	8.7	11.1	753	4.3	
1	8	4.7	2263.8	1324.8	2275.8	2.380	2.593	10.9	8.2	10.1	131	4.3	
2	1	4.7	2361.6	1412.8	2367.0	2.475	2.580	11.3	4.1	5.7	0	4.3	
2	2	4.7	2363.6	1402.5	2370.9	2.441	2.580	11.2	5.4	7.1	0	4.3	
2	3	4.7	2270.0	1332.5	2283.0	2.388	2.580	10.9	7.4	15.2	0	4.3	
2	4	4.7	2270.4	1335.4	2282.2	2.398	2.580	11.0	7.1	9.9	0	4.3	
2	5	4.7	2224.5	1307.3	2239.5	2.386	2.580	10.9	7.5	12.6	135	4.3	
2	6	4.7	2236.5	1302.7	2258.0	2.341	2.580	10.7	9.3	11.4	405	4.3	
2	7	4.7	2178.3	1274.2	2210.5	2.326	2.580	10.6	9.8	24.3	1941	4.3	
2	8	4.7	2158.3	1260.5	2190.3	2.321	2.580	10.6	10.0	13.0	1942	4.3	

Input By:

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A12: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.00	0.0	100.0	0.00	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	100.0	**100.0**	100.0	0.0	100.0	0.00	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.00	99.6
12.5	3.12	89.2	84.4	91.1	88.2	3.5	85.4	89.0	87.8	87.4	1.8	87.8	0.59	88.9
9.5	2.75	74.4	68.1	75.5	72.7	4.0	68.2	70.9	71.5	70.2	1.8	71.4	1.74	76.8
4.75	2.02	44.0	39.0	42.9	42.0	2.6	39.2	40.7	41.1	40.3	1.0	41.2	1.15	52.2
2.36	1.47	28.2	25.7	27.5	27.1	1.3	25.3	25.9	25.8	25.7	0.3	26.4	1.04	30.3
1.18	1.08	20.9	19.6	20.6	20.4	0.7	18.5	18.8	18.7	18.7	0.2	19.5	1.20	19.3
0.6	0.8	15.9	15.0	15.7	15.5	0.5	14.1	14.5	14.4	14.3	0.2	14.9	0.85	14.1
0.3	0.58	9.6	8.9	9.5	9.3	0.4	8.3	8.7	8.6	8.5	0.2	8.9	0.57	8.2
0.15	0.43	6.8	6.4	6.7	6.6	0.2	5.9	6.2	6.1	6.1	0.2	6.4	0.40	5.9
0.075	0.31	5.5	5.2	5.5	5.4	0.2	4.8	5.2	5.1	5.0	0.2	5.2	0.26	4.6
Asphalt Content		**Sample 1**					**Sample 2**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		4.90	4.50	4.80	4.73	0.21	4.80	4.70	4.60	4.70	0.10	4.72	0.02	5.3

Table A13: Coarse Aggregate Properties for Project 2

Test	#68's	
Bulk / Apparent Specific Gravit	2.798/2.862	
Absorption, %	0.8	
LA Abrasion, % Loss	16.6	
Flat and Elongated, %		
3 to 1		
5 to 1	0.7	
Coarse Aggregate Flow, %	44.6	
Crushed Content, %		
One Face	100	
Two+ Faces	100	
Data provided by either the agency or determined at NCAT lab		

Table A14: Fine Aggregate Properties for Project 2

Test	#10's	Conc. Sand	RAP
Bulk / Apparent Specific Gravi	2.748/2.862	2.645/2.664	2.786/2.805
Absorption, %	1.45	0.27	0.3
Fine Aggregate Angularity, %	44.6	44.6	47.9
Sand Equivalent	85	86	71
Data provided by either the agency or determined at NCAT lab			

Project 3:

Project 3 was evaluated on May 23, 2002, and consisted of a 38.1 mm of an existing HMA pavement in the eastbound lane of a two-lane county highway. The mix consisted of a 9.5mm nominal maximum aggregate size fine-graded bland designed at an N_{design} of 65 gyrations resulting in a design asphalt content of 5.5 percent. The asphalt binder used was a PG 64-22. A liquid anti-stripping agent was used at a rate of 0.5 percent. The weather conditions during paving were approximately 70-75°F, sunny, with a slight wind. The mix design and gradation information are provided in Tables A15 and A16.

The project was located approximately 35-40 miles from the plant. Dump trucks fed the mix directly into the paver. Breakdown and intermediate rolling were both conducted using the same Ingersoll Rand DD110 HF roller, with breakdown rolling beginning immediately after the mat was laid down, approximately at a temperature of 265°F. Maximum amplitude and frequency were used for both breakdown and intermediate rolling, with intermediate rolling beginning at a temperature of 235°F. A rolling pattern of two to three passes was used for both breakdown and intermediate rolling. Finish rolling was performed using a Dynapac roller operating in static mode making two passes at a starting temperature of about 140°.

While at the plant, the following materials were obtained: individual aggregate stockpiles used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A17-A21.

Table A15: Project 3 Mix Design Summary Information	
JMF I.D. Number:	2065-02-09
Date(s) on Project:	5/23/02
Number of Stockpiles Used:	3
- Coarse Aggregate Angularity:	100% 2+ crushed faces
- Fine Aggregate Angularity:	49.3
Percent RAP:	15
Gradation:	Fine
Ninitial, Ndesign, Nmax:	7, 65, 65
Type Asphalt Binder Used:	PG 64-22
Design Asphalt Binder Content:	5.5
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Liquid ARR MAZ
Percent Anti-Strip Used:	0.5
Design Voids in Total Mix:	3.9
Design Voids in Mineral Aggregate:	15.7
Design Voids Filled with Asphalt:	75
Tensile Strength Ratio:	0.85
Dust/Asphalt Ratio:	1.07

Table A16: Design Gradation for Project 3			
Sieve Size	Sieve Size, mm	Recommended Limits From JMF	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5	100	100
3/8 in	9.5	90-100	95.7
No. 4	4.75	90 max	56.7
No. 8	2.36	38-67	39.1
No. 16	1.18		30.0
No. 30	0.6		21.9
No. 50	0.3		13.2
No. 100	0.15		9.6
No. 200	0.075	2-10	6.1

Table A17: Results from SGC Compactions **Ndesign = 65**

Project: 3														Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.676		Bulk Sp. Gr. (Gsb): 2.658		Mix Description: 9.5mm Coarse					9/4/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %
1	1	5.5	4960.6	2864.1	4967.6	2.358	2.461	83.8	12.6	147.2	4.2	16.2	74.2	5.3
1	2	5.5	4965.8	2874.0	4971.8	2.367	2.461	84.2	12.7	147.7	3.8	15.8	75.9	5.3
1	3	5.5	4967.5	2878.1	4973.6	2.371	2.461	84.3	12.7	147.9	3.7	15.7	76.6	5.3
2	1	5.6	4963.2	2883.2	4968.3	2.380	2.456	84.5	13.0	148.5	3.1	15.5	80.1	5.4
2	2	5.6	4964.1	2880.9	4969.6	2.377	2.456	84.4	12.9	148.3	3.2	15.6	79.3	5.4
2	3	5.6	4963.3	2886.8	4970.8	2.382	2.456	84.6	13.0	148.6	3.0	15.4	80.4	5.4
3	1	5.5	4958.8	2868.3	4966.3	2.364	2.459	84.0	12.6	147.5	3.9	16.0	75.7	5.3
3	2	5.5	4963.9	2858.9	4972.5	2.349	2.459	83.5	12.6	146.5	4.5	16.5	72.8	5.3
3	3	5.5	4966.4	2868.6	4976.0	2.357	2.459	83.8	12.6	147.1	4.2	16.2	74.3	5.3
Input By:													Checked By:	

SSD = Saturated Surface Dry — cc = cubic centimeter — VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density — AC = Asphalt Cement — VFA = Voids Filled With Asphalt Cement
gm = gram — pcf = pounds per cubic foot — VTM = Voids in Total Mix

Table A18: Results of Height Sample SGC Compactions **Ndesign = 65**

Project: 3													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.676		Bulk Sp. Gr. (Gsb): 2.658	Mix Description: 9.5mm Coarse					9/4/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	5.5	1637.1	924.0	1648.7	2.259	2.461	12.1	8.2	10.8	354.0	5.3	
1	2	5.5	1638.5	930.2	1645.5	2.291	2.461	12.3	6.9	10.4	21.0	5.3	
1	3	5.5	1534.8	867.7	1544.7	2.267	2.461	12.1	7.9	10.5	238.0	5.3	
1	4	5.5	1538.2	869.9	1555.9	2.242	2.461	12.0	8.9	11.9	424.0	5.3	
1	5	5.5	1430.5	806.9	1443.6	2.247	2.461	12.0	8.7	11.1	393.0	5.3	
1	6	5.5	1435.2	811.0	1450.8	2.243	2.461	12.0	8.9	11.6	627.0	5.3	
1	7	5.5	1339.7	754.5	1371.9	2.170	2.461	11.6	11.8	16.7	6936.0	5.3	
1	8	5.5	1333.0	750.2	1368.2	2.157	2.461	11.5	12.4	24.1	3111.0	5.3	
2	1	5.6	1510.6	852.8	1519.2	2.267	2.456	12.3	7.7	9.5	268.5	5.4	
2	2	5.6	1523.8	859.7	1532.7	2.264	2.456	12.3	7.8	10.4	205.3	5.4	
2	3	5.6	1416.9	796.7	1432.6	2.228	2.456	12.1	9.3	14.7	787.0	5.4	
2	4	5.6	1419.5	799.8	1432.6	2.243	2.456	12.2	8.7	12.0	314.0	5.4	
2	5	5.6	1378.5	771.7	1401.7	2.188	2.456	11.9	10.9	14.8	778.7	5.4	
2	6	5.6	1385.4	777.1	1414.5	2.174	2.456	11.8	11.5	14.3	2323.8	5.4	
2	7	5.6	1339.3	749.4	1372.7	2.149	2.456	11.7	12.5	16.3	3907.4	5.4	
2	8	5.6	1329.7	746.1	1364.6	2.150	2.456	11.7	12.5	17.3	2307.0	5.4	
3	1	5.5	1436.1	808.3	1448.2	2.244	2.459	12.0	8.7	16.1	347.9	5.3	
3	2	5.5	1416.6	796.0	1436.0	2.213	2.459	11.8	10.0	12.7	1570.8	5.3	
3	3	5.5	1370.1	769.4	1396.0	2.187	2.459	11.7	11.1	14.7	2325.1	5.3	
3	4	5.5	1386.7	781.4	1412.6	2.197	2.459	11.8	10.7	14.5	2293.2	5.3	
3	5	5.5	1364.5	767.0	1391.7	2.184	2.459	11.7	11.2	15.2	3423.2	5.3	
3	6	5.5	1365.1	770.6	1397.4	2.178	2.459	11.7	11.4	16.2	3448.1	5.3	
3	7	5.5	1336.2	755.6	1373.0	2.164	2.459	11.6	12.0	16.7	6793.8	5.3	
3	8	5.5	1335.0	756.6	1370.0	2.176	2.459	11.6	11.5	16.7	6881.1	5.3	

Input By:

SSD = Saturated Surface Dry; cc = cubic centimeter
TMD = Theoretical Maximum Density; AC = Asphalt Cement
gm = gram; pcf = pounds per cubic foot; VTM = Voids in Total Mix

Table A19: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Sample 3					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
25.0	4.26	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.00	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0	99.6	100.0	99.9	0.2	100.0	100.0	100.0	100.0	0.0	100.0	0.08	100.0
12.5	3.12	98.5	99.5	98.7	98.9	0.5	99.4	98.5	98.3	98.7	0.6	98.2	99.6	98.1	98.6	0.8	98.8	0.13	100.0
9.5	2.75	91.2	91.3	91.2	91.2	0.1	94.2	92.2	92.8	93.1	1.0	93.2	93.2	90.6	92.3	1.5	92.2	0.92	95.7
4.75	2.02	50.9	52.9	51.5	51.8	1.0	56.3	55.5	54.4	55.4	1.0	51.6	52.7	49.3	51.2	1.7	52.8	2.28	56.7
2.36	1.47	32.9	33.3	32.9	33.0	0.2	36.3	35.5	34.6	35.5	0.9	32.3	32.5	31.1	32.0	0.8	33.5	1.79	39.1
1.18	1.08	25.4	25.5	25.2	25.4	0.2	27.8	27.3	26.8	27.3	0.5	24.8	25.0	24.2	24.7	0.4	25.8	1.36	30.0
0.6	0.8	19.1	19.3	19.0	19.1	0.2	21.1	20.8	20.3	20.7	0.4	18.8	19.0	18.4	18.7	0.3	19.5	1.06	21.9
0.3	0.58	11.4	11.6	11.3	11.4	0.2	12.8	12.6	12.2	12.5	0.3	11.0	11.2	10.8	11.0	0.2	11.7	0.79	13.2
0.15	0.43	7.9	8.1	7.9	8.0	0.1	8.9	8.7	8.4	8.7	0.3	7.5	7.6	7.4	7.5	0.1	8.0	0.59	9.6
0.075	0.31	5.6	5.7	5.6	5.6	0.1	6.3	6.1	5.9	6.1	0.2	5.4	5.4	5.2	5.3	0.1	5.7	0.39	6.1
Asphalt Content		Sample 1					Sample 2					Sample 3					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		5.50	5.40	5.50	5.47	0.06	5.70	5.60	5.50	5.60	0.10	5.50	5.50	5.40	5.47	0.06	5.51	0.08	5.5

Table A20: Coarse Aggregate Properties for Project 3

Test	#8's	
Bulk / Apparent Specific Gravit	2.627/2.711	
Absorption, %	1.2	
LA Abrasion, % Loss	15	
Flat and Elongated, %		
3 to 1		
5 to 1	2.7	
Coarse Aggregate Flow, %	47.4	
Crushed Content, %		
One Face	100	
Two+ Faces	100	
Data provided by either the agency or determined at NCAT lab		

Table A21: Fine Aggregate Properties for Project 3

Test	#10's	Conc. Sand	RAP
Bulk / Apparent Specific Gravi	2.493/2.689	2.604/2.636	2.518/2.688
Absorption, %	2.9	0.5	2.5
Fine Aggregate Angularity, %	51.8	46.5	47.9
Sand Equivalent	63	90	41
Data provided by either the agency or determined at NCAT lab			

Project 4:

Project 4 was evaluated on April 16, 2002 and consisted of the placement of 63.5mm of new hot mix asphalt on an aggregate base laid on the shoulder of an existing interstate highway. The mix consisted of a 12.5mm nominal maximum aggregate size granite/RAP fine-graded blend designed at an N_{design} of 75 gyrations resulting in a design asphalt content of 5.7 percent. The asphalt binder that was used was a type RA295. A liquid anti-stripping agent was used at a rate of 0.5 percent. The weather conditions during paving were approximately 90°F, sunny, and windy. The design and gradation information are provided in Tables A22 and A23.

The project was located approximately 15 miles from the plant. Dump trucks fed the mix to the paver. Breakdown rolling was conducted by a Caterpillar CB634C roller making four to five passes in static mode starting at a temperature of approximately 265°F, with the mat being laid at a temperature of 300°F. Intermediate rolling began when the mat reached 240°F and was performed by an Ingersoll Rand DD125 roller operating in static mode making approximately six passes over the mat. Finish rolling was performed using an Ingersoll Rand DD110 starting at just under 200°F and was conducted in static mode making four to five passes.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mixture are provided in Tables A24-A28.

Table A23: Project 4 Mix Design Summary Information	
JMF I.D. Number:	SP02-1601A (TL-C)
Date(s) on Project:	4/16/02
Number of Stockpiles Used:	3
- Coarse Aggregate Angularity:	100% 2+ crushed faces
- Fine Aggregate Angularity:	45
Percent RAP:	28
Gradation:	12.5mm Fine Graded
Ninitial, Ndesign, Nmax:	7, 75, 125
Type Asphalt Binder Used:	RA925
Design Asphalt Binder Content:	5.7
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Liquid ARR MAZ
Percent Anti-Strip Used:	0.5
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	15.2
Design Voids Filled with Asphalt:	75.2
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	1.02

Table A23: Design Gradation for Project 4			
Sieve Size	Sieve Size, mm	Recommended Limits From JMF	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0	100	100
½ in.	12.5	90-100	93
3/8 in	9.5	90 max	86
No. 4	4.75		66
No. 8	2.36	**28-58**	47
No. 16	1.18		35
No. 30	0.6		26
No. 50	0.3		19
No. 100	0.15		9
No. 200	0.075	2-10	4.7

Table A24: SGC Sample Properties **Ndesign = 75**

Project: 4											Mix Description: 12.5mm Fine				Date 9/4/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.663		Bulk Sp. Gr. (Gsb): 2.636								
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	4.9	4788.1	2785.1	4791.2	2.387	2.469	86.1	11.4	148.9	3.3	13.9	76.0	4.5	
1	2	4.9	4764.6	2773.1	4768.7	2.388	2.469	86.1	11.4	149.0	3.3	13.9	76.2	4.5	
1	3	4.9	4798.5	2781.7	4801.1	2.376	2.469	85.7	11.3	148.3	3.8	14.3	73.7	4.5	
2	1	5.0	4799.2	2797.6	4802.6	2.394	2.466	86.3	11.6	149.4	2.9	13.7	78.6	4.6	
2	2	5.0	4800.9	2795.0	4806.5	2.387	2.466	86.0	11.6	148.9	3.2	14.0	77.0	4.6	
2	3	5.0	4819.5	2807.1	4823.0	2.391	2.466	86.2	11.6	149.2	3.1	13.8	77.9	4.6	
3	1	5.1	4787.0	2775.7	4789.6	2.377	2.467	85.6	11.8	148.3	3.6	14.4	74.7	4.7	
3	2	5.1	4795.6	2781.0	4797.8	2.378	2.467	85.6	11.8	148.4	3.6	14.4	74.9	4.7	
3	3	5.1	4800.3	2789.0	4804.7	2.381	2.467	85.7	11.8	148.6	3.5	14.3	75.7	4.7	
Input By:													Checked By:		

SSD = Saturated Surface Dry | cc = cubic centimeter | VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density | AC = Asphalt Cement | VFA = Voids Filled With Asphalt Cement
gm = gram | pcf = pounds per cubic foot | VTM = Voids in Total Mix

Table A25: Results of Height Sample SGC Compactions **Ndesign = 75**

Project: 4													
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.663		Bulk Sp. Gr. (Gsb): 2.636	Mix Description: 12.5mm Fine					Date 9/4/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	4.9	2095.3	1214.1	2097.1	2.373	2.469	11.3	3.9	4.9	0	4.5	
1	2	4.9	2091.5	1205.1	2093.5	2.354	2.469	11.2	4.6	7.5	0	4.5	
1	3	4.9	2041.3	1181.5	2042.8	2.370	2.469	11.3	4.0	4.8	0	4.5	
1	4	4.9	2046.1	1185.2	2048.6	2.370	2.469	11.3	4.0	5.3	0	4.5	
1	5	4.9	1987.7	1135.5	1991.0	2.323	2.469	11.1	5.9	7.1	18	4.5	
1	6	4.9	1995.0	1144.2	1998.1	2.336	2.469	11.1	5.4	6.6	0	4.5	
1	7	4.9	1941.8	1091.7	1946.7	2.271	2.469	10.8	8.0	10.4	54	4.5	
1	8	4.9	1940.9	1092.4	1946.2	2.273	2.469	10.8	7.9	9.3	38	4.5	
2	1	5.0	2080.7	1202.4	2082.7	2.364	2.466	11.5	4.2	4.9	0	4.6	
2	2	5.0	2075.2	1207.4	2076.9	2.387	2.466	11.6	3.2	4.5	0	4.6	
2	3	5.0	2028.5	1171.9	2030.1	2.364	2.466	11.5	4.1	5.4	0	4.6	
2	4	5.0	2025.0	1168.0	2026.6	2.358	2.466	11.5	4.4	5.6	0	4.6	
2	5	5.0	1970.4	1120.2	1973.9	2.308	2.466	11.2	6.4	7.6	0	4.6	
2	6	5.0	1972.9	1125.0	1976.9	2.316	2.466	11.3	6.1	7.1	10	4.6	
2	7	5.0	1923.9	1077.9	1929.9	2.258	2.466	11.0	8.4	10.5	86	4.6	
2	8	5.0	1926.5	1077.8	1932.3	2.255	2.466	11.0	8.6	10.4	86	4.6	
3	1	5.1	2068.4	1189.2	2070.0	2.348	2.467	11.7	4.8	5.2	0	4.7	
3	2	5.1	2069.8	1188.0	2072.3	2.341	2.467	11.6	5.1	6.0	0	4.7	
3	3	5.1	2021.9	1160.0	2023.8	2.341	2.467	11.6	5.1	5.7	0	4.7	
3	4	5.1	2024.4	1162.8	2025.9	2.345	2.467	11.6	4.9	5.7	0	4.7	
3	5	5.1	1969.8	1122.8	1974.6	2.313	2.467	11.5	6.3	7.5	13	4.7	
3	6	5.1	1971.1	1120.4	1974.1	2.309	2.467	11.5	6.4	7.7	75	4.7	
3	7	5.1	1923.8	1077.9	1928.8	2.261	2.467	11.2	8.4	9.7	73	4.7	
3	8	5.1	1786.5	961.5	1800.6	2.129	2.467	10.6	13.7	15.3	787	4.7	
Input By:													

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A26: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Sample 3					Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
25.0	4.26	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.00	100.0
19	3.76	99.3	100.0	99.2	99.5	0.4	100.0	100.0	99.5	99.8	0.3	98.6	99.1	100.0	99.2	0.7	99.5	0.30	100.0
12.5	3.12	95.2	95.8	94.4	95.1	0.7	94.4	94.5	93.1	94.0	0.8	91.7	93.2	94.8	93.2	1.6	94.1	0.96	93.0
9.5	2.75	88.8	90.0	88.8	89.2	0.7	87.6	88.7	85.9	87.4	1.4	85.6	86.5	89.3	87.1	1.9	87.9	1.12	86.0
4.75	2.02	67.0	68.5	67.8	67.8	0.8	66.3	68.0	66.6	67.0	0.9	65.2	66.7	69.5	67.1	2.2	67.3	0.42	66.0
2.36	1.47	47.1	48.4	47.7	47.7	0.7	46.4	48.1	46.7	47.1	0.9	46.0	47.1	49.0	47.4	1.5	47.4	0.33	47.0
1.18	1.08	33.3	33.8	33.4	33.5	0.3	32.3	33.2	32.4	32.6	0.5	32.1	32.7	33.9	32.9	0.9	33.0	0.44	35.0
0.6	0.8	25.6	25.8	25.5	25.6	0.2	24.6	25.1	24.7	24.8	0.3	24.4	24.6	25.5	24.8	0.6	25.1	0.47	26.0
0.3	0.58	19.4	19.4	19.3	19.4	0.1	18.4	18.6	18.4	18.5	0.1	18.0	18.0	18.8	18.3	0.5	18.7	0.59	19.0
0.15	0.43	11.2	11.1	11.3	11.2	0.1	10.6	10.6	10.6	10.6	0.0	10.3	9.8	10.3	10.1	0.3	10.6	0.53	9.0
0.075	0.31	5.4	5.1	5.4	5.3	0.2	4.9	4.9	5.0	4.9	0.1	4.1	4.0	4.3	4.1	0.2	4.8	0.60	4.7
Asphalt Content		**Sample 1**					**Sample 2**					**Sample 3**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		4.80	4.90	5.00	4.90	0.10	5.00	5.20	4.90	5.03	0.15	5.00	5.10	5.10	5.07	0.06	5.00	0.09	5.7

Table A27: Coarse Aggregate Properties for Project 4

Test	#67 Stone	#89 Stone
Bulk / Apparent Specific Gravity	2.627/2.684	2.587/2.658
Absorption, %	0.8	1
LA Abrasion, % Loss	15.5	15.9
Flat and Elongated, %		
3 to 1	14.4	4.3
5 to 1	0.9	0.6
Coarse Aggregate Flow, %	45.3	45.6
Crushed Content, %		
One Face	31.9	20.6
Two+ Faces	68.1	79.4
Data provided by either the agency or determined at NCAT lab		

Table A28: Fine Aggregate Properties for Project 4

Test	W-12 Scrns	RAP
Bulk / Apparent Specific Gravi	2.671/2.762	2.469/2.638
Absorption, %	1.2	2.6
Fine Aggregate Angularity, %	46.3	43.8
Sand Equivalent	87	72
Data provided by either the agency or determined at NCAT lab		

Project 5:

Project 5 was evaluated on May 29, 2002 and consisted of the 31.8mm overlay of an existing HMA pavement in the eastbound lane of a two-lane state highway. The mix consisted of a 9.5mm nominal maximum aggregate size fine-graded blend designed at an N_{design} of 100 gyrations resulting in a design asphalt content of 7.0 percent. The asphalt binder that was used was a PG 70-22. A liquid anti-stripping agent was used at a rate of 0.5 percent. The weather conditions during paving were approximately 80°F, sunny, with no wind. The design and gradation information are provided in Tables A29 and A30.

The project was located approximately 15-20 miles from the plant. The mat was laid over a tack coat that had an application rate of 0.3 gallons per square yard, and was laid at a temperature of approximately 285°F. An Ingersoll Rand DD110HF roller performed the breakdown rolling, making four to five passes using maximum amplitude and frequency starting at a temperature of about 240°F. Intermediate rolling was also conducted in maximum amplitude and frequency, starting at a temperature of about 170°F and performed by a Caterpillar CB634C roller making three passes over the mat. Finish rolling was conducted using a Hamm HD12 making two passes in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A31-A35.

Table A29: Project 5 Mix Design Summary Information	
JMF I.D. Number:	01-606-152
Date(s) on Project:	5/29/02
Number of Stockpiles Used:	3
- Coarse Aggregate Angularity:	NA
- Fine Aggregate Angularity:	NA
Percent RAP:	15.4
Gradation:	9.5mm Fine Graded
Ninitial, Ndesign, Nmax:	8, 100, 160
Type Asphalt Binder Used:	PG 70-22
Design Asphalt Binder Content:	7.0
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Liquid ARR MAZ
Percent Anti-Strip Used:	0.5
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	15.0
Design Voids Filled with Asphalt:	73
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	NA

Table A30: Design Gradation for Project 5			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5		100
3/8 in	9.5		99
No. 4	4.75		81
No. 8	2.36		60
No. 16	1.18		44
No. 30	0.6		30
No. 50	0.3		19
No. 100	0.15		9.0
No. 200	0.075		4.5

Table A31: Results from SGC Compactions **Ndesign = 100**

Project: 5															
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa) 2.615		Eff. Sp. Gr. (Gse): 2.612		Bulk Sp. Gr. (Gsb): 2.476		Mix Description: 9.5mm Fine						Date 9/4/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	6.8	4545.8	2515.9	4548.5	2.236	2.363	84.2	14.8	139.6	5.4	15.8	66.1	4.8	
1	2	6.8	4542.7	2517.1	4546.1	2.239	2.363	84.3	14.8	139.7	5.3	15.7	66.6	4.8	
1	3	6.8	4294.8	2376.3	4298.4	2.234	2.363	84.1	14.8	139.4	5.4	15.9	65.8	4.8	
2	1	7.0	4530.7	2504.2	4534.4	2.232	2.355	83.8	15.2	139.3	5.2	16.2	67.6	5.0	
2	2	7.0	4535.0	2503.7	4536.1	2.231	2.355	83.8	15.2	139.2	5.3	16.2	67.6	5.0	
2	3	7.0	4534.9	2507.2	4536.9	2.234	2.355	83.9	15.2	139.4	5.1	16.1	68.1	5.0	
3	1	7.0	4528.3	2520.8	4530.0	2.254	2.364	84.7	15.3	140.6	4.7	15.3	69.6	5.0	
3	2	7.0	4528.9	2519.3	4530.9	2.251	2.364	84.6	15.3	140.5	4.8	15.4	69.1	5.0	
3	3	7.0	4530.3	2517.9	4532.0	2.249	2.364	84.5	15.3	140.4	4.9	15.5	68.7	5.0	
Input By:													Checked By:		
SSD = Saturated Surface Dry				cc = cubic centimeter			VMA = Voids in Mineral Aggregate								
TMD = Theoretical Maximum Density				AC = Asphalt Cement			VFA = Voids Filled With Asphalt Cement								
gm = gram				pcf = pounds per cubic foot			VTM = Voids in Total Mix								

Table A33: Results of Height Sample SGC Compactions **Ndesign = 100**

Project: 5													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.612		Bulk Sp. Gr. (Gsb): 2.476		Mix Description: 9.5mm Fine				9/4/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	6.8	1145.7	613.1	1150.9	2.130	2.363	14.1	9.8	11.8	105	4.8	
1	2	6.8	1145.7	601.7	1151.7	2.083	2.363	13.8	11.8	12.9	191	4.8	
1	3	6.8	1045.2	546.4	1051.7	2.068	2.363	13.7	12.5	14.5	244	4.8	
1	4	6.8	1042.2	545.1	1046.2	2.080	2.363	13.8	12.0	14.0	222	4.8	
1	5	6.8	1004.6	514.0	1011.6	2.019	2.363	13.4	14.6	17.6	605	4.8	
1	6	6.8	1004.2	514.6	1017.2	1.998	2.363	13.2	15.4	17.1	605	4.8	
1	7	6.8	964.4	489.0	985.3	1.943	2.363	12.9	17.8	21.3	1809	4.8	
1	8	6.8	963.3	486.1	978.6	1.956	2.363	12.9	17.2	18.6	1797	4.8	
2	1	7.0	1097.2	580.8	1101.3	2.108	2.355	14.4	10.5	12.9	101	5.0	
2	2	7.0	1099.7	581.5	1102.7	2.110	2.355	14.4	10.4	13.9	109	5.0	
2	3	7.0	1047.2	548.8	1051.2	2.084	2.355	14.2	11.5	13.1	204	5.0	
2	4	7.0	1045.1	546.0	1049.8	2.074	2.355	14.1	11.9	13.0	245	5.0	
2	5	7.0	1019.1	524.6	1025.0	2.037	2.355	13.9	13.5	14.8	486	5.0	
2	6	7.0	1017.4	523.0	1023.7	2.032	2.355	13.8	13.7	15.9	609	5.0	
2	7	7.0	997.6	514.7	1011.6	2.008	2.355	13.7	14.7	21.0	807	5.0	
2	8	7.0	997.2	520.0	1017.7	2.004	2.355	13.6	14.9	17.0	810	5.0	
3	1	7.0	1074.4	574.2	1076.6	2.139	2.364	14.6	9.5	11.2	52	5.0	
3	2	7.0	1071.3	569.3	1074.3	2.121	2.364	14.4	10.3	10.4	135	5.0	
3	3	7.0	1033.9	535.6	1041.8	2.042	2.364	13.9	13.6	13.2	348	5.0	
3	4	7.0	1043.7	546.5	1048.3	2.080	2.364	14.2	12.0	14.4	245	5.0	
3	5	7.0	999.6	512.6	1012.1	2.001	2.364	13.6	15.3	16.2	811	5.0	
3	6	7.0	1004.3	517.5	1015.5	2.017	2.364	13.7	14.7	16.8	812	5.0	
3	7	7.0	965.9	485.4	979.3	1.956	2.364	13.3	17.3	17.6	2675	5.0	
3	8	7.0	975.8	498.4	991.3	1.980	2.364	13.5	16.3	18.7	1797	5.0	
Input By:													

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A30: Gradations and Asphalt Content

Gradation		Sample 1					Sample 2					Sample 3					Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.00	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.00	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.00	100.0
12.5	3.12	99.7	99.6	99.4	99.6	0.2	100.0	99.8	99.7	99.8	0.2	99.9	99.5	100.0	99.8	0.3	99.7	0.15	100.0
9.5	2.75	98.1	97.8	97.6	97.8	0.3	98.9	97.2	97.4	97.8	0.9	98.7	98.3	98.9	98.6	0.3	98.1	0.46	99.0
4.75	2.02	81.8	81.5	79.4	80.9	1.3	83.0	80.8	79.4	81.1	1.8	83.2	81.5	81.3	82.0	1.0	81.3	0.59	81.0
2.36	1.47	61.7	61.4	60.3	61.1	0.7	61.4	60.4	59.0	60.3	1.2	61.5	60.0	59.6	60.4	1.0	60.6	0.47	60.0
1.18	1.08	46.0	45.9	45.4	45.8	0.3	46.1	45.3	44.6	45.3	0.8	46.2	45.1	45.1	45.5	0.6	45.5	0.22	44.0
0.6	0.8	31.8	31.9	31.7	31.8	0.1	31.6	31.2	30.9	31.2	0.4	32.0	31.3	31.5	31.6	0.4	31.5	0.29	30.0
0.3	0.58	17.4	17.5	17.5	17.5	0.1	16.7	16.7	16.5	16.6	0.1	17.1	16.7	17.1	17.0	0.2	17.0	0.42	19.0
0.15	0.43	7.7	7.9	8.0	7.9	0.2	7.3	7.3	7.3	7.3	0.0	7.5	7.3	7.6	7.5	0.2	7.5	0.29	9.0
0.075	0.31	4.0	4.1	4.2	4.1	0.1	3.9	3.6	3.7	3.7	0.2	3.8	3.7	3.9	3.8	0.1	3.9	0.20	4.5
Asphalt Content		**Sample 1**					**Sample 2**					**Sample 3**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		6.80	6.90	6.70	6.80	0.10	7.10	7.00	6.90	7.00	0.10	7.10	6.90	6.90	6.97	0.12	6.92	0.11	7.00

Table A34: Coarse Aggregate Properties for Project 5

Test	14M	
Bulk / Apparent Specific Gravit	2.285/2.552	
Absorption, %	4.6	
LA Abrasion, % Loss	41.3	
Flat and Elongated, %		
3 to 1	18.1	
5 to 1	1.5	
Coarse Aggregate Flow, %	45.3	
Crushed Content, %		
One Face	100	
Two+ Faces	100	
Data provided by either the agency or determined at NCAT lab		

Table A35: Fine Aggregate Properties for Project 5

Test	Conc. Sand	Nat. Sand	RAP
Bulk / Apparent Specific Gravi	2.529/2.666	2.619/2.644	2.606/2.662
Absorption, %	2	0.4	0.8
Fine Aggregate Angularity, %	46.3	42.6	43.6
Sand Equivalent	95	94	70
Data provided by either the agency or determined at NCAT lab			

Project 6:

Project 6 was evaluated on August 13, 2002 and consisted of the placement of 57.2mm of new hot mix asphalt over an unbound base in the eastbound lane of an existing highway. The mix consisted of a 12.5mm nominal maximum aggregate size coarse-graded gravel/sand blend designed at an N_{design} of 75 gyrations resulting in a design asphalt content of 5.95 percent. The asphalt binder that was used was an unmodified PG 58-28. One percent hydrated lime was used as an anti-stripping agent. The weather conditions during paving were approximately 80°F, sunny, with a light wind. The design and gradation information are provided in Tables A36 and A37.

The project was located approximately 15-20 miles from the drum plant. Windrow paving construction was accomplished with belly dump trucks in conjunction with an Ingersoll Rand PF5510 paver configured with a Barber Greene BG650 windrow elevator. Breakdown rolling was performed immediately after the mat was laid down by an Ingersoll Rand DD130 roller in maximum amplitude and frequency making three passes over the mat. A Caterpillar PS360B pneumatic tire roller, starting at a pavement temperature of 210F, performed intermediate rolling by making four to five passes. Finish rolling was conducted by an Ingersoll Rand DD130 making two passes in static mode, starting at a temperature of approximately 130F.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A38-A43.

Table A36: Project 6 Mix Design Summary Information	
JMF I.D. Number:	0440729-1
Date(s) on Project:	8/13/02
Number of Stockpiles Used:	3
- Coarse Aggregate Angularity:	100% 2+ crushed faces
- Fine Aggregate Angularity:	14.9
Percent RAP:	None
Gradation:	12.5mm Coarse Graded
Ninitial, Ndesign, Nmax:	7, 75, NA
Type Asphalt Binder Used:	PG 58-28
Design Asphalt Binder Content:	5.95
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Hydrated Lime
Percent Anti-Strip Used:	None
Design Voids in Total Mix:	3.5
Design Voids in Mineral Aggregate:	14.9
Design Voids Filled with Asphalt:	76.7
Tensile Strength Ratio:	0.85
Dust/Asphalt Ratio:	1.0

Table A37: Design Gradation for Project 6			
Sieve Size	Sieve Size, mm	Recommended Limits From JMF	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0	100	100
½ in.	12.5	90-100	91
3/8 in	9.5	72-82	77
No. 4	4.75	45-55	50
No. 8	2.36	30-38	34
No. 16	1.18		24
No. 30	0.6	4-20	18
No. 50	0.3		12
No. 100	0.15		9
No. 200	0.075	4.4-8.4	6.4

Table A38: Results from SGC Compactions **Ndesign = 75**

Project:	**6**													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.612		Bulk Sp. Gr. (Gsb): 2.537		Mix Description: 12.5mm Coarse					9/5/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %
1	1	6.0	4635.2	2661.1	4639.4	2.343	2.396	86.8	13.7	146.2	2.2	13.2	83.2	4.9
1	2	6.0	4639.0	2660.0	4644.5	2.338	2.396	86.6	13.6	145.9	2.4	13.4	81.8	4.9
1	3	6.0	4639.5	2667.9	4642.3	2.350	2.396	87.1	13.7	146.6	1.9	12.9	85.1	4.9
2	1	6.6	4636.6	2658.1	4639.9	2.340	2.390	86.1	15.0	146.0	2.1	13.9	84.8	5.5
2	2	6.6	4669.5	2674.5	4672.3	2.337	2.390	86.0	15.0	145.8	2.2	14.0	84.2	5.5
2	3	6.6	4633.3	2656.6	4636.7	2.340	2.390	86.1	15.0	146.0	2.1	13.9	84.9	5.5
3	1													
3	2													
3	3													
Input By:													Checked By:	

SSD = Saturated Surface Dry | cc = cubic centimeter | VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density | AC = Asphalt Cement | VFA = Voids Filled With Asphalt Cement
gm = gram | pcf = pounds per cubic foot | VTM = Voids in Total Mix

Table A39: Results of Height Sample SGC Compactions **Ndesign = 75**

Project: 6													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.612		Bulk Sp. Gr. (Gsb): 2.537	Mix Description: 12.5mm Coarse					9/5/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	6.0	1999.6	1145.5	2000.6	2.338	2.396	13.6	2.4	4.0	0	4.9	
1	2	6.0	2010.5	1154.6	2012.0	2.345	2.396	13.7	2.1	3.6	0	4.9	
1	3	6.0	1910.6	1066.6	1919.3	2.241	2.396	13.1	6.5	8.0	55	4.9	
1	4	6.0	1905.1	1067.2	1912.2	2.255	2.396	13.2	5.9	7.7	24	4.9	
1	5	6.0	1868.7	1030.9	1882.3	2.195	2.396	12.8	8.4	9.8	174	4.9	
1	6	6.0	1871.5	1036.0	1886.1	2.202	2.396	12.8	8.1	10.0	138	4.9	
1	7	6.0	1824.5	1009.4	1855.4	2.157	2.396	12.6	10.0	11.5	400	4.9	
1	8	6.0	1836.6	1011.8	1859.7	2.166	2.396	12.6	9.6	11.1	307	4.9	
2	1	6.3	1890.6	1050.4	1901.9	2.220	2.390	13.6	7.1	7.8	34	5.2	
2	2	6.3	1909.4	1060.7	1915.1	2.235	2.390	13.7	6.5	7.5	0	5.2	
2	3	6.3	1812.2	990.5	1832.9	2.151	2.390	13.2	10.0	10.8	400	5.2	
2	4	6.3	1836.8	1005.8	1855.7	2.161	2.390	13.2	9.6	10.5	308	5.2	
2	5	6.3	1758.7	964.3	1794.8	2.118	2.390	13.0	11.4	13.0	NA	5.2	
2	6	6.3	1762.7	961.6	1804.0	2.092	2.390	12.8	12.4	13.7	1487	5.2	
2	7	6.3	1731.6	949.0	1783.3	2.076	2.390	12.7	13.2	14.5	2230	5.2	
2	8	6.3	1740.8	943.2	1782.9	2.073	2.390	12.7	13.3	14.9	NA	5.2	

Input By:

SSD = Saturated Surface Dry; cc = cubic centimeter
TMD = Theoretical Maximum Density; AC = Asphalt Cement; NA = No Data Available
gm = gram; pcf = pounds per cubic foot; VTM = Voids in Total Mix

Table A40: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.00	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.00	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.00	100.0
12.5	3.12	95.6	96.4	96.1	96.0	0.4	97.1	95.9	92.6	95.2	2.3	95.6	0.59	91.0
9.5	2.75	82.0	83.4	84.2	83.2	1.1	84.1	82.0	79.2	81.8	2.5	82.5	1.01	77.0
4.75	2.02	56.0	56.6	57.4	56.7	0.7	57.0	55.1	53.7	55.3	1.7	56.0	0.99	50.0
2.36	1.47	39.0	39.3	40.3	39.5	0.7	39.8	38.3	37.5	38.5	1.2	39.0	0.71	34.0
1.18	1.08	27.9	28.1	28.4	28.1	0.3	27.7	26.9	26.3	27.0	0.7	27.6	0.82	24.0
0.6	0.8	21.1	21.3	21.3	21.2	0.1	20.7	20.1	19.6	20.1	0.6	20.7	0.78	18.0
0.3	0.58	15.8	16.1	15.9	15.9	0.2	15.2	14.8	14.4	14.8	0.4	15.4	0.80	12.0
0.15	0.43	11.7	12.1	11.7	11.8	0.2	11.0	10.6	10.5	10.7	0.3	11.3	0.80	--
0.075	0.31	8.3	8.7	8.2	8.4	0.3	7.5	7.2	7.2	7.3	0.2	7.9	0.78	6.4
Asphalt Content		**Sample 1**					**Sample 2**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		5.93	5.74	6.40	6.02	0.34	6.65	6.46	5.91	6.34	0.38	6.18	0.22	5.95

Table A41: Coarse Aggregate Properties for Project 6

Test	CA	IA
Bulk / Apparent Specific Gravity	2.577/2.700	2.550/2.702
Absorption, %	1.8	2.2
LA Abrasion, % Loss	16.4	22.8
Flat and Elongated, %		
3 to 1	28.6	53.3
5 to 1	4.3	22.7
Coarse Aggregate Flow, %	48.1	50.4
Crushed Content, %		
One Face	11.2	15.6
Two+ Faces	88.8	84.4
Data provided by either the agency or determined at NCAT lab		

Table A42: Fine Aggregate Properties for Project 6

Test	Cr. Fines	
Bulk / Apparent Specific Gravity	2.518/2.706	
Absorption, %	2.76	
Fine Aggregate Angularity, %	48.5	
Sand Equivalent	67	
Data provided by either the agency or determined at NCAT lab		

Project 7:

Project 7 was evaluated on August 14, 2002 and consisted of the placement of 50.8mm of new hot mix asphalt in the westbound lane of an existing highway. The mix consisted of a 9.5mm nominal maximum aggregate size fine-graded gravel/sand blend designed at an N_{design} of 75 gyrations resulting in a design asphalt content of 5.7 percent. The asphalt binder that was used was a PG 64-28. One percent hydrated lime was used as an anti-stripping agent. The weather conditions during paving were approximately 75°F, sunny, and breezy (15-20mph). The mix design and gradation information are provided in Tables A43 and A44.

The project was located less than 5 miles from the drum plant. Windrow paving construction was accomplished with belly dump trucks in conjunction with a Blaw Knox PF220 paver configured with a windrow elevator. Breakdown rolling, starting at a temperature of approximately 200F, was performed a Caterpillar CB634C roller in medium amplitude and frequency making three passes over the mat. Finish rolling was started when the mat was cooled to a temperature of 150F and was conducted by another Caterpillar CB634C roller, this one making three to four passes in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A45-A49.

Table A43: Project 7 Mix Design Summary Information	
JMF I.D. Number:	NH 0403-0454
Date(s) on Project:	8/14/02
Number of Stockpiles Used:	3
- Coarse Aggregate Angularity:	100% 2+ crushed faces
- Fine Aggregate Angularity:	49.6
Percent RAP:	None
Gradation:	9.5mm Fine Graded
Ninitial, Ndesign, Nmax:	7, 75, NA
Type Asphalt Binder Used:	PG 64-28
Design Asphalt Binder Content:	5.7
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Hydrated Lime
Percent Anti-Strip Used:	None
Design Voids in Total Mix:	NA
Design Voids in Mineral Aggregate:	NA
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	NA

Table A44: Design Gradation for Project 7			
Sieve Size	Sieve Size, mm	Recommended Limits From JMF	Percent Passing
11/2 in.	37.5		
1 in.	25.0		
¾ in.	19.0	100	
½ in.	12.5	90-100	
3/8 in	9.5	83-95	
No. 4	4.75	57-67	
No. 8	2.36	44-54	
No. 16	1.18		
No. 30	0.6	24-32	
No. 50	0.3		
No. 100	0.15		
No. 200	0.075	4.9-8.9	

Table A45: Results from SGC Compactions **Ndesign = 75**

Project: 7															Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.728		Bulk Sp. Gr. (Gsb): 2.747		Mix Description: 9.5mm Fine						9/5/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	5.7	4892.9	2841.2	4897.3	2.380	2.494	81.7	13.2	148.5	4.6	18.3	75.0	5.9	
1	2	5.7	4891.2	2845.5	4893.4	2.388	2.494	82.0	13.2	149.0	4.2	18.0	76.5	5.9	
1	3	5.7	4898.6	2847.7	4900.5	2.386	2.494	81.9	13.2	148.9	4.3	18.1	76.1	5.9	
2	1	5.7	4918.3	2870.1	4922.6	2.396	2.494	82.3	13.3	149.5	3.9	17.7	77.9	5.9	
2	2	5.7	4915.6	2871.0	4917.9	2.401	2.494	82.4	13.3	149.9	3.7	17.6	78.9	5.9	
2	3	5.7					2.494							5.9	
Input By:													Checked By:		

SSD = Saturated Surface Dry | cc = cubic centimeter | VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density | AC = Asphalt Cement | VFA = Voids Filled With Asphalt Cement
gm = gram | pcf = pounds per cubic foot | VTM = Voids in Total Mix

Table 46: Results of Height Sample SGC Compactions **Ndesign = 75**

Project: 7													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.728		Bulk Sp. Gr. (Gsb): 2.747	Mix Description: 9.5mm Fine					9/11/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	5.7	2111.4	1243.1	2112.3	2.429	2.494	13.5	2.6	2.8	0	5.9	
1	2	5.7	2089.8	1219.6	2090.2	2.400	2.494	13.3	3.8	3.8	0	5.9	
1	3	5.7	1968.7	1100.7	1971.1	2.262	2.494	12.5	9.3	9.3	33	5.9	
1	4	5.7	1973.8	1105.7	1976.7	2.266	2.494	12.6	9.1	8.9	36	5.9	
1	5	5.7	1944.2	1079.0	1947.8	2.238	2.494	12.4	10.3	10.0	71	5.9	
1	6	5.7	1958.2	1090.2	1962.3	2.245	2.494	12.5	10.0	9.4	52	5.9	
1	7	5.7	1929.0	1068.0	1938.3	2.216	2.494	12.3	11.1	10.9	154	5.9	
1	8	5.7	1903.4	1041.0	1908.1	2.195	2.494	12.2	12.0	11.6	143	5.9	
2	1	5.5	2046.3	1178.3	2047.5	2.354	2.494	12.6	5.6	5.9	0	5.7	
2	2	5.5	2047.1	1184.6	2050.3	2.365	2.494	12.7	5.2	5.4	0	5.7	
2	3	5.5	1941.3	1074.3	1948.2	2.221	2.494	11.9	10.9	10.7	143	5.7	
2	4	5.5	1951.8	1080.7	1956.4	2.229	2.494	11.9	10.6	10.7	121	5.7	
2	5	5.5	1901.4	1036.1	1907.4	2.182	2.494	11.7	12.5	12.3	191	5.7	
2	6	5.5	1905.1	1040.3	1910.8	2.189	2.494	11.7	12.2	11.9	236	5.7	
2	7	5.5	1863.8	1006.3	1871.7	2.154	2.494	11.5	13.6	11.6	334	5.7	
2	8	5.5	1860.8	1000.0	1867.0	2.146	2.494	11.5	14.0	13.4	400	5.7	
Input By:													

SSD = Saturated Surface Dry cc = cubic centimeter
TMD = Theoretical Maximum Density AC = Asphalt Cement
gm = gram pcf = pounds per cubic foot VTM = Voids in Total Mix

Table A47: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.00	
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.00	
19	3.76	100	100	100	100.0	0.0	100	100	100	100.0	0.0	100.0	0.00	
12.5	3.12	98.7	98.8	99.3	98.9	0.3	99.8	99.6	99.9	99.8	0.2	99.35	0.59	
9.5	2.75	89.2	90.2	89.8	89.7	0.5	91.8	92.2	93	92.3	0.6	91.03	1.84	
4.75	2.02	65.3	68.1	68	67.1	1.6	65	65.9	67.6	66.2	1.3	66.65	0.68	
2.36	1.47	51.7	54.6	54.3	53.5	1.6	50.3	51.3	52.4	51.3	1.1	52.43	1.56	
1.18	1.08	40.2	42.5	42.2	41.6	1.3	38.9	39.6	40.4	39.6	0.8	40.63	1.41	
0.6	0.8	30.1	31.8	31.6	31.2	0.9	29.2	29.5	30.2	29.6	0.5	30.40	1.08	
0.3	0.58	20.6	21.8	21.6	21.3	0.6	20.1	20.3	20.8	20.4	0.4	20.87	0.66	
0.15	0.43	11.7	12.6	12.3	12.2	0.5	11.8	11.7	12.2	11.9	0.3	12.05	0.21	
0.075	0.31	6	6.8	6.4	6.4	0.4	6.4	6.3	6.7	6.5	0.2	6.43	0.05	
Asphalt Content		Sample 1					Sample 2					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		5.60	5.80	5.70	5.70	0.10	5.40	5.60	5.60	5.53	0.12	5.62	0.12	5.7

Table A48: Coarse Aggregate Properties for Project 7

Test	1/2"	
Bulk / Apparent Specific Gravit	2.687/2.785	
Absorption, %	1.3	
LA Abrasion, % Loss	13.6	
Flat and Elongated, %		
3 to 1	49.5	
5 to 1	3.9	
Coarse Aggregate Flow, %	46.4	
Crushed Content, %		
One Face	20	
Two+ Faces	80	
Data provided by either the agency or determined at NCAT lab		

Table A49: Fine Aggregate Properties for Project 7

Test	Cr. Fines	W. Sand
Bulk / Apparent Specific Gravi	2.745/2.784	2.587/2.654
Absorption, %	0.5	1
Fine Aggregate Angularity, %	49.1	42.2
Sand Equivalent	62	74
Data provided by either the agency or determined at NCAT lab		

Project 8:

Project 8 was evaluated on the night of August 20, 2002 and the morning of August 21, 2002 (this project was conducted at night) and consisted of the placement of 50.8mm of new hot mix asphalt over a milled Portland Cement Concrete pavement. The mix consisted of a 19.0mm nominal maximum aggregate size coarse-graded limestone/sand blend designed at an N_{design} of 100 gyrations resulting in a design asphalt content of 5.3 percent. The asphalt binder that was used was a PG 64-22. One percent baghouse fines was used as an anti-stripping agent. The weather conditions during paving were approximately 70°F and clear. The mix design and gradation information are provided in Tables A50 and A51.

The project was located approximately 10 miles from the CMI drum plant. Pavement construction was conducted with end dump trucks in conjunction with a paver and a Roadtec 2500B material transfer device. Breakdown rolling was conducted by two Ingersoll Rand DD130 rollers, operating in echelon, making five passes each in maximum amplitude and frequency. Intermediate rolling was performed by an Ingersoll Rand PT220R pneumatic tire roller, using 90psi tire inflation pressure, making five passes over the mat. Finish rolling was conducted by an Ingersoll Rand DD90 roller making two passes in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A52-A56.

Table A50: Project 8 Mix Design Summary Information	
JMF I.D. Number:	J4P1347
Date(s) on Project:	8/20/02
Number of Stockpiles Used:	5
- Coarse Aggregate Angularity:	100% 2+ crushed faces
- Fine Aggregate Angularity:	NA
Percent RAP:	None
Gradation:	19.0mm Coarse Graded
Ninitial, Ndesign, Nmax:	8, 100, 160
Type Asphalt Binder Used:	PG 64-22
Design Asphalt Binder Content:	5.3
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Baghouse Fines
Percent Anti-Strip Used:	None
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	14.1
Design Voids Filled with Asphalt:	72
Tensile Strength Ratio:	91
Dust/Asphalt Ratio:	0.9

Table A51: Design Gradation for Project 8			
Sieve Size	Sieve Size, mm	Recommended Limits From JMF	Percent Passing
11/2 in.	37.5		100
1 in.	25.0	100	100
¾ in.	19.0	90-100	95
½ in.	12.5	90 max	79.8
3/8 in	9.5		72.4
No. 4	4.75		48.4
No. 8	2.36	23-49	29.9
No. 16	1.18		17.7
No. 30	0.6		10.6
No. 50	0.3		6.2
No. 100	0.15		4.6
No. 200	0.075	2-8	3.0

Table A52: Results from SGC Compactions **Ndesign = 100**

Project: 8															Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.697		Bulk Sp. Gr. (Gsb): 2.577		Mix Description: 19.0mm Coarse						9/5/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	4.2	4732.4	2710.8	4739.1	2.333	2.477	86.7	9.5	145.6	5.8	13.3	56.2	2.5	
1	2	4.2	4747.0	2708.3	4756.3	2.318	2.477	86.2	9.5	144.6	6.4	13.8	53.6	2.5	
1	3	4.2	4756.2	2729.9	4763.0	2.339	2.477	87.0	9.6	146.0	5.6	13.0	57.4	2.5	
2	1	4.2	4746.8	4771.6	4771.6	2.326	2.490	86.5	9.5	145.1	6.6	13.5	51.3	2.5	
2	2	4.2	4799.8	4812.1	4812.1	2.354	2.490	87.5	9.6	146.9	5.5	12.5	56.3	2.5	
2	3	4.2	4749.8	4777.6	4777.6	2.334	2.490	86.8	9.5	145.6	6.3	13.2	52.7	2.5	
Input By:														Checked By:	

SSD = Saturated Surface Dry cc = cubic centimeter VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density AC = Asphalt Cement VFA = Voids Filled With Asphalt Cement
gm = gram pcf = pounds per cubic foot VTM = Voids in Total Mix

Table A52: Results of Height Sample SGC Compactions **Ndesign = 100**

Project: 8													
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.712		Bulk Sp. Gr. (Gsb): 2.574	Mix Description: 19.0mm Coarse					Date 9/5/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	4.2	2348.3	1355.5	2351.1	2.359	2.477	9.6	4.8	5.5	0	2.3	
1	2	4.2	2382.2	1368.5	2385.0	2.344	2.477	9.6	5.4	5.7	0	2.3	
1	3	4.2	2254.5	1288.1	2259.4	2.321	2.477	9.5	6.3	7.1	10	2.3	
1	4	4.2	2299.1	1318.1	2305.1	2.329	2.477	9.5	6.0	6.8	0	2.3	
1	5	4.2	2232.8	1270.3	2239.9	2.303	2.477	9.4	7.0	7.4	43	2.3	
1	6	4.2	2235.2	1270.9	2242.9	2.300	2.477	9.4	7.2	7.8	33	2.3	
1	7	4.2	2222.9	1263.0	2235.3	2.286	2.477	9.3	7.7	8.5	322	2.3	
1	8	4.2	2170.7	1233.3	2188.7	2.272	2.477	9.3	8.3	10.5	889	2.3	
2	1	4.2	2165.1	1221.9	2190.3	2.236	2.490	9.1	10.2	11.0	490	2.3	
2	2	4.2	2156.5	1229.7	2183.8	2.260	2.490	9.2	9.2	11.6	884	2.3	
2	3	4.2	2039.7	1170.5	2092.2	2.213	2.490	9.0	11.1	18.5	8207	2.3	
2	4	4.2	2061.4	1173.9	2111.9	2.198	2.490	9.0	11.7	16.2	5441	2.3	
2	5	4.2	2008.2	1148.9	2060.4	2.203	2.490	9.0	11.5	18.3	8116	2.3	
2	6	4.2	2002.1	1141.5	2058.5	2.183	2.490	8.9	12.3	18.4	8118	2.3	
2	7	4.2	1919.3	1102.3	1972.1	2.207	2.490	9.0	11.4	21.7	16931	2.3	
2	8	4.2	1962.7	1124.6	2014.0	2.207	2.490	9.0	11.4	17.8	8454	2.3	
Input By:													

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A54: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.00	0.00	100.0
19	3.76	94.9	90.0	92.3	92.4	2.5	94.4	92.3	94.0	93.6	1.1	92.98	0.82	95.0
12.5	3.12	73.9	72.1	69.6	71.9	2.2	73.7	72.4	75.0	73.7	1.3	72.78	1.30	79.8
9.5	2.75	64.2	61.0	57.8	61.0	3.2	63.3	61.8	64.1	63.1	1.2	62.03	1.46	72.4
4.75	2.02	38.9	36.5	34.4	36.6	2.3	37.3	36.6	37.6	37.2	0.5	36.88	0.40	48.4
2.36	1.47	22.7	22.0	21.3	22.0	0.7	22.4	21.8	22.3	22.2	0.3	22.08	0.12	29.9
1.18	1.08	14.8	14.7	14.6	14.7	0.1	15.2	14.6	15.1	15.0	0.3	14.83	0.19	17.7
0.6	0.8	10.1	10.0	10.1	10.1	0.1	10.8	10.0	10.3	10.4	0.4	10.22	0.21	10.6
0.3	0.58	7.1	6.9	7.1	7.0	0.1	7.7	7.0	7.3	7.3	0.4	7.18	0.21	6.2
0.15	0.43	5.1	5.0	5.2	5.1	0.1	5.6	5.0	5.1	5.2	0.3	5.17	0.09	4.6
0.075	0.31	3.7	3.5	3.8	3.7	0.2	4.1	3.6	3.6	3.8	0.3	3.72	0.07	3.0
Asphalt Content		Sample 1					Sample 2					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		4.20	4.21	4.05	4.15	0.09	4.12	4.27	4.14	4.18	0.08	4.17	0.02	5.3

Table A55: Coarse Aggregate Properties for Project 8

Test	1" LMS	3/4" LMS	3/8" LMS
Bulk / Apparent Specific Gravity	2.609/2.711	2.626/2.716	2.595/2.712
Absorption, %	1.5	1.3	1.7
LA Abrasion, % Loss	12.7	13.7	11.3
Flat and Elongated, %			
3 to 1	30.9	20.1	25.6
5 to 1	1.8	0.5	11.2
Coarse Aggregate Flow, %	48.7	46.8	48.4
Crushed Content, %			
One Face	100	100	100
Two+ Faces	100	100	100
Data provided by either the agency or determined at NCAT lab			

Table A56: Fine Aggregate Properties for Project 8

Test	Drag Sand	Man Snad
Bulk / Apparent Specific Gravi	2.520/2.669	2.469/2.729
Absorption, %	2.2	3.9
Fine Aggregate Angularity, %	38.9	44.1
Sand Equivalent	85	77
Data provided by either the agency or determined at NCAT lab		

Project 9:

Project 9 was evaluated on 23, 2002 and consisted of the placement of 101.6mm of new hot mix asphalt in the construction of a new state highway. The mix consisted of a 25.0mm nominal maximum aggregate size limestone/sand coarse-graded blend designed at an N_{design} of 100 gyrations resulting in a design asphalt content of 4.5 percent. The asphalt binder that was used was a PG 64-22. One percent baghouse fines was used as an anti-stripping agent. The weather conditions during paving were approximately 95°F (with a heat index of 105°), sunny, with no wind. The mix design and gradation information are provided in Tables A57 and A58.

The project was located approximately 10 miles from the drum plant. Pavement construction was conducted with end dump trucks in conjunction with a Cedarrapids CR461paver and a Roadtec 2500B material transfer device. The mat was being laid at a temperature of about 315°F. Breakdown rolling was conducted by an Ingersoll Rand DD130 roller, starting at a pavement temperature of approximately 250°F, making three to four passes in maximum amplitude and frequency. An Ingersoll Rand PT240R pneumatic tire roller making eight passes and staying right behind the breakdown roller performed intermediate rolling. Finish rolling started when the mat had cooled to a temperature of about 225°F and made three passes, two in low vibratory mode and one in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A59-A63.

Table A57: Project 9 Mix Design Summary Information	
JMF I.D. Number:	NA
Date(s) on Project:	08-23-02
Number of Stockpiles Used:	5
- Coarse Aggregate Angularity:	NA
- Fine Aggregate Angularity:	NA
Percent RAP:	None
Gradation:	19.0mm Coarse Graded
Ninitial, Ndesign, Nmax:	8, 100, 160
Type Asphalt Binder Used:	PG 64-22
Design Asphalt Binder Content:	4.5
Type Modifier Used:	Ultra Pave 5000
Type Anti-Strip Additive Used:	Hydrated Lime
Percent Anti-Strip Used:	2
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	12.9
Design Voids Filled with Asphalt:	69
Tensile Strength Ratio:	93
Dust/Asphalt Ratio:	1.0

Table A59: Design Gradation for Project 9			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		89.5
½ in.	12.5		74.1
3/8 in	9.5		63.5
No. 4	4.75		39
No. 8	2.36		21.8
No. 16	1.18		12.9
No. 30	0.6		8.8
No. 50	0.3		6.2
No. 100	0.15		4.4
No. 200	0.075		3.8

Table A59: Results from SGC Comapctions **Ndesign = 100**

Project: 9															Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.653		Bulk Sp. Gr. (Gsb): 2.624		Mix Description: 19.0mm Coarse						9/5/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	4.5	4760.0	2742.1	4772.7	2.344	2.474	85.3	10.3	146.3	5.2	14.7	64.3	4.1	
1	2	4.5	4768.3	2743.3	4780.4	2.341	2.474	85.2	10.2	146.1	5.4	14.8	63.6	4.1	
1	3	4.5	4756.1	2747.2	4765.5	2.356	2.474	85.8	10.3	147.0	4.7	14.2	66.6	4.1	
2	1	4.5	4794.5	2809.0	4800.4	2.408	2.479	87.6	10.5	150.2	2.9	12.4	76.7	4.1	
2	2	4.5	4775.8	2770.0	4793.3	2.360	2.479	85.9	10.3	147.3	4.8	14.1	66.1	4.1	
2	3	4.5	4773.0	2794.4	4777.5	2.407	2.479	87.6	10.5	150.2	2.9	12.4	76.5	4.1	
Input By:													Checked By:		

SSD = Saturated Surface Dry | cc = cubic centimeter | VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density | AC = Asphalt Cement | VFA = Voids Filled With Asphalt Cement
gm = gram | pcf = pounds per cubic foot | VTM = Voids in Total Mix

Table A60: Results of Height Sample SGC Compactions **Ndesign = 100**

Project: 9			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse):		Bulk Sp. Gr. (Gsb):	Mix Description: 19.0mm Coarse				Date 9/5/2003
AC Sp. Gr. (Gb) = 1.028					2.653		2.624					
			Masses			SPECIFIC GRAVITIES			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %
1	1	4.4	4204.9	2426.2	4219.8	2.344	2.474	10.0	5.2	6.8	55	4.0
1	2	4.4	4180.9	2456.9	4185.8	2.418	2.474	10.4	2.3	3.3	6	4.0
1	3	4.4	4079.9	2379.4	4088.2	2.388	2.474	10.2	3.5	4.9	23	4.0
1	4	4.4	4076.5	2375.1	4084.7	2.384	2.474	10.2	3.6	4.9	57	4.0
1	5	4.4	3962.4	2277.1	3975.9	2.332	2.474	10.0	5.7	7.3	102	4.0
1	6	4.4	3956.5	2262.1	3973.7	2.312	2.474	9.9	6.6	8.0	202	4.0
1	7	4.4	3899.8	2203.2	3918.6	2.273	2.474	9.7	8.1	9.5	334	4.0
1	8	4.4	3900.4	2206.3	3920.8	2.275	2.474	9.7	8.0	9.8	166	4.0
2	1	4.5	4065.0	2358.6	4074.1	2.370	2.479	10.4	4.4	6.1	0	4.1
2	2	4.5	4077.1	2369.8	4086.0	2.376	2.479	10.4	4.2	5.6	47	4.1
2	3	4.5	3956.5	2272.5	3977.9	2.320	2.479	10.2	6.4	8.3	86	4.1
2	4	4.5	3959.7	2271.6	3977.9	2.321	2.479	10.2	6.4	7.7	81	4.1
2	5	4.5	3898.4	2228.7	3927.7	2.295	2.479	10.0	7.4	9.4	231	4.1
2	6	4.5	3928.1	2250.8	3955.4	2.304	2.479	10.1	7.0	8.9	174	4.1
2	7	4.5	3895.4	2219.3	3918.5	2.292	2.479	10.0	7.5	9.3	259	4.1
2	8	4.5	3834.3	2256.5	3954.3	2.258	2.479	9.9	8.9	7.9	101	4.1

Input By:

SSD = Saturated Surface Dry
cc = cubic centimeter
TMD = Theoretical Maximum Density
AC = Asphalt Cement
gm = gram
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A61: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.0	100.0
19	3.76	96.4	90.5	90.2	92.4	3.5	89.6	89.9	93.8	91.1	2.3	91.7	0.9	89.5
12.5	3.12	83.3	80.1	78.3	80.6	2.5	81.3	81.9	81.9	81.7	0.3	81.1	0.8	74.2
9.5	2.75	71.3	68.9	64.7	68.3	3.3	72.0	70.8	72.3	71.7	0.8	70.0	2.4	63.5
4.75	2.02	44.5	42.6	40.1	42.4	2.2	45.2	45.6	46.1	45.6	0.5	44.0	2.3	39.0
2.36	1.47	21.7	21.8	20.7	21.4	0.6	24.4	24.3	24.2	24.3	0.1	22.9	2.1	21.8
1.18	1.08	13.0	13.4	12.7	13.0	0.4	15.3	15.3	14.9	15.2	0.2	14.1	1.5	12.9
0.6	0.8	8.8	9.4	8.8	9.0	0.3	10.9	11.0	10.5	10.8	0.3	9.9	1.3	8.8
0.3	0.58	6.5	7.1	6.6	6.7	0.3	8.4	8.5	7.9	8.3	0.3	7.5	1.1	6.2
0.15	0.43	5.0	5.7	5.1	5.3	0.4	6.6	6.7	6.1	6.5	0.3	5.9	0.8	4.4
0.075	0.31	3.9	4.4	3.9	4.1	0.3	5.1	5.2	4.5	4.9	0.4	4.5	0.6	3.8
Asphalt Content		Sample 1					Sample 2					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		4.40	4.60	4.20	4.40	0.20	4.60	4.40	4.60	4.53	0.12	4.47	0.09	4.5

Table A62: Coarse Aggregate Properties for Project 9

Test	1 1/2" LMS	3/4" LMS	1/2" LMS
Bulk / Apparent Specific Gravity	2.667/2.714	2.664/2.717	2.640/2.708
Absorption, %	0.6	0.7	1
LA Abrasion, % Loss	35.5	29.4	32.8
Flat and Elongated, %			
3 to 1	17.3	18.4	52.4
5 to 1		8.7	1.8
Coarse Aggregate Flow, %	46.6	47.5	47.6
Crushed Content, %			
One Face	100	100	100
Two+ Faces	100	100	100
Data provided by either the agency or determined at NCAT lab			

Table A63: Fine Aggregate Properties for Project 9

Test	1/2" Base	Man Snad
Bulk / Apparent Specific Gravity	2.569/2.681	2.611/2.847
Absorption, %	1.8	3.2
Fine Aggregate Angularity, %	42.4	44
Sand Equivalent	100	100
Data provided by either the agency or determined at NCAT lab		

Project 10:

Project 10 was evaluated on August 5, 2002 and consisted of the placement of 57.2mm of new hot mix asphalt over a granular base in the westbound lane of an existing highway. The mix consisted of a 19.0mm nominal maximum aggregate size coarse-graded blend designed at an N_{design} of 100 gyrations resulting in a design asphalt content of 5.6 percent. The asphalt binder that was used was a PG 64-34. One percent hydrated lime was used as an anti-stripping agent. The weather conditions during paving were approximately 90-95°F, mostly sunny, and windy. The mix design and gradation information are provided in Tables A64 and A65.

The project was located approximately 25 miles from the batch plant. Windrow paving construction was accomplished with belly dump trucks in conjunction with a Champion 1110W paver configured with a windrow elevator and a Roadtec SB2500B material transfer device. Breakdown rolling was originally started with an Ingersoll Rand DD130 roller, but was later replaced with a Caterpillar 634C roller due to the original roller breaking down. Breakdown rolling was being conducted in vibratory mode as well. Intermediate rolling was conducted by a Caterpillar PS360B pneumatic tire roller. Finish rolling was conducted another Caterpillar 634C roller, starting at a pavement temperature of about 130F, in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A66-A70.

Table A64: Project 10 Mix Design Summary Information	
JMF I.D. Number:	NA
Date(s) on Project:	8/5/02
Number of Stockpiles Used:	NA
- Coarse Aggregate Angularity:	NA
- Fine Aggregate Angularity:	NA
Percent RAP:	None
Gradation:	19.0mm Coarse Graded
Ninitial, Ndesign, Nmax:	8, 100, 160
Type Asphalt Binder Used:	PG 64-34
Design Asphalt Binder Content:	5.7
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Hydrated Lime
Percent Anti-Strip Used:	None
Design Voids in Total Mix:	NA
Design Voids in Mineral Aggregate:	NA
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	NA

Table A65: Design Gradation for Project 10			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5	69-81	75
3/8 in	9.5		
No. 4	4.75		
No. 8	2.36	29-39	34
No. 16	1.18		
No. 30	0.6		
No. 50	0.3	9-15	12
No. 100	0.15		
No. 200	0.075	4.9-8.9	6.9

Table A66: Results from SGC Compactions **Ndesign = 100**

Project: 10															Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.663		Bulk Sp. Gr. (Gsb):		Mix Description: 19.0mm Coarse						9/5/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	5.7	4989.5	2870.2	5019.2	2.322	2.442		12.9	144.9	4.9				
1	2	5.7	4914.6	2818.5	4957.4	2.298	2.442		12.7	143.4	5.9				
1	3	5.7	4772.1	2738.6	4819.2	2.294	2.442		12.7	143.1	6.1				
Input By:													Checked By:		

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VMA = Voids in Mineral Aggregate
VFA = Voids Filled With Asphalt Cement
VTM = Voids in Total Mix

Table A67: Results of Height Sample SGC Compactions **Ndesign = 100**

Project: 10													
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.663		Bulk Sp. Gr. (Gsb):	Mix Description: 19.0mm Coarse					Date 9/5/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	5.7	2258.9	1301.3	2284.8	2.297	2.442	12.7	5.9	8.3	931		
1	2	5.7	2262.1	1297.5	2294.2	2.270	2.442	12.6	7.1	11.7	5389		
1	3	5.7	2143.4	1223.9	2170.9	2.263	2.442	12.5	7.3	11.3	1146		
1	4	5.7	2162.6	1243.5	2192.9	2.278	2.442	12.6	6.7	10.5	2029		
1	5	5.7	2123.6	1212.2	2147.0	2.272	2.442	12.6	7.0	10.1	1122		
1	6	5.7	2126.6	1219.5	2152.7	2.279	2.442	12.6	6.7	10.2	909		
1	7	5.7	1906.5	1091.5	1971.5	2.166	2.442	12.0	11.3	18.9	9908		
1	8	5.7	1957.3	1113.4	2002.3	2.202	2.442	12.2	9.8	16.3	3308		
Input By:													

SSD = Saturated Surface Dry — cc = cubic centimeter
TMD = Theoretical Maximum Density — AC = Asphalt Cement
gm = gram — pcf = pounds per cubic foot — VTM = Voids in Total Mix

Table A68: Gradations and Asphalt Contents

Gradation		Sample 1					
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0
25.0	4.26	100.0	100.0	100.0	100.0	0.0	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0
12.5	3.12	77.2	78.7	77.7	77.9	0.8	75.0
9.5	2.75	57.7	62.1	62.9	60.9	2.8	
4.75	2.02	43.1	46.0	45.3	44.8	1.5	
2.36	1.47	29.7	31.7	31.2	30.9	1.0	34.0
1.18	1.08	20.9	22.3	21.8	21.7	0.7	
0.6	0.8	15.6	16.7	16.2	16.2	0.6	
0.3	0.58	11.9	12.8	12.3	12.3	0.5	12.0
0.15	0.43	9.0	9.1	8.8	9.0	0.2	
0.075	0.31	5.5	5.8	5.6	5.6	0.2	6.9
Asphalt Content		Sample 1					
		Rep1	Rep2	Rep3	Avg.	Std Dev	Opt. AC
		5.30	5.60	5.60	5.50	0.17	5.7

Table A69: Coarse Aggregate Properties for Project 10

Test	CA	IA
Bulk / Apparent Specific Gravit	2.510/2.687	2.504/2.705
Absorption, %	2.63	2.96
LA Abrasion, % Loss	18.2	13.3
Flat and Elongated, %		
3 to 1	22.6	45.2
5 to 1	3.2	9
Coarse Aggregate Flow, %	46.6	48.2
Crushed Content, %		
One Face	9.1	5.6
Two+ Faces	90.9	94.4
Data provided by either the agency or determined at NCAT lab		

Table A70: Fine Aggregate Properties for Project 10

Test	Fines	
Bulk / Apparent Specific Gravi	2.557/2.737	
Absorption, %	2.6	
Fine Aggregate Angularity, %	49.6	
Sand Equivalent	84	
Data provided by either the agency or determined at NCAT lab		

Project 11:

Project 11 was evaluated on August 8, 2002 and consisted of the mill and fill placement of 38.1mm of new hot mix asphalt in the southbound lane of an interstate highway. The mix consisted of a 19.0mm nominal maximum aggregate size coarse-graded blend designed at an N_{design} of 125 gyrations resulting in a design asphalt content of 4.9 percent. The asphalt binder that was used was a PG 64-34. One percent hydrated lime was used as an anti-stripping agent. The weather conditions during paving were approximately 90-95°F, sunny, and windy. The mix design and gradation information are provided in Tables A71 and A72.

The project was located approximately eight miles from the drum plant. Windrow paving construction was accomplished with belly dump trucks in conjunction with a paver configured with a windrow elevator. Breakdown rolling was conducted with an Ingersoll Rand DD130 roller making four passes in maximum amplitude and frequency. The mat was being laid at a temperature of about 300F with breakdown rolling beginning at a temperature of about 250F. Intermediate rolling was accomplished by an Ingersoll Rand Propac Series 100DA roller making five passes, alternating between static and vibratory modes. Finish rolling was performed in medium amplitude and frequency by an Ingersoll Rand DD130 roller, making four to five passes.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A73-A77.

Table A71: Project 11 Mix Design Summary Information	
JMF I.D. Number:	IM-15-4(40)169
Date(s) on Project:	8/8/02
Number of Stockpiles Used:	NA
- Coarse Aggregate Angularity:	NA
- Fine Aggregate Angularity:	NA
Percent RAP:	None
Gradation:	19.0mm Coarse Graded
Ninitial, Ndesign, Nmax:	9, 125, 205
Type Asphalt Binder Used:	PG 64-34
Design Asphalt Binder Content:	4.9
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	Hydrated Lime
Percent Anti-Strip Used:	None
Design Voids in Total Mix:	NA
Design Voids in Mineral Aggregate:	14.3
Design Voids Filled with Asphalt:	83
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	1.2

Table A72: Design Gradation for Project 11			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		99
½ in.	12.5		87
3/8 in	9.5		76
No. 4	4.75		40
No. 8	2.36		23
No. 16	1.18		18
No. 30	0.6		10
No. 50	0.3		
No. 100	0.15		
No. 200	0.075		4.9

Table A72: Results from SGC Compactions **Ndesign = 125**

Project: 11										Mix Description: 19.0mm Coarse					Date 9/5/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.654		Bulk Sp. Gr. (Gsb): 2.639								
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	4.9	4816.8	2790.8	4832.7	2.359	2.468	85.0	11.2	147.2	4.4	15.0	70.5	4.7	
1	2	4.9	4797.4	2779.1	4817.4	2.354	2.468	84.8	11.2	146.9	4.6	15.2	69.5	4.7	
1	3	4.9	4794.3	2777.7	4805.6	2.364	2.468	85.2	11.3	147.5	4.2	14.8	71.6	4.7	
2	1	4.9	4743.1	2781.8	4746.4	2.414	2.465	87.0	11.5	150.7	2.1	13.0	84.2	4.7	
2	2	4.9	4764.3	2791.4	4769.5	2.409	2.465	86.8	11.5	150.3	2.3	13.2	82.7	4.7	
2	3	4.9	4767.2	2791.6	4771.9	2.407	2.465	86.8	11.5	150.2	2.3	13.2	82.3	4.7	
3	1	4.9	4776.9	2795.5	4785.5	2.400	2.458	86.5	11.4	149.8	2.3	13.5	82.7	4.7	
3	2	4.9	4773.2	2797.4	4779.4	2.408	2.458	86.8	11.5	150.3	2.0	13.2	84.7	4.7	
3	3	4.9	4775.1	2797.4	4782.4	2.406	2.458	86.7	11.5	150.1	2.1	13.3	84.0	4.7	
Input By:														Checked By:	

SSD = Saturated Surface Dry; cc = cubic centimeter; VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density; AC = Asphalt Cement; VFA = Voids Filled With Asphalt Cement
gm = gram; pcf = pounds per cubic foot; VTM = Voids in Total Mix

Table A74: Results of Height Sample SGC Compactions **Ndesign = 100**

Project: 11													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.655		Bulk Sp. Gr. (Gsb): 2.639	Mix Description: 19.0mm Coarse					9/5/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	4.5	1529.1	874.2	1560.6	2.228	2.468	9.8	9.7	14.3	3829	4.3	
1	2	4.5	1526.4	876.2	1545.0	2.282	2.468	10.0	7.5	11.4	1054	4.3	
1	3	4.5	1428.1	821.5	1447.3	2.282	2.468	10.0	7.5	12.0	3508	4.3	
1	4	4.5	1426.9	820.9	1444.1	2.290	2.468	10.0	7.2	10.9	991	4.3	
1	5	4.5	1327.9	762.8	1363.3	2.211	2.468	9.7	10.4	17.0	6965	4.3	
1	6	4.5	1328.3	764.0	1361.5	2.223	2.468	9.7	9.9	16.3	6927	4.3	
1	7	4.5	1300.7	751.3	1333.1	2.236	2.468	9.8	9.4	17.7	6854	4.3	
1	8	4.5	1299.7	746.3	1337.0	2.200	2.468	9.6	10.8	18.1	6922	4.3	
2	1	4.7	1464.5	834.6	1475.4	2.285	2.458	10.4	7.0	8.9	173	4.5	
2	2	4.7	1470.5	841.4	1481.1	2.299	2.458	10.5	6.5	8.8	242	4.5	
2	3	4.7	1367.3	779.3	1400.0	2.203	2.458	10.1	10.4	14.2	2304	4.5	
2	4	4.7	1368.1	782.6	1401.8	2.209	2.458	10.1	10.1	14.3	2304	4.5	
2	5	4.7	1326.9	755.8	1367.8	2.168	2.458	9.9	11.8	16.7	3431	4.5	
2	6	4.7	1327.3	752.8	1363.6	2.173	2.458	9.9	11.6	16.7	6896	4.5	
2	7	4.7	1287.6	732.5	1331.0	2.151	2.458	9.8	12.5	17.9	6855	4.5	
2	8	4.7	1286.6	722.9	1324.2	2.140	2.458	9.8	12.9	18.1	6803	4.5	
3	1	4.7	1449.3	826.3	1465.9	2.266	2.465	10.4	8.1	11.9	519	4.5	
3	2	4.7	1446.3	827.0	1459.8	2.286	2.465	10.4	7.3	9.4	389	4.5	
3	3	4.7	1399.3	791.8	1419.0	2.231	2.465	10.2	9.5	12.6	1036	4.5	
3	4	4.7	1398.0	790.8	1418.5	2.227	2.465	10.2	9.6	13.0	1026	4.5	
3	5	4.7	1347.7	763.9	1379.7	2.189	2.465	10.0	11.2	14.8	3435	4.5	
3	6	4.7	1348.7	763.1	1383.5	2.174	2.465	9.9	11.8	15.1	3444	4.5	
3	7	4.7	1298.2	733.5	1332.4	2.168	2.465	9.9	12.1	18.1	5884	4.5	
3	8	4.7	1296.1	732.6	1333.5	2.157	2.465	9.9	12.5	18.0	5884	4.5	

Input By:

SSD = Saturated Surface Dry — cc = cubic centimeter
TMD = Theoretical Maximum Density — AC = Asphalt Cement
gm = gram — pcf = pounds per cubic foot — VTM = Voids in Total Mix

Table A75: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Sample 3					Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.50	5.11	100.00	100.00	100.00	100.00	0.0	100.00	100.00	100.00	100.00	0.0	**100.00**	**100.00**	**100.00**	100.00	0.0	100.00	0.00	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.00	100.0
19	3.76	97.5	100	99.4	99.0	1.3	98.9	98.3	98.4	98.5	0.3	98.3	98.3	99.6	98.7	0.8	98.7	0.22	100.0
12.5	3.12	87.3	84.7	88.3	86.8	1.9	85.8	90.5	88.1	88.1	2.4	88.2	88.5	91.2	89.3	1.7	88.1	1.27	99.0
9.5	2.75	71.1	69.6	74	71.6	2.2	74.5	79.4	79.2	77.7	2.8	76.6	77.6	80.7	78.3	2.1	75.9	3.73	87.0
4.75	2.02	35	34.1	37.6	35.6	1.8	42.4	45.2	44.4	44.0	1.4	41.4	41.9	44.9	42.7	1.9	40.8	4.55	76.0
2.36	1.47	21.2	21	22.1	21.4	0.6	25.5	26.7	26.2	26.1	0.6	25.7	25.8	27	26.2	0.7	24.6	2.72	40.0
1.18	1.08	15.9	15.9	16.6	16.1	0.4	19.8	20.5	20	20.1	0.4	20.1	20	20.9	20.3	0.5	18.9	2.36	23.0
0.6	0.8	12.7	12.7	13.3	12.9	0.3	16.2	16.7	16.3	16.4	0.3	16.5	16.4	17	16.6	0.3	15.3	2.09	18.0
0.3	0.58	9.1	9.2	9.6	9.3	0.3	12	12.5	12.1	12.2	0.3	12.4	12.3	12.7	12.5	0.2	11.3	1.76	10.0
0.15	0.43	5.6	5.6	5.9	5.7	0.2	7.7	8.2	7.6	7.8	0.3	8.2	8.2	8.2	8.2	0.0	7.2	1.35	
0.075	0.31	3.3	3.3	3.5	3.4	0.1	4.7	5.2	4.6	4.8	0.3	5.3	5.3	5.3	5.3	0.0	4.5	1.01	4.9
Asphalt Content		**Sample 1**					**Sample 2**					**Sample 3**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		4.80	4.20	4.40	4.47	0.31	4.70	4.70	4.70	4.70	0.00	4.70	4.70	4.70	4.70	0.00	4.62	0.13	4.9

Table A76: Coarse Aggregate Properties for Project 11

Test	3/4"	9/16"	7/16"
Bulk / Apparent Specific Gravity	2.614/2.670	2.568/2.679	2.531/2.675
Absorption, %	0.8	1.6	2.9
LA Abrasion, % Loss	22.2	20.4	19.4
Flat and Elongated, %			
3 to 1	7	16.6	16.3
5 to 1	0.67	1.5	3.4
Coarse Aggregate Flow, %	46.4	45.6	45
Crushed Content, %			
One Face	100	100	100
Two+ Faces	100	100	100
Data provided by either the agency or determined at NCAT lab			

Table A77: Fine Aggregate Properties for Project 11

Test	Type 3	
Bulk / Apparent Specific Gravity	2.493/2.687	
Absorption, %	2.9	
Fine Aggregate Angularity, %	45	
Sand Equivalent	56	
Data provided by either the agency or determined at NCAT lab		

Project 12:

Project 12 was evaluated on July 23, 2002 and consisted of the mill and fill placement of 60.0mm of new hot mix asphalt in the northbound lane of an interstate highway. The mix consisted of a 25.0mm nominal maximum aggregate size coarse-graded limestone/sand Stone Matrix Asphalt (SMA) blend designed using the Marshall mix design method, using a blow count of 50 blows. For research purposes, however, this number was converted to an N_{design} of 50 gyrations, resulting in a design asphalt content of 5.5 percent. The asphalt binder that was used was a PG 76-22. 0.3 percent mineral fiber was added to the mix. The weather conditions during paving were approximately 80-85°F, mostly sunny, with a slight breeze throughout the day. The mix design and gradation information are provided in Tables A78 and A79.

The project was located approximately five miles from the CMI batch plant. Breakdown rolling began at a pavement temperature of 315F and was conducted with an Dyanpac CC522 roller operating in maximum amplitude and frequency. Intermediate rolling was also accomplished by a Dynapac CC522 roller, but began when the mat was at a temperature of approximately 230F. Finish rolling was accomplished by making three to four passes in static mode by an Ingersoll Rand ST105 roller.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are presented in Tables A80-A84.

Table A75: Project 12 Mix Design Summary Information	
JMF I.D. Number:	NA
Date(s) on Project:	7/23/02
Number of Stockpiles Used:	4
- Coarse Aggregate Angularity:	100% 2+ Crushed Faces
- Fine Aggregate Angularity:	47
Percent RAP:	10
Gradation:	25.0mm SMA
Ninitial, Ndesign, Nmax:	50 Blow Marshall
Type Asphalt Binder Used:	PG 76-22
Design Asphalt Binder Content:	5.5
Type Modifier Used:	None
Type Anti-Strip Additive Used:	Mineral Fiber
Percent Anti-Strip Used:	0.3
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	17.0
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	86
Dust/Asphalt Ratio:	NA

Table A79: Design Gradation for Project 12			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		90
½ in.	12.5		74
3/8 in	9.5		54
No. 4	4.75		28
No. 8	2.36		21
No. 16	1.18		17
No. 30	0.6		15
No. 50	0.3		11
No. 100	0.15		9
No. 200	0.075		8.0

Table A80: Results from SGC Compactions **Ndesign = 50**

Project: 12															Date 9/11/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.784		Bulk Sp. Gr. (Gsb): 2.784		Mix Description: 25.0mm SMA						
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	5.1	4992.1	3018.9	4997.4	2.523	2.563	86.0	12.5	157.4	1.6	14.0	88.9	5.1	
1	2	5.1	4980.5	3007.4	4991.4	2.510	2.563	85.6	12.5	156.6	2.1	14.4	85.8	5.1	
1	3	5.1	4996.7	3024.0	5001.4	2.527	2.563	86.1	12.5	157.7	1.4	13.9	89.8	5.1	
2	1	4.7	4974.9	3038.4	4976.7	2.567	2.578	87.9	11.7	160.2	0.4	12.1	96.4	4.7	
2	2	4.7	4974.8	3034.7	4976.3	2.562	2.578	87.7	11.7	159.9	0.6	12.3	95.0	4.7	
2	3	4.7	4990.5	3022.6	4996.1	2.529	2.578	86.6	11.6	157.8	1.9	13.4	85.8	4.7	
3	1	5.1	4984.7	3032.9	4985.9	2.552	2.558	87.0	12.7	159.3	0.2	13.0	98.3	5.1	
3	2	5.1	4980.1	3024.2	4982.0	2.544	2.558	86.7	12.6	158.7	0.6	13.3	95.8	5.1	
3	3	5.1	4989.4	3011.6	4999.3	2.510	2.558	85.6	12.5	156.6	1.9	14.4	87.0	5.1	
Input By:													Checked By:		

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VMA = Voids in Mineral Aggregate
VFA = Voids Filled With Asphalt Cement
VTM = Voids in Total Mix

Table A81: Results of Height Sample SGC Compactions **Ndesign = 50**

Project: 12													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.811		Bulk Sp. Gr. (Gsb): 2.784	Mix Description: 25.0mm SMA					9/11/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	5.1	2470.3	1492.8	2472.1	2.523	2.563	12.5	1.6	2.2	0	4.8	
1	2	5.1	2470.3	1495.1	2472.7	2.527	2.563	12.5	1.4	2.4	0	4.8	
1	3	5.1	2366.1	1412.7	2373.3	2.463	2.563	12.2	3.9	5.1	178	4.8	
1	4	5.1	2366.4	1418.8	2374.6	2.476	2.563	12.3	3.4	5.3	165	4.8	
1	5	5.1	2321.3	1379.0	2332.1	2.436	2.563	12.1	5.0	6.6	119	4.8	
1	6	5.1	2330.3	1396.3	2339.5	2.471	2.563	12.3	3.6	6.1	562	4.8	
1	7	5.1	2287.9	1356.9	2302.7	2.419	2.563	12.0	5.6	7.8	640	4.8	
1	8	5.1	2293.0	1366.1	2305.5	2.441	2.563	12.1	4.8	7.0	746	4.8	
2	1	4.7	2470.4	1497.5	2474.0	2.530	2.578	11.6	1.9	2.7	0	4.4	
2	2	4.7	2471.6	1499.3	2473.3	2.538	2.578	11.6	1.6	4.5	0	4.4	
2	3	4.7	2378.1	1426.7	2384.2	2.484	2.578	11.4	3.7	5.0	102	4.4	
2	4	4.7	2375.4	1425.3	2382.1	2.483	2.578	11.4	3.7	5.5	67	4.4	
2	5	4.7	2338.4	1399.3	2350.8	2.458	2.578	11.2	4.7	7.2	344	4.4	
2	6	4.7	2327.3	1386.4	2337.5	2.447	2.578	11.2	5.1	8.8	320	4.4	
2	7	4.7	2269.3	1346.4	2282.6	2.424	2.578	11.1	6.0	9.2	298	4.4	
2	8	4.7	2257.0	1328.4	2273.4	2.388	2.578	10.9	7.4	12.5	2231	4.4	
3	1	5.1	2440.4	1470.4	2443.7	2.507	2.558	12.4	2.0	3.0	13	4.8	
3	2	5.1	2434.5	1465.4	2437.0	2.506	2.558	12.4	2.0	3.1	21	4.8	
3	3	5.1	2334.5	1384.1	2342.3	2.436	2.558	12.1	4.8	6.3	86	4.8	
3	4	5.1	2331.6	1387.4	2340.2	2.447	2.558	12.1	4.3	6.1	153	4.8	
3	5	5.1	2293.1	1361.3	2305.1	2.430	2.558	12.1	5.0	7.4	357	4.8	
3	6	5.1	2310.1	1367.2	2319.6	2.426	2.558	12.0	5.2	6.9	79	4.8	
3	7	5.1	2270.9	1345.3	2284.1	2.419	2.558	12.0	5.4	9.5	358	4.8	
3	8	5.1	2268.9	1335.6	2279.9	2.403	2.558	11.9	6.1	8.4	85	4.8	

Input By:

SSD = Saturated Surface Dry — cc = cubic centimeter
TMD = Theoretical Maximum Density — AC = Asphalt Cement
gm = gram — pcf = pounds per cubic foot — VTM = Voids in Total Mix

Table A82: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Sample 3					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.00	100.0
25.0	4.26	**100.0**	**100.0**	**97.3**	99.1	1.6	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	99.7	0.52	100.0
19	3.76	86.9	92.9	83.3	87.7	4.8	81.2	81.0	86.7	83.0	3.2	88.3	89.4	89.0	88.9	0.6	86.5	3.14	90.0
12.5	3.12	67.1	79.0	66.2	70.8	7.1	64.8	63.1	68.9	65.6	3.0	68.0	70.3	68.9	69.1	1.2	68.5	2.63	74.0
9.5	2.75	53.1	63.2	52.5	56.3	6.0	51.3	51.0	54.7	52.3	2.1	54.5	57.9	55.6	56.0	1.7	54.9	2.20	54.0
4.75	2.02	28.4	32.2	27.5	29.4	2.5	27.0	27.4	28.0	27.5	0.5	29.6	31.0	30.2	30.3	0.7	29.0	1.43	28.0
2.36	1.47	22.7	25.3	22.2	23.4	1.7	21.9	22.4	22.7	22.3	0.4	23.6	24.4	23.8	23.9	0.4	23.2	0.81	21.0
1.18	1.08	19.3	21.2	19.2	19.9	1.1	18.9	18.8	19.6	19.1	0.4	20.2	20.8	20.3	20.4	0.3	19.8	0.67	17.0
0.6	0.8	16.0	17.4	16.2	16.5	0.8	15.9	15.8	16.4	16.0	0.3	17.0	17.6	16.8	17.1	0.4	16.6	0.55	15.0
0.3	0.58	11.8	12.7	12.4	12.3	0.5	12.1	11.9	12.5	12.2	0.3	13.2	13.5	12.7	13.1	0.4	12.5	0.52	11.0
0.15	0.43	8.0	8.6	8.6	8.4	0.3	8.7	8.3	8.9	8.6	0.3	9.8	9.9	9.3	9.7	0.3	8.9	0.67	9.0
0.075	0.31	5.2	5.6	5.7	5.5	0.3	6.0	5.7	6.1	5.9	0.2	7.1	7.1	6.6	6.9	0.3	6.1	0.74	8.0
Asphalt Content		Sample 1					Sample 2					Sample 3					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		5.00	5.40	4.90	5.10	0.26	4.60	4.70	4.80	4.70	0.10	5.10	5.20	5.10	5.13	0.06	4.98	0.24	5.5

Table A83: Coarse Aggregate Properties for Project 12

Test	#78 LMS	#57 LMS
Bulk / Apparent Specific Gravit	2.806/2.850	2.833/2.840
Absorption, %	0.56	0.22
LA Abrasion, % Loss	28.1	28.4
Flat and Elongated, %		
3 to 1	14.2	3.9
5 to 1	1.6	
Coarse Aggregate Flow, %	46.3	45.8
Crushed Content, %		
One Face	100	100
Two+ Faces	100	100
Data provided by either the agency or determined at NCAT lab		

Table A84: Fine Aggregate Properties for Project 12

Test	M-10's	RAP
Bulk / Apparent Specific Gravi	2.661/2.715	2.558/2.696
Absorption, %	0.74	2
Fine Aggregate Angularity, %	48.5	42.4
Sand Equivalent	65	64
Data provided by either the agency or determined at NCAT lab		

Project 13:

Project 13 was evaluated on August 29, 2002 and consisted of the placement of 69.9mm of new hot mix asphalt in the construction of a new lane in the eastbound lane of an existing highway. The mix consisted of a 25.0mm nominal maximum aggregate size fine-graded limestone/sand blend designed at an N_{design} of 100 gyrations, resulting in a design asphalt content of 3.9 percent. One percent baghouse fines was used as an anti-stripping agent. The asphalt binder that was used was a PG 67-22 (unmodified). The weather conditions during paving were approximately 80°F, overcast, with a slight chance of rain throughout the day. The mix design and gradation information are provided in Tables A85 and A86.

The project was located approximately 12 miles from the ASTEC Double Barrel drum plant. Dump trucks fed the mix to a Cedarrapids 451 paver, which in turn laid the mix down at a temperature of about 295F. Breakdown rolling began immediately after the mix was laid down and was conducted in maximum amplitude and frequency by an Ingersoll Rand DD110 roller, making three passes, two while in vibratory mode and one in static mode. It was observed that the mix was moving a great deal when the rollers hit it at temperatures above 165F, so finish rolling began when the mix had cooled to a temperature of around 150F, and was performed by an Ingersoll Rand DD90, making two passes in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A87-A91.

Table A85: Project 13 Mix Design Summary Information	
JMF I.D. Number:	NA
Date(s) on Project:	8/29/02
Number of Stockpiles Used:	4
- Coarse Aggregate Angularity:	97/93
- Fine Aggregate Angularity:	45
Percent RAP:	15
Gradation:	Coarse
Ninitial, Ndesign, Nmax:	8, 100, 160
Type Asphalt Binder Used:	PG 67-22
Design Asphalt Binder Content:	3.9
Type Modifier Used:	None
Type Anti-Strip Additive Used:	Baghouse Fines
Percent Anti-Strip Used:	1.0
Design Voids in Total Mix:	NA
Design Voids in Mineral Aggregate:	13.4
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	90
Dust/Asphalt Ratio:	1.18

Table A86: Design Gradation for Project 13			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		99
¾ in.	19.0		89
½ in.	12.5		69
3/8 in	9.5		61
No. 4	4.75		48
No. 8	2.36		32
No. 16	1.18		23
No. 30	0.6		15
No. 50	0.3		9
No. 100	0.15		6
No. 200	0.075		4.6

Table A87: Results from SGC Compactions **Ndesign = 100**

Project: 13											Mix Description: 25.0mm Fine				Date 9/11/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.726		Bulk Sp. Gr. (Gsb): 2.735								
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	3.9	4906.6	2879.9	4913.7	2.413	2.542	84.8	9.2	150.5	5.1	15.2	66.6	4.0	
1	2	3.9	4925.6	2911.9	4933.1	2.437	2.542	85.6	9.2	152.1	4.1	14.4	71.3	4.0	
1	3	3.9	4916.5	2916.0	4924.4	2.448	2.542	86.0	9.3	152.8	3.7	14.0	73.6	4.0	
2	1	3.9	4929.1	2925.5	4938.3	2.449	2.581	86.0	9.3	152.8	5.1	14.0	63.3	4.0	
2	2	3.9	4936.8	2931.6	4958.4	2.436	2.581	85.6	9.2	152.0	5.6	14.4	61.0	4.0	
2	3	3.9	4919.9	2919.5	4930.1	2.447	2.581	86.0	9.3	152.7	5.2	14.0	63.0	4.0	
Input By:														Checked By:	

SSD = Saturated Surface Dry | cc = cubic centimeter | VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density | AC = Asphalt Cement | VFA = Voids Filled With Asphalt Cement
gm = gram | pcf = pounds per cubic foot | VTM = Voids in Total Mix

Table A88: Results of Height Sample SGC Compactions **Ndesign = 100**

Project: 13													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.727		Bulk Sp. Gr. (Gsb): 2.735	Mix Description: 25.0mm Fine					9/11/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	3.8	3142.8	1855.6	3151.6	2.425	2.542	9.0	4.6	5.8	0	3.9	
1	2	3.8	3140.4	1857.6	3149.0	2.432	2.542	9.0	4.3	5.5	0	3.9	
1	3	3.8	3084.2	1803.0	3096.6	2.384	2.542	8.8	6.2	7.1	0	3.9	
1	4	3.8	3109.8	1826.3	3117.7	2.408	2.542	8.9	5.3	6.3	0	3.9	
1	5	3.8	3039.8	1765.7	3060.0	2.349	2.542	8.7	7.6	8.7	24	3.9	
1	6	3.8	3072.4	1798.0	3090.8	2.377	2.542	8.8	6.5	7.5	128	3.9	
1	7	3.8	3047.0	1776.8	3075.0	2.347	2.542	8.7	7.7	8.9	66	3.9	
1	8	3.8	3058.6	1783.7	3078.5	2.362	2.542	8.7	7.1	8.4	31	3.9	
2	1	3.2	3251.4	1930.1	3253.4	2.457	2.581	7.6	4.8	5.7	0	3.3	
2	2	3.2	3221.7	1912.1	3224.5	2.455	2.581	7.6	4.9	5.8	0	3.3	
2	3	3.2	3128.0	1843.7	3135.0	2.422	2.581	7.5	6.1	7.5	0	3.3	
2	4	3.2	3161.6	1881.2	3167.7	2.458	2.581	7.6	4.8	6.2	0	3.3	
2	5	3.2	3013.3	1749.0	3044.2	2.327	2.581	7.2	9.9	10.9	61	3.3	
2	6	3.2	3014.8	1750.0	3058.3	2.304	2.581	7.2	10.7	11.8	386	3.3	
2	7	3.2	2973.3	1713.3	3013.0	2.288	2.581	7.1	11.4	12.5	152	3.3	
2	8	3.2	2978.5	1714.2	3018.0	2.284	2.581	7.1	11.5	12.4	170	3.3	
Input By:													

SSD = Saturated Surface Dry | cc = cubic centimeter
TMD = Theoretical Maximum Density | AC = Asphalt Cement
gm = gram | pcf = pounds per cubic foot | VTM = Voids in Total Mix

Table A89: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.0	99.0
19	3.76	88.5	88.6	90.1	89.1	0.9	88.6	85.9	88.0	87.5	1.4	88.3	1.1	89.0
12.5	3.12	80.2	77.1	78.3	78.5	1.6	73.0	71.2	73.5	72.6	1.2	75.6	4.2	69.0
9.5	2.75	78.3	75.2	76.5	76.7	1.6	70.0	67.9	70.4	69.4	1.3	73.1	5.1	61.0
4.75	2.02	62.0	59.2	60.0	60.4	1.4	52.6	51.0	53.4	52.3	1.2	56.4	5.7	48.0
2.36	1.47	39.5	37.4	38.3	38.4	1.1	33.6	32.7	33.7	33.3	0.6	35.9	3.6	32.0
1.18	1.08	28.3	26.7	27.3	27.4	0.8	24.3	23.6	24.3	24.1	0.4	25.8	2.4	23.0
0.6	0.8	18.8	17.8	18.2	18.3	0.5	16.2	15.7	16.2	16.0	0.3	17.2	1.6	15.0
0.3	0.58	9.5	9.0	9.3	9.3	0.3	10.7	7.8	8.1	8.9	1.6	9.1	0.3	9.0
0.15	0.43	5.8	5.5	5.8	5.7	0.2	5.4	5.0	5.2	5.2	0.2	5.5	0.4	6.0
0.075	0.31	4.0	3.7	4.0	3.9	0.2	4.0	3.6	3.8	3.8	0.2	3.9	0.1	4.6
Asphalt Content		Sample 1					Sample 2					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		3.90	3.80	3.70	3.80	0.10	3.20	3.10	3.30	3.20	0.10	3.50	0.42	3.9

Table A90: Coarse Aggregate Properties for Project 13

Test	#57 LMS	
Bulk / Apparent Specific Gravity	2.833/2.840	
Absorption, %	0.22	
LA Abrasion, % Loss	28.4	
Flat and Elongated, %		
3 to 1	3.9	
5 to 1		
Coarse Aggregate Flow, %	45.8	
Crushed Content, %		
One Face	100	100
Two+ Faces	100	100
Data provided by either the agency or determined at NCAT lab		

Table A91: Fine Aggregate Properties for Project 13

Test	#8910 LMS	C. Sand	Pea GVL	RAP
Bulk / Apparent Specific Gravity	2.632/2.746			
Absorption, %	0.02			
Fine Aggregate Angularity, %	44.3			
Sand Equivalent	81			
Data provided by either the agency or determined at NCAT lab				

Project 14:

Project 14 was evaluated on the night of August 9, 2002 and consisted of the placement of 25.4mm of new hot mix asphalt in the southbound lane of an interstate highway. The mix consisted of a 12.5mm nominal maximum aggregate size coarse-graded granite Stone Matrix Asphalt (SMA) blend designed using the Marshall mix design method, using a blow count of 50 blows. For research purposes, however, this number was converted to an N_{design} of 75 gyrations, resulting in a design asphalt content of 6.7 percent. The asphalt binder that was used was a PG 76-22. 0.3 percent mineral fiber was added to the mix. The weather conditions during paving were approximately 60-65°F with a slight breeze throughout the night. The mix design and gradation information are provided in Tables A92 and A93.

The project was located approximately five miles from the CMI batch plant. Dump trucks fed the mix into a Roadtec 2500B material transfer device, which fed a Blaw-Knox PF-3200 paver. The mat was laid at a temperature of 290°F. Breakdown rolling was conducted by a Dynapac roller making five to six passes in vibratory mode. Intermediate rolling began when the mat was approximately 185°F and was accomplished by another Dynapac roller making four passes in vibratory mode. Finish rolling was conducted by a Cowin ST105 roller, making one pass in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mix are provided in Tables A94-A98.

Table A92: Project 14 Mix Design Summary Information	
JMF I.D. Number:	NA
Date(s) on Project:	9/9/02
Number of Stockpiles Used:	4
- Coarse Aggregate Angularity:	100% 2+ Crushed Faces
- Fine Aggregate Angularity:	47
Percent RAP:	None
Gradation:	9.5mm SMA
Ninitial, Ndesign, Nmax:	50 Blow Marshall
Type Asphalt Binder Used:	PG 76-22
Design Asphalt Binder Content:	6.7
Type Modifier Used:	None
Type Anti-Strip Additive Used:	Mineral Fiber
Percent Anti-Strip Used:	0.3
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	17.9
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	NA

Table A93: Design Gradation for Project 14			
Sieve Size	Sieve Size, mm	Recommended Limits	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5		100
3/8 in	9.5		100
No. 4	4.75		53
No. 8	2.36		25
No. 16	1.18		19
No. 30	0.6		16
No. 50	0.3		14
No. 100	0.15		11
No. 200	0.075		9.1

Table A94: Results from SGC Compactions **Ndesign = 75 Blows**

Project: 13															
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.674		Bulk Sp. Gr. (Gsb): 2.682		Mix Description: 9.5mm SMA						Date 9/11/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	6.4	4671.1	2694.2	4680.2	2.352	2.425	82.1	14.6	146.8	3.0	17.9	83.2	6.5	
1	2	6.4	4646.8	2680.0	4654.8	2.353	2.425	82.1	14.6	146.8	3.0	17.9	83.4	6.5	
1	3	6.4	4710.7	2723.5	4719.2	2.360	2.425	82.4	14.7	147.3	2.7	17.6	84.9	6.5	
2	1	6.4	4706.4	2706.4	4719.8	2.338	2.426	81.6	14.6	145.9	3.6	18.4	80.2	6.5	
2	2	6.4	4764.0	2738.1	4778.9	2.334	2.426	81.5	14.5	145.7	3.8	18.5	79.6	6.5	
2	3	6.4	4675.4	2689.3	4687.7	2.340	2.426	81.6	14.6	146.0	3.6	18.4	80.6	6.5	
Input By:													Checked By:		

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VMA = Voids in Mineral Aggregate
VFA = Voids Filled With Asphalt Cement
VTM = Voids in Total Mix

Table A95: Results of Height Sample SGC Compactions — **Ndesign = 75 Blows**

Project: 14													
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.674		Bulk Sp. Gr. (Gsb): 2.682	Mix Description: 9.5mm SMA					Date 9/11/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
2	1	6.4	1140.1	623.3	1159.7	2.125	2.426	13.2	12.4	15.5	6017	6.5	
2	2	6.4	1127.5	625.3	1143.7	2.175	2.426	13.5	10.3	13.5	1930	6.5	
2	3	6.4	1039.7	574.8	1060.1	2.142	2.426	13.3	11.7	14.4	2703	6.5	
2	4	6.4	1038.3	579.3	1053.0	2.192	2.426	13.6	9.6	13.5	2689	6.5	
2	5	6.4	1025.5	570.3	1042.8	2.170	2.426	13.5	10.5	14.7	2703	6.5	
2	6	6.4	976.4	541.2	1003.5	2.112	2.426	13.1	12.9	18.1	5407	6.5	
2	7	6.4	931.7	509.3	955.2	2.089	2.426	13.0	13.9	21.2	9141	6.5	
2	8	6.4										6.5	

Input By:

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A96: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.00	100.00	100.00	100.00	0.0	100.00	100.00	100.00	100.00	0.0	100.00	0.00	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.00	0.00	100.0
19	3.76	100	100	100	100.0	0.0	100	100	100	100.0	0.0	100.00	0.00	100.0
12.5	3.12	100	100	100	100.0	0.0	100	100	100	100.0	0.0	100.00	0.00	100.0
9.5	2.75	100	100	100	100.0	0.0	100	100	100	100.0	0.0	100.00	0.00	100.0
4.75	2.02	52.6	53	54.2	53.3	0.8	56	55.1	55.4	55.5	0.5	54.38	1.58	53.0
2.36	1.47	25.6	26.3	26.4	26.1	0.4	26.1	26.4	26.3	26.3	0.2	26.18	0.12	25.0
1.18	1.08	20.4	20.9	21.1	20.8	0.4	20.6	21.1	21	20.9	0.3	20.85	0.07	19.0
0.6	0.8	17.1	17.6	17.7	17.5	0.3	17.4	17.9	17.7	17.7	0.3	17.57	0.14	16.0
0.3	0.58	13.9	14.3	14.4	14.2	0.3	14.1	14.6	14.3	14.3	0.3	14.27	0.09	14.0
0.15	0.43	10.7	11	11.1	10.9	0.2	11.1	11.3	11.1	11.2	0.1	11.05	0.16	11.0
0.075	0.31	8.2	8.3	8.4	8.3	0.1	8.7	8.7	8.5	8.6	0.1	8.47	0.24	9.1
Asphalt Content		Sample 1					Sample 2					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		6.60	6.30	6.20	6.37	0.21	6.40	6.20	6.60	6.40	0.20	6.38	0.02	6.7

Table A97: Coarse Aggregate Properties for Project 14

Test	#89's Granite	
Bulk / Apparent Specific Gravity	2.610/2.741	
Absorption, %	1.8	
LA Abrasion, % Loss	13.4	
Flat and Elongated, %		
3 to 1	55	
5 to 1	9	
Coarse Aggregate Flow, %	42.1	
Crushed Content, %		
One Face	100	
Two+ Faces	100	
Data provided by either the agency or determined at NCAT lab		

Table 98: Fine Aggregate Properties for Project 14

Test	M-10's	
Bulk / Apparent Specific Gravity	2.661/2.715	
Absorption, %	0.74	
Fine Aggregate Angularity, %	48.5	
Sand Equivalent	65	
Data provided by either the agency or determined at NCAT lab		

Project 15:

Project 15 was evaluated on October 3, 2002 and consisted of the placement of 57.2mm of hot mix asphalt over Portland Cement Concrete the northbound lane of an existing highway. The mix consisted of a 19.0mm nominal maximum aggregate size coarse-graded limestone/gravel blend designed at an N_{design} of 100 gyrations resulting in a design asphalt content of 4.2 percent. The asphalt binder that was used was a PG 76-22. A liquid anti-stripping agent was used at a rate of 0.5 percent. The weather conditions during paving were approximately 90°F with little to no breeze. The mix design and gradation information are provided in Tables A99 and A100.

The project was located approximately 20-25 miles from the Gencor drum plant. Dump trucks fed the mix to the Cedarapids CR451 paver, which laid the mix at a temperature of about 315°F. Breakdown rolling began when the mat cooled to a temperature of about 250°F and was conducted by an Ingersoll Rand DD110 roller making one pass in high amplitude and frequency, then making two static passes. Finish rolling was accomplished with an Ingersoll Rand DD90 paver making two passes in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mixture are provided in Tables A101-A105.

Table A99: Project 15 Mix Design Summary Information	
JMF I.D. Number:	NA
Date(s) on Project:	10/03/2002
Number of Stockpiles Used:	4
- Coarse Aggregate Angularity:	99/98
- Fine Aggregate Angularity:	45
Percent RAP:	20
Gradation:	19.0mm Coarse Graded
Ninitial, Ndesign, Nmax:	8, 100, 160
Type Asphalt Binder Used:	PG 76-22
Design Asphalt Binder Content:	4.2
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	ADHERE
Percent Anti-Strip Used:	0.5
Design Voids in Total Mix:	3.8
Design Voids in Mineral Aggregate:	13.9
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	87
Dust/Asphalt Ratio:	1.13

Table A100: Design Gradation for Project 15			
Sieve Size	Sieve Size, mm	Recommended Limits from Job Mix	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		99
½ in.	12.5		81
3/8 in	9.5		72
No. 4	4.75		53
No. 8	2.36		37
No. 16	1.18		25
No. 30	0.6		15
No. 50	0.3		8
No. 100	0.15		6
No. 200	0.075		4.7

Table A101: Results from SGC Compactions **Ndesign = 100**

Project: 15										Mix Description: 19.0mm Coarse					Date 9/11/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.714		Bulk Sp. Gr. (Gsb): 2.717								
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	4.3	4934.2	2918.7	4940.1	2.441	2.529	86.0	10.2	152.3	3.5	14.0	75.2	4.3	
1	2	4.3	4928.5	2919.2	4933.0	2.447	2.529	86.2	10.2	152.7	3.2	13.8	76.6	4.3	
1	3	4.3	4933.9	2917.9	4937.8	2.443	2.529	86.0	10.2	152.4	3.4	14.0	75.5	4.3	
2	1	4.0	4919.0	2921.6	4923.3	2.457	2.550	86.8	9.6	153.3	3.6	13.2	72.4	4.0	
2	2	4.0	4922.3	2920.0	4925.9	2.454	2.550	86.7	9.5	153.1	3.8	13.3	71.7	4.0	
2	3	4.0	4915.8	2921.3	4924.8	2.454	2.550	86.7	9.5	153.1	3.8	13.3	71.6	4.0	
Input By:													Checked By:		

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VMA = Voids in Mineral Aggregate
VFA = Voids Filled With Asphalt Cement
VTM = Voids in Total Mix

Table A102: Results of Height Sample SGC Compactions **Ndesign = 100**

Project:	**15**												
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.714		Bulk Sp. Gr. (Gsb): 2.717	Mix Description: 19.0mm Coarse				Date 9/11/2003	
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	4.3	2453.3	1439.4	2455.5	2.414	2.529	10.1	4.5	5.7	NF	4.3	
1	2	4.3	2444.7	1434.6	2446.8	2.415	2.529	10.1	4.5	5.7	NF	4.3	
1	3	4.3	2340.0	1373.4	2344.5	2.410	2.529	10.1	4.7	6.1	56	4.3	
1	4	4.3	2343.8	1364.9	2348.9	2.382	2.529	10.0	5.8	6.8	133	4.3	
1	5	4.3	2306.4	1342.0	2316.5	2.367	2.529	9.9	6.4	8.5	266	4.3	
1	6	4.3	2304.4	1339.6	2317.5	2.356	2.529	9.9	6.8	7.7	70	4.3	
1	7	4.3	2272.6	1316.0	2288.1	2.338	2.529	9.8	7.6	8.1	153	4.3	
1	8	4.3	2261.5	1308.2	2277.8	2.332	2.529	9.8	7.8	9.4	195	4.3	
2	1	4.0	2332.7	1364.7	2336.6	2.400	2.550	9.3	5.9	7.3	29	4.0	
2	2	4.0	2340.3	1371.8	2345.4	2.404	2.550	9.4	5.7	7.0	20	4.0	
2	3	4.0	2230.7	1298.5	2251.9	2.340	2.550	9.1	8.2	10.8	498	4.0	
2	4	4.0	2247.9	1305.1	2267.3	2.336	2.550	9.1	8.4	10.5	375	4.0	
2	5	4.0	2196.1	1281.6	2235.8	2.302	2.550	9.0	9.7	11.9	1122	4.0	
2	6	4.0	2189.9	1276.1	2229.6	2.297	2.550	8.9	9.9	12.1	897	4.0	
2	7	4.0	2172.3	1265.0	2219.5	2.276	2.550	8.9	10.8	13.3	1494	4.0	
2	8	4.0	2160.4	1260.8	2199.6	2.301	2.550	9.0	9.8	13.8	1504	4.0	
Input By:													

SSD = Saturated Surface Dry — cc = cubic centimeter
TMD = Theoretical Maximum Density — AC = Asphalt Cement
gm = gram — pcf = pounds per cubic foot — VTM = Voids in Total Mix

Table A103: Asphalt Content and Gradation

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.00	100.00	100.00	100.00	0.0	100.00	100.00	100.00	100.00	0.0	100.00	0.00	100.00
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.00	0.00	100.0
19	3.76	100	100	100	100.0	0.0	100	100	100	100.0	0.0	100.00	0.00	99
12.5	3.12	88.3	84.6	86.6	86.5	1.9	80	79.4	76.9	78.8	1.6	82.63	5.47	81
9.5	2.75	79.2	72.7	74.6	75.5	3.3	65.6	66	64.4	65.3	0.8	70.42	7.19	72
4.75	2.02	55.8	49	51.5	52.1	3.4	45.3	45.1	43.7	44.7	0.9	48.40	5.23	53
2.36	1.47	35.5	32	33.4	33.6	1.8	30.4	30	29	29.8	0.7	31.72	2.71	37
1.18	1.08	23.3	22.1	22.6	22.7	0.6	20.8	20.6	20.1	20.5	0.4	21.58	1.53	25
0.6	0.8	14.8	14.2	14.5	14.5	0.3	13.6	13.3	13.1	13.3	0.3	13.92	0.82	15
0.3	0.58	9.2	8.9	9.1	9.1	0.2	8.4	8.2	8.2	8.3	0.1	8.67	0.57	8
0.15	0.43	6.5	6.3	6.6	6.5	0.2	6.1	5.8	5.8	5.9	0.2	6.18	0.40	6
0.075	0.31	4.8	4.5	4.7	4.7	0.2	4.4	4.1	4.2	4.2	0.2	4.45	0.31	4.7
Asphalt Content		Sample 1					Sample 2					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		4.50	4.10	4.30	4.30	0.20	4.10	3.90	3.90	3.97	0.12	4.13	0.24	4.2

Table 104: Coarse Aggregate Properties for Project 15

Test	#67 LMS	Shot GVL
Bulk / Apparent Specific Gravity	2.714/2.758	2.573/2.651
Absorption, %	0.01	0.01
LA Abrasion, % Loss	41.5	33.3
Flat and Elongated, %		
3 to 1	37.5	22.3
5 to 1	8.4	4.7
Coarse Aggregate Flow, %	46.7	42.5
Crushed Content, %		
One Face	100	24.1
Two+ Faces	100	64.8
Data provided by either the agency or determined at NCAT lab		

Table 105: Fine Aggregate Properties for Project 15

Test	#8910 LMS	C. Sand	RAP
Bulk / Apparent Specific Gravity	2.632/2.746	2.611/2.648	2.619/2.628
Absorption, %	0.02	0.01	0.1
Fine Aggregate Angularity, %	44.3	47	44.6
Sand Equivalent	81	83	87
Data provided by either the agency or determined at NCAT lab			

Project 16:

Project 16 was evaluated on November 13, 2002 and consisted of the placement of 38.1mm of new hot mix asphalt in the construction of a new state highway. The mix consisted of a 12.5mm nominal maximum aggregate size coarse-graded gravel/RAP blend designed at an N_{design} of 86 gyrations resulting in a design asphalt content of 5.8 percent. The asphalt binder that was used was a PG 67-22 (unmodified). The weather conditions during paving were approximately 65°F and clear. The mix design and gradation information are provided in Tables A106 and A107.

The project was located approximately 35 miles from the Astec Double Barrel drum plant. Windrow paving construction was accomplished with end dump trucks in conjunction with a windrow elevator configured with a Cedarapids CR461R paver. Breakdown rolling was conducted by two Caterpillar CB634C rollers running in tandem, each making four vibratory passes and one static pass. Intermediate rolling was performed by a PS-150B pneumatic roller, while finish rolling was accomplished with a Dynapac CC42 operating in static mode.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mixture are provided in Tables A108-A112.

Table A106: Project 16 Mix Design Summary Information	
JMF I.D. Number:	NA
Date(s) on Project:	11/13/2002
Number of Stockpiles Used:	4
- Coarse Aggregate Angularity:	NA
- Fine Aggregate Angularity:	44.9
Percent RAP:	15
Gradation:	12.5mm Coarse Graded
Ninitial, Ndesign, Nmax:	7, 86, 134
Type Asphalt Binder Used:	PG 67-22
Design Asphalt Binder Content:	5.8
Type Modifier Used:	None
Type Anti-Strip Additive Used:	None
Percent Anti-Strip Used:	0.0
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	15.1
Design Voids Filled with Asphalt:	72.5
Tensile Strength Ratio:	93
Dust/Asphalt Ratio:	1.10

Table A107: Design Gradation for Project 16			
Sieve Size	Sieve Size, mm	Recommended Limits from Job Mix	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5		100
3/8 in	9.5		91
No. 4	4.75		55
No. 8	2.36		36
No. 16	1.18		26
No. 30	0.6		20
No. 50	0.3		12
No. 100	0.15		7
No. 200	0.075		5.4

Table 108: Results from SGC Compactions **Ndesign = 86**

Project: 16															Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.526		Bulk Sp. Gr. (Gsb): 2.494		Mix Description: 12.5mm Coarse						9/11/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	5.8	4522.6	2520.4	4537.0	2.243	2.327	84.7	12.7	139.9	3.6	15.3	76.3	5.3	
1	2	5.8	4527.1	2526.8	4536.5	2.253	2.327	85.1	12.7	140.6	3.2	14.9	78.6	5.3	
1	3	5.8	4548.3	2540.5	4558.8	2.254	2.327	85.1	12.7	140.6	3.2	14.9	78.8	5.3	
2	1	5.8	4537.6	2550.8	4544.0	2.277	2.332	86.0	12.8	142.1	2.4	14.0	83.0	5.3	
2	2	5.8	4533.0	2546.1	4539.7	2.274	2.332	85.9	12.8	141.9	2.5	14.1	82.3	5.3	
2	3	5.8	4521.2	2537.6	4532.0	2.267	2.332	85.6	12.8	141.5	2.8	14.4	80.6	5.3	
Input By:														Checked By:	

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VMA = Voids in Mineral Aggregate
VFA = Voids Filled With Asphalt Cement
VTM = Voids in Total Mix

Table A109: Results of Height Sample SGC Compactions **Ndesign = 86**

Project: 16												Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.527		Bulk Sp. Gr. (Gsb): 2.494	Mix Description: 12.5mm Coarse				9/11/2003
			Masses			SPECIFIC GRAVITIES			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %
1	1	5.6	1563.3	865.0	1565.1	2.233	2.327	12.2	4.0	5.7	61	5.1
1	2	5.6	1555.4	859.1	1558.5	2.224	2.327	12.1	4.4	6.3	99	5.1
1	3	5.6	1455.0	795.1	1460.9	2.185	2.327	11.9	6.1	8.3	127	5.1
1	4	5.6	1407.0	770.8	1411.5	2.196	2.327	12.0	5.6	8.1	211	5.1
1	5	5.6	1352.5	735.8	1357.3	2.176	2.327	11.9	6.5	9.2	288	5.1
1	6	5.6	1358.1	738.8	1365.4	2.167	2.327	11.8	6.9	8.9	241	5.1
1	7	5.6	1333.0	718.0	1334.4	2.163	2.327	11.8	7.1	10.5	483	5.1
1	8	5.6	1338.3	714.5	1355.1	2.089	2.327	11.4	10.2	13.0	1543	5.1
2	1	5.5	1374.7	746.4	1382.5	2.161	2.332	11.6	7.3	9.7	294	5.0
2	2	5.5	1381.2	758.4	1385.3	2.203	2.332	11.8	5.5	7.5	103	5.0
2	3	5.5	1282.0	685.1	1299.9	2.085	2.332	11.2	10.6	13.8	1010	5.0
2	4	5.5	1265.0	671.7	1283.2	2.069	2.332	11.1	11.3	14.8	3021	5.0
2	5	5.5	1230.8	652.9	1259.1	2.030	2.332	10.9	12.9	16.5	3343	5.0
2	6	5.5	1238.0	661.6	1267.4	2.044	2.332	10.9	12.4	16.0	2240	5.0
2	7	5.5	1196.0	624.7	1221.4	2.004	2.332	10.7	14.0	18.0	3330	5.0
2	8	5.5	1207.3	643.0	1234.7	2.040	2.332	10.9	12.5	17.5	6642	5.0
Input By:												

SSD = Saturated Surface Dry; cc = cubic centimeter
TMD = Theoretical Maximum Density; AC = Asphalt Cement
gm = gram; pcf = pounds per cubic foot; VTM = Voids in Total Mix

Table A110: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.0	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
12.5	3.12	99.3	99.1	98.6	99.0	0.4	98.7	98.6	99.0	98.8	0.2	98.9	0.2	100.0
9.5	2.75	89.4	89.9	89.1	89.5	0.4	90.3	90.0	90.0	90.1	0.2	89.8	0.4	91.0
4.75	2.02	55.9	56.1	53.6	55.2	1.4	57.9	56.3	56.9	57.0	0.8	56.1	1.3	55.0
2.36	1.47	36.3	36.3	35.2	35.9	0.6	37.9	37.0	37.7	37.5	0.5	36.7	1.1	36.0
1.18	1.08	26.3	26.1	25.6	26.0	0.4	27.5	27.0	27.5	27.3	0.3	26.7	0.9	26.0
0.6	0.8	20.1	19.8	19.6	19.8	0.3	21.2	20.9	21.0	21.0	0.2	20.4	0.8	20.0
0.3	0.58	12.6	12.2	12.1	12.3	0.3	13.8	13.6	13.3	13.6	0.3	12.9	0.9	12.0
0.15	0.43	7.4	7.0	7.0	7.1	0.2	8.6	8.7	7.9	8.4	0.4	7.8	0.9	7.0
0.075	0.31	5.0	4.6	4.7	4.8	0.2	6.3	6.6	5.4	6.1	0.6	5.4	0.9	5.4
Asphalt Content		**Sample 1**					**Sample 2**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		5.40	5.90	5.40	5.57	0.29	5.60	5.30	5.60	5.50	0.17	5.53	0.05	5.8

Table A111: Coarse Aggregate Properties for Project 16

Test	1/2" Cr. GVL	#78 LMS
Bulk / Apparent Specific Gravity	2.422/2.586	2.741/2.769
Absorption, %	2.62	0.37
LA Abrasion, % Loss	15.3	
Flat and Elongated, %		
3 to 1	52	
5 to 1	11	
Coarse Aggregate Flow, %	44.1	
Crushed Content, %		
One Face	36.2	
Two+ Faces	61.9	
Data provided by either the agency or determined at NCAT lab		

Table A112: Fine Aggregate Properties for Project 16

Test	C. Sand	#8910 LMS	RAP
Bulk / Apparent Specific Gravity	2.635/2.665	2.668/2.719	2.486/2.583
Absorption, %	0.43	0.7	1.51
Fine Aggregate Angularity, %	42.4		
Sand Equivalent	95		
Data provided by either the agency or determined at NCAT lab			

Project 17:

Project 17 was evaluated on June 9, 2003, and consisted of the placement of 37.5mm of new hot mix asphalt on the southbound lane of a county road. The mix consisted of a 12.5mm nominal maximum aggregate size fine-graded granite/RAP blend designed at an N_{design} of 75 gyrations resulting in a design asphalt content of 4.8 percent. The asphalt binder that was used was a PG 64-22 (unmodified). A liquid anti-stripping agent was used at a rate of 0.75 percent. The weather conditions during paving were approximately 90°F, humid, and cloudy. The mix design and gradation information are provided in Tables A113 and A114.

The project was located approximately 15 miles from the Astec Double Barrel drum plant. Dump trucks fed the mix into the Blaw Knox PF-3200 paver at a temperature of approximately 255°F. Breakdown rolling was conducted by an Ingersoll Rand DD 110 roller making four passes in static mode, starting at a pavement temperature of 230°F. Finish rolling was conducted by an Ingersoll Rand DD 90, but during paving evaluation, this roller was not being used due to malfunction.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mixture are provided in Tables A115-A119.

Table A113: Project 17 Mix Design Summary Information	
JMF I.D. Number:	NA
Date(s) on Project:	6/09/03
Number of Stockpiles Used:	6
- Coarse Aggregate Angularity:	NA
- Fine Aggregate Angularity:	45
Percent RAP:	18
Gradation:	12.5mm Fine Graded
Ninitial, Ndesign, Nmax:	NA/ 75/ NA
Type Asphalt Binder Used:	PG 64-22
Design Asphalt Binder Content:	4.8
Type Modifier Used:	None
Type Anti-Strip Additive Used:	Liquid
Percent Anti-Strip Used:	0.75
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	14.9
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	NA

Table A114: Design Gradation for Project 17			
Sieve Size	Sieve Size, mm	Recommended Limits from Job Mix	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0	100	100
½ in.	12.5	90-100	94
3/8 in	9.5	-90	85
No. 4	4.75		59
No. 8	2.36	28-58	44
No. 16	1.18		40
No. 30	0.6		33
No. 50	0.3		17
No. 100	0.15		6
No. 200	0.075	2-10	4.5

Table A115: Results from SGC Compactions **Ndesign = 75**

Project: 17										Mix Description: 12.5mm Fine				Date 9/11/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.744		Bulk Sp. Gr. (Gsb): 2.733							
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %
1	1	4.8	4958.1	2930.8	4960.6	2.443	2.544	85.1	11.4	152.4	4.0	14.9	73.3	4.7
1	2	4.8	4942.9	2928.9	4945.6	2.451	2.544	85.4	11.4	152.9	3.7	14.6	75.0	4.7
1	3	4.8	4921.2	2913.5	4923.5	2.448	2.544	85.3	11.4	152.8	3.8	14.7	74.5	4.7
2	1	4.8	4687.3	2788.1	4688.9	2.466	2.535	85.9	11.5	153.9	2.7	14.1	80.7	4.7
2	2	4.8	4707.4	2794.3	4709.7	2.458	2.535	85.6	11.5	153.4	3.1	14.4	78.8	4.7
2	3	4.8	4707.0	2794.3	4709.5	2.458	2.535	85.6	11.5	153.4	3.0	14.4	78.8	4.7
Input By:													Checked By:	

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram

cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot

VMA = Voids in Mineral Aggregate
VFA = Voids Filled With Asphalt Cement
VTM = Voids in Total Mix

Table A116: Results of Height Sample SGC Compactions **Ndesign = 75**

Project: 17													Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.744		Bulk Sp. Gr. (Gsb): 2.733	Mix Description: 12.5mm Fine					9/11/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	4.8	1600.1	945.8	1601.4	2.441	2.544	11.4	4.1	5.0	0	4.7	
1	2	4.8	1581.4	933.5	1582.1	2.438	2.544	11.4	4.2	4.8	0	4.7	
1	3	4.8	1512.2	873.5	1515.2	2.357	2.544	11.0	7.4	10.2	12	4.7	
1	4	4.8	1484.7	850.6	1491.5	2.317	2.544	10.8	8.9	8.6	4	4.7	
1	5	4.8	1492.1	855.9	1497.0	2.327	2.544	10.9	8.5	9.7	14	4.7	
1	6	4.8	1486.0	855.4	1492.0	2.334	2.544	10.9	8.2	9.5	7	4.7	
1	7	4.8	1427.6	806.3	1438.3	2.259	2.544	10.5	11.2	13.1	25	4.7	
1	8	4.8	1421.3	803.7	1433.5	2.257	2.544	10.5	11.3	12.8	14	4.7	
2	1	4.8	1632.1	956.9	1633.2	2.413	2.535	11.3	4.8	4.7	0	4.7	
2	2	4.8	1631.2	959.8	1632.4	2.425	2.535	11.3	4.3	5.2	0	4.7	
2	3	4.8	1572.0	922.0	1572.9	2.415	2.535	11.3	4.7	5.8	0	4.7	
2	4	4.8	1576.1	925.4	1577.8	2.416	2.535	11.3	4.7	6.7	0	4.7	
2	5	4.8	1635.1	930.1	1637.1	2.313	2.535	10.8	8.8	7.2	2	4.7	
2	6	4.8	1533.4	892.8	1537.4	2.379	2.535	11.1	6.2	6.6	0	4.7	
2	7	4.8	1487.6	850.9	1492.9	2.317	2.535	10.8	8.6	10.1	17	4.7	
2	8	4.8	1472.8	844.7	1479.8	2.319	2.535	10.8	8.5	9.6	6	4.7	

Input By:

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A117: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.0	100.0
19	3.76	100.0	98.9	100.0	99.6	0.6	99.7	99.4	97.6	98.9	1.1	99.3	0.5	100.0
12.5	3.12	97.8	98.6	97.4	97.9	0.6	97.4	97.0	95.2	96.5	1.2	97.2	1.0	94.0
9.5	2.75	90.9	90.4	87.6	89.6	1.8	87.5	89.1	86.9	87.8	1.1	88.7	1.3	85.0
4.75	2.02	58.6	56.9	54.1	56.5	2.3	54.4	56.6	56.7	55.9	1.3	56.2	0.4	59.0
2.36	1.47	48.5	47.2	45.3	47.0	1.6	43.9	45.8	45.4	45.0	1.0	46.0	1.4	44.0
1.18	1.08	41.9	41.0	39.5	40.8	1.2	37.7	39.2	38.9	38.6	0.8	39.7	1.6	40.0
0.6	0.8	32.7	32.2	31.1	32.0	0.8	29.1	30.2	29.9	29.7	0.6	30.9	1.6	33.0
0.3	0.58	18.9	18.8	18.3	18.7	0.3	17.5	18.0	17.9	17.8	0.3	18.2	0.6	17.0
0.15	0.43	7.3	7.3	7.3	7.3	0.0	7.4	7.6	7.5	7.5	0.1	7.4	0.1	6.0
0.075	0.31	3.6	3.6	3.7	3.6	0.1	3.8	3.8	3.6	3.7	0.1	3.7	0.1	4.5
Asphalt Content		Sample 1					Sample 2					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		4.61	4.43	4.22	4.42	0.20	4.42	4.43	4.47	4.44	0.03	4.43	0.01	4.8

Table A118: Coarse Aggregate Properties for Project 17

Test	#67 Granite	#78 Granite	#89 Granite
Bulk / Apparent Specific Gravity	2.809/NA	2.808/NA	2.799/NA
Absorption, %			
LA Abrasion, % Loss	5.1	12	7.2
Flat and Elongated, %			
3 to 1	59.5	23.1	91.8
5 to 1	37.2		13.3
Coarse Aggregate Flow, %	46.3	50.4	46.1
Crushed Content, %			
One Face	9.7	13.9	9.2
Two+ Faces	90.3	86.2	90.9
Data provided by either the agency or determined at NCAT lab			

Table A119: Fine Aggregate Properties for Project 17

Test	W-10's	Sand	RAP
Bulk / Apparent Specific Gravity	2.770/NA	2.626/NA	2.626/NA
Absorption, %			
Fine Aggregate Angularity, %	47.1	44.5	41.2
Sand Equivalent	85	96	93
Data provided by either the agency or determined at NCAT lab			

Project 18:

Project 18 was evaluated on June 19, 2003, and consisted of the placement of 38.1mm of new hot mix asphalt on the eastbound lane of a state highway. The mix consisted of a 12.5mm nominal maximum aggregate size coarse-graded granite/RAP blend designed at an N_{design} of 75 gyrations resulting in a design asphalt content of 5.1 percent. The asphalt binder that was used was a PG 67-22 (unmodified). Lime was added to the mix at a rate of one percent. The weather conditions during paving were approximately 85°F, humid, and mostly cloudy. The mix design and gradation information are provided in Tables A120 and A121.

The project was located approximately 45 minutes from the drum plant. Dump trucks fed the mix into a material transfer device, which in turn fed the mix into the paver. Breakdown rolling was conducted by an Ingersoll Rand DD 130 roller making two passes in vibratory mode in medium amplitude and frequency, then making four passes in static mode. Intermediate rolling was accomplished with an Ingersoll Rand PT-125 pneumatic tire roller making seven total passes across the mat. Finish rolling was conducted by an Ingersoll Rand DD 90 making seven total passes across the mat.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mixture are provided in Tables A122-126.

Table A120: Project 18 Mix Design Summary8 Information	
JMF I.D. Number:	NA
Date(s) on Project:	6/19/03
Number of Stockpiles Used:	5
- Coarse Aggregate Angularity:	NA
- Fine Aggregate Angularity:	NA
Percent RAP:	15
Gradation:	12.5mm Coarse Graded
Ninitial, Ndesign, Nmax:	NA/ 75/ NA
Type Asphalt Binder Used:	PG 67-22
Design Asphalt Binder Content:	5.1
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	NA
Percent Anti-Strip Used:	NA
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	NA
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	NA

Table A121: Design Gradation for Project 18			
Sieve Size	Sieve Size, mm	Recommended Limits from Job Mix	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5		98
3/8 in	9.5		85
No. 4	4.75		55
No. 8	2.36		37
No. 16	1.18		
No. 30	0.6		
No. 50	0.3		14
No. 100	0.15		
No. 200	0.075		6.5

Table A122: Results from SGC Compactions **Ndesign = 75**

Project: 18											Mix Description: 12.5mm Coarse				Date 9/11/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa) 2.759		Eff. Sp. Gr. (Gse): 2.729		Bulk Sp. Gr. (Gsb): 2.680								
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %	
1	1	5.1	4927.6	2909.1	4933.1	2.435	2.538	86.2	12.1	151.9	4.1	13.8	70.5	4.4	
1	2	5.1	4930.6	2914.3	4935.7	2.439	2.538	86.4	12.1	152.2	3.9	13.6	71.4	4.4	
1	3	5.1	4929.1	2919.3	4932.5	2.448	2.538	86.7	12.1	152.8	3.5	13.3	73.5	4.4	
2	1	5.1	4922.2	2924.1	4923.6	2.462	2.518	87.2	12.2	153.6	2.2	12.8	82.6	4.4	
2	2	5.1	4942.0	2937.4	4942.8	2.464	2.518	87.3	12.2	153.8	2.1	12.7	83.3	4.4	
2	3	5.1	4929.6	2925.2	4933.1	2.455	2.528	86.9	12.2	153.2	2.9	13.1	77.9	4.4	
Input By:													Checked By:		

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram

cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot

VMA = Voids in Mineral Aggregate
VFA = Voids Filled With Asphalt Cement
VTM = Voids in Total Mix

Table A123: Results of Height Sample SGC Compactions **Ndesign = 75**

Project: 18												Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa) 2.759		Eff. Sp. Gr. (Gse): 2.729		Bulk Sp. Gr. (Gsb): 2.680	Mix Description: 12.5mm Coarse				9/11/2003
			Masses			SPECIFIC GRAVITIES			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	VTM, %		Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %
1	1	5.1	1637.6	956.7	1640.8	2.394	2.538	11.9	5.7	7.3	2018	4.4
1	2	5.1	1633.1	949.7	1636.4	2.378	2.538	11.8	6.3	7.8	474	4.4
1	3	5.1	1540.3	896.6	1544.6	2.377	2.538	11.8	6.3	7.8	1215	4.4
1	4	5.1	1527.7	887.2	1532.8	2.366	2.538	11.7	6.8	9.9	1132	4.4
1	5	5.1	1493.2	855.5	1503.8	2.303	2.538	11.4	9.2	11.3	7672	4.4
1	6	5.1	1483.6	856.2	1495.4	2.321	2.538	11.5	8.5	10.6	6819	4.4
1	7	5.1	1439.1	821.3	1455.2	2.270	2.538	11.3	10.6	13.4	7978	4.4
1	8	5.1	1443.3	824.3	1458.2	2.277	2.538	11.3	10.3	13.0	10229	4.4
2	1	5.1	1631.7	939.2	1639.6	2.330	2.518	11.6	7.5	9.6	3580	4.4
2	2	5.1	1633.2	940.1	1639.4	2.335	2.518	11.6	7.2	9.0	836	4.4
2	3	5.1	1528.0	870.7	1542.6	2.274	2.518	11.3	9.7	11.9	3799	4.4
2	4	5.1	1527.9	873.1	1537.7	2.299	2.518	11.4	8.7	10.7	4938	4.4
2	5	5.1	1489.9	849.9	1512.3	2.249	2.518	11.2	10.7	13.5	13167	4.4
2	6	5.1	1489.2	853.8	1508.7	2.274	2.518	11.3	9.7	12.4	7182	4.4
2	7	5.1	1434.6	821.4	1451.4	2.277	2.518	11.3	9.6	12.9	8343	4.4
2	8	5.1	1399.6	800.4	1425.4	2.239	2.518	11.1	11.1	14.4	25029	4.4
Input By:												

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A124: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.0	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
12.5	3.12	98.9	98.4	98.7	98.7	0.3	98.4	97.3	98.6	98.1	0.7	98.4	0.4	98.0
9.5	2.75	86.5	84.4	85.2	85.4	1.1	85.3	83.7	87.4	85.5	1.9	85.4	0.1	85.0
4.75	2.02	56.9	54.1	54.8	55.3	1.5	53.6	53.9	55.8	54.4	1.2	54.9	0.6	55.0
2.36	1.47	37.2	35.7	36.3	36.4	0.8	34.2	34.7	35.2	34.7	0.5	35.6	1.2	37.0
1.18	1.08	25.4	24.6	24.8	24.9	0.4	23.2	23.3	23.7	23.4	0.3	24.2	1.1	
0.6	0.8	18.3	17.7	17.9	18.0	0.3	16.7	16.8	17.0	16.8	0.2	17.4	0.8	
0.3	0.58	13.2	12.8	12.9	13.0	0.2	12.2	12.3	12.5	12.3	0.2	12.7	0.4	14.0
0.15	0.43	9.1	8.8	8.8	8.9	0.2	8.6	8.7	8.8	8.7	0.1	8.8	0.1	
0.075	0.31	6.1	5.9	5.8	5.9	0.2	5.9	6.0	6.1	6.0	0.1	6.0	0.0	6.5
Asphalt Content		**Sample 1**					**Sample 2**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		4.69	4.57	4.46	4.57	0.12	4.87	4.88	4.98	4.91	0.06	4.74	0.24	5.1

Table A125: Coarse Aggregate Properties for Project 18

Test	#7's	#89's
Bulk / Apparent Specific Gravity	2.710/2.738	2.703/2.737
Absorption, %	0.4	0.5
LA Abrasion, % Loss	9.8	10.3
Flat and Elongated, %		
3 to 1	53.5	83.7
5 to 1	16.6	23.8
Coarse Aggregate Flow, %	46.7	49.5
Crushed Content, %		
One Face	8.3	100
Two+ Faces	91.8	100
Data provided by either the agency or determined at NCAT lab		

Table A126: Fine Aggregate Properties for Project 18

Test	W-10's	M-10's	RAP
Bulk / Apparent Specific Gravity	2.728/2.757	2.624/2.744	2.501/2.666
Absorption, %	0.38	1.67	2.48
Fine Aggregate Angularity, %	40	42.1	42.7
Sand Equivalent	100	94	90
Data provided by either the agency or determined at NCAT lab			

Project 19:

Project 19 was evaluated on June 23, 2003, and consisted of the placement of 31.8mm of new hot mix asphalt on the westbound lane of a state highway. The mix consisted of a 9.5mm nominal maximum aggregate size fine-graded granite/RAP blend designed at an N_{design} of 75 gyrations resulting in a design asphalt content of 5.5 percent. The asphalt binder that was used was a PG 67-22 (unmodified). Lime was added to the mix at a rate of one percent. The weather conditions during paving were approximately 90°F and clear. The mix design and gradation information are provided in Tables A127 and A128.

The project was located approximately one hour from the drum plant. Dump trucks fed the mix into the paver. Breakdown rolling was conducted by an Ingersoll Rand DD 90 roller making three passes in vibratory mode in medium amplitude and frequency, then making two passes in static mode. Intermediate rolling was accomplished with an pneumatic tire roller making fifteen total passes across the mat. Finish rolling was conducted by a second Ingersoll Rand DD 90 making six total passes across the mat.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mixture are provided in Tables A129-A133.

Table A127: Project 19 Mix Design Summary8 Information	
JMF I.D. Number:	NA
Date(s) on Project:	6/23/03
Number of Stockpiles Used:	4
- Coarse Aggregate Angularity:	NA
- Fine Aggregate Angularity:	NA
Percent RAP:	10
Gradation:	9.5mm Fine Graded
Ninitial, Ndesign, Nmax:	NA/ 75/ NA
Type Asphalt Binder Used:	PG 67-22
Design Asphalt Binder Content:	5.5
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	NA
Percent Anti-Strip Used:	NA
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	NA
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	NA
Dust/Asphalt Ratio:	NA

Table A128: Design Gradation for Project 17			
Sieve Size	Sieve Size, mm	Recommended Limits from Job Mix	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5		100
3/8 in	9.5		98
No. 4	4.75		70
No. 8	2.36		46
No. 16	1.18		
No. 30	0.6		
No. 50	0.3		15
No. 100	0.15		
No. 200	0.075		6.2

Table A129: Results from SGC Compactions **Ndesign = 75**

Project: 19														
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa) 2.747		Eff. Sp. Gr. (Gse): 2.736		Bulk Sp. Gr. (Gsb): 2.639		Mix Description: 9.5mm Fine					Date 9/11/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %
1	1	5.5	4889.7	2889.5	4891.4	2.443	2.506	87.5	13.1	152.4	2.5	12.5	79.8	4.2
1	2	5.5	4866.4	2878.0	4868.6	2.445	2.506	87.5	13.1	152.5	2.4	12.5	80.4	4.2
1	3	5.5	4875.4	2886.1	4876.5	2.449	2.506	87.7	13.1	152.8	2.3	12.3	81.6	4.2
2	1	5.5	4851.6	2871.6	4853.0	2.449	2.509	87.7	13.1	152.8	2.4	12.3	80.4	4.2
2	2	5.5	4887.9	2892.1	4889.0	2.448	2.509	87.7	13.1	152.7	2.4	12.3	80.2	4.2
2	3	5.5	4888.8	2896.3	4889.9	2.452	2.509	87.8	13.1	153.0	2.3	12.2	81.4	4.2
Input By:													Checked By:	

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VMA = Voids in Mineral Aggregate
VFA = Voids Filled With Asphalt Cement
VTM = Voids in Total Mix

Table A130: Results of Height Sample SGC Compactions **Ndesign = 75**

Project: 19													
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa) 2.747		Eff. Sp. Gr. (Gse): 2.736		Bulk Sp. Gr. (Gsb): 2.639	Mix Description: 9.5mm Fine					Date 9/11/2003
			Masses			SPECIFIC GRAVITIES			VOIDS				
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %	
1	1	5.5	1372.0	775.4	1379.4	2.272	2.506	12.2	9.4	10.9	2688	4.2	
1	2	5.5	1379.0	783.9	1385.9	2.291	2.506	12.3	8.6	10.0	1837	4.2	
1	3	5.5	1251.6	716.2	1259.5	2.304	2.506	12.3	8.1	9.6	1632	4.2	
1	4	5.5	1235.3	702.6	1243.2	2.285	2.506	12.2	8.8	10.3	2086	4.2	
1	5	5.5	1200.2	674.9	1211.7	2.236	2.506	12.0	10.8	12.9	6257	4.2	
1	6	5.5	1207.6	679.6	1217.4	2.245	2.506	12.0	10.4	12.2	4693	4.2	
1	7	5.5	1154.3	639.5	1172.7	2.165	2.506	11.6	13.6	15.7	15409	4.2	
1	8	5.5	1155.3	640.4	1172.5	2.171	2.506	11.6	13.4	15.4	12515	4.2	
2	1	5.5	1329.2	760.9	1333.0	2.323	2.509	12.4	7.4	8.1	637	4.2	
2	2	5.5	1326.3	761.1	1328.6	2.337	2.509	12.5	6.9	8.2	233	4.2	
2	3	5.5	1237.6	701.1	1242.3	2.287	2.509	12.2	8.9	10.4	1666	4.2	
2	4	5.5	1234.7	700.0	1239.9	2.287	2.509	12.2	8.9	10.6	1809	4.2	
2	5	5.5	1206.6	673.5	1214.1	2.232	2.509	11.9	11.0	12.6	5276	4.2	
2	6	5.5	1209.4	679.0	1216.8	2.249	2.509	12.0	10.4	12.3	3518	4.2	
2	7	5.5	1168.2	647.2	1182.3	2.183	2.509	11.7	13.0	15.1	7915	4.2	
2	8	5.5	1170.8	653.3	1186.4	2.196	2.509	11.8	12.5	14.6	7035	4.2	
Input By:													

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A131: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.0	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
12.5	3.12	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
9.5	2.75	98.7	99.2	98.5	98.8	0.4	98.5	98.7	98.8	98.7	0.2	98.7	0.1	98.0
4.75	2.02	73.3	75.2	74.9	74.5	1.0	73.4	74.3	73.2	73.6	0.6	74.1	0.6	70.0
2.36	1.47	48.2	49.4	49.1	48.9	0.6	49.8	50.9	50.1	50.3	0.6	49.6	1.0	46.0
1.18	1.08	34.0	34.6	34.5	34.4	0.3	34.8	35.5	35.2	35.2	0.4	34.8	0.6	
0.6	0.8	24.6	25.0	25.0	24.9	0.2	25.1	25.5	25.4	25.3	0.2	25.1	0.3	
0.3	0.58	17.4	17.6	17.8	17.6	0.2	17.6	17.9	17.9	17.8	0.2	17.7	0.1	15.0
0.15	0.43	10.1	10.2	10.4	10.2	0.2	10.1	10.4	10.4	10.3	0.2	10.3	0.0	
0.075	0.31	5.6	5.6	5.8	5.7	0.1	5.6	5.7	5.7	5.7	0.1	5.7	0.0	6.2
Asphalt Content		**Sample 1**					**Sample 2**					**Overall**		
		Rep1	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Rep3**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		5.48	5.63	5.52	5.54	0.08	5.29	5.31	5.34	5.31	0.03	5.43	0.16	5.5

Table A132: Coarse Aggregate Properties for Project 19

Test	#89's	
Bulk / Apparent Specific Gravity	2.601/2.726	
Absorption, %	1.8	
LA Abrasion, % Loss	9.7	
Flat and Elongated, %		
3 to 1	74.9	
5 to 1	37.7	
Coarse Aggregate Flow, %	44.8	
Crushed Content, %		
One Face	34.6	
Two+ Faces	65.4	
Data provided by either the agency or determined at NCAT lab		

Table A133: Fine Aggregate Properties for Project 19

Test	W-10's	M-10's	RAP
Bulk / Apparent Specific Gravity	2.615/2.711	2.601/2.726	2.669/2.719
Absorption, %	1.35	1.8	0.7
Fine Aggregate Angularity, %	35.4		48.4
Sand Equivalent	96		96
Data provided by either the agency or determined at NCAT lab			

Project 20:

Project 20 was evaluated on June 26, 2003, and consisted of the placement of 38.1mm of new hot mix asphalt on the southbound lane of a United States highway. The mix consisted of a 12.5mm nominal maximum aggregate size fine-graded granite/limestone/RAP blend designed at an N_{design} of 80 gyrations resulting in a design asphalt content of 5.0 percent. The asphalt binder that was used was a PG 64-22 (unmodified). The weather conditions during paving were approximately 95°F and partly cloudy. The mix design and gradation information and gradation shape are provided in Tables A134 and A135.

The project was located approximately 15 miles from the Astec drum plant. Dump trucks fed the mix into the paver. Breakdown rolling was conducted by an Ingersoll Rand DD 90 roller making two passes in vibratory mode in medium amplitude and frequency, then making three passes in static mode. Finish rolling was conducted by a Dynapac roller making six total passes across the mat, starting at a temperature of 165°F.

While at the plant, the following materials were obtained: individual stockpiles that were used, asphalt binder used, and loose mixture. Results from the loose mixture are provided in Tables A136-A140.

Table A134: Project 20 Mix Design Summary8 Information	
JMF I.D. Number:	NA
Date(s) on Project:	6/26/03
Number of Stockpiles Used:	6
- Coarse Aggregate Angularity:	94/93
- Fine Aggregate Angularity:	46
Percent RAP:	10
Gradation:	Coarse
Ninitial, Ndesign, Nmax:	7/ 80/ 125
Type Asphalt Binder Used:	PG 64-22
Design Asphalt Binder Content:	5.0
Type Modifier Used:	NA
Type Anti-Strip Additive Used:	NA
Percent Anti-Strip Used:	NA
Design Voids in Total Mix:	4.0
Design Voids in Mineral Aggregate:	14.5
Design Voids Filled with Asphalt:	NA
Tensile Strength Ratio:	0.92
Dust/Asphalt Ratio:	1.07

Table A135: Design Gradation for Project 20			
Sieve Size	Sieve Size, mm	Recommended Limits from Job Mix	Percent Passing
11/2 in.	37.5		100
1 in.	25.0		100
¾ in.	19.0		100
½ in.	12.5		97
3/8 in	9.5		85
No. 4	4.75		55
No. 8	2.36		37
No. 16	1.18		29
No. 30	0.6		22
No. 50	0.3		11
No. 100	0.15		8
No. 200	0.075		4.9

Table A136: Results from SGC Compactions **Ndesign = 80**

Project: 20														Date
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.675		Bulk Sp. Gr. (Gsb): 2.642		Mix Description: 12.5mm Fine					9/11/2003
			Masses			SPECIFIC GRAVITIES		VOLUMES AT Ndes			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	Aggregate Volume cc	AC by Volume %	Unit Weight, pcf	VTM, %	VMA, %	VFA, %	Eff. AC Content %
1	1	5.0	4831.5	2824.6	4835.0	2.403	2.482	86.4	11.7	150.0	3.2	13.6	76.6	4.5
1	2	5.0	4839.0	2833.7	4840.1	2.412	2.482	86.7	11.7	150.5	2.8	13.3	78.7	4.5
1	3	5.0	4823.8	2815.6	4825.3	2.400	2.482	86.3	11.7	149.8	3.3	13.7	75.9	4.5
2	1	5.0	4821.4	2823.5	4822.6	2.412	2.473	86.7	11.7	150.5	2.5	13.3	81.4	4.5
2	2	5.0	4821.4	2819.1	4822.6	2.406	2.473	86.5	11.7	150.2	2.7	13.5	80.0	4.5
2	3	5.0	4814.5	2808.6	4816.0	2.398	2.473	86.2	11.7	149.7	3.0	13.8	78.1	4.5
Input By:													Checked By:	

SSD = Saturated Surface Dry　　cc = cubic centimeter　　VMA = Voids in Mineral Aggregate
TMD = Theoretical Maximum Density　　AC = Asphalt Cement　　VFA = Voids Filled With Asphalt Cement
gm = gram　　pcf = pounds per cubic foot　　VTM = Voids in Total Mix

Table A137: Results of Height Sample SGC Compactions **Ndesign = 80**

Project: 20									Mix Description: 12.5mm Fine			Date 9/11/2003
AC Sp. Gr. (Gb) = 1.028			App. Sp. Gr. (Gsa)		Eff. Sp. Gr. (Gse): 2.675		Bulk Sp. Gr. (Gsb): 2.642					
			Masses			SPECIFIC GRAVITIES			VOIDS			
Sample Number	Specimen Number	Asphalt Content	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	AC by Volume %	T166 VTM, %	CoreLok VTM, %	Avg Lab Perm (10E-5 cm/s)	Eff. AC Content %
1	1	5.0	1598.8	922.0	1600.8	2.355	2.482	11.5	5.1	5.8	0	4.5
1	2	5.0	1597.1	924.5	1599.8	2.365	2.482	11.5	4.7	5.7	0	4.5
1	3	5.0	1496.4	864.1	1497.7	2.362	2.482	11.5	4.8	6.8	127	4.5
1	4	5.0	1495.8	863.2	1496.6	2.362	2.482	11.5	4.9	6.3	293	4.5
1	5	5.0	1460.9	840.7	1462.2	2.351	2.482	11.4	5.3	6.1	0	4.5
1	6	5.0	1459.4	840.4	1460.2	2.355	2.482	11.5	5.1	5.8	0	4.5
1	7	5.0	1408.0	810.1	1412.2	2.338	2.482	11.4	5.8	5.7	0	4.5
1	8	5.0	1405.9	808.6	1407.4	2.348	2.482	11.4	5.4	5.7	0	4.5
2	1	5.0	1600.7	926.3	1602.0	2.369	2.473	11.5	4.2	5.3	143	4.5
2	2	5.0	1595.7	919.4	1596.8	2.356	2.473	11.5	4.7		158	4.5
2	3	5.0	1557.7	900.3	1559.7	2.362	2.473	11.5	4.5	9.8	0	4.5
2	4	5.0	1544.2	891.6	1545.8	2.360	2.473	11.5	4.6	5.7	115	4.5
2	5	5.0	1525.7	872.4	1527.9	2.328	2.473	11.3	5.9	6.9	0	4.5
2	6	5.0	1498.5	851.1	1502.9	2.299	2.473	11.2	7.0	8.3	0	4.5
2	7	5.0	1487.8	841.7	1492.4	2.286	2.473	11.1	7.5	8.8	674	4.5
2	8	5.0	1459.9	822.0	1468.9	2.257	2.473	11.0	8.7	10.0	1117	4.5
Input By:												

SSD = Saturated Surface Dry
TMD = Theoretical Maximum Density
gm = gram
cc = cubic centimeter
AC = Asphalt Cement
pcf = pounds per cubic foot
VTM = Voids in Total Mix

Table A138: Gradations and Asphalt Contents

Gradation		Sample 1					Sample 2					Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	JMF
37.50	5.11	100.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
25.0	4.26	**100.0**	**100.0**	**100.0**	100.0	0.0	**100.0**	**100.0**	**100.0**	100.0	0.0	100.0	0.0	100.0
19	3.76	100.0	100.0	100.0	100.0	0.0	100.0	99.0	100.0	99.7	0.6	99.8	0.2	100.0
12.5	3.12	98.2	98.2	98.4	98.3	0.1	97.9	96.2	97.5	97.2	0.9	97.7	0.8	97.0
9.5	2.75	88.4	90.1	87.8	88.8	1.2	88.0	87.4	89.6	88.3	1.1	88.6	0.3	85.0
4.75	2.02	60.5	61.4	58.2	60.0	1.7	58.9	57.8	61.1	59.3	1.7	59.7	0.5	55.0
2.36	1.47	43.4	43.9	41.7	43.0	1.2	42.7	41.1	43.3	42.4	1.1	42.7	0.4	37.0
1.18	1.08	36.4	36.9	35.3	36.2	0.8	35.3	34.3	35.9	35.2	0.8	35.7	0.7	29.0
0.6	0.8	30.4	30.8	29.6	30.3	0.6	29.2	28.4	29.6	29.1	0.6	29.7	0.8	22.0
0.3	0.58	12.5	12.8	12.2	12.5	0.3	12.4	12.1	12.5	12.3	0.2	12.4	0.1	11.0
0.15	0.43	6.7	6.9	6.5	6.7	0.2	6.9	6.8	7.0	6.9	0.1	6.8	0.1	8.0
0.075	0.31	4.4	4.6	4.3	4.4	0.2	4.7	4.5	4.7	4.6	0.1	4.5	0.1	4.9
Asphalt Content		Sample 1					Sample 2					Overall		
		Rep1	Rep2	Rep3	Avg.	Std Dev	Rep1	Rep2	Rep3	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		4.97	4.93	4.76	4.89	0.11	4.73	4.80	4.80	4.78	0.04	4.83	0.08	5.00

Table A139: Coarse Aggregate Properties for Project 20

Test	#78's LMS	Shot GVL
Bulk / Apparent Specific Gravity	2.741/2.773	2.588/2.645
Absorption, %	0.41	0.84
LA Abrasion, % Loss	8.3	
Flat and Elongated, %		
3 to 1	81.9	72.4
5 to 1	18.1	7.3
Coarse Aggregate Flow, %	46.7	39.3
Crushed Content, %		
One Face	100	17.6
Two+ Faces	100	82.3
Data provided by either the agency or determined at NCAT lab		

Table A140: Fine Aggregate Properties for Project 20

Test	LMS Scrns	Cr. GVL	Sand	RAP
Bulk / Apparent Specific Gravity	2.680/2.856	2.624/2.649	2.552/2.647	2.797/2.926
Absorption, %	2.3	0.4	1.4	1.57
Fine Aggregate Angularity, %	44.1	47.5	49.3	42.9
Sand Equivalent	87	92	97	90
Data provided by either the agency or determined at NCAT lab				

TASK 5 APPENDIX B

FIELD PROJECT REPORTS, TEST RESULTS AND DISCUSSION

In the following section of the report, brief site reports are presented for each of the twenty projects evaluated. The information consists of a description of the actual construction project, mix design information, quality control data from the mobile laboratory, and test results from the cores and loose mix brought back to NCAT. The project evaluations were based on the results produced from the actual mixture being placed at the time of the evaluations and not on the job mix formulas. An overall analysis of the combined results obtained from all the projects is presented after the presentation of the individual projects.

5.1 Project 1:

Project 1was the overlay of an existing HMA pavement on a two-lane county highway. The mix consisted of a 9.5 mm NMAS fine-graded blend designed at an N_{design} of 65 gyrations. The optimum binder content for the mix was 5.8 percent. The asphalt binder for this project was a PG 70-22.

Average test results from Project 1 are presented in Table 4. Results include asphalt contents (solvent extraction) and washed gradations of the extracted aggregate. The results are separated into the individual sublots evaluated during the day on site.

Table 4: Average Gradations and Binder Contents per Sublot, Project 1

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff[1]	Avg	% Diff[1]	Avg	% Diff[1]
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0	100.0	0.0
12.5	100.0	99.9	0.1	99.9	0.1	99.9	0.1
9.5	94.5	95.1	-0.6	95.6	-1.1	94.5	0.0
4.75	64.7	67.9	-3.1	68.8	-4.1	66.9	-2.2
2.36	52.6	52.0	0.6	52.0	0.6	52.0	0.6
1.18	39.2	38.8	0.4	38.6	0.6	39.0	0.2
0.6	29.6	30.3	-0.7	30.3	-0.7	30.4	-0.8
0.3	15.7	17.0	-1.3	17.3	-1.6	16.7	-1.0
0.15	8.0	8.8	-0.8	9.1	-1.1	8.5	-0.5
0.075	4.8	5.3	-0.5	5.5	-0.7	5.2	-0.4
Asphalt Content	5.8	5.5	0.3	5.3	0.5	5.7	0.1

Note: 1) Percent Difference Between JMF and Actual

Based on Table 4, the average binder content of the obtained samples was 5.5 percent, 0.3 percent lower than the job mix formula. The binder content for sublot 1 was 5.3 percent, 0.5 percent lower than the JMF, while for sublot 2 the binder content was 5.7 percent, 0.1 percent lower than the JMF. The overall average gradation was fairly close to the job mix formula values, with the largest difference coming on the 4.75mm sieve (3.1 percent finer than the job mix formula (JMF)). Gradations for both sublots were reasonably close to the job mix formula.

Table 5 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis), and water absorption values (from AASHTO T166) for each core taken from Project 1. One core was damaged during transportation back to NCAT and could not be tested. Table 6 presents the average in-place air voids for the combined data and for each sublot. Also included are the standard deviations for the combined data and for each sublot. An initial observation of Table 6 shows that, on average, the dimensional analysis method of determining the bulk specific gravity yielded the highest air void contents, followed by the CoreLok method, AASHTO T166, and the CoreReader, respectively.

Table 5: Core In-place Air Voids and Water Absorption, Project 1

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	6.9	6.6	5.8	8.6	0.4
2	1	8.1	8.5	8.2	10.7	0.7
3	1	8.6	9.1	7.3	10.4	0.8
4	1	7.8	8.2	6.2	10.7	0.8
5	1	7.3	8.0	5.4	9.3	0.7
6	2	6.7	6.2	4.9	8.7	0.7
7	2			Damaged		
8	2	12.4	14.1	14.1	16.8	2.1
9	2	9.3	9.6	8.9	10.9	1.1
10	2	7.9	8.4	6.6	10.0	1.0

Table 6: Average Core In-place Air Voids and Standard Deviations, Project 1

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	8.3	1.7	8.8	2.3	7.5	2.8	10.7	2.4
sublot 1	7.7	0.7	8.1	0.9	6.6	1.1	9.9	1.0
sublot 2	9.1	2.5	9.6	3.3	8.6	4.0	11.6	3.6

The in-place air voids from the project averaged 8.3 percent, ranging from a low of 6.7 percent to a high of 12.4 percent, based upon AASHTO T166 bulk specific gravity measurements. The average in-place air voids for sublot 1 was 7.7 percent and 9.1 percent for sublot 2.

Lift thickness, field, and lab permeability results for cores are shown in Table 7. As mentioned earlier, one core was damaged and could not be tested. From the lift thickness results in Table 7, the average lift thickness for the project was 48.7 mm, 10.6 mm higher than the design thickness. Lift thickness ranged from 38.8 mm to 66.9 mm or from a t/NMAS ratio of 4.1:1 to 7.0:1.

The relationship between lift thickness and in-place air voids is shown in Figure 7. There was a very weak relationship between the two properties as the coefficient of determination was low ($R^2 = 0.07$). An analysis of variance (ANOVA) for the regression confirmed that the relationship was not significant (probability of F-statistic greater than F-critical (p-value) was 0.49). Also, the thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 7: Average Lift Thickness, Field, and Lab Permeability for Cores, Project 1

Sample ID	Sublot	Avg Thickness	Avg Field Permeability	Avg Lab Permeability

		(mm)	(10x-5 cm/s)	(10x-5 cm/s)
1	1	43.1	3	0
2	1	45.4	31	21
3	1	47.9	33	88
4	1	47.7	22	43
5	1	38.8	10	7
6	2	66.9	9	0
7	2	NA	211	NA
8	2	44.1	345	279
9	2	50.4	67	75
10	2	53.7	7	16

NA = No Data

The in-place density results determined by the Pavement Quality Indicator (PQI) are presented in Table 8. The three individual runs correlate to the three individual field permeability test locations shown in Figure 2. The core average is the average of five density measurements from the location the core was taken. The five measurements were taken in a counter-clockwise fashion and one measurement taken directly in the middle of the core location.

Table 8: Pavement Quality Indicator In-place Density Results, Project 1

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	130.1	129.8	129.8	129.5
2	1	127.8	127.8	127.4	127.9
3	1	127.8	126.0	127.5	127.5
4	1	127.0	127.2	127.3	127.2
5	1	127.8	127.7	127.9	127.9
6	2	129.4	128.1	127.6	128.3
7	2	124.0	124.3	124.3	124.2
8	2	122.7	123.7	123.4	123.6
9	2	126.2	126.2	126.5	125.9
10	2	129.0	128.5	128.9	128.3

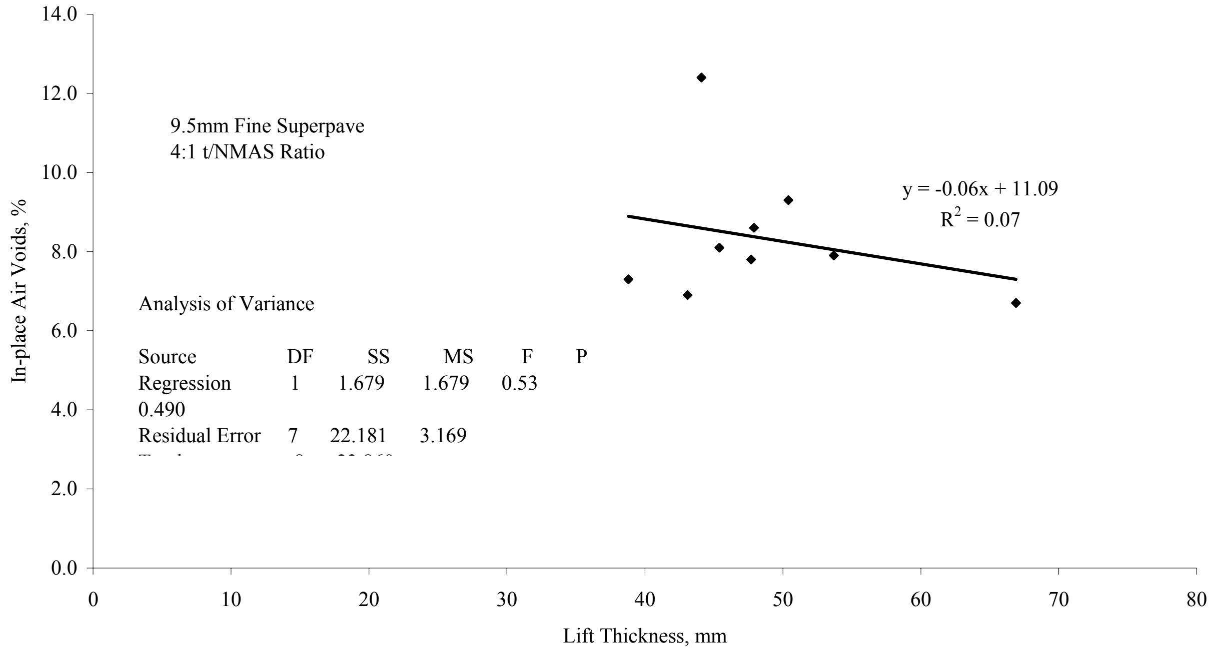

Figure 7: Relationship of Lift Thickness and In-place Air Voids, Project 1

Figures 8 and 9 illustrate the relationship between permeability and air voids. Figure 8 was included to give a comparison of the relationship when test locations that had no permeability were included in the regression. Figure 9 shows the relationship when these points were removed form the regression. This comparison was demonstrated for this first project only. For the remaining projects, only the regression that does not include zero permeability points is presented.

Figure 8 illustrates three relationships between permeability and air void content with all test locations included. These relationships include field and lab permeability results versus in-place air voids and lab permeability results versus air void content for the lab compacted samples that were produced in NCAT's mobile lab. The lab permeability results for the lab compacted samples are presented in Table 9. Observation of the air voids for the lab compacted samples indicated that the air void contents were higher than anticipated. This was also observed for several other projects described later. This may have been caused by several things, such as aggregate orientation or a thin design lift thickness using larger nominal maximum aggregate sizes. This observation of the difficulty compacting to a design lift thickness suggests that there is a need for a minimum lift thickness for nominal maximum aggregate sizes.

Based on Figure 8, the R^2 value for the field permeability results versus in-place air voids was 0.87, which represents a strong correlation. There was also a reasonable correlation between the lab permeability results on cores versus in-place air voids (R^2 = 0.64). A strong correlation was also observed for the lab permeability results for the lab compacted samples (R^2 = 0.85). Previous research has shown that for the majority of pavement types, the permeability value that correlates to excessive permeability ranges from 100 to 150x10^{-5} cm/s (10, 11, 12). Throughout the discussion of the individual projects, a permeability value of 125x10^{-5} cm/s, which is the average between the two values taken from the literature, was used for assessing the in-place air void content at which mixes became permeable. Based upon a permeability value of 125x10^{-5} cm/s, Project 1 started to show excessive permeability between 10.5 and 11 percent in-place air voids for all three relationships.

In Figure 9, the regression for the field permeability data stayed at 0.87. The regression for the lab permeability results conducted on the cores increased to 0.78, which is a stronger correlation that the regression with all data points included. For the lab permeability data for the lab compacted samples, the regression increased to 0.89. All three relationships still indicated that the mix became permeable at in-place air voids between 10 and 11 percent.

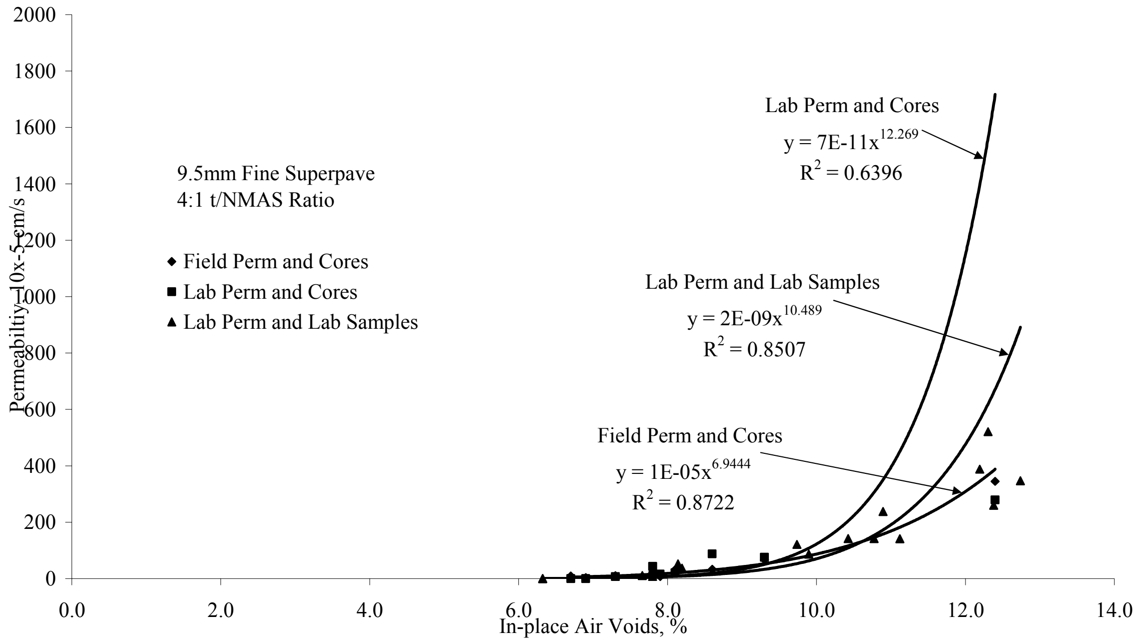

Figure 8: Relationships between Permeability and In-place Air Voids, All Data Points, Project 1.

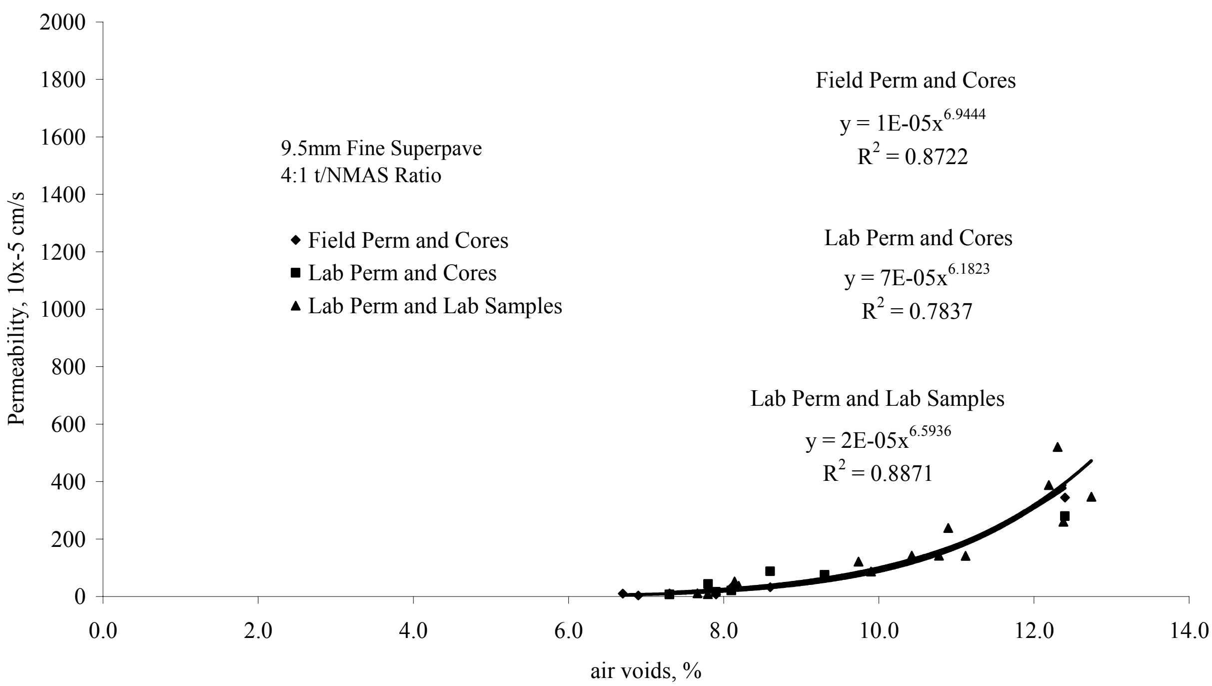

Figure 9: Relationships between Permeability and In-place Air Voids, Zero Perm Points Removed, Project 1.

Table 9: Lab Permeability Results for Lab Compacted Samples, Project 1

Sample ID	Sublot	T166 VTM %	Avg Lab Permeability (10x-5 cm/s)
1	1	7.8	8
2	1	7.7	11
3	1	8.2	37
4	1	8.1	52
5	1	10.4	142
6	1	10.8	142
7	1	12.3	521
8	1	12.7	347
9	2	6.3	0
10	2	6.3	0
11	2	9.7	121
12	2	9.9	87
13	2	10.9	238
14	2	11.1	141
15	2	12.4	260
16	2	12.2	388

5.2 Project 2

Project 2 involved the placement of hot mix asphalt (HMA) for a new pavement. The mix consisted of a 19.0 mm NMAS coarse-graded blend designed at an N_{design} of 65 gyrations. The optimum binder content for the mix was 5.3 percent. The asphalt binder used for this project was a PG 64-22.

Average test results from the plant produced material for the project are presented in Table 10. Results include asphalt content (solvent extraction) and washed gradation of the extracted aggregate. These results are separated into the individual sublots evaluated during the day on site.

Table 10: Average Gradations and Binder Contents per Sublot, Project 2

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0

19	99.6	100.0	-0.4	100.0	-0.4	100.0	-0.4
12.5	88.9	87.8	1.1	88.2	0.7	87.4	1.5
9.5	76.8	71.4	5.4	72.7	4.1	70.2	6.6
4.75	52.2	41.2	11.1	42.0	10.2	40.3	11.9
2.36	30.3	26.4	3.9	27.1	3.2	25.7	4.6
1.18	19.3	19.5	-0.2	20.4	-1.1	18.7	0.6
0.6	14.1	14.9	-0.8	15.5	-1.4	14.3	-0.2
0.3	8.2	8.9	-0.7	9.3	-1.1	8.5	-0.3
0.15	5.9	6.4	-0.4	6.6	-0.7	6.1	-0.2
0.075	4.6	5.2	-0.6	5.4	-0.8	5.0	-0.4
Asphalt Content	5.3	4.7	0.6	4.7	0.6	4.7	0.6

From Table 10, the average binder content from the obtained samples for both sublots was 4.7 percent, 0.6 percent lower than the job mix formula. The overall average gradation for the two sublots deviated from the job mix formula values, with the largest difference coming on the 4.75mm sieve (11.1 percent less than the JMF).

Table 11 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption (AASHTO T166) values for each core taken from Project 2. Average in-place air voids for Project 2 was 6.5 percent, ranging from a low of 4.2 percent to a high of 10.3 percent. For sublot 1, the average air void content was 6.0 percent, and for sublot 2 the average air void content was 6.9 percent, using AASHTO T166 test method. In Table 12, average core in-place air voids and standard deviations are shown for each sublot. Both the water displacement method and the CoreReader produced very similar in-place air void contents. As with Project 1, dimensional analysis provided the highest in-place air void contents.

Table 11: Core In-place Air Voids and Water Absorption, Project 2

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	4.2	4.7	1.8	7.0	0.3
2	1	10.3	14.4	13.7	14.7	3.6

3	1	4.1	5.7	3.9	7.7	0.5
4	1	5.1	5.9	4.6	8.0	0.4
5	1	6.5	8.1	6.5	9.5	0.6
6	2	7.3	8.4	7.0	10.2	0.7
7	2	6.7	7.8	7.0	9.5	0.5
8	2	6.2	7.0	6.6	9.4	0.6
9	2	6.9	8.1	7.2	9.5	0.7
10	2	7.2	8.1	6.8	9.6	0.5

Table 12: Average Core In-place Air Voids and Standard Deviations, Project 2

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	6.5	1.8	7.8	2.6	6.5	3.1	9.5	2.1
sublot 1	6.0	2.6	7.8	3.9	6.1	4.6	9.4	3.1
sublot 2	6.9	0.4	7.9	0.5	6.9	0.2	9.6	0.3

Table 13 contains average lift thickness, field, and lab permeability results on cores taken for Project 2. Table 13 shows the average lift thickness for the project to be 65.7 mm, 2.2 mm higher than the target thickness. Thicknesses ranged from 54.6 mm to 77.7 mm, or from a t/NMAS ratio of 2.9:1 to 4.1:1. Several cores could not be tested because they could not fit into the lab permeability device. These samples were cut down to a size that would fit the device and tested. The remaining two cores were damaged during sawing and could not be tested. PQI density results are presented in Table 14.

The relationship between lift thickness and in-place air voids is shown in Figure 10. As with Project 1, the relationship produced a low R^2 (0.03). An ANOVA for the regression confirmed that the relationship was not significant (p-value of 0.613). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 13: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 2

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	67.2	9	0
2	1	60.2	288	NA
3	1	56.4	1	0
4	1	54.6	1	8
5	1	68.0	39	0
6	2	66.4	20	19
7	2	77.7	15	NA
8	2	67.6	2	0
9	2	68.0	15	12
10	2	70.6	9	0

NA = No Data

Table 14: Pavement Quality Indicator In-place Density Results, Project 2

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	129.6	130.7	130.9	130.8
2	1	127.7	127.3	126.9	127.2
3	1	130.9	130.6	130.9	131.3
4	1	130.5	126.8	125.6	129.9
5	1	128.3	124.5	127.9	126.0
6	2	129.3	128.1	127.6	128.2
7	2	125.6	127.2	128.0	125.3
8	2	127.9	127.6	128.1	128.2
9	2	128.4	127.9	127.8	126.6
10	2	128.4	128.8	128.5	128.0

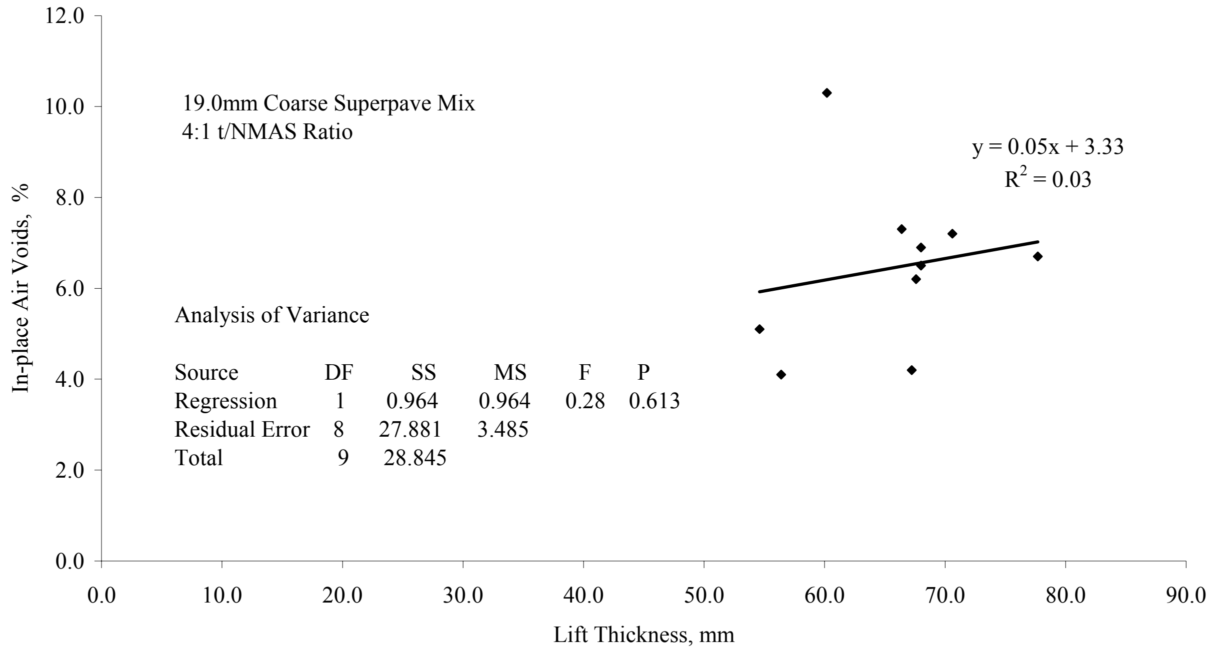

Figure 10: Relationship of Lift Thickness and In-place Air Voids, Project 2

The relationship between in-place air voids and permeability for Project 2 is shown in Figure 11. Similar to Figure 9, Figure 11 includes field permeability and lab permeability results versus in-place air voids and lab permeability results for the lab compacted height samples from the mobile lab. Results from the lab permeability tests conducted on the lab compacted samples are presented in Table 15. From the results of field permeability testing, there was a reasonable correlation between in-place air voids and field permeability (R^2 = 0.61). There was also a strong correlation between the lab permeability results for the lab samples and in-place air voids (R^2 = 0.81). A trend could not be made for the relationship between lab permeability results for cores and in-place air voids because the permeability values were close to zero for the range of air voids measured from the cores. But from observation of the other two relationships, both follow the same trend until about 7.5 percent air voids, when the field permeability results tended to increase at a higher rate than the lab permeability. The regression equations for the field permeability and lab permeability results for the lab samples indicated that the mix became permeability at in-place air voids between 7.8 (lab samples) and 10.5 (field permeability and cores).

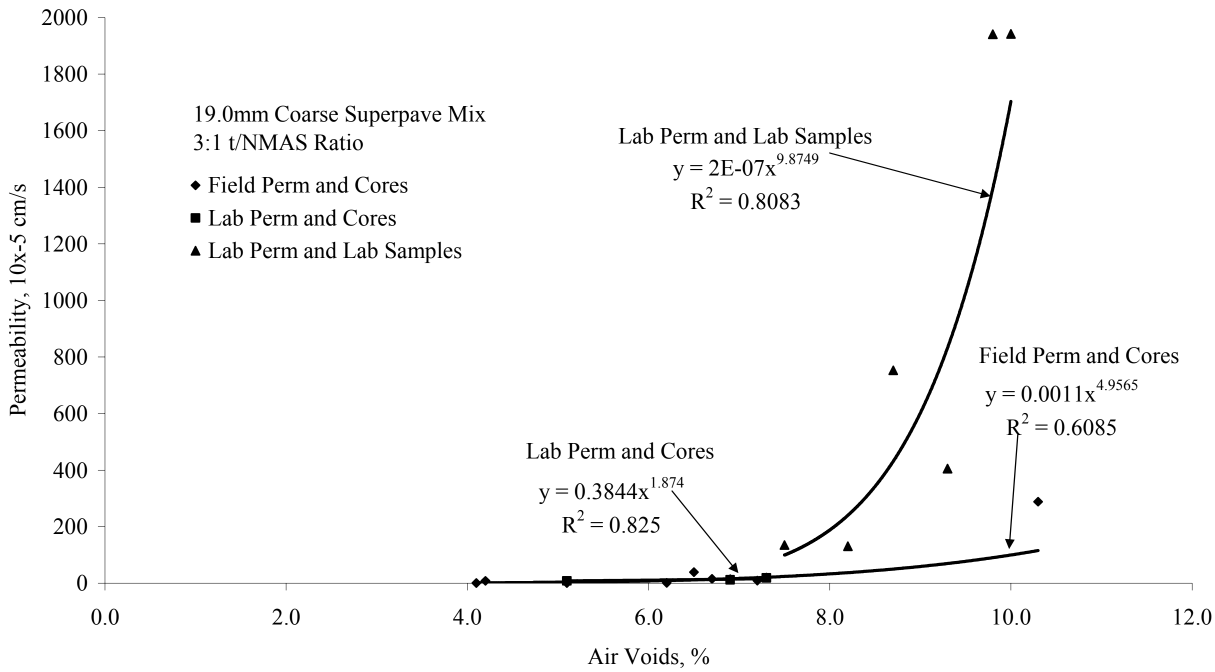

Figure 11: Relationship Between Permeability and In-place Air Voids, Project 2.

Table 15: Lab Permeability Results for Lab Compacted Samples, Project 2

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	5.2	0
2	1	4.5	0
3	1	5.5	0
4	1	5.8	0
5	1	6.8	0
6	1	6.6	0
7	1	8.7	753
8	1	8.2	131
9	2	4.1	0
10	2	5.4	0
11	2	7.4	0

12	2	7.1	0
13	2	7.5	135
14	2	9.3	405
15	2	9.8	1941
16	2	10	1942

5.3 Project 3:

Project 3 was an overlay of an existing HMA pavement on a two-lane county highway. The mix consisted of a 9.5 mm NMAS coarse-graded blend designed at an N_{design} of 65 gyrations. Optimum binder content for the mix was 5.5 percent. The asphalt binder for this project was a PG 64-22.

Average test results from Project 3 are presented in Table 16. Results include asphalt contents (solvent extraction) and washed gradations of the extracted aggregate. These results are separated into the individual sublots evaluated during the day on site.

Table 16: Average Gradation and Binder Content per Sublot, Project 3

Gradation		Overall		Sublot 1		Sublot 2		Sublot 3	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0	99.9	0.1	100.0	0.0
12.5	100.0	98.8	1.2	98.9	1.1	98.7	1.3	98.6	1.4
9.5	95.7	92.2	3.5	91.2	4.5	93.1	2.6	92.3	3.4
4.75	56.7	52.8	3.9	51.8	4.9	55.4	1.3	51.2	5.5
2.36	39.1	33.5	5.6	33.0	6.1	35.5	3.6	32.0	7.1
1.18	30.0	25.8	4.2	25.4	4.6	27.3	2.7	24.7	5.3
0.6	21.9	19.5	2.4	19.1	2.8	20.7	1.2	18.7	3.2
0.3	13.2	11.7	1.5	11.4	1.8	12.5	0.7	11.0	2.2

0.15	9.6	8.0	1.6	8.0	1.6	8.7	0.9	7.5	2.1
0.075	6.1	5.7	0.4	5.6	0.5	6.1	0.0	5.3	0.8
Asphalt Content	5.5	5.5	0.0	5.5	0.0	5.6	-0.1	5.5	0.0

From Table 16, the average binder content from the obtained samples for Project 3 was 5.5 percent, which matched the design binder content. The measured asphalt contents for all three sublots were approximately the same as the job mix formula. The average gradation for Project 3 was coarser than the job mix formula, with the largest difference being on the 2.36mm sieve (5.6 percent lower than the JMF).

Table 17 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for each core taken from Project 3. Two cores were damaged while being brought back to NCAT and could not be tested. Table 18 shows that the average in-place air voids for Project 3 was 9.0 percent, ranging from a low of 5.1 percent to a high of 11.9 percent, based on AASHTO T166 testing. For sublot 1, the average air void content was 9.7 percent, for sublot 2 the average air void content was 9.4 percent, and for sublot 3 the average air void content was 8.1 percent (AASHTO T166).

Table 17: Core In-place Air Voids and Water Absorption, Project 3

Sample ID	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	11.9	15.4	13.4	16.8	4.9
2	11.4	13.4	11.3	15.8	4.2
3	7.6	9.6	9.4	12.2	1.7
4	10.6	12.7	12.2	15.0	3.6
5	7.2	8.2	7.2	10.5	1.1
6	9.8	12.8	10.7	15.5	3.3
7	8.6	11.2	11.4	14.5	1.5
8	Damaged				
9	Damaged				

10	9.8	11.3	10.5	13.7	2.5
11	5.2	6.2	3.1	8.8	0.9
12	5.1	5.9	4.4	8.3	0.8
13	11.8	16.4	12.4	17.2	5.1
14	9.6	11.3	10.1	14.4	3.1
15	8.8	11.0	11.8	14.8	2.2

Table 18: Average Core In-place Air Voids and Standard Deviations, Project 3

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	9.0	2.3	11.2	3.2	9.9	3.1	13.7	2.9
sublot 1	9.7	2.2	11.9	2.9	10.7	2.4	14.1	2.6
sublot 2	9.4	0.7	11.8	0.9	10.9	4.6	14.6	0.9
sublot 3	8.1	2.9	10.2	4.3	8.4	4.3	12.7	3.9

Average lift thickness, field, and lab permeability results for cores are presented in Table 19. As mentioned earlier, Project 3 was designed with a lift thickness of 38.1 mm. From the data in Table 19, the average lift thickness for Project 3 was 32.3 mm, 5.8 mm lower than the design thickness. The lift thickness ranged from 25.7 to 39.9 mm, or a t/NMAS ratio of 2.7:1 to 4.2:1. PQI density results for Project 3 are presented in Table 20.

The relationship between lift thickness and in-place air voids can be seen in Figure 12. From observation of the data in Figure 12, there was no relationship between the two properties. This was confirmed by conducting an ANOVA on the regression (p-value = 0.965). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 19: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 3

Sample ID Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)

1	1	33.8	2833	1711
2	1	39.9	1392	1171
3	1	35.3	277	115
4	1	26.6	900	547
5	1	39.2	154	75
6	2	25.7	932	NA
7	2	36.8	319	386
8	2	Damaged	1276	Damaged
9	2	Damaged	757	Damaged
10	2	35.5	470	323
11	3	28.0	22	14
12	3	31.3	7	9
13	3	26.8	602	1407
14	3	32.6	1290	750
15	3	28.1	450	388

NA = No Data Available

Table 20: Pavement Quality Indicator In-place Density Results, Project 3

Test Number	Sublot	Run1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	121.4	121.6	122.1	121.7
2	1	119.3	120.0	121.0	120.1
3	1	122.6	123.3	120.7	122.2
4	1	121.4	119.2	121.7	120.8
5	1	122.7	123.1	123.2	123.0
6	2	122.7	121.7	122.2	122.2
7	2	123.3	122.6	121.4	122.4

8	2	121	120.6	121.0	120.9
9	2	121.2	120.8	121.2	121.1
10	2	120.4	120.6	121.0	120.7
11	3	139.3	139.1	131.4	136.6
12	3	137.1	136.3	136.6	136.7
13	3	122.8	123	123.6	123.1
14	3	121.6	121	119.7	120.8
15	3	124.5	125.2	124.3	124.7

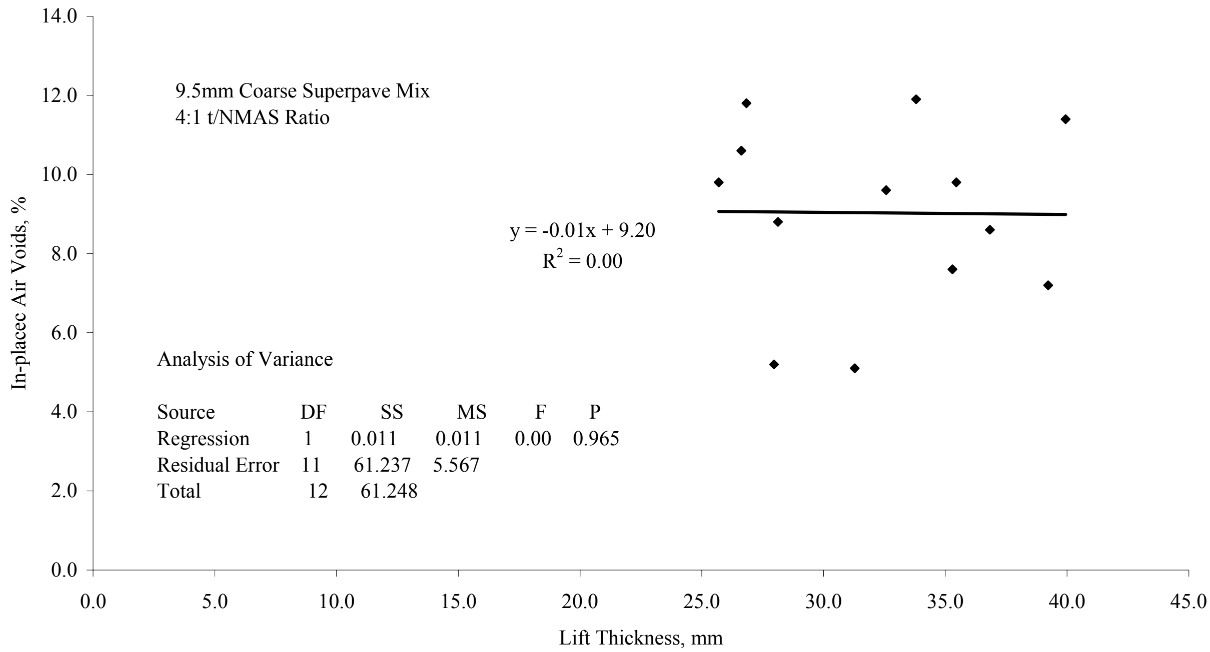

Figure 12: Relationship Between Lift Thickness and In-place Air Voids, Project 3

Figure 13 contains the relationship between in-place air voids and permeability. In Figure 13, the data is presented for three relationships: field permeability and lab permeability results versus core in-place air voids, and lab permeability results for the lab compacted samples produced in the mobile lab. The lab permeability results on the lab compacted samples are presented in Table 21. As discussed previously, the air void contents for the lab compacted samples were higher than anticipated, due to aggregate orientation within the thin lift thickness.

Based on Figure 13, there was a strong relationship for all three plots (R^2 values of 0.89, 0.97, and 0.87, respectively). Based on the regression lines, the mix became permeable at an in-place air void content between 7 and 8 percent for all three relationships.

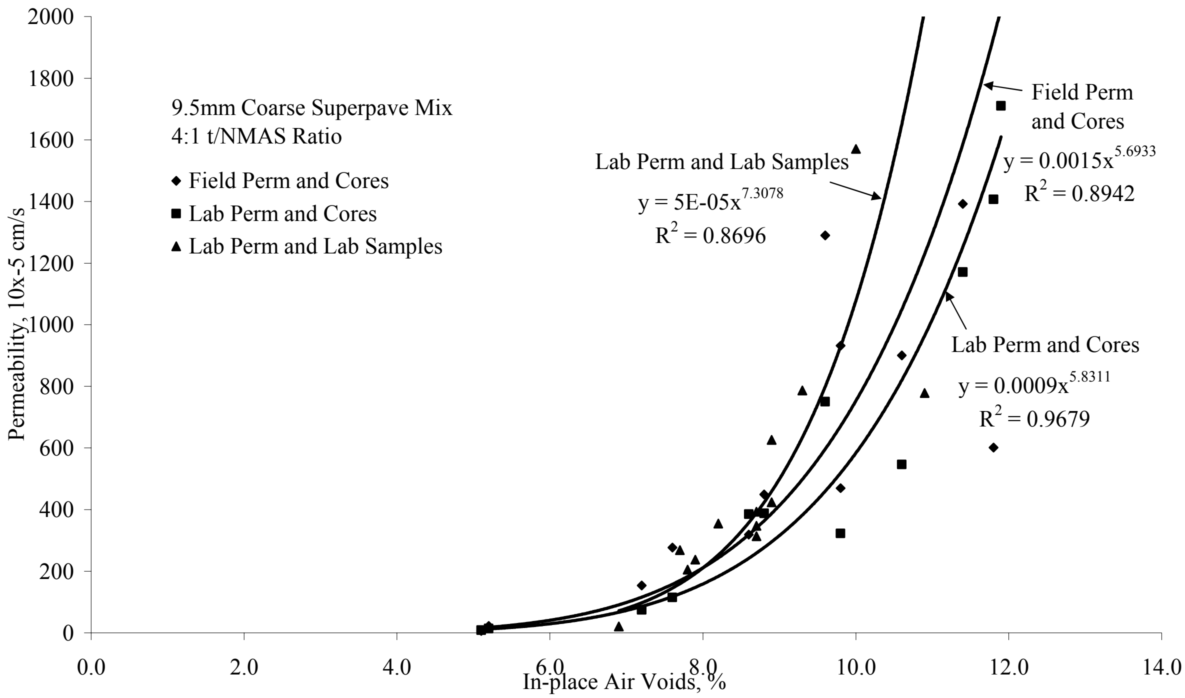

Figure 13: Relationship Between Permeability and In-place Air Voids, Project 3

Table 21: Lab Permeability Results for Lab Compacted Samples, Project 3

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)	Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	8.2	354	17	3	8.7	348
2	1	6.9	21	18	3	10.0	1571
3	1	7.9	238	19	3	11.7	2325
4	1	8.9	424	20	3	10.7	2293
5	1	8.7	393	21	3	11.2	3423

6	1	8.9	626	22	3	11.4	3448
7	1	11.8	6936	23	3	12.0	6794
8	1	12.4	3111	24	3	11.5	6881
9	2	7.7	269				
10	2	7.8	205				
11	2	9.3	787				
12	2	8.7	314				
13	2	10.9	779				
14	2	11.5	2324				
15	2	12.5	3907				
16	2	12.5	2307				

5.4 Project 4:

Project 4 was the placement of a hot mix asphalt on an aggregate base on the shoulder of an interstate highway. The mix consisted of a 12.5 mm NMAS fine-graded blend designed at an N_{design} of 75 gyrations. The optimum binder content for Project 4 was 5.7 percent. The asphalt binder used was an RA295.

Average binder content (solvent extraction) and washed gradation test results are presented in Table 22. Results are separated into the three sublots taken during the day on site. The average binder content from the obtained samples for Project 4 produced mix was 5.0 percent, 0.7 percent lower than the job mix formula. For sublot 1, the measures asphalt content was 4.9 percent, 0.8 percent lower than the JMF. Sublot 2 had an asphalt content of 5.0, 0.7 percent lower than the job mix formula, and sublot 3 had a measured asphalt content of 5.1 percent, 0.6 percent lower than the JMF. Based on the average gradation data in Table 19, the average mix gradation was close to the job mix formula, with the largest difference coming on the 1.18mm sieve (2.0 percent coarser than the JMF).

Table 22: Average Gradations and Binder Contents per Sublot, Project 4

Gradation		Overall		Sublot 1		Sublot 2		Sublot 3	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	99.5	0.5	99.5	0.5	99.8	0.2	99.2	0.8
12.5	93.0	94.1	-1.1	95.1	-2.1	94.0	-1.0	93.2	-0.2
9.5	86.0	87.9	-1.9	89.2	-3.2	87.4	-1.4	87.1	-1.1
4.75	66.0	67.3	-1.3	67.8	-1.8	67.0	-1.0	67.1	-1.1
2.36	47.0	47.4	-0.4	47.7	-0.7	47.1	-0.1	47.4	-0.4
1.18	35.0	33.0	2.0	33.5	1.5	32.6	2.4	32.9	2.1
0.6	26.0	25.1	0.9	25.6	0.4	24.8	1.2	24.8	1.2
0.3	19.0	18.7	0.3	19.4	-0.4	18.5	0.5	18.3	0.7
0.15	9.0	10.6	-1.6	11.2	-2.2	10.6	-1.6	10.1	-1.1
0.075	4.7	4.8	-0.1	5.3	-0.6	4.9	-0.2	4.1	0.6
Asphalt Content	5.7	5.0	0.7	4.9	0.8	5.0	0.7	5.1	0.6

Table 23 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and the water absorption values (from AASHTO T166) for each core obtained from Project 4. The average in-place air void results and standard deviations are presented in Table 23. Observation of Tables 23 and 24 shows that the average in-place air void content was 6.1 percent, ranging from 4.9 to 7.9 percent, based on AASHTO T166 bulk specific gravity measurements. Standard deviation values were generally low for all test procedures.

Table 23: Core In-place Air Voids and Water Absorption, Project 4

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	5.7	5.7	4.9	6.9	0.3
2	1	5.5	5.6	5.7	6.9	0.3
3	1	5.7	5.6	5.6	7.2	0.4
4	1	5.7	6.4	5.1	7.1	0.5
5	1	4.9	5.3	5.0	6.5	0.3

6	2	5.8	5.7	5.0	6.5	0.4
7	2	6.1	6.3	5.1	7.1	0.3
8	2	6.2	6.3	5.8	7.4	0.4
9	2	5.1	5.3	4.0	5.6	0.3
10	2	6.8	7.0	5.7	7.8	0.6
11	3	6.2	7.0	5.9	7.5	0.4
12	3	7.9	11.3	8.3	9.9	0.6
13	3	7.4	8.0	7.0	9.1	0.6
14	3	5.8	6.1	4.6	7.4	0.4
15	3	6.7	6.7	5.9	7.5	0.3

Table 24: Average Core In-place Air Voids and Standard Deviations, Project 4

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	6.1	0.8	6.6	1.5	5.6	1.0	7.4	1.0
sublot 1	5.5	0.3	5.7	0.4	5.3	0.4	6.9	0.3
sublot 2	6.0	0.6	6.1	0.6	5.1	0.7	6.9	0.9
sublot 3	6.8	0.9	7.8	2.1	6.3	1.4	8.3	1.1

Table 25 presents lift thickness, field, and lab permeability results for cores from Project 4. The design lift thickness for Project 4 was 63.5 mm. On average, the lift thickness was 68.6 mm, 5.1 mm larger than the design lift thickness. Lift thickness ranged from a low of 49.1 mm to a high of 89.6 mm, resulting in a t/NMAS of 3.9:1 to 7.2:1. PQI density results are presented in Table 26.

The relationship between lift thickness and in-place air voids is shown on Figure 14. A poor R^2 value was produced from the regression (0.18). An ANOVA conducted on the regression confirmed that the relationship was not significant (p-value = 0.12). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 25: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 4

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	82.6	23	0
2	1	61.2	39	201
3	1	79.5	64	0
4	1	75.3	129	0
5	1	58.1	53	0
6	2	89.6	41	0
7	2	74.1	49	12
8	2	87.3	95	13
9	2	81.3	90	14
10	2	77.8	52	36
11	3	58.6	87	26
12	3	49.1	812	113
13	3	52.3	382	21
14	3	51.4	92	17
15	3	50.3	136	34

Table 26: Pavement Quality Indicator In-place Density Results, Project 4

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	125.1	125.9	126.5	125.3
2	1	125.4	124.8	125.9	125.3
3	1	124.1	123.5	124.4	124.6
4	1	123.9	124.4	124.0	124.0
5	1	124.1	124.4	124.5	124.3
6	2	124.8	123.8	124.7	124.3
7	2	123.3	123.4	124.1	123.8
8	2	123.7	123.8	124.0	124.1
9	2	123.0	122.5	122.4	122.7
10	2	123.6	123.7	124.3	123.9
11	3	126.2	125.4	125.6	125.6
12	3	123.1	122.3	121.6	122.9
13	3	124.4	124.9	124.1	124.2
14	3	124.9	124.9	125.8	125.3
15	3	124.6	124.4	124.3	125.0

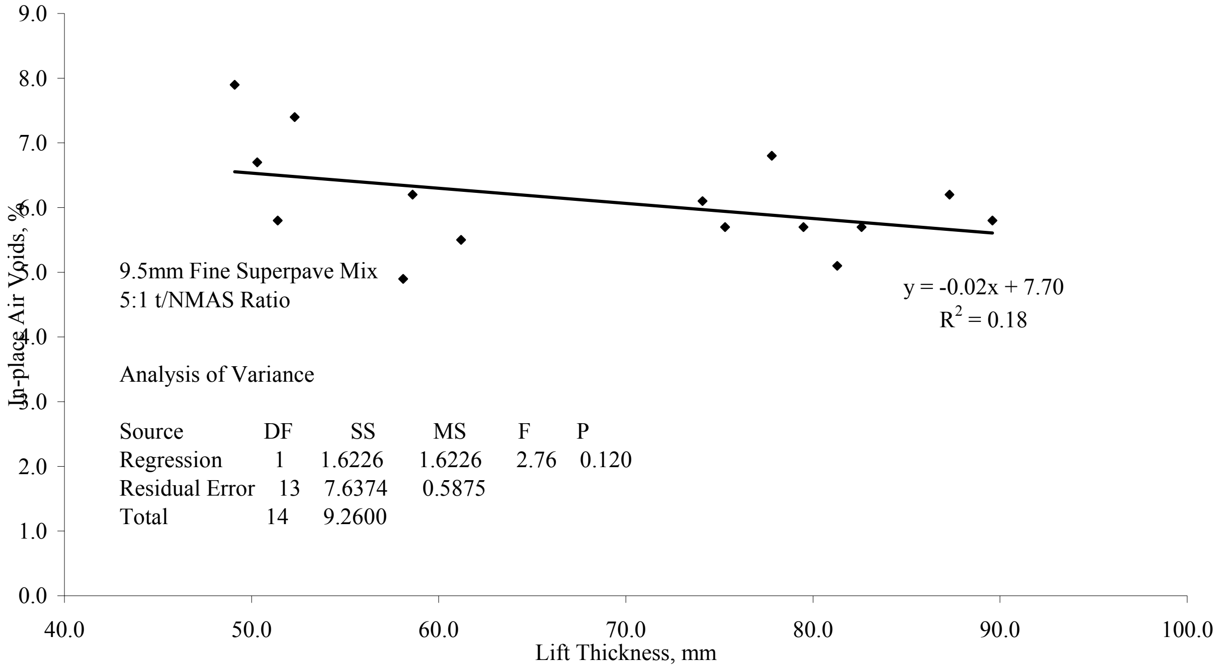

Figure 14: Relationship Between Lift Thickness and In-place Air Voids, Project 4

The relationship between permeability and in-place air voids is shown in Figure 15. The data was broken down into three relationships: field permeability and lab permeability versus in-place air voids and lab permeability versus air voids for lab compacted samples. The lab permeability results for the lab compacted samples are presented in Table 27. The strongest relationship was between lab permeability and air voids for the lab compacted samples (R^2 = 0.84). There was a fair correlation between both the field and lab permeability and air voids on cores (R^2 values of 0.50 and 0.57, respectively). Based on the regression line equations, the field permeability results suggests that the mix became permeable at an in-place air void content between 6 and 7 percent, while the lab permeability results suggest between 9 and 10.

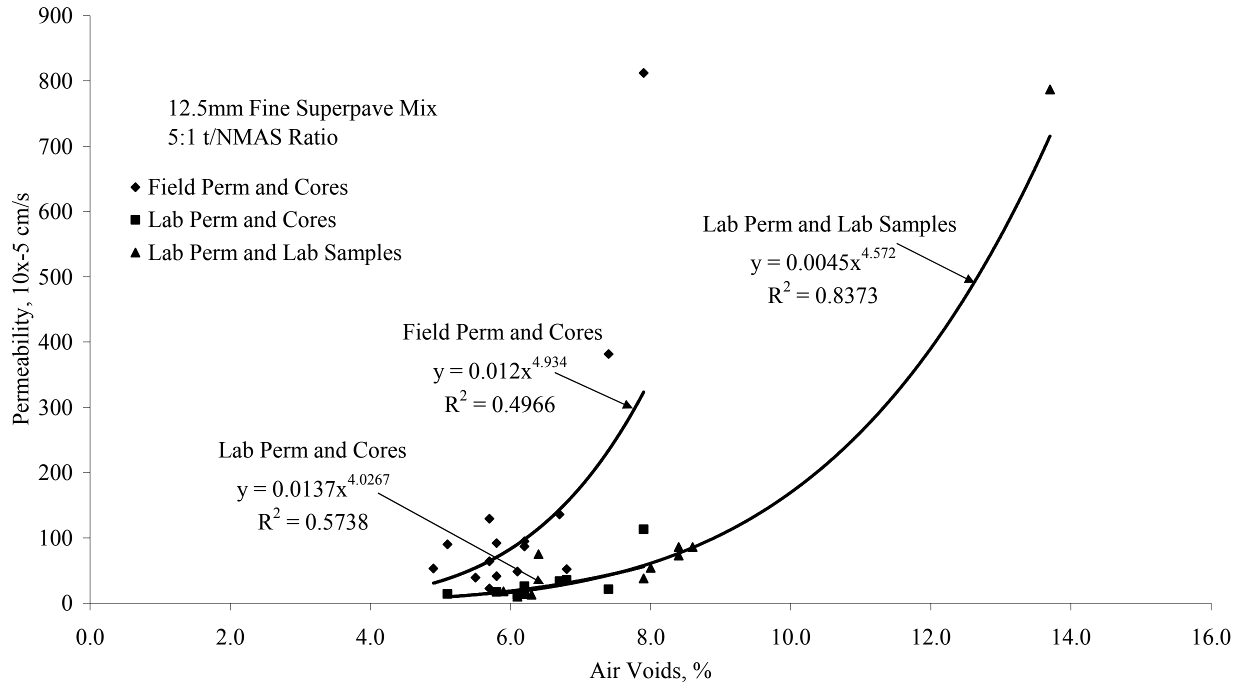

Figure 15: Relationship Between Permeability and In-place Air Voids, Project 4

Table 27: Lab Permeability Results for the Lab Compacted Samples, Project 4

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)	Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	3.9	0	17	3	4.8	0
2	1	4.6	0	18	3	5.1	0
3	1	4.0	0	19	3	5.1	0
4	1	4.0	0	20	3	4.9	0
5	1	5.9	18	21	3	6.3	13
6	1	5.4	0	22	3	6.4	75
7	1	8.0	54	23	3	8.4	73
8	1	7.9	38	24	3	13.7	787
9	2	4.2	0				
10	2	3.2	0				
11	2	4.2	0				
12	2	4.4	0				
13	2	6.4	0				
14	2	6.1	10				
15	2	8.4	86				
16	2	8.6	86				

5.5 Project 5:

Project 5 was an overlay of an existing HMA pavement on a two-lane state highway. The mix consisted of a 9.5 mm NMAS fine-graded blend designed at an N_{design} of 100 gyrations. The optimum binder content for this project was 7.0 percent. The asphalt binder used was a PG 70-22.

Average washed gradation and binder content (solvent extraction) test results for each sublot are presented in Table 28. The average measured binder content from the obtained samples for the overall project was 6.9 percent, 0.1 percent lower than the job mix formula. Sublot 1 was 0.2 percent lower than the JMF while sublots 2 and 3 were equal to the JMF. The average gradation for Project 5 was close to the job mix formula, with the largest difference coming on the 0.3 mm sieve (2.0 percent lower than the JMF).

Table 28: Average Gradations and Binder Contents per Sublot, Project 5

Gradation		Overall		Sublot 1		Sublot 2		Sublot 3	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
12.5	100.0	99.7	0.3	99.6	0.4	99.8	0.2	99.8	0.2
9.5	99.0	98.1	0.9	97.8	1.2	97.8	1.2	98.6	0.4
4.75	81.0	81.3	-0.3	80.9	0.1	81.1	-0.1	82.0	-1.0
2.36	60.0	60.6	-0.6	61.1	-1.1	60.3	-0.3	60.4	-0.4
1.18	44.0	45.5	-1.5	45.8	-1.8	45.3	-1.3	45.5	-1.5
0.6	30.0	31.5	-1.5	31.8	-1.8	31.2	-1.2	31.6	-1.6
0.3	19.0	17.0	2.0	17.5	1.5	16.6	2.4	17.0	2.0
0.15	9.0	7.5	1.5	7.9	1.1	7.3	1.7	7.5	1.5
0.075	4.5	3.9	0.6	4.1	0.4	3.7	0.8	3.8	0.7
Asphalt Content	7.00	6.9	0.1	6.8	0.2	7.0	0.0	7.0	0.0

Table 29 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and the water absorption values (from AASHTO T166) from each core taken from Project 5. Table 30 presents the average in-place air voids and the standard deviations for the combined data and for each sublot. Based on the average in-place air void contents shown in Table 30, the CoreReader indicated the lowest in-place air void contents, with AASHTO T166 next to lowest. Dimensional analysis produced the highest in-place air void contents, similar to the previous projects.

Table 29: Core Air Voids and Water Absorption, Project 5

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	8.2	8.5	5.3	10.3	0.7
2	1	7.9	8.3	5.2	9.7	0.7
3	1	7.5	7.9	5.1	10.0	0.7
4	1	9.1	9.6	6.6	9.9	1.0
5	1	9.1	9.9	6.7	10.3	1.0
6	2	11.7	12.4	9.9	13.6	2.2
7	2	10.4	11.1	10.5	10.6	2.4
8	2	12.0	12.4	9.9	14.8	3.4
9	2	8.9	9.3	6.1	10.7	1.1
10	2	9.4	9.8	7.2	11.6	2.4

Table 30: Average Core In-place Air Voids and Standard Deviations, Project 5

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	9.4	1.5	9.9	1.6	7.3	2.1	11.2	1.7
sublot 1	8.4	0.7	8.9	0.9	5.8	0.8	10.0	0.3
sublot 2	10.5	1.4	11.0	1.4	8.7	1.9	12.3	1.9

The in-place air voids for the project averaged 9.4 percent, ranging from a low of 7.5 percent to a high of 12.0 percent, based on AASHTO T166 bulk specific gravity measurements. The average in-place air voids for sublot 1 was 8.4 percent for sublot 2 the average in-place air voids was 10.5 percent.

Lift thickness, field, and lab permeability results are presented in Table 31. The design lift thickness for Project 5 was 31.8 mm. From the results in Table 31, the average lift thickness for this project was 41.0 mm, 9.2 mm higher than the design lift thickness. The lift thickness ranged from 34.1 mm to 49.8 mm, or from a t/NMAS ratio of 3.6:1 to 5.2:1. PQI density results are presented in Table 32.

The relationship between lift thickness and in-place air voids can be seen in Figure 16. There was a fair relationship between lift thickness and in-place air voids (R^2 = 0.47). An ANOVA conducted on the regression indicated that the relationship between lift thickness and in-place air voids was significant (p-value = 0.00). From observation of Figure 16, in-place air voids decreased as lift thickness increased.

Table 31: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 5

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	49.8	41	23
2	1	45.7	25	21
3	1	44.1	28	28
4	1	42.6	49	63
5	1	42.0	63	78
6	2	37.8	160	339
7	2	38.4	148	182
8	2	35.4	158	261
9	2	34.1	58	66
10	2	40.2	36	120

Table 32: Pavement Quality Indicator In-place Density Results, Project 5

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	129.2	129.1	128.8	129.1
2	1	128.0	128.0	128.4	127.9
3	1	127.9	127.8	128.4	127.8
4	1	127.0	126.4	126.2	126.2
5	1	126.1	125.9	126.1	126.1
6	2	124.4	123.9	124.7	123.7
7	2	124.5	124.4	124.6	124.3
8	2	123.4	123.3	125.0	123.8
9	2	125.1	125.3	125.5	125.9

10	2	126.1	125.8	125.8	125.7

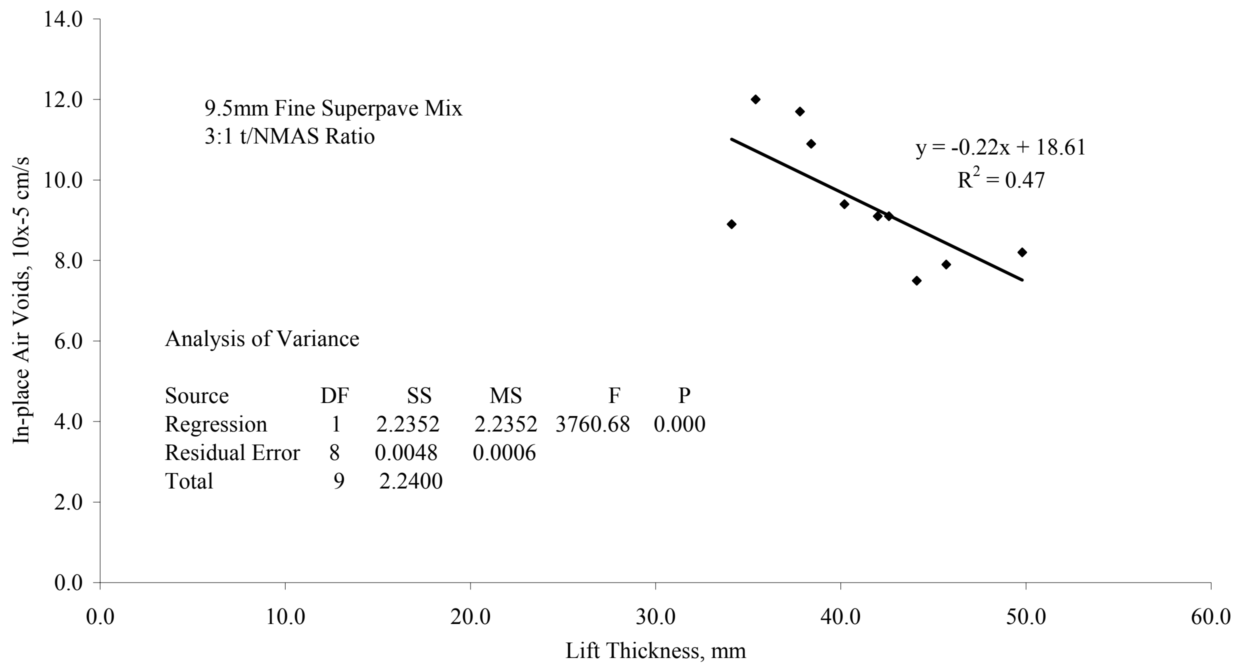

Figure 16: Relationship Between Lift Thickness and In-place Air Voids, Project 5

Figure 17 shows the relationship between in-place air voids and permeability. Figure 17 contains three relationships. These relationships include field permeability and lab permeability results versus in-place air voids and lab permeability results for the lab compacted samples that were produced in NCAT's mobile lab. Lab permeability results for the lab compacted samples are presented in Table 33. The air void contents for the lab compacted samples were higher than expected, due to the reasons discussed earlier.

From the R^2 values from all three plots, there was a very strong relationship between permeability and in-place air voids (R^2 values of 0.89, 0.92. 0.90, for field permeability and cores, lab permeability and cores, and lab permeability and lab samples, respectively). Based on the regression line equations from Figure 17 and a permeability value of 125x10^{-5} cm/s, the mix became permeable at an in-place air void content between 10 and 11percent.

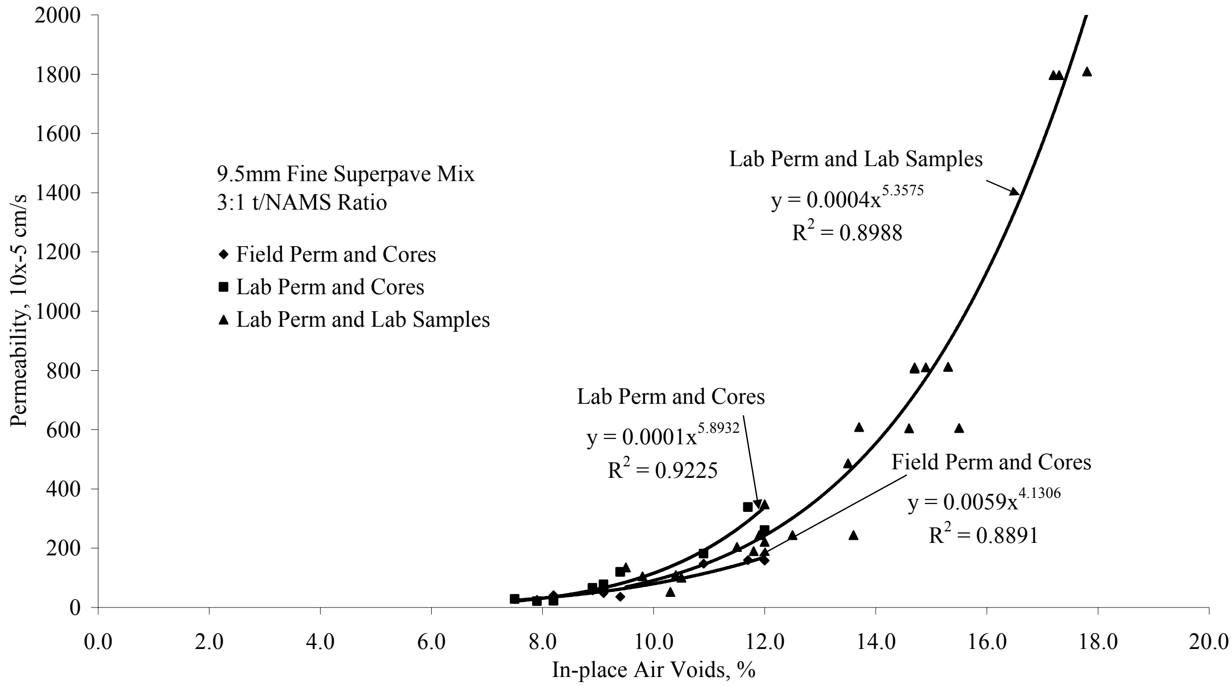

Figure 17: Relationship Between Permeability and In-place Air Voids, Project 5

Table 33: Lab Permeability Results for the Lab Compacted Samples, Project 5

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)	Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	9.8	105	17	3	10.3	52
2	1	11.8	191	18	3	9.5	135
3	1	12.5	244	19	3	12.0	348
4	1	12.0	222	20	3	13.6	245
5	1	14.6	605	21	3	14.7	811
6	1	15.5	605	22	3	15.3	812
7	1	17.8	1809	23	3	16.3	2675
8	1	17.2	1797	24	3	17.3	1797
9	2	10.5	101				
10	2	10.4	109				
11	2	11.5	204				
12	2	11.9	245				
13	2	13.5	486				
14	2	13.7	609				
15	2	14.7	807				

16	2	14.9	810

5.6 Project 6:

Project 6 was the mill and fill placement of 57.2 mm of new HMA over an unbound base of an existing highway. The mix consisted of a 12.5 mm NMAS coarse-graded blend designed at an N_{design} of 75 gyrations, resulting in a design asphalt content of 6.0 percent. The asphalt binder used was an unmodified PG 58-28.

Average asphalt content (solvent extraction) and washed gradation results are presented in Table 34. Results are separated into individual sublots from Project 6. Based on the results in Table 34, the average binder content from the obtained samples for this project was 6.2 percent, 0.2 percent higher than the job mix formula. The average binder content for sublot 1 matched the design binder content, while for sublot 2 the average content was 6.3 percent, 0.3 percent higher than the JMF. From Table 29, the overall gradation was much finer than the job mix formula, with the largest difference coming on the 4.75 mm sieve (6.0 percent above than the JMF). The percent passing the 0.075 mm sieve was 1.5 percent higher than the job mix formula.

Table 34: Average Gradations and Binder Contents per Sublot, Project 6

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0	100.0	0.0
12.5	91.0	95.6	-4.6	96.0	-5.0	95.2	-4.2
9.5	77.0	82.5	-5.5	83.2	-6.2	81.8	-4.8
4.75	50.0	56.0	-6.0	56.7	-6.7	55.3	-5.3
2.36	34.0	39.0	-5.0	39.5	-5.5	38.5	-4.5
1.18	24.0	27.6	-3.6	28.1	-4.1	27.0	-3.0
0.6	18.0	20.7	-2.7	21.2	-3.2	20.1	-2.1

0.3	12.0	15.4	-3.4	15.9	-3.9	14.8	-2.8
0.15	--	11.3	NA	11.8	NA	10.7	NA
0.075	6.4	7.9	-1.5	8.4	-2.0	7.3	-0.9
Asphalt Content	5.95	6.2	-0.2	6.0	-0.1	6.3	-0.4

Table 35 contains in-place air voids (water displacement, CoreLok, and effective), and absorption values (from AASHTO T166) for each core from Project 6. Table 36 presents the average in-place air voids and standard deviations for the combined data and for each sublot. AASHTO T166 and CoreLok indicated the same average in-place air voids, based on Table 35. CoreReader produced the highest average in-place air void contents for Project 6.

The average construction in-place air voids for this project was 5.6 percent, ranging from a low of 4.4 percent to a high of 6.6 percent, based upon AASHTO T166 bulk specific gravity measurements. For sublot 1 the average in-place air void content was 5.3 percent, and for sublot 2 the average air void content was 5.8 percent.

Table 35: Core In-place Air Voids and Water Absorption, Project 6

Sample ID	Sublot	T166 VTM, %	Corelok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	5.7	5.3	7.1	7.1	0.6
2	1	5.6	5.3	9.2	7.6	0.6
3	1	4.9	5.1	7.5	7.6	0.4
4	1	5.6	5.9	9.4	10.6	0.4
5	1	4.9	4.9	7.9	7.6	0.4
6	2	5.8	5.8	8.1	8.4	1.1
7	2	6.4	6.1	8.9	8.0	1.7
8	2	4.4	4.2	5.4	6.1	0.4
9	2	5.8	5.2	10.4	9.6	0.8
10	2	6.6	7.8	9.4	8.8	1.0

Table 36: Average Core In-place Air Voids and Standard Deviations, Project 6

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev

all data	5.6	0.7	5.6	1.0	8.3	1.4	8.1	1.3
sublot 1	5.3	0.4	5.3	0.4	8.2	1.0	8.1	1.4
sublot 2	5.8	0.9	5.8	1.3	8.4	1.9	8.2	1.3

Lift thickness, field, and lab permeability results for Project 6 are presented in Table 37. As mentioned before, the design lift thickness for this project was 57.2 mm. From the results in Table 32, the average lift thickness was 50.3 mm, 6.9 mm below the target value. The lift thickness ranged from 47.0 to 54.5 mm, or from a t/NMAS ratio of 3.8:1 to 4.4:1. PQI density results are presented in Table 38.

The relationship between lift thickness and in-place air voids can be seen in Figure 18. From the graph, there is no correlation between the two properties ($R^2 = 0.06$). An ANOVA conducted on the regression confirmed that the relationship between lift thickness and in-place density was not significant (p-value = 0.499). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 37: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 6

Sample ID	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	54.5	114	21
2	47.3	155	26
3	53.3	40	10
4	47.6	30	9
5	54.1	114	15
6	49.0	206	64
7	47.0	427	161
8	48.0	23	7
9	52.8	63	28
10	49.8	290	83

Table 38: Pavement Quality Indicator In-place Density Results, Project 6

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	133.5	131.1	130.1	131.6
2	1	136.8	133.2	126.9	132.3
3	1	135.1	136.2	136.0	135.8
4	1	132.5	133.6	134.1	133.4
5	1	135.0	132.7	134.3	134.0
6	2	134.0	133.5	133.1	133.5
7	2	128.4	134.2	133.3	132.0
8	2	134.2	134.7	134.3	134.4
9	2	134.3	134.6	135.3	134.7
10	2	131.4	127.2	132.3	130.3

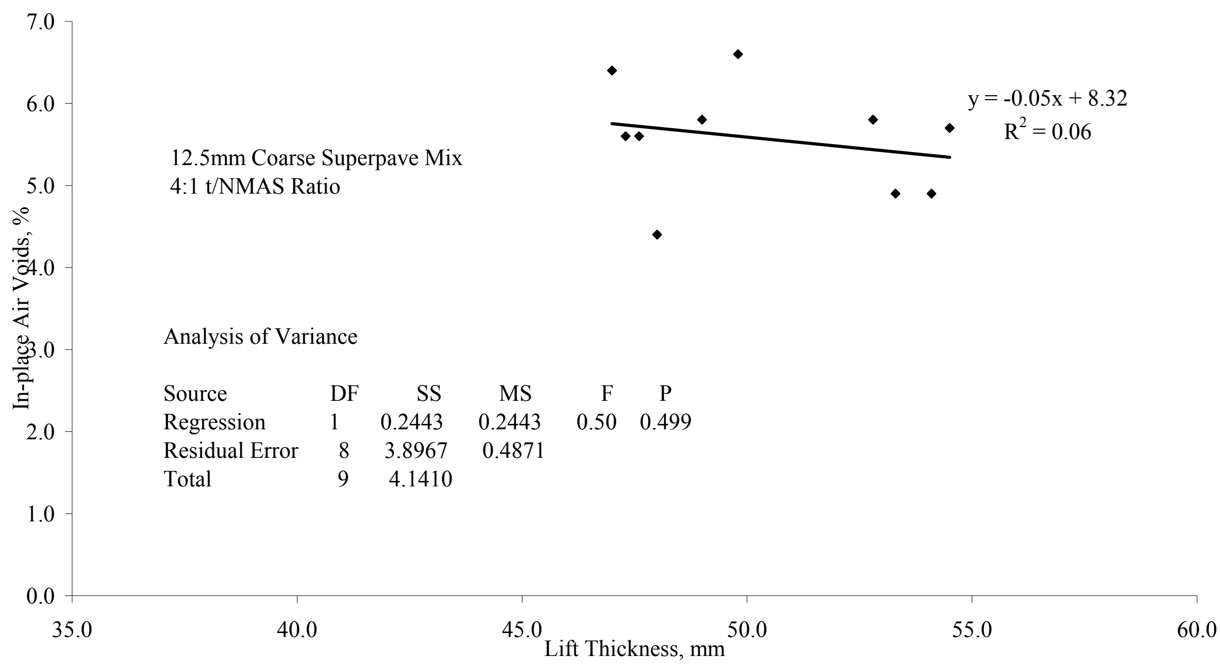

Figure 18: Relationship Between Lift Thickness and In-place Air Voids, Project 6

The relationship between permeability and in-place air voids for Project 6 are shown in Figure 19. In Figure 19, three relationships were produced. They include field permeability and lab permeability results versus in-place air voids and lab permeability results for the lab compacted samples. The lab permeability results for the lab samples are presented in Table 39. Based on Figure 19, the R^2 value for the field permeability results versus in-place air voids was 0.58, which is a fair relationship. There is a stronger relationship between lab permeability and in-place air voids for both cores and the lab compacted samples (R^2 values of 0.71 and 0.97, respectively). From the regression line equations and a permeability value of 125x10^{-5} cm/s, the field permeability results suggest that the mix became permeable at an in-place air void content between 5.5 and 6 percent. The lab permeability test results suggest an in-place air void content between 6.5 and 8.0 percent.

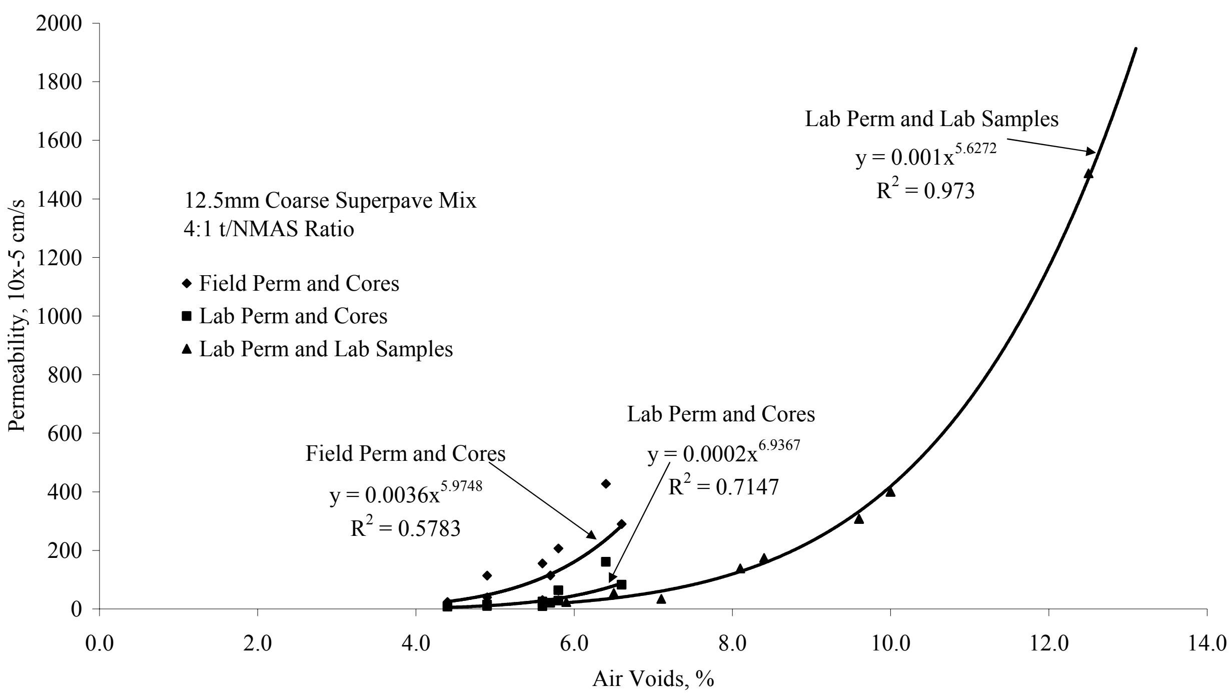

Figure 19: Relationship Between In-place Air Voids and Permeability, Project 6

Table 39: Lab Permeability Results for Lab Compacted Samples, Project 6

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	2.4	0
2	1	2.1	0
3	1	6.5	55
4	1	5.9	24
5	1	8.4	174
6	1	8.1	138
7	1	10	400
8	1	9.6	307
9	2	7.1	34
10	2	6.5	0
11	2	10	400
12	2	9.6	308
13	2	11.4	NA
14	2	12.5	1487
15	2	13.1	223
16	2	13.3	NA

NA = No Data Available

5.7 Project 7:

Project 7 was the placement of new HMA on an existing highway. The mix consisted of a 12.5 mm NMAS fine-graded blend designed at an N_{design} of 75 gyrations. Optimum binder content for this project was 5.7 percent. The asphalt binder used was a PG 64-28.

Average measured binder content and washed gradation test results are shown in Table 40. Results are separated into the two sublots tested. The average binder content from the obtained samples for Project 7 was 5.6 percent, 0.1 percent lower than the target value. For sublot 1, the average binder content matched the target binder content, and sublot 2 was 0.2 percent low.

No comparison for gradation could be made because the job mix formula was not obtained for this project. But from the average of the two sublots, the gradation remained consistent throughout the day.

Table 40: Average Gradation and Binder Content per Sublot, Project 7

Gradation				
Sieve Size (mm)	JMF	Avg	Sublot 1	Sublot 2
37.50	NA	100.0	100.0	100.0
25.0	NA	100.0	100.0	100.0
19	NA	100.0	100.0	100.0
12.5	NA	99.4	98.9	99.8
9.5	NA	91.0	89.7	92.3
4.75	NA	66.7	67.1	66.2
2.36	NA	52.4	53.5	51.3
1.18	NA	40.6	41.6	39.6
0.6	NA	30.4	31.2	29.6
0.3	NA	20.9	21.3	20.4
0.15	NA	12.1	12.2	11.9
0.075	NA	6.4	6.4	6.5
Asphalt Content	5.7	5.6	5.7	5.5

In-place air voids for cores taken from Project 7 are shown in Table 41. The average in-place air voids and standard deviations for cores are presented in Table 42. Average in-place air voids were 5.6 percent, ranging from 3.1 to 8.5 percent, based on AASHTO T166. From Table 41, sublot 1 averaged 4.9 percent and sublot 2 averaged 6.3 percent. From observation of Table 41, AASHTO T166 and the CoreLok device produced very similar in-place air void values, with the CoreLok device values slightly higher.

Table 41: Core In-place Air Voids and Water Absorption, Project 7

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	4.4	4.1	6.6	7.2	0.3
2	1	3.7	3.5	5.8	6.1	0.2
3	1	3.1	2.9	4.3	5.0	1.1
4	1	4.6	4.2	6.3	6.1	1.4
5	1	8.5	8.8	7.7	10.9	1.0
6	2	7.8	8.5	8.1	10.5	0.4
7	2	6.8	8.3	9.0	10.0	0.8
8	2	5.5	6.4	7.8	8.1	0.4
9	2	5.4	6.0	7.5	9.6	0.5
10	2	6.0	6.2	8.4	9.3	0.4

Table 42: Average In-place Air Voids and Standard Deviations, Project 7

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	5.6	1.7	5.9	2.2	7.2	1.4	8.3	2.1
sublot 1	4.9	2.1	4.7	2.4	6.1	1.2	7.1	2.3
sublot 2	6.3	1.0	7.1	1.2	8.2	0.6	9.5	0.9

Lift thickness, field, and lab permeability results for Project 7 are presented in Table 43. A design lift thickness of 50.8mm was used for Project 7. The average lift thickness was 40.6 mm, 10.2 mm lower than the target value. Lift thickness ranged from about 25.5 to 51.5 mm, or from a t/NMAS ratio of 2.7:1 to 5.4:1. PQI density results for Project 7 are presented in Table 44.

The relationship between lift thickness and in-place air voids is shown in Figure 20, and produced an R^2 value of 0.29. An ANOVA conducted on the regression showed that the relationship between lift thickness and in-place air voids was not significant (p-value = 0.133). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 43: Average Lift Thickness, Field, and Lab Permeability for Cores, Project 7

Sample ID	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	38.7	0	0
2	41.9	1	0
3	36.1	12	0
4	50.5	1	0
5	25.5	40	28
6	34.6	24	12
7	46.7	12	15
8	37.0	0	0
9	43.7	3	0
10	51.5	10	11

Table 44: Pavement Quality Indicator In-place Density Results, Project 7

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	126.8	127.3	126.7	126.7
2	1	125.1	125.3	126.2	125.6
3	1	126.3	126.9	126.9	126.9
4	1	126.5	125.8	126.4	126.4
5	1	123.9	124.1	124.4	123.9
6	2	124.4	124.3	123.8	124.2
7	2	124.7	124.4	124.8	124.8
8	2	122.8	120.0	123.2	122.8
9	2	124.3	124.6	124.6	123.8
10	2	123.6	124.2	120.4	123.5

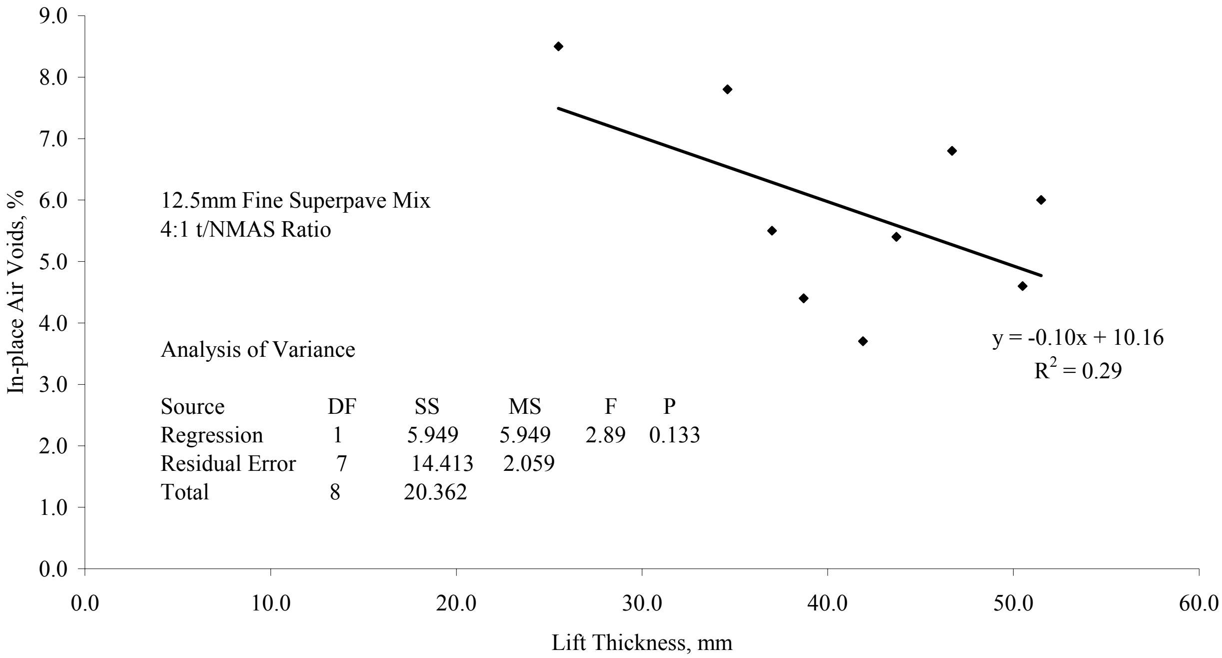

Figure 20: Relationship Between Lift Thickness and In-place Air Voids, Project 7

Figure 21 shows the relationship between permeability and in-place air voids. For Figure 21, the three relationships produced were field permeability and lab permeability results versus in-place air voids and lab permeability results for the lab compacted samples from the mobile lab. The results from lab permeability testing on the lab compacted samples are presented in Table 45. Based on the R^2 values from Figure 21, the field permeability results produced a strong relationship with in-place air voids (R^2 = 0.97). The lab permeability results produced a fair correlation (0.54 for cores) and a strong correlation (0.93 for lab samples). Based on the regression equations and a permeability value of $125x10^{-5}$ cm/s, the relationships suggest that the mix became permeable at an in-place air void content between 10 and 12 percent. The permeability values from the lab permeability data for the cores were close to zero and was not included in estimating the air void level at which the mix became permeable.

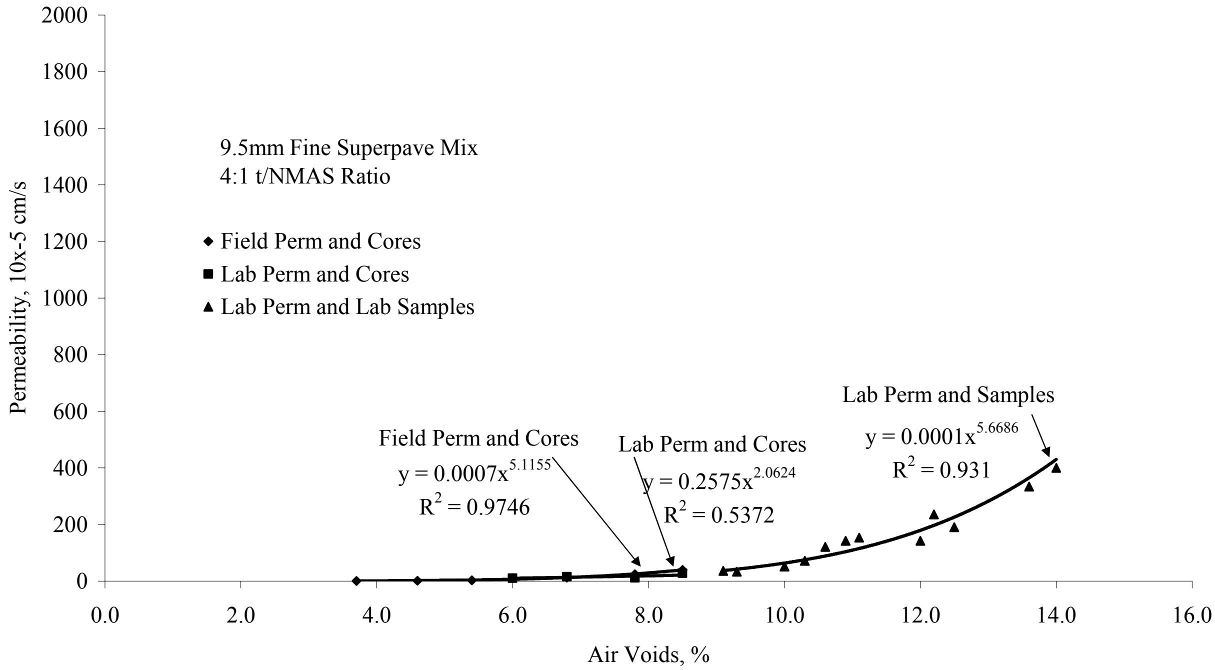

Figure 21: Relationship Between Permeability and In-place Air Voids, Project 7

Table 45: Lab Permeability Results for Lab Compacted Samples, Project 7

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	2.6	0
2	1	3.8	0
3	1	9.3	34
4	1	9.1	36
5	1	10.3	72
6	1	10.0	52
7	1	11.1	154
8	1	12.0	143
9	2	5.6	0
10	2	5.2	0
11	2	10.9	143
12	2	10.6	121
13	2	12.5	191
14	2	12.2	236
15	2	13.6	334
16	2	14.0	400

5.8 *Project 8:*

Project 8 was the placement of new HMA over a milled Portland Cement Concrete (PCC) pavement. The mix consisted of a 19.0 mm NMAS coarse-graded blend designed at an N_{design} of 100 gyrations. Optimum binder content for the project was 5.3 percent. The asphalt binder was a PG 64-22.

Average binder content (solvent extraction) and washed gradation test results are presented in Table 46. The average measured binder content from the obtained samples was 4.2 percent; over 1.0 percent lower than the job mix formula. Both sublots averaged 4.2 percent. For gradation, the average for the project was coarser than the JMF, with the two largest differences coming on the 9.5 and 4.75 mm sieves (10.4 and 11.5 lower than the target values, respectively).

Table 46: Average Gradations and Binder Contents per Sublot, Project 8

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	95.0	93.0	2.0	92.4	2.6	93.6	1.4
12.5	79.8	72.8	7.0	71.9	7.9	73.7	6.1
9.5	72.4	62.0	10.4	61.0	11.4	63.1	9.3
4.75	48.4	36.9	11.5	36.6	11.8	37.2	11.2
2.36	29.9	22.1	7.8	22.0	7.9	22.2	7.7
1.18	17.7	14.8	2.9	14.7	3.0	15.0	2.7
0.6	10.6	10.2	0.4	10.1	0.5	10.4	0.2
0.3	6.2	7.2	-1.0	7.0	-0.8	7.3	-1.1
0.15	4.6	5.2	-0.6	5.1	-0.5	5.2	-0.6
0.075	3.0	3.7	-0.7	3.7	-0.7	3.8	-0.8
Asphalt Content	5.3	4.2	1.1	4.2	1.1	4.2	1.1

Table 47 contains in-place air voids and water absorption values (from AASHTO T166) for each core from Project 8. Table 48 presents average in-place air voids and standard deviations for cores from Project 8. On average, AASHTO T166 produced the lowest values, and the CoreReader produced the highest in-place air voids.

Table 47: Core In-place Air Voids and Water Absorption, Project 8

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	10.8	11.4	14.4	13.7	2.1
2	1	10.0	11.0	12.8	12.4	1.0
3	1	8.7	9.2	9.6	9.8	0.4
4	1	8.2	9.1	10.6	10.8	0.9
5	1	9.3	9.3	10.3	8.9	0.8
6	2	9.7	10.2	12.1	11.0	0.7
7	2	10.9	12.3	13.6	13.1	2.0
8	2	10.5	11.2	11.8	11.1	0.9
9	2	9.3	10.3	13.7	15.0	1.1
10	2	7.3	7.9	8.9	9.2	0.5

Table 48: Average Core In-place Air Voids and Standard Deviations, Project 8

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	9.5	1.2	10.2	1.3	11.8	1.9	11.5	2.0
sublot 1	9.4	1.0	10.0	1.1	11.5	2.0	11.1	1.9
sublot 2	9.5	1.4	10.4	1.6	12.0	1.9	11.9	2.2

For Project 8, the average construction in-place air void content was 9.5 percent, ranging from 7.3 to 10.9 percent, based on AASHTO T166 bulk specific gravity measurements. The average air void content for sublot 1 was 9.4 percent, and for sublot 2 the average air void content was 9.5 percent.

Lift thickness, field, and lab permeability results for Project 8 are presented in Table 49. As previously stated, the design thickness was 50.8 mm. From Table 49, the average thickness was 58.9 mm, 8.1 mm above the target value. Thickness ranged from 45.4 to 74.0 mm, or from a t/NMAS ratio of 2.4:1 to 3.9:1. PQI density results are presented in Table 50.

The relationship between lift thickness and in-place air voids can be seen in Figure 22, which produced an R^2 value of 0.21. An ANOVA conducted on the regression showed that the relationship between lift thickness and in-place air voids was not significant (p-value = 0.185). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 49: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 8

Sample ID	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	61.6	457	341
2	74.0	415	221
3	68.0	41	0
4	55.2	127	31
5	56.8	206	51
6	58.1	129	53
7	60.1	921	233
8	61.9	207	35
9	45.4	183	91
10	47.8	24	17

Table 50: Pavement Quality Indicator In-place Density Results, Project 8

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	127.7	126.0	128.1	127.2
2	1	121.0	126.0	127.3	126.4
3	1	128.0	126.0	126.2	128.2
4	1	126.8	127.8	130.7	129.8
5	1	127.7	127.5	127.9	127.8
6	2	125.4	125.4	125.7	126.9
7	2	126.4	126.2	126.5	126.6
8	2	126.3	127.6	127.2	127.1
9	2	127.3	128.0	130.1	129.0
10	2	130.1	131.1	128.7	130.2

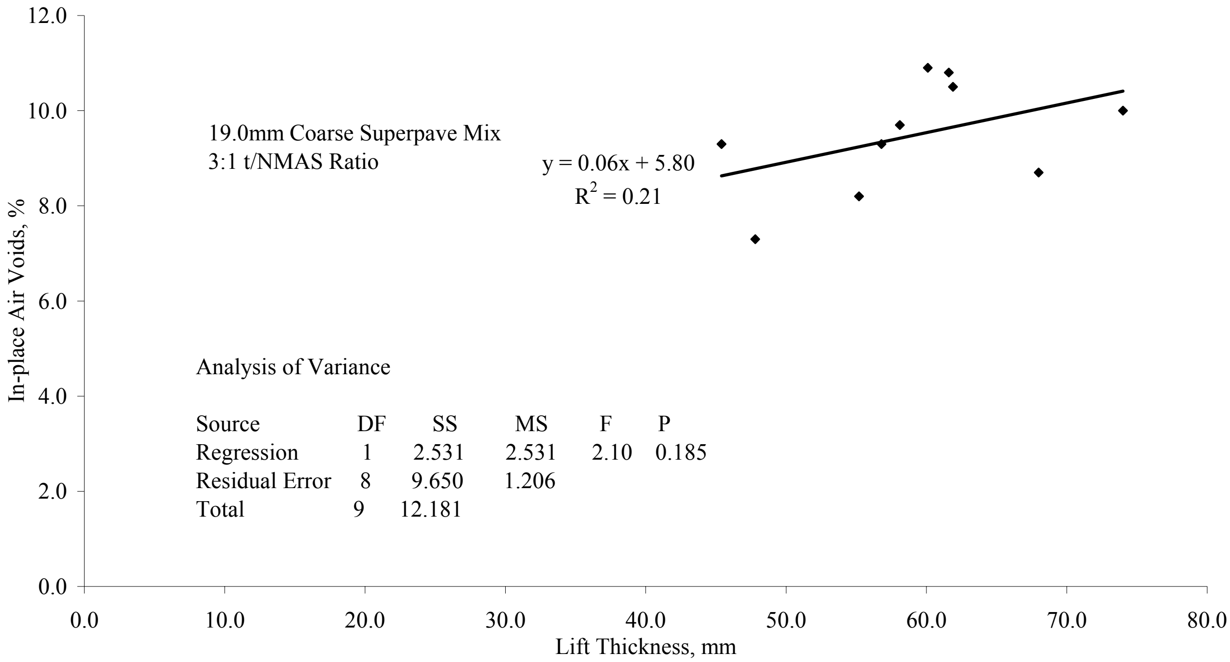

Figure 22: Relationship Between Lift Thickness and In-place Air Voids, Project 8

The relationship between permeability and in-place air voids is shown in Figure 23. In Figure 23, three relationships are shown. They include field permeability and lab permeability results versus in-place air voids and lab permeability results for the lab compacted samples produced in the mobile lab. Lab permeability results for the lab compacted samples are presented in Table 51. Based on Figure 23, there were strong correlations for both the field permeability results and the lab permeability results for the lab compacted samples (R^2 of 0.77 and 0.91, respectively). The R^2 value for the lab permeability results for cores was smaller than anticipated (0.59). Based on the regression line equations from Figure 23 and a permeability value of $125x10^{-5}$ cm/s, the field permeability results suggest the mix became permeable at 9.0 percent in-place air voids. The lab permeability results suggest the mix became permeable between 7 and 11 percent in-place air voids.

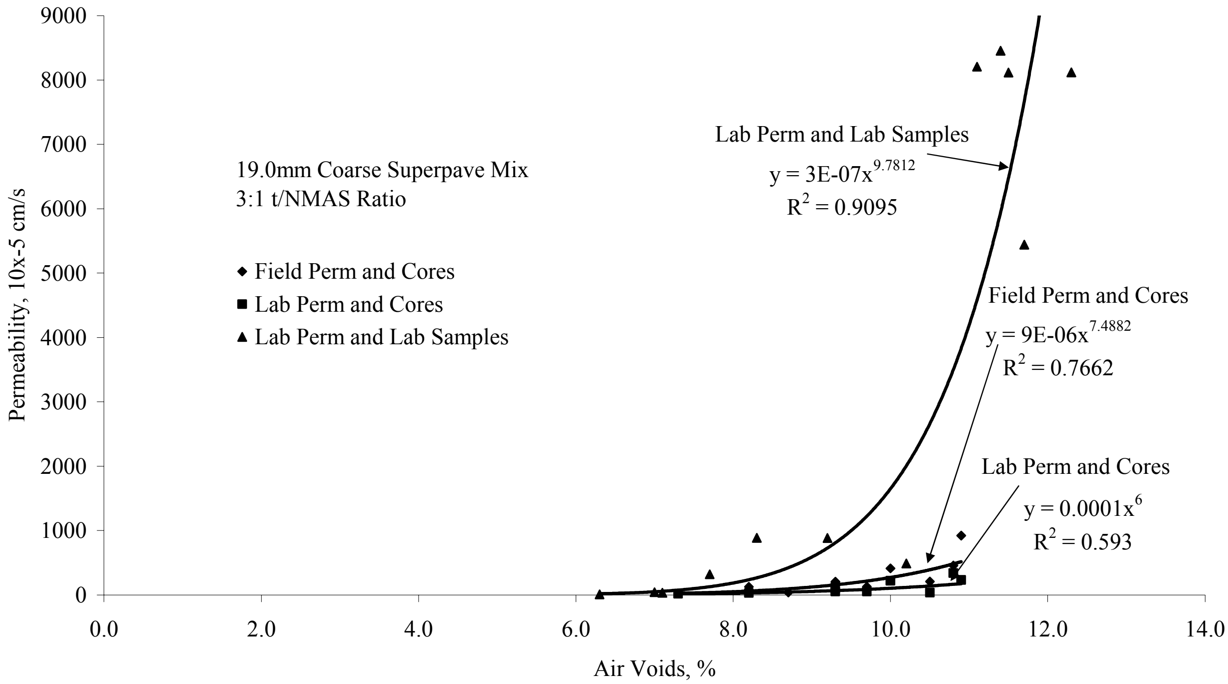

Figure 23: Relationship Between Permeability and In-place Air Voids, Project 8

Table 51: Lab Permeability Results for Lab Compacted Samples, Project 8

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	4.8	0
2	1	5.4	0
3	1	6.3	10
4	1	6	0
5	1	7	43
6	1	7.1	33
7	1	7.7	322
8	1	8.3	889
9	2	10.2	490
10	2	9.2	884
11	2	11.1	8207
12	2	11.7	5441
13	2	11.5	8116
14	2	12.3	8118
15	2	11.4	16931
16	2	11.4	8454

5.9 Project 9:

Project 9 was the placement of new HMA in the construction of a new state highway. The mix consisted of a 19.0 mm NMAS coarse-graded blend designed at an N_{design} of 100 gyrations, resulting in a design binder content of 4.5 percent. The asphalt binder used was an unmodified PG 64-22.

Average binder content (solvent extraction) and washed gradation test results are presented in Table 52. Results are separated into individual sublots for Project 9. The overall binder content from the obtained samples was 4.5 percent, which matched the design binder content. The binder content for sublot 1 was 4.4 percent, just 0.1 percent lower than the JMF, while sublot 2 also matched the job mix formula. From Table 44, the overall gradation was close to the job mix formula, with the largest difference coming on the larger sieve sizes (12.5, 9.5, and 4.75mm: 6.9, 6.5, and 5.0 percent above than the job mix formula, respectively).

Table 52: Average Gradation and Binder Content per Sublot, Project 9

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	89.5	91.7	-2.2	92.4	-2.9	91.1	-1.6
12.5	74.2	81.1	-6.9	80.6	-6.4	81.7	-7.5
9.5	63.5	70.0	-6.5	68.3	-4.8	71.7	-8.2
4.75	39.0	44.0	-5.0	42.4	-3.4	45.6	-6.6
2.36	21.8	22.9	-1.1	21.4	0.4	24.3	-2.5
1.18	12.9	14.1	-1.2	13.0	-0.1	15.2	-2.3
0.6	8.8	9.9	-1.1	9.0	-0.2	10.8	-2.0
0.3	6.2	7.5	-1.3	6.7	-0.5	8.3	-2.1
0.15	4.4	5.9	-1.5	5.3	-0.9	6.5	-2.1
0.075	3.8	4.5	-0.7	4.1	-0.3	4.9	-1.1
Asphalt Content	4.5	4.5	0.0	4.4	0.1	4.5	0.0

Table 53 contains construction in-place air voids and water absorption values (AASHTO T166) for cores obtained from Project 9. Table 54 presents the average in-place air voids and standard deviation results for the combined data and for each sublot tested. On average, the water displacement method produced approximately 1.0 percent lower in-place air void contents than the CoreLok device.

Table 53: Core In-place Air Voids and Water Absorption, Project 9

Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	6.6	7.2	9.7	9.1	0.4
1	5.4	5.9	8.2	8.3	0.4
1	5.9	7.0	9.9	8.4	0.2
1	5.4	6.2	10.3	10.3	0.2
1	5.5	6.0	8.6	9.3	0.2
2	4.0	5.9	9.0	8.2	0.1
2	5.5	6.5	9.4	7.6	0.2
2	7.8	9.6	11.8	10.7	0.8
2	4.9	6.0	8.9	9.2	0.3
2	5.3	5.9	8.2	7.7	0.1

Table 54: Average Core In-place Air Voids and Standard Deviations, Project 9

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	5.6	1.0	6.6	1.1	9.4	1.1	8.9	1.0
sublot 1	5.8	0.5	6.5	0.6	9.3	0.9	9.1	0.8
sublot 2	5.5	1.4	6.8	1.6	9.5	1.4	8.7	1.3

The average in-place air void content was 5.6 percent, ranging from 4.0 to 7.8 percent (AASHTO T166). Sublot 1 had an average air void content of 5.8 percent, and sublot 2 had a content of 5.5 percent.

Lift thickness, field, and lab permeability results for Project 9 are presented in Table 55. Again, the target lift thickness for this project was 101.6 mm. The average lift thickness was 96.4 mm, 5.2 mm lower then the design thickness. The lift thickness ranged from a low of 89.5 mm to a high of 104.7 mm, or from a t/NMAS ratio of 4.7:1 to 5.5:1. PQI density results for Project 9 are presented in Table 56.

The relationship between lift thickness and in-place air voids can be seen in Figure 24, and produced an R^2 of 0.23. An ANOVA conducted on the regression confirmed that the relationship between lift thickness and in-place air voids was not significant (p-value = 0.163). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 55: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 9

Sample ID	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	92.8	1620	88
2	97.1	953	0
3	94.3	600	0
4	102.6	404	0
5	94.5	607	24
6	104.1	289	8
7	89.5	267	17
8	95.8	1924	510
9	100.7	406	0
10	92.9	135	0

Table 56: Pavement Quality Indicator In-place Density Results, Project 9

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	128.7	130.2	128.4	130.4
2	1	129.7	131.7	134.2	131.6
3	1	132.2	131.4	131.4	131.2
4	1	131.0	127.9	130.5	129.9
5	1	130.0	128.9	130.6	130.2
6	2	132.3	129.8	133.2	132.9
7	2	131.7	132.2	132.9	131.8
8	2	129.4	129.7	130.3	129.6
9	2	131.9	134.0	130.1	132.1
10	2	133.1	131.9	132.5	132.9

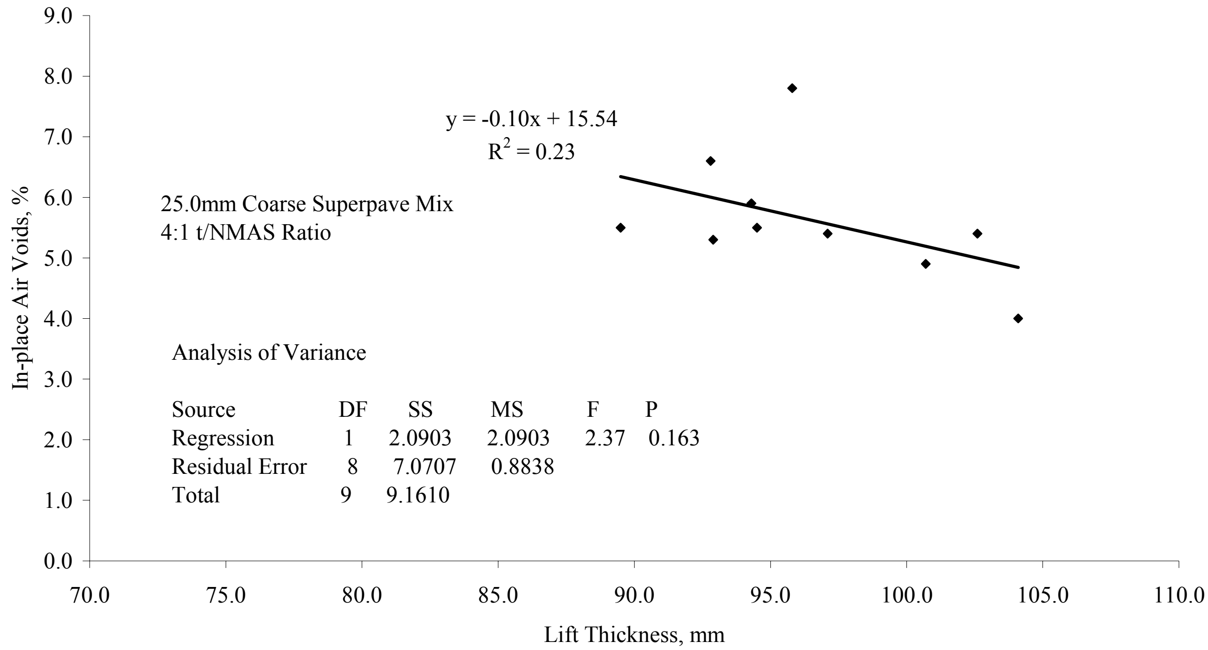

Figure 24: Relationship Between Lift Thickness and In-place Air Voids, Project 9

The relationship between permeability and in-place air voids is shown in Figure 25. Field permeability and lab permeability results versus in-place air voids and the lab permeability results for the lab compacted samples are presented in Figure 25. The lab permeability results for the lab compacted samples are presented in Table 59. From Figure 25, there is a fair correlation between field permeability and in-place air voids (R^2 = 0.51). Another fair correlation exists between lab permeability and in-place air voids for the lab compacted samples (0.42). The R^2 value for the lab permeability values on the cores was higher than the other two R^2 values (0.89). Based on the regression equations from Figure 32 and a permeability value of 125×10^{-5} cm/s, the field permeability results indicated the mix became permeable at an in-place air void content between 3 and 4 percent. The lab permeability test results suggest the mix became permeable between 6.5 and 7 percent air voids.

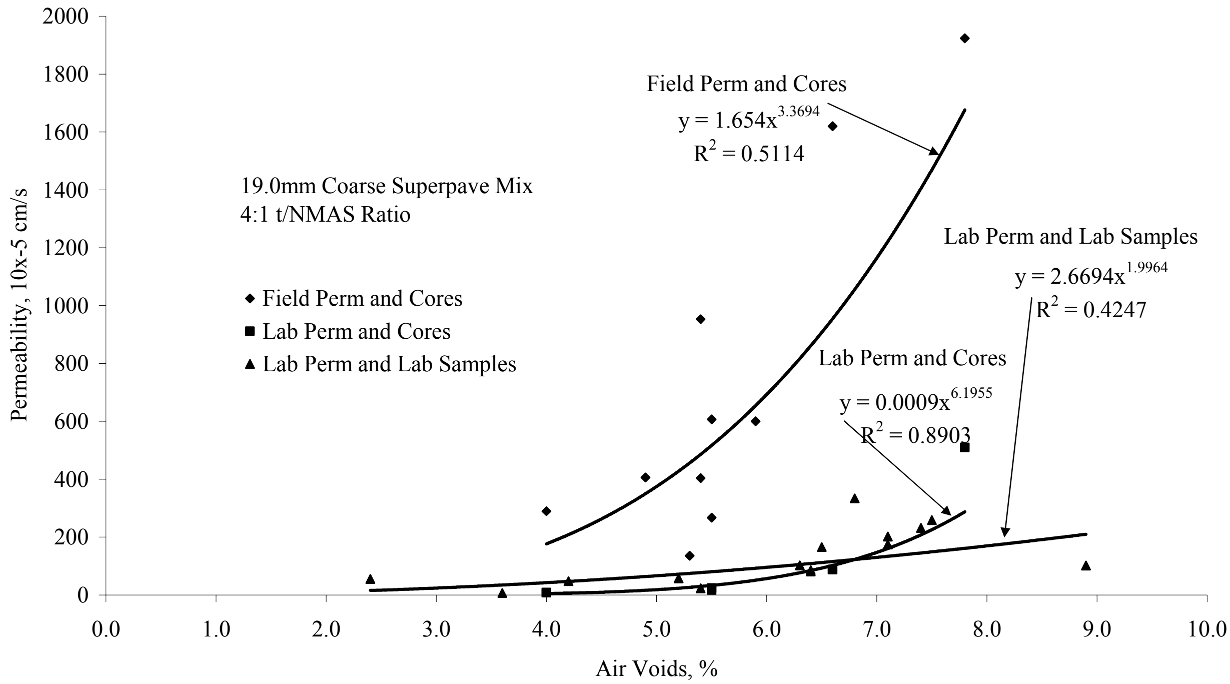

Figure 25: Relationship Between Permeability and In-place Air Voids, Project 9

Table 57: Lab Permeability Results for the Lab Compacted Samples, Project 9

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	2.4	55
2	1	3.6	6
3	1	5.4	23
4	1	5.2	57
5	1	6.3	102
6	1	7.1	202
7	1	6.8	334
8	1	6.5	166
9	2	4.4	0
10	2	4.2	47
11	2	6.4	86
12	2	6.4	81
13	2	7.4	231
14	2	7.1	174
15	2	7.5	259
16	2	8.9	101

5.10 Project 10:

Project 10 involved the placement of new HMA over a granular base in the construction of a new highway. The mix consisted of a 19.0 mm NMAS coarse-graded blend designed at an N_{design} of 100 gyrations, resulting in a design binder content of 5.6 percent.

The average test results from Project 10 are shown in Table 58. Results include asphalt contents (solvent extraction) and washed gradations of the extracted material. This project contained only one sublot obtained at the asphalt plant, so overall averages are also sublot 1 averages. Based on Table 58, the average measured binder content was 5.7 percent, 0.2 percent higher than the target value. The overall gradation was close to the job mix formula, with the largest difference coming on the 2.36mm sieve (3.1 percent below than the JMF).

Table 58: Average Gradation and Asphalt Content per Sublot, Project 10

Gradation		Overall		Sublot 1	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0
12.5	75.0	77.9	-2.9	77.9	-2.9
9.5		60.9		60.9	
4.75		44.8		44.8	
2.36	34.0	30.9	3.1	30.9	3.1
1.18		21.7		21.7	
0.6		16.2		16.2	
0.3	12.0	12.3	-0.3	12.3	-0.3
0.15		9.0		9.0	
0.075	6.9	5.6	1.3	5.6	1.3
Asphalt Content	5.7	5.5	0.2	5.5	0.2

Table 59 contains the in-place air voids and the water absorption values (from AASHTO T166) from the cores obtained. Table 59 also contains the average in-place air voids and standard deviations for this project. The construction in-place air voids for the project averaged 6.4 percent, ranging from 5.7 to 7.7 percent (AASHTO T166). From observation of Table 59, AASHTO T166 produced the lowest in-place air void contents. The CoreReader produced the highest values.

Table 59: Core In-place Air Voids and Percent Absorption, Project 10

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	5.7	6.7	10.1	9.6	1.1
2	1	5.7	6.5	9.2	7.8	0.9
3	1	6.1	8.8	10.9	11.1	1.4
4	1	6.5	7.7	9.8	10.0	1.2
5	1	6.0	9.2	11.9	11.2	1.7
6	2	6.3	7.3	12.3	11.1	0.9
7	2	7.7	9.3	12.8	10.8	1.5
8	2	6.4	7.9	10.4	9.1	1.3
9	2	7.4	8.6	11.3	11.0	1.4
10	2	5.9	7.2	11.8	10.7	1.2
Average		6.4	7.9	11.1	10.2	1.3
Std Dev.		0.7	1.0	1.2	1.1	0.3

Lift thickness, field, and lab permeability results are shown in Table 60. The first two field permeability locations could not be found (field permeability testing was performed after all paving was conducted for the day on hand) and were not tested. As previously stated, the design lift thickness for the project was 57.2 mm. Actual lift thickness averaged 70.9 mm, 13.7 mm higher than the target value. Lift thickness ranged from a low of 55.9 mm to a high of 78.5 mm, or a from a t/NMAS ratio of 2.9:1 to 4.1:1. PQI density results for Project 10 are presented in Table 61.

The relationship between lift thickness and in-place air voids is shown in Figure 26. With such a low R^2 value (0.06), there was no correlation between lift thickness and in-place air voids. An ANOVA conducted on the regression confirmed that there was no relationship between these two properties (p-value = 0.512). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 60: Average Lift Thickness, Field, and Lab Permeability for Cores, Project 10

Sample ID	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	78.5	NA	308
2	75.9	NA	41
3	61.8	440	601
4	75.7	241	354
5	61.9	354	274
6	75.5	498	72
7	78.5	393	508
8	55.9	580	1190
9	74.8	416	196
10	70.1	282	353

NA = No Data Available

Table 61: Pavement Quality Indicator In-place Density Results, Project 10

Test Number	Sublot	Run 1	Run 2	Run 3	Avg.
1	1				
2	1				
3	1	133.4	134.0	133.9	132.8
4	1	133.7	133.4	133.4	131.9
5	1	133.4	130.5	132.6	132.5
6	2	132.2	131.7	132.4	131.4
7	2	132.2	124.7	130.3	130.8
8	2	132.6	130.9	132.2	132.1
9	2	131.6	129.8	126.1	130.8
10	2	133.4	132.2	130.5	132.0

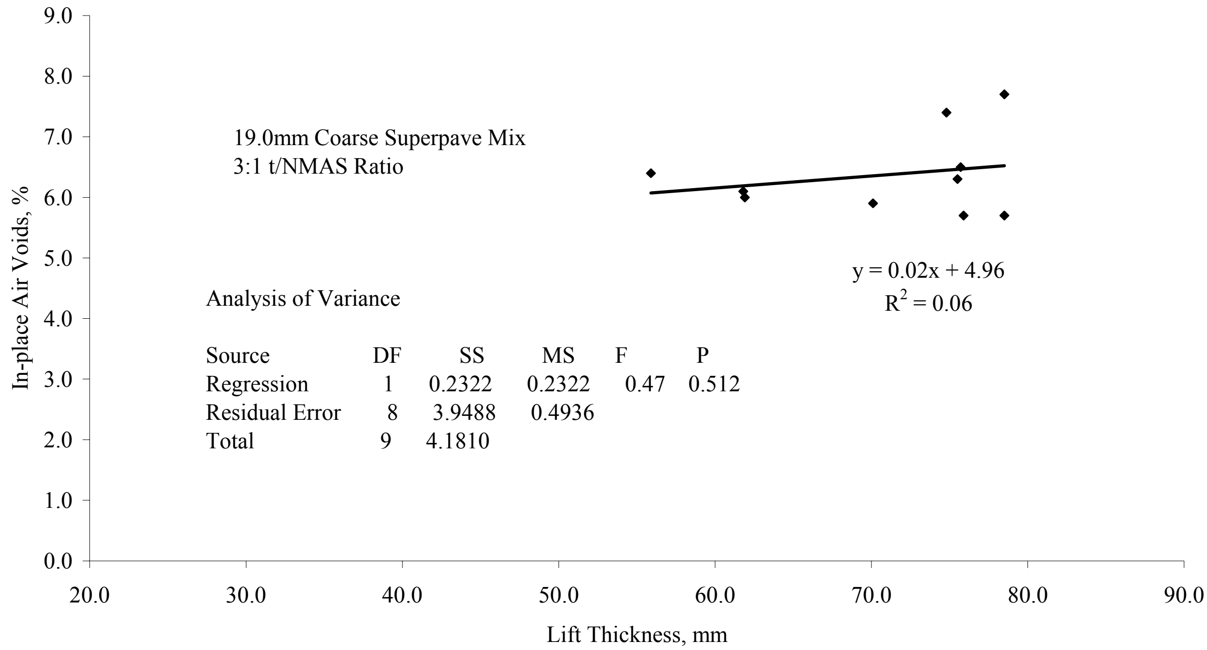

Figure 26: Relationship Between Lift Thickness and In-place Air Voids, Project 10

Figure 27 shows the relationship between permeability and in-place air voids. In Figure 27, there are three relationships: field permeability and lab permeability results versus in-place air voids and lab permeability results versus lab compacted sample air voids. Lab permeability results for the lab samples are found in Table 62. Based on Figure 27, there was no correlation between air voids and permeability for neither the field permeability data nor the lab permeability data for the core (R^2 values of 0.02 and 0.07, respectively). This may have been caused by a small range of data. For the lab permeability results for the cores, a fair correlation was found ($R^2 = 0.60$). From the regression equations from the lab permeability data for the cores and lab samples and a critical permeability value of 125×10^{-5} cm/s, the mix became permeable between 3 and 5 percent air voids. The regression equation for the field permeability was not used because it was basically a flat line.

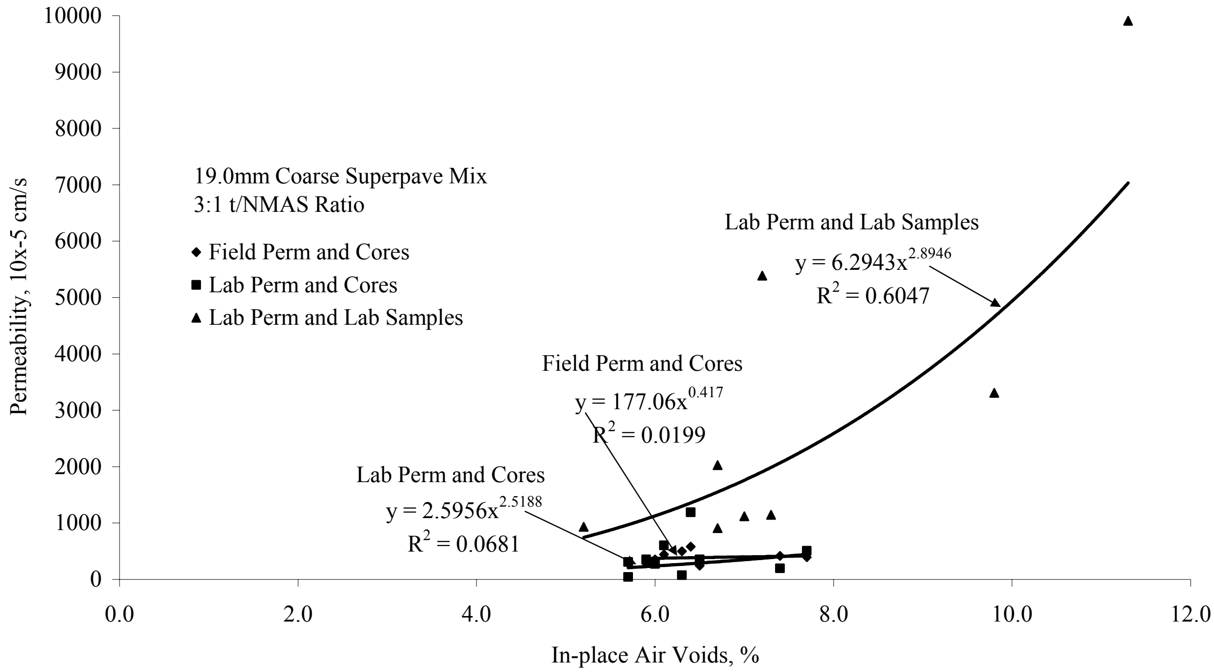

Figure 27: Relationship Between Permeability and In-place Air Voids, Project 10

Table 62: Lab Permeability Results for Lab Compacted Samples, Project 10

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	5.2	931
2	1	7.2	5389
3	1	7.3	1146
4	1	6.7	2029
5	1	7.0	1122
6	1	6.7	909
7	1	11.3	9908
8	1	9.8	3308

5.11 Project 11:

Project 11 was a mill and fill project on an interstate highway. The mix consisted of a 19.0 mm NMAS coarse-graded blend designed at an N_{design} of 125 gyrations. The optimum binder content for this project was 4.9 percent. The asphalt binder used was a PG 64-34.

Average asphalt content (solvent extraction) and washed gradation results are shown in Table 63. Three sublots were obtained at the plant, but due to traffic constraints, only two field sublots were obtained. The average measured binder content from the obtained samples for the project was 4.6 percent, 0.3 percent lower than the target value. For sublot 1, the average binder content was 0.4 percent low, while both sublots 2 and 3 were 0.2 percent lower than the job mix formula.

Table 63: Average Gradation and Asphalt Content per Sublot, Project 11

Gradation		Overall		Sublot 1		Sublot 2		Sublot 3	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
19	99.0	98.7	0.3	99.0	0.0	98.5	0.5	98.7	0.3
12.5	87.0	88.1	-1.1	86.8	0.2	88.1	-1.1	89.3	-2.3
9.5	76.0	75.9	0.1	71.6	4.4	77.7	-1.7	78.3	-2.3
4.75	40.0	40.8	-0.8	35.6	4.4	44.0	-4.0	42.7	-2.7
2.36	23.0	24.6	-1.6	21.4	1.6	26.1	-3.1	26.2	-3.2
1.18	18.0	18.9	-0.9	16.1	1.9	20.1	-2.1	20.3	-2.3
0.6	NA	15.3	NA	12.9	NA	16.4	NA	16.6	NA
0.3	10.0	11.3	-1.3	9.3	0.7	12.2	-2.2	12.5	-2.5
0.15	NA	7.2	NA	5.7	NA	7.8	NA	8.2	NA
0.075	4.9	4.5	0.4	3.4	1.5	4.8	0.1	5.3	-0.4
Asphalt Content	4.9	4.6	0.3	4.5	0.4	4.7	0.2	4.7	0.2

The overall gradation for Project 11 was close to the job mix formula. The amount passing the 0.075 mm sieve increased throughout the day's evaluation, from 1.5 percent below the JMF to 0.4 percent above the job mix formula.

Table 54 contains the in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for cores from Project 11. The average values for in-place air voids and standard deviations are shown in Table 55. The construction in-place air voids for the project averaged 7.2 percent. For Sublot 1, the average was 7.9 percent, and was 6.5 percent for sublot 2, based on the water displacement method.

Table 64: Core In-place Air Voids and Percent Absorption, Project 11

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	8.4	9.1	10.1	11.9	2.1
2	1	8.0	8.6	10.1	11.4	1.5
3	1	9.4	11.1	11.2	12.7	2.4
4	1	7.0	8.2	9.1	11.1	1.5
5	1	6.8	8.1	10.0	10.6	1.5
6	2	5.8	6.6	7.2	8.9	1.0
7	2	5.7	6.8	6.5	8.4	1.3
8	2	6.5	6.8	8.4	10.1	1.1
9	2	8.2	9.2	9.9	11.7	1.9
10	2	6.3	7.1	7.8	9.7	0.9

Table 65: Average Core In-place Air Voids and Standard Deviations, Project 11

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	7.2	1.2	8.2	1.4	9.0	1.5	10.7	1.4
sublot 1	7.9	1.1	9.0	1.2	10.1	0.7	11.5	0.8
sublot 2	6.5	1.0	7.3	1.1	8.0	1.3	9.8	1.3

Table 56 contains average lift thickness, field, and lab permeability results for the cores obtained. The design lift thickness for the project was 38.1 mm; the actual average lift thickness was 38.0 mm, very close the target value. The lift thickness ranged from 34.0 mm to 46.7 mm, or from a t/NMAS ratio of 1.8:1 to 2.5:1. PQI density results for Project 11 are presented in Table 57.

The relationship between lift thickness and in-place air voids can be seen in Figure 28. From the plot, there is no correlation between the two properties (R^2 = 0.08). An ANOVA conducted for the regression confirmed that the relationship was not significant (p-value = 0.423). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 66: Average Lift Thickness, Field, and Lab Permeability for Cores, Project 11

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	46.7	328	248
2	1	34.4	328	213
3	1	35.5	236	806
4	1	39.7	143	162
5	1	41.3	150	318
6	2	34.9	748	20
7	2	37.9	821	63
8	2	35.4	408	144
9	2	40.5	2467	359
10	2	34.0	2083	81

Table 67: Pavement Quality Indicator In-place Density Results, Project 11

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	117.8	117.1	118.7	117.7
2	1	118.3	120.7	120.4	120.2
3	1	119.2	120.1	119.6	119.1
4	1	120.3	120.5	120.2	120.7
5	1	121.6	122.1	122.6	121.8
6	2	120.2	119.4	120.5	120.3
7	2	120.6	119.4	120.3	119.7
8	2	122.9	122.5	121.8	122.5
9	2	119.6	118.7	119.3	117.9
10	2	118.7	120.1	118.3	118.7

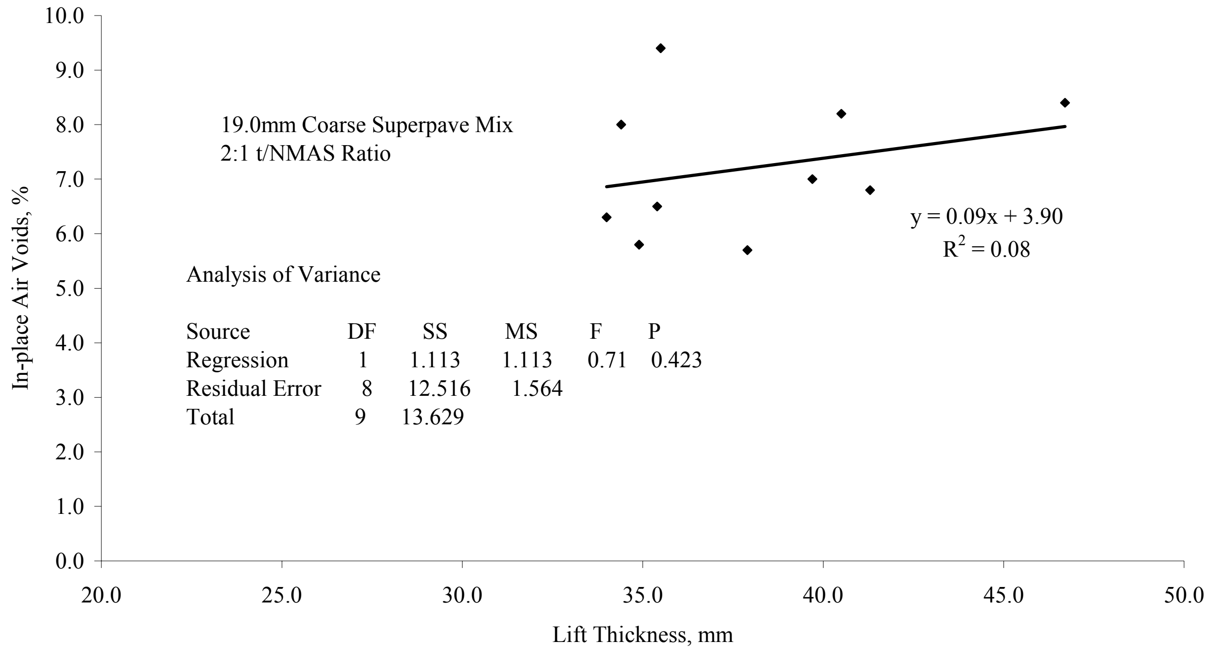

Figure 28: Relationship Between Lift Thickness and In-place Air Voids, Project 11

The relationship between permeability and in-place air voids is shown in Figure 29. For Figure 29, the data is broken down into three relationships: field permeability and lab permeability results versus in-place air voids and lab permeability results versus in-place air voids for the lab compacted samples. The lab permeability results for the lab compacted samples are shown in Table 68. Based on the R^2 value for the field data (0.06), no relationship seems to exist between field permeability and in-place air voids, but this may be due to a small range in in-place air voids. The relative thinness of the mat may have also contributed to the low R^2 value as well. A fairly strong R^2 value was found for both lab permeability on cores (0.75) and for lab permeability for the lab compacted samples (0.65). Based on the regression equations from Figure 29, the lab permeability test results suggest that the mix became permeable at air void contents between 4.5 and 7 percent.

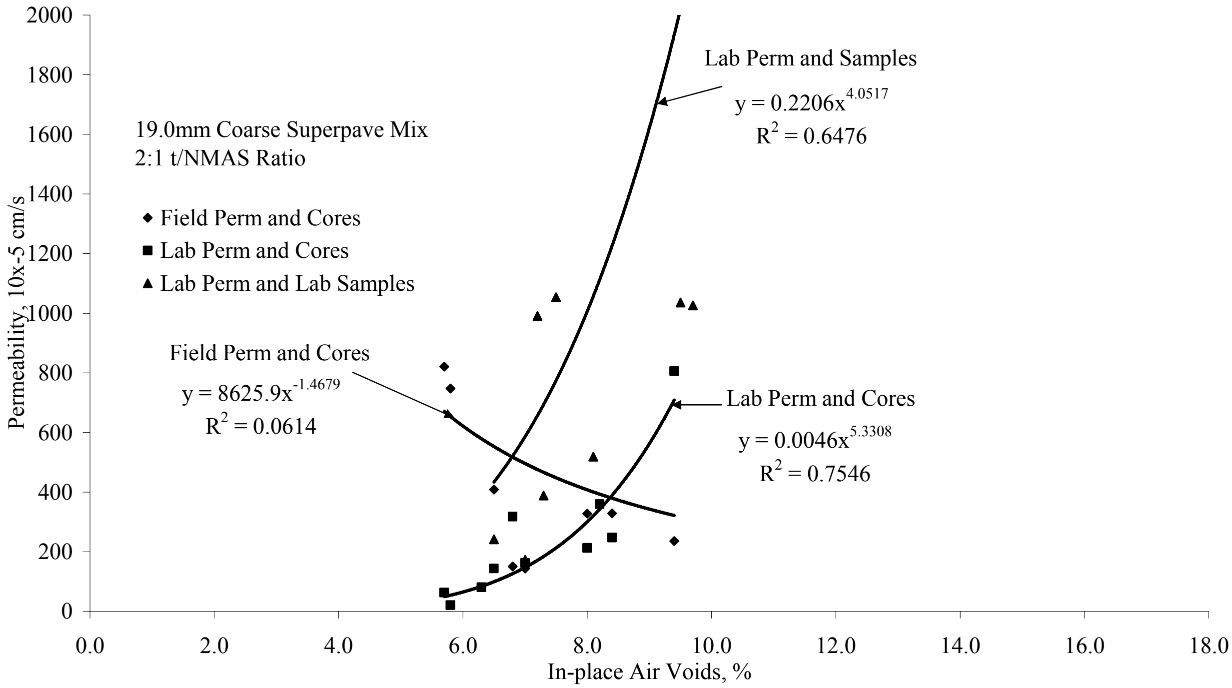

Figure 29: Relationship Between Permeability and In-place Air Voids, Project 11

Table 68: Lab Permeability Results for Lab Compacted Samples, Project 11

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)	Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	9.7	3829	17	3	8.1	519
2	1	7.5	1054	18	3	7.3	389
3	1	7.5	3508	19	3	9.5	1036
4	1	7.2	991	20	3	9.7	1026
5	1	15.5	6965	21	3	11.1	3435
6	1	9.9	6927	22	3	11.8	3444
7	1	9.4	6854	23	3	12.0	5884
8	1	10.8	6922	24	3	12.5	5884
9	2	7.0	173				
10	2	6.5	242				
11	2	10.4	2304				
12	2	10.1	2304				
13	2	11.8	3431				
14	2	11.6	6896				
15	2	12.5	6855				
16	2	12.9	6803				

5.12 Project 12:

Project 12 was a mill and fill project on an interstate highway. The mix consisted of a 25.0 mm NMAS Stone Matrix Asphalt (SMA) blend designed using 50 blows per face of the Marshall hammer. For research purposes, however, this number was converted to an N_{design} of 50 gyrations, resulting in a design asphalt content of 5.5 percent. The asphalt binder that was used was a PG 76-22.

Average binder content (solvent extraction) and washed gradation test results are presented in Table 58. The results are separated into the three sublots tested during the day on site. The average measured binder content from the obtained samples for the overall project was 5.0 percent, 0.5 percent lower than the job mix formula. Sublot 1 was 0.4 percent lower than the design binder percent, sublot 2 was 0.8 percent lower, and sublot 3 was 0.4 percent lower than the target value.

The overall average was close to the job mix formula, with the largest difference coming on the 1.18 mm sieve (2.8 percent higher than the JMF). The amount passing the 0.075 mm sieve gradually neared the job mix formula value, beginning at 2.5 percent below the JMF at the beginning of the day and moving to 1.1 percent below the JMF by the end of the day.

Table 69: Average Gradation and Binder Content per Sublot, Project 12

Gradation		Overall		Sublot 1		Sublot 2		Sublot 3	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	99.7	0.3	99.1	0.9	100.0	0.0	100.0	0.0
19	90.0	86.5	3.5	87.7	2.3	83.0	7.0	88.9	1.1
12.5	74.0	68.5	5.5	70.8	3.2	65.6	8.4	69.1	4.9
9.5	54.0	54.9	-0.9	56.3	-2.3	52.3	1.7	56.0	-2.0
4.75	28.0	29.0	-1.0	29.4	-1.4	27.5	0.5	30.3	-2.3
2.36	21.0	23.2	-2.2	23.4	-2.4	22.3	-1.3	23.9	-2.9
1.18	17.0	19.8	-2.8	19.9	-2.9	19.1	-2.1	20.4	-3.4
0.6	15.0	16.6	-1.6	16.5	-1.5	16.0	-1.0	17.1	-2.1
0.3	11.0	12.5	-1.5	12.3	-1.3	12.2	-1.2	13.1	-2.1
0.15	9.0	8.9	0.1	8.4	0.6	8.6	0.4	9.7	-0.7
0.075	8.0	6.1	1.9	5.5	2.5	5.9	2.1	6.9	1.1
Asphalt Content	5.5	5.0	0.5	5.1	0.4	4.7	0.8	5.1	0.4

Table 59 contains in-place air voids and water absorption values (from AASHTO T166) for individual cores from Project 12. Table 60 presents the average in-place air voids and standard deviations for the combined data and for each sublot. In-place air voids for the project averaged 5.5 percent, ranging from 3.9 percent to 7.6 percent, based on AASHTO T166 bulk specific gravity measurements. By observation of the data in Table 60, the in-place air voids increased throughout the day (based on AASHTO T166). Also, as with the majority of the previous projects, AASHTO T166 produced the lowest in-place air voids, with dimensional analysis producing the highest in-place air voids.

Table 70: Core In-place Air Voids and Absorption Percents, Project 12

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	5.1	6.8	7.7	12.1	1.3
2	1	5.5	6.5	9.2	10.8	1.3
3	1	3.9	6.5	7.1	9.8	0.5
4	1	4.1	5.5	6.1	10.3	0.4
5	1	4.6	5.3	6.2	10.3	0.3
6	2	4.5	6.7	8.4	11.7	1.1
7	2	6.5	6.4	10.3	12.0	1.0
8	2	4.8	5.5	6.9	10.2	0.5
9	2	6.7	8.6	13.2	13.2	1.6
10	2	6.7	8.6	13.6	12.2	1.5
11	3	5.6	6.4	11.0	12.2	0.4
12	3	4.9	5.7	7.4	10.6	0.6
13	3	7.6	9.1	11.6	14.5	1.5
14	3	5.3	7.0	9.0	11.7	0.7
15	3	7.3	9.4	12.4	14.8	3.0

Table 71: Average Core In-place Air Voids and Standard Deviations, Project 12

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	5.5	1.2	6.9	1.3	9.3	2.5	11.8	1.5
sublot 1	4.6	0.7	6.1	0.7	7.3	1.3	10.7	0.9
sublot 2	5.8	1.1	7.2	1.4	10.5	2.9	11.9	1.1
sublot 3	6.1	1.2	7.5	1.6	10.3	2.0	12.8	1.8

Lift thickness, field, and lab permeability results are presented in Table 61. The design lift thickness for the project was 61.0 mm; Project 12 averaged 42.6 mm, 18.4 mm lower than the target value. The lift thickness ranged from 34.1 mm to 48.6 mm, or from a t/NMAS of 1.4:1 to 1.9:1. PQI density results for Project 12 are presented in Table 73.

The relationship between lift thickness and in-place air voids is illustrated in Figure 30. There was no relationship between lift thickness and in-place air voids for this particular project (R^2 = 0.08). An ANOVA conducted on the regression confirmed that the relationship was not significant (p-value = 0.300). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 72: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 12

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	38.2	322	67
2	1	42.9	113	34
3	1	43.6	157	0
4	1	41.3	9	0
5	1	48.6	35	0
6	2	41.4	99	0
7	2	37.9	187	279
8	2	43.0	191	0
9	2	45.8	585	533
10	2	43.8	1195	327
11	3	46.1	564	24
12	3	41.7	127	0
13	3	34.1	114	139
14	3	47.5	146	0
15	3	43.5	1794	1969

Table 73: Pavement Quality Indicator In-place Density Results, Project 12

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	128.3	127.3	126.1	127.8
2	1	127.3	128.5	125.9	127.1
3	1	126.5	125.7	126.3	126.5
4	1	128.7	128.5	126.3	127.8
5	1	125.4	127.0	126.7	126.5
6	2	118.5	116.5	116.4	117.4
7	2	118.7	119.4	118.1	117.5
8	2	116.8	115.5	116.3	118.9
9	2	114.4	116.4	115.5	116.1
10	2	116.4	117.5	117.8	116.9
11	3	127.9	126.8	124.8	126.7
12	3	127.4	128.4	128.7	128.5
13	3	128.0	128.8	128.8	128.7
14	3	126.8	127.3	128.3	127.9
15	3	124.8	125.8	123.3	125.2

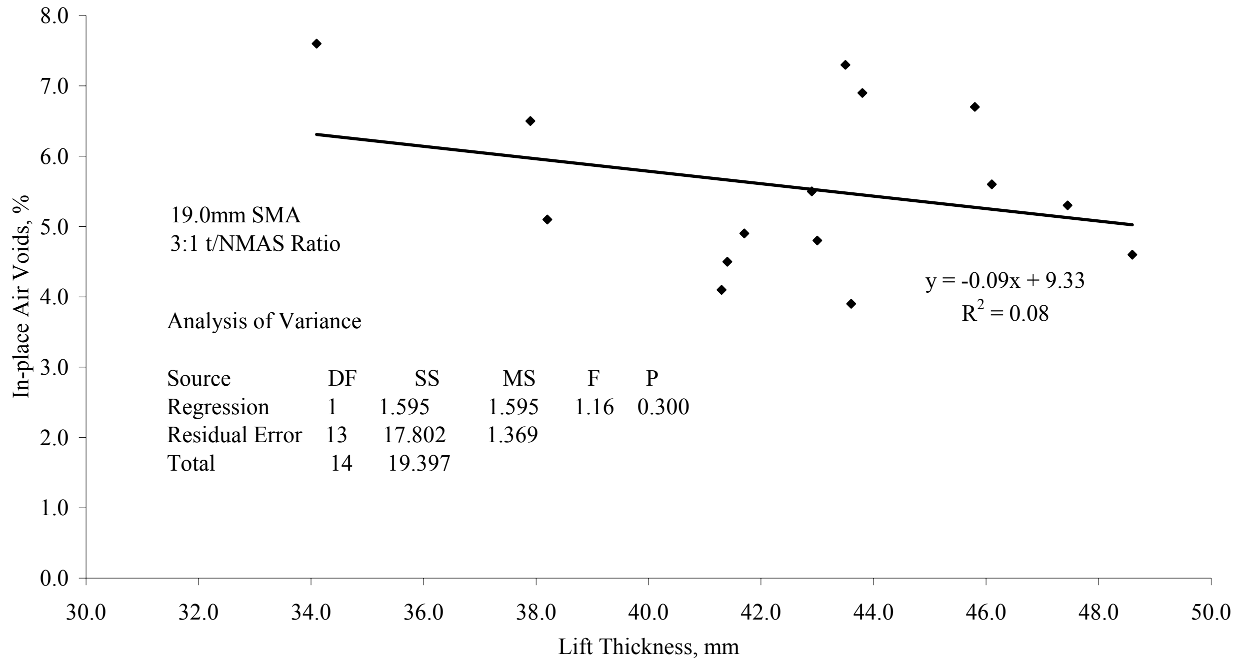

Figure 30: Relationship Between Lift Thickness and In-place Air Voids, Project 12

Figure 31 illustrated the relationship between in-place air voids and permeability. For Figure 31, three relationships were produced. They include field permeability and lab permeability results versus in-place air voids and lab permeability results for the compacted samples from the mobile lab. Table 62 presents the lab permeability results for the lab compacted samples. From Figure 31, reasonable R^2 values were found for both the field permeability results and lab permeability results for the lab compacted samples (0.60 and 0.54, respectively). A low R^2 value was found for the lab permeability data for the cores (0.23). Based on the regression line equations from Figure 31 and a permeability value of 125×10^{-5} cm/s, the field permeability results suggested that the mix became permeable at an in-place air void content between 4 and 5 percent. The lab permeability results suggest that the mix became permeable between 4 and 6 percent.

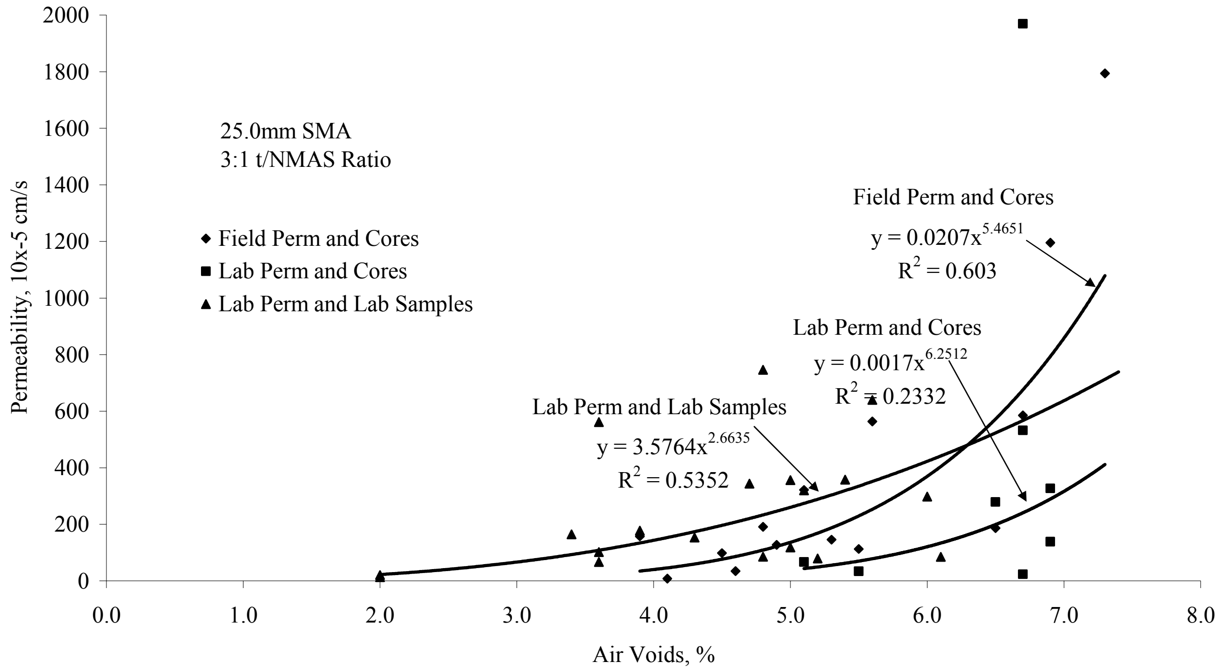

Figure 31: Relationship Between Permeability and In-place Air Voids, Project 12

Table 74: Lab Permeability Results for Lab Compacted Samples, Project 12

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)	Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	1.6	0	17	3	2.0	13
2	1	1.4	0	18	3	2.0	21
3	1	3.9	178	19	3	4.8	86
4	1	3.4	165	20	3	4.3	153
5	1	5.0	119	21	3	5.0	357
6	1	3.6	562	22	3	5.2	79
7	1	5.6	640	23	3	5.4	358
8	1	4.8	746	24	3	6.1	85
9	2	1.9	0				
10	2	1.6	0				
11	2	3.6	102				
12	2	3.6	67				
13	2	4.7	344				
14	2	5.1	320				
15	2	6.0	298				
16	2	7.4	2231				

5.13 Project 13:

Project 13 involved the placement of new HMA on an existing highway. The mix consisted of a 25.0 mm NMAS fine-graded blend designed at an N_{design} of 100 gyrations, resulting in a design asphalt content of 3.9 percent. The asphalt binder used was a PG 67-22 (unmodified).

Average asphalt content (solvent extraction) and washed gradation test results are shown in Table 75. The measured binder content from the obtained samples for the project was 3.5 percent, 0.4 percent lower than the target value. For sublot 1, the average binder content was 0.1 percent low, while sublot 2 dropped to 0.7 percent below the job mix formula. For gradation, the sieves with the largest deviations were the 9.5 and 4.75 mm sieves (12.1 and 8.4 percent lower than the JMF).

Table 75: Average Gradation and Asphalt Content per Sublot, Project 13

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	99.0	100.0	-1.0	100.0	-1.0	100.0	-1.0
19	89.0	88.3	0.7	89.1	-0.1	87.5	1.5
12.5	69.0	75.6	-6.6	78.5	-9.5	72.6	-3.6
9.5	61.0	73.1	-12.1	76.7	-15.7	69.4	-8.4
4.75	48.0	56.4	-8.4	60.4	-12.4	52.3	-4.3
2.36	32.0	35.9	-3.9	38.4	-6.4	33.3	-1.3
1.18	23.0	25.8	-2.8	27.4	-4.4	24.1	-1.1
0.6	15.0	17.2	-2.2	18.3	-3.3	16.0	-1.0
0.3	9.0	9.1	-0.1	9.3	-0.3	8.9	0.1
0.15	6.0	5.5	0.6	5.7	0.3	5.2	0.8
0.075	4.6	3.9	0.8	3.9	0.7	3.8	0.8
Asphalt Content	3.9	3.5	0.4	3.8	0.1	3.2	0.7

In-place air voids and water absorption values for Project 13 are presented in Table 76. The results are presented for individual cores; average in-place air voids and standard deviation values for the combined data and for each sublot are presented in

Table 77. The in-place air voids for the project was 9.3 percent, ranging from 7.7 to 10.4 percent, based on AASHTO T166 bulk specific gravity measurements. The average in-place air void content for sublot 1 was 9.7 percent, and was 8.5 percent for sublot 2. Sublot 2 contained only two cores due to traffic control constraints.

Table 76: Core In-place Air Voids and Absorption Percents, Project 13

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	9.8	10.6	12.0	11.2	1.5
2	1	9.6	10.7	12.9	13.2	1.6
3	1	10.0	11.1	12.3	12.6	1.7
4	1	8.5	9.5	12.4	11.7	2.2
5	1	10.4	10.8	12.3	13.1	1.2
6	2	7.7	8.7	9.8	10.3	1.6
7	2	9.3	9.9	10.4	12.1	1.0

Table 77: Average Core In-place Air Voids and Standard Deviations, Project 13

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	9.3	0.9	10.2	0.9	11.7	1.2	12.0	1.1
sublot 1	9.7	0.7	10.5	0.6	12.4	0.3	12.4	0.9
sublot 2	8.5	1.1	9.3	0.8	10.1	0.4	11.2	1.3

Lift thickness, field, and lab permeability results are presented in Table 78. The design thickness for the project was 69.9 mm. From the results in Table 78, the average lift thickness was 70.0 mm, right at the design thickness. Lift thickness ranged from 52.4 mm to 85.3 mm, or from a t/NMAS ratio of 2.1:1 to 3.4:1. PQI density results for Project 13 are presented in Table 79.

Figure 32 illustrates the relationship between lift thickness and in-place air voids for Project 13. With an R^2 of 0.03, there was no relationship between lift thickness and in-place air voids for this particular project. An ANOVA conducted for the regression confirmed that the relationship was not significant (p-value of 0.720). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 78: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 13

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	70.6	1335	248
2	1	52.4	2023	506
3	1	64.4	1607	369
4	1	58.3	661	376
5	1	81.4	409	243
6	2	85.3	512	183
7	2	77.3	766	178

Table 79: Pavement Quality Indicator In-place Density Results, Project 13

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	125.5	127.0	126.2	125.9
2	1	124.6	126.9	125.5	124.6
3	1	126.1	125.8	125.4	126.0
4	1	121.7	123.8	125.2	124.9
5	1	121.0	121.7	121.4	122.6
6	2	127.3	126.7	127.4	126.5
7	2	123.7	124.7	123.8	125.0
8	2	126.6	124.5	125.5	126.9
9	2	124.0	125.0	123.9	124.0
10	2	125.5	128.0	126.3	126.7

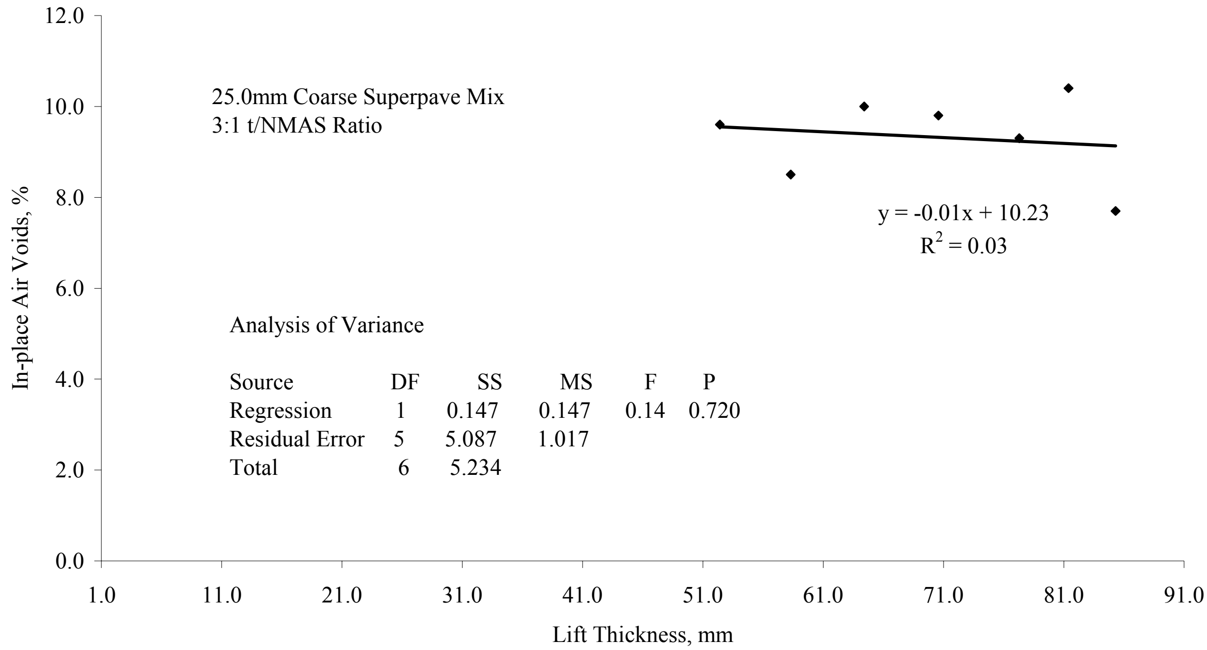

Figure 32: Relationship Between Lift Thickness and In-place Air Voids, Project13

The relationship between permeability and in-place air voids is illustrated in Figure 33. Figure 33 contains the relationship for field permeability and lab permeability results versus core in-place air voids and for lab permeability results versus in-place air voids for the lab compacted samples. Table 80 contains the lab permeability results for the lab compacted samples. For the field permeability and lab permeability results for the cores, small R^2 values were produced (0.13 and 0.08, respectively). This was due to the variability in the permeability values for a small range of in-place air voids. For the lab permeability results on the lab compacted samples, a reasonable R^2 was found (0.52). From the regression line equations produced from Figure 33 and a permeability value of 125×10^{-5} cm/s, the field permeability test results and the lab permeability test results from the cores suggested that the mix became permeable at an in-place air void content between 3 and 4 percent. The lab permeability test results from the lab compacted samples suggested that the mix became permeable at an in-place air void content between 9 and 10 percent.

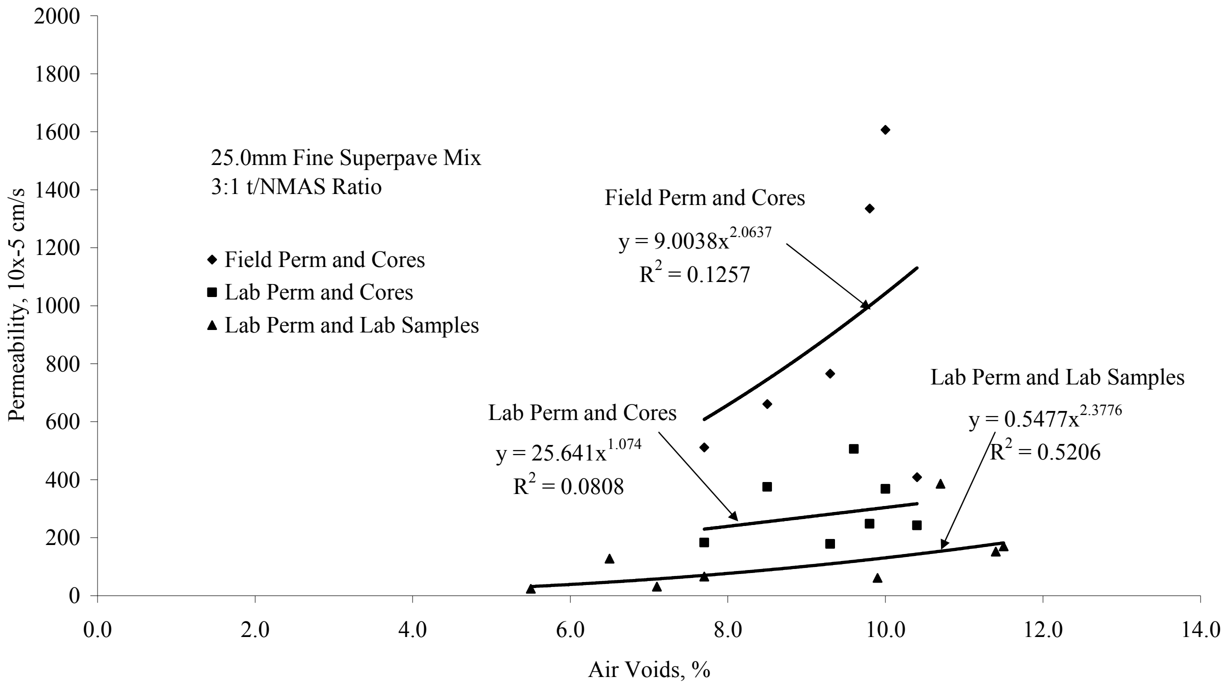

Figure 33: Relationship Between Permeability and In-place Air Voids, Project 13

Table 80: Lab Permeability Results for Lab Compacted Samples, Project 13

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	4.6	0
2	1	4.2	0
3	1	6.2	0
4	1	5.3	0
5	1	5.5	24
6	1	6.5	128
7	1	7.7	66
8	1	7.1	31
9	2	4.8	0
10	2	5.0	0
11	2	6.2	0
12	2	4.8	0
13	2	9.9	61
14	2	10.7	386
15	2	11.4	152
16	2	11.5	170

5.14 Project 14:

Project 14 involved the placement of new hot mix asphalt on an interstate highway. The mix consisted of a 9.5 mm NMAS Stone Matrix Asphalt (SMA) blend designed using 50 blows per face of a Marshall hammer. For research purposes, however, this number was converted to an N_{design} of 75 gyrations, which resulted in a design asphalt content of 6.7 percent. The asphalt binder used was a PG 76-22.

Average washed gradation and binder content (solvent extraction) test results for each sublot are shown in Table 81. The average measured binder content from the obtained samples for the overall project was 6.4 percent, 0.3 percent below the target value. Both sublots had an average binder content of 6.4 percent. For gradation, the average was very close to the job mix formula, with all sieves having less then two percent deviation from the target values.

Table 81: Average Gradation and Asphalt Content per Sublot, Project 14

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0	100.0	0.0
12.5	100.0	100.0	0.0	100.0	0.0	100.0	0.0
9.5	100.0	100.0	0.0	100.0	0.0	100.0	0.0
4.75	53.0	54.4	-1.4	53.3	-0.3	55.5	-2.5
2.36	25.0	26.2	-1.2	26.1	-1.1	26.3	-1.3
1.18	19.0	20.9	-1.9	20.8	-1.8	20.9	-1.9
0.6	16.0	17.6	-1.6	17.5	-1.5	17.7	-1.7
0.3	14.0	14.3	-0.3	14.2	-0.2	14.3	-0.3
0.15	11.0	11.1	-0.1	10.9	0.1	11.2	-0.2
0.075	9.1	8.5	0.6	8.3	0.8	8.6	0.5
Asphalt Content	6.7	6.4	0.3	6.4	0.3	6.4	0.3

Table 82 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for

individual cores obtained for Project 14. In Table 83, the average in-place air voids and standard deviation values for the combined data and for each sublot are given. The in-place air voids for the project averaged 10.2 percent, ranging from 6.1 to 12.4 percent, based on AASHTO T166 bulk specific gravity measurements. Sublot 1 averaged 8.8 percent, sublot 2 averaged 10.4 percent, and sublot 3 averaged 11.4 percent.

Table 82: Core In-place Air Voids and Absorption Percents, Project 14

Sample ID	Sublot	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	1	5.5	7.8	10.1	13.3	0.3
2	1	11.2	14.4	16.9	20.7	4.1
3	1	11.2	14.4	14.8	22.7	3.4
4	1	7.7	9.0	12.1	14.5	1.2
5	1	8.5	11.4	12.9	16.5	1.7
6	2	10.9	14.8	15.9	17.7	3.4
7	2	7.5	10.4	10.6	15.1	1.3
8	2	11.7	16.3	17.3	16.7	3.7
9	2	9.5	9.6	12.9	16.7	1.7
10	2	12.4	17.8	16.0	19.0	5.4
11	3	10.5	14.8	17.7	19.5	3.7
12	3	9.4	12.3	16.5	18.5	2.0
13	3	11.5	16.1	18.7	21.0	3.2
14	3	15.3	23.5	18.3	19.4	7.0
15	3	10.3	13.1	10.3	17.2	1.9

Table 83: Average Core In-place Air Voids and Standard Deviations, Project 14

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	10.2	2.3	13.7	4.0	14.7	3.0	17.9	2.6
sublot 1	8.8	2.4	11.4	3.0	13.4	2.6	17.5	4.0
sublot 2	10.4	1.9	13.8	3.6	14.5	2.7	17.0	1.4
sublot 3	11.4	2.3	16.0	4.5	16.3	3.5	19.1	1.4

Lift thickness, field, and lab permeability results on the cores are presented in Table 84. On average, the project had a lift thickness of approximately 26.8 mm, 1.4 mm higher than the design lift thickness. The lift thickness ranged from a low of 20.7 mm to a high of 34.7 mm, or from a t/NMAS from 2.2:1 to 3.7:1. For sublot 3, the field permeability values are the average of two runs due to time constraints. PQI density results for Project 14 are presented in Table 85.

Figure 34 illustrates the relationship between lift thickness and in-place air voids for the project. The regression produced a low R^2 value of 0.20. An ANOVA conducted on the regression showed that the relationship was not significant (p-value of 0.133). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 84: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 14

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	34.7	21	14
2	1	26.8	151	1766
3	1	22.5	137	2488
4	1	30.1	9	183
5	1	28.0	37	425
6	2	24.9	116	2098
7	2	27.0	47	242
8	2	29.2	416	2014
9	2	28.1	227	668
10	2	28.2	1101	4754
11	3	20.7	557	1827
12	3	28.1	140	467
13	3	24.3	174	1564
14	3	27.9	1474	9086
15	3	21.5	225	795

Table 85: Pavement Quality Indicator In-place Density Results, Project 14

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	124.5	124.6	124.2	124.2
2	1	122.3	121.3	122.2	121.9
3	1	122.8	122.5	122.7	122.4
4	1	124.9	125.4	125.1	124.5
5	1				123.7
6	2	121.3	124.1	123.9	123.2
7	2	125.0	124.7	124.6	124.0
8	2	120.0	122.1	121.0	121.5
9	2	123.3	123.5	121.8	122.2
10	2	119.0	119.7	119.7	119.8
11	3	123.6	123.8		123.5
12	3	123.9	123.8		123.6
13	3	123.3	123.6		123.7
14	3	120.1	120.4		119.8
15	3	122.4	123.7		123.0

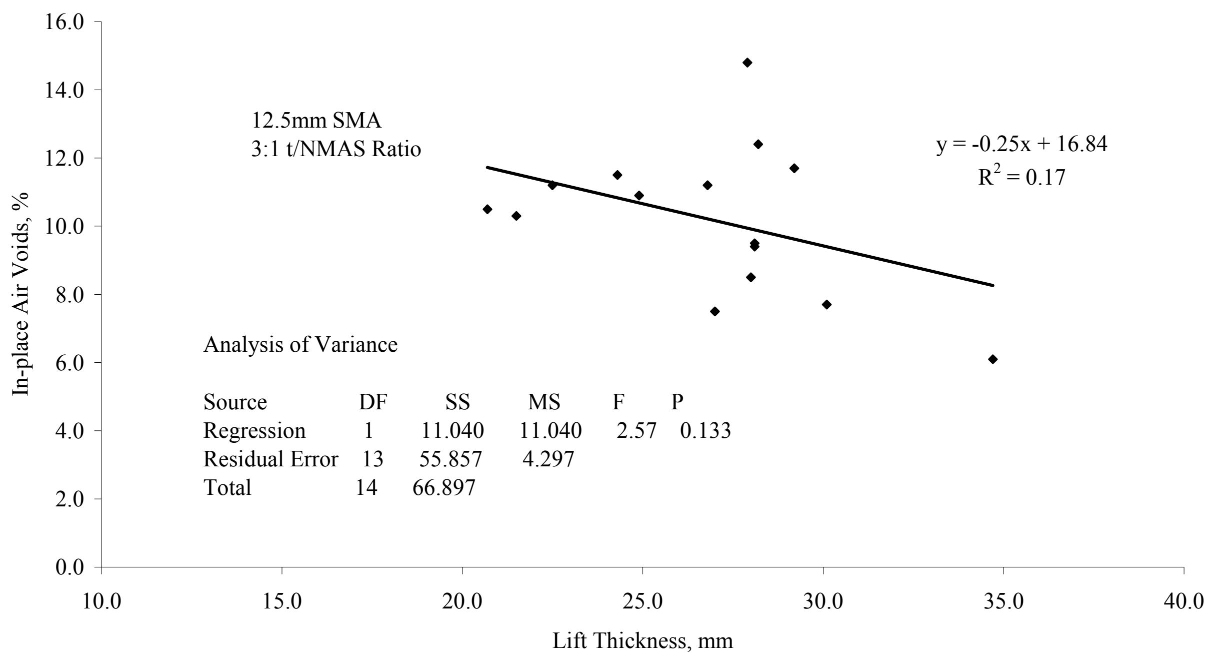

Figure 34: Relationship Between Lift Thickness and In-place Air Voids, Project 14

Figure 35 illustrate the relationship between permeability and in-place air voids for Project 14. Figure 35 contains three relationships. They include field permeability and lab permeability results versus in-place air voids and lab permeability results versus air voids for the lab compacted samples. Table 86 contains the lab permeability results for the lab compacted samples. Due to problems encountered during testing, only seven lab compacted samples were produced. All three relationships produced strong R^2 values (0.74 for the field permeability, 0.94 for the lab permeability and cores, and 0.79 for the lab permeability and lab compacted samples). From observation of Figure 35, lab permeability tended to be higher than the field permeability for a given in-place air void level. Based on the regression equations produced in Figure 35 and a permeability value of 125×10^{-5} cm/s, the field permeability test results suggested that the mix became permeable at an in-place air void content between 9 and 10 percent. The lab permeability test results suggest that the mix became permeable between 4.5 and 7.5 percent air voids.

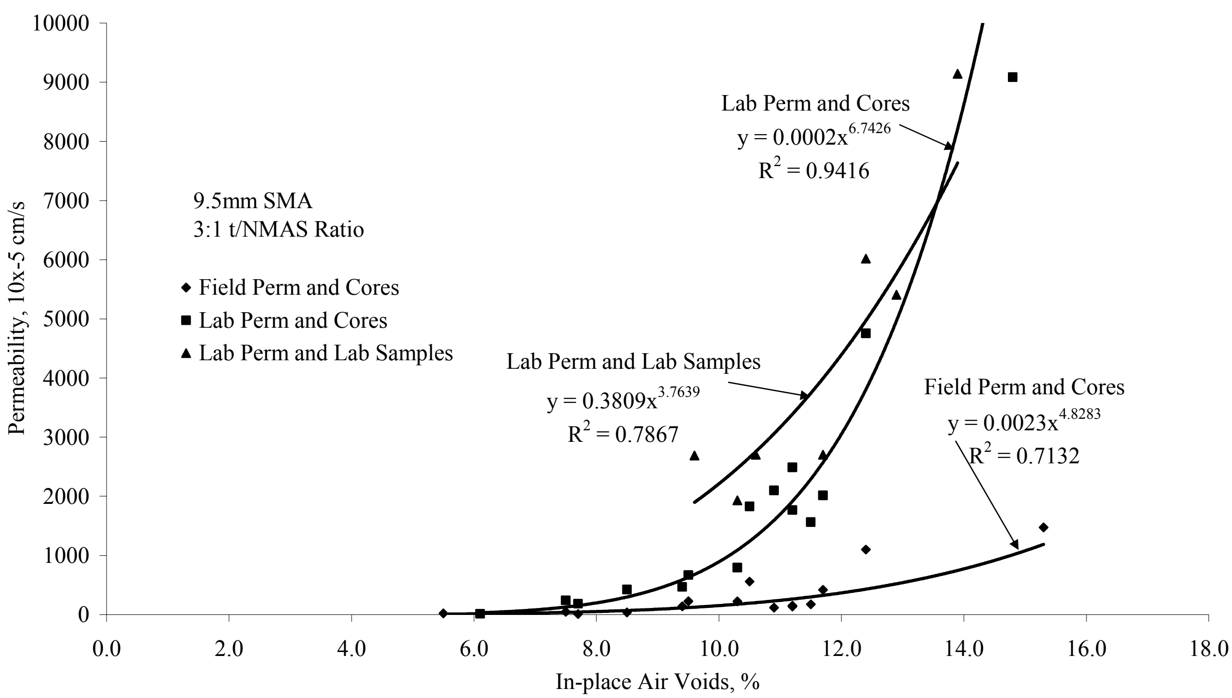

Figure 35: Relationship Between Permeability and In-place Air Voids, Project 14

Table 86: Lab Permeability Results for Lab Compacted Samples, Project 14

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	12.4	6017
2	1	10.3	1930
3	1	11.7	2703
4	1	9.6	2689
5	1	10.6	2703
6	1	12.9	5407
7	1	13.9	9141

5.15 Project 15:

Project 15 was the placement of hot mix asphalt over Portland Cement Concrete (PCC) on an existing highway. The mix consisted of a 19.0 mm NMAS coarse-graded blend designed at an N_{design} level of 100 gyrations, which resulted in a design asphalt content of 4.2 percent. The asphalt binder was a PG 76-22.

Average washed gradation and binder content (solvent extraction) test results for each sublot are presented in Table 87. The overall average binder content from the obtained samples for the project was 4.1 percent, 0.1 percent below the job mix formula. For sublot 1, the average binder content was 0.1 percent above the design content, while sublot 2 was 0.2 percent below the target value. The average gradation for Project 15 deviated from the job mix formula, with the largest difference coming on the 2.36 mm sieve (5.3 percent below the JMF).

Table 87: Average Gradation and Binder Content per Sublot, Project 15

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	99.0	100.0	-1.0	100.0	-1.0	100.0	-1.0
12.5	81.0	82.6	-1.6	86.5	-5.5	78.8	2.2
9.5	72.0	70.4	1.6	75.5	-3.5	65.3	6.7
4.75	53.0	48.4	4.6	52.1	0.9	44.7	8.3
2.36	37.0	31.7	5.3	33.6	3.4	29.8	7.2
1.18	25.0	21.6	3.4	22.7	2.3	20.5	4.5
0.6	15.0	13.9	1.1	14.5	0.5	13.3	1.7
0.3	8.0	8.7	-0.7	9.1	-1.1	8.3	-0.3
0.15	6.0	6.2	-0.2	6.5	-0.5	5.9	0.1
0.075	4.7	4.5	0.3	4.7	0.0	4.2	0.5
Asphalt Content	4.2	4.1	0.1	4.3	-0.1	4.0	0.2

Table 88 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for individual cores obtained for Project 15. In Table 89, average in-place air voids and standard deviations for the combined data and for each sublot are presented. The construction in-place air voids for the project averaged 11.5 percent, ranging from 8.4 percent to 13.6 percent, based on AASHTO T166 bulk specific gravity measurements. Sublot 1 averaged 11.1 percent and sublot 2 averaged 12.0 percent. Observation of Table 89 shows that all test procedures produced average in-place air voids that were over 10 percent, with AASHTO T166 producing the lowest values.

Table 88: Core In-place Air Voids and Percent Absorption, Project 15

Sample ID	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	9.8	10.9	11.9	14.0	2.7
2	14.6	17.2	19.2	20.7	4.9
3	9.0	11.0	12.0	14.0	2.2
4	8.4	9.1	11.3	12.7	1.4
5	13.6	16.6	18.0	19.5	5.5
6	10.7	12.1	13.2	15.5	3.8
7	11.0	14.5	14.3	16.4	3.5
8	12.6	14.4	17.4	17.8	5.2
9	12.4	14.6	15.8	18.2	5.3
10	13.3	15.2	17.4	18.2	5.7

Table 89: Average Core In-place Air Voids and Standard Deviations, Project 15

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	11.5	2.1	13.6	2.7	15.1	2.9	16.7	2.6
sublot 1	11.1	2.8	13.0	3.7	14.5	3.8	16.2	3.6
sublot 2	12.0	1.1	14.2	1.2	15.6	1.9	17.2	1.2

Lift thickness, field, and lab permeability results on cores obtained are presented in Table 90. The design lift thickness for Project 15 was 57.2 mm; actual lift thickness averaged 50.4 mm, 4.8 mm lower than the target value. The thickness ranged from 35.5 mm to 55.3 mm, or from a t/NMAS ratio of 1.9:1 to 2.9:1. From the data in Table 90, the lift thickness increased throughout the course of the day. PQI density results for Project 15 are presented in Table 91.

Figure 36 illustrates the relationship between lift thickness and in-place air voids. Performing a regression on all the data produced an R^2 of 0.08, which suggested that there was no relationship between lift thickness and in-place air voids. An ANOVA conducted on the regression confirmed that the relationship was not significant (p-value = 0.437). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 90: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 15

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	35.5	864	411
2	1	45.6	3965	1872
3	1	50.4	375	324
4	1	49.2	856	171
5	1	54.2	3602	2721
6	2	53.2	1480	761
7	2	52.8	1271	623
8	2	52.2	3388	1513
9	2	55.2	2429	1104
10	2	55.3	4618	1247

Table 91: Pavement Quality Indicator In-place Density Results, Project 15

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	136.4	133.4	129.0	131.8
2	1	125.2	125.0	126.0	126.4
3	1	133.8	133.9	133.7	135.2
4	1	135.3	135.8	136.4	135.0
5	1	128.7	128.5	128.6	128.4
6	2	127.1	129.4	130.0	130.3
7	2	131.1	129.4	130.7	129.3
8	2	127.9	127.9	127.7	128.3
9	2	128.0	128.2	129.2	127.0
10	2	124.8	127.6	126.5	127.2

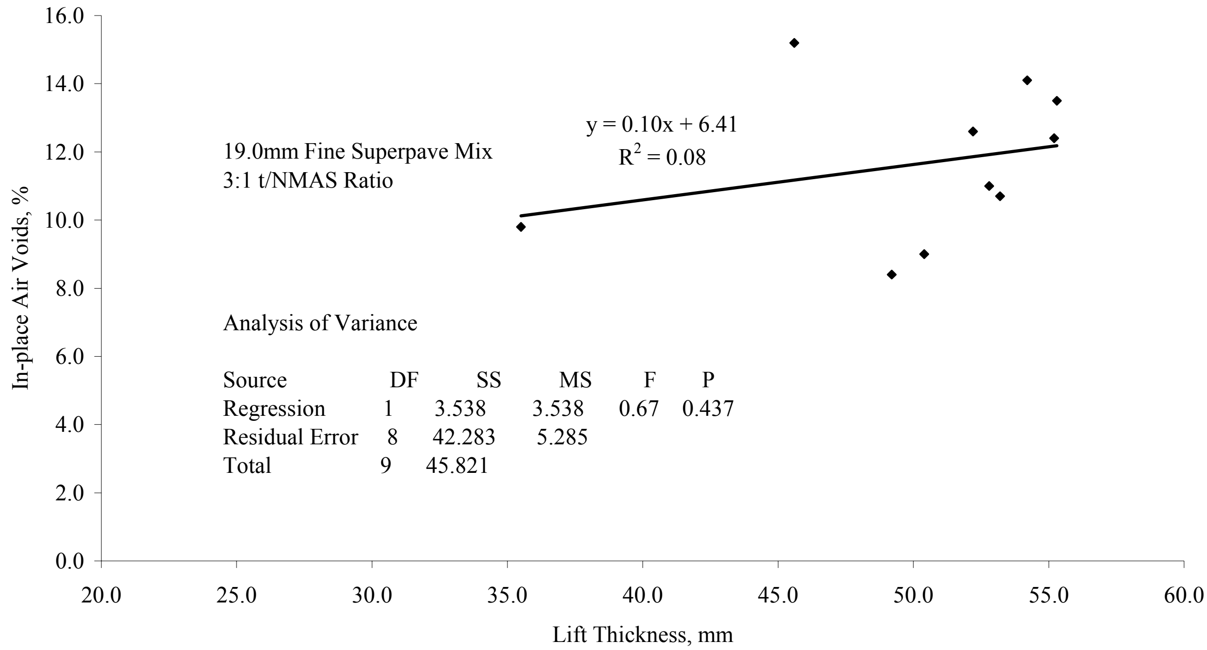

Figure 36: Relationship Between Lift Thickness and In-place Air Voids, Project 15

Figure 37 illustrates the relationship between permeability and in-place air voids for Project 15. For Figure 37, there are three relationships. They include field permeability and lab permeability results versus in-place air voids and lab permeability results versus in-place air voids for the lab compacted samples. The results for the lab permeability testing on the lab compacted samples are presented in Table 92. Reasonable to strong R^2 value were obtained for all three regressions (field permeability = 0.85, lab permeability on cores = 0.93, lab permeability on lab samples = 0.78). Based on the regression equations from all three regressions, the mix became permeable at an air void content between 5.5 and 7.5 percent.

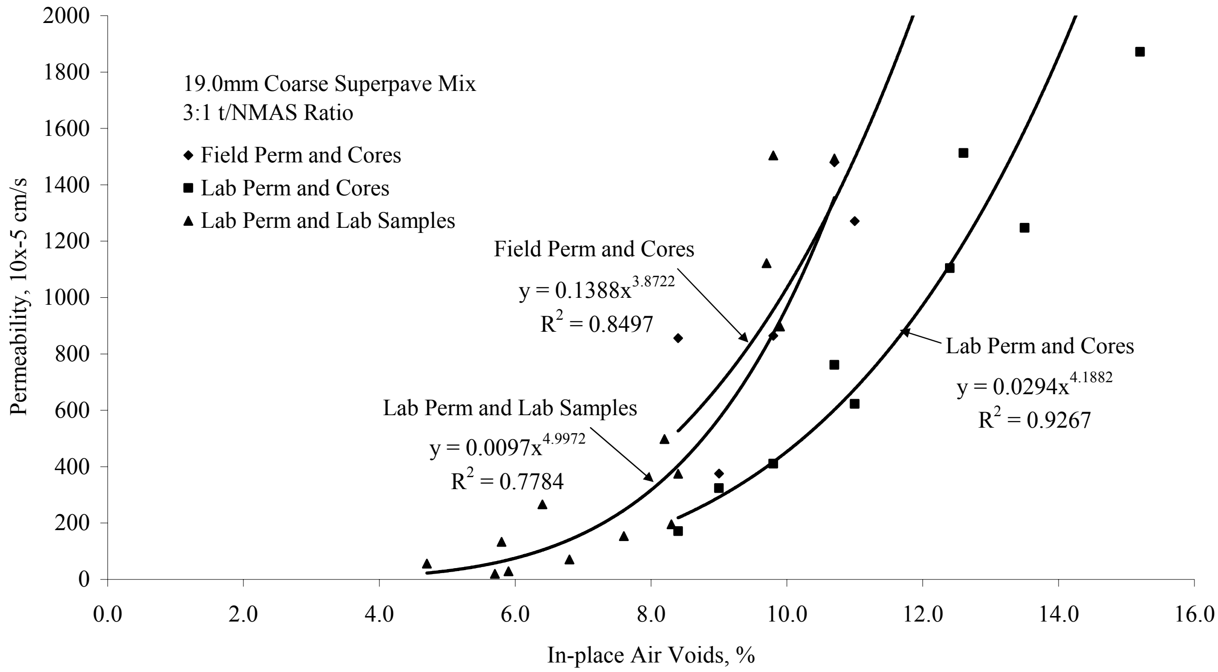

Figure 37: Relationship Between Permeability and In-place Air Voids, Project 15

Table 92: Lab Permeability Results for Lab Compacted Samples

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	4.5	0
2	1	4.5	0
3	1	4.7	56
4	1	5.8	133
5	1	6.4	266
6	1	6.8	70
7	1	7.6	153
8	1	8.3	195
9	2	5.9	29
10	2	5.7	20
11	2	8.2	498
12	2	8.4	375
13	2	9.7	1122
14	2	9.9	897
15	2	10.7	1494
16	2	9.8	1504

5.16 Project 16:

Project 16 was the placement of new HMA in the construction of a new state highway. The mix consisted of a 12.5 mm NMAS fine-graded blend designed at an N_{design} of 86 gyrations, which resulted in a design asphalt content of 5.8 percent. The asphalt binder used was a PG 67-22 (unmodified).

Average gradation and binder content (solvent extraction) test results are presented in Table 93. The overall average binder content from the obtained samples for the project was 5.5 percent, 0.3 percent below the design binder content. For sublot 1, the average binder content was 0.2 percent low, and for sublot 2 the average binder content was 0.3 percent below the job mix formula. The average gradation was close to the job mix formula, with the majority of the sieves below than the job mix formula. However, all the amounts were less than one percent off from the target values.

Table 93: Average Gradation and Binder Content per Sublot, Project 16

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0	100.0	0.0
12.5	100.0	98.9	1.1	99.0	1.0	98.8	1.2
9.5	91.0	89.8	1.2	89.5	1.5	90.1	0.9
4.75	55.0	56.1	-1.1	55.2	-0.2	57.0	-2.0
2.36	36.0	36.7	-0.7	35.9	0.1	37.5	-1.5
1.18	26.0	26.7	-0.7	26.0	0.0	27.3	-1.3
0.6	20.0	20.4	-0.4	19.8	0.2	21.0	-1.0
0.3	12.0	12.9	-0.9	12.3	-0.3	13.6	-1.6
0.15	7.0	7.8	-0.8	7.1	-0.1	8.4	-1.4
0.075	5.4	5.4	0.0	4.8	0.6	6.1	-0.7
Asphalt Content	5.8	5.5	0.3	5.6	0.2	5.5	0.3

Table 94 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for

individual cores obtained for Project 16. In Table 95, average in-place air voids and standard deviations for the combined data and for each sublot are given.

Table 94: Core In-place Air Voids and Percent Absorption, Project 16

Sample ID	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	6.8	8.9	8.1	11.1	1.4
2	9.0	10.7	10.9	12.0	2.9
3	5.5	7.4	7.0	9.0	1.1
4	11.6	13.5	14.3	16.4	4.2
5	9.3	12.3	11.8	13.2	3.7
6	6.8	7.8	7.4	8.6	1.6
7	9.6	11.4	12.5	13.7	3.5
8	6.1	7.3	7.3	9.3	1.0
9	6.7	8.0	8.3	9.3	1.8
10	8.4	9.3	9.4	11.1	1.3

Table 95: Average In-place Air Voids and Standard Deviations, Project 16

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	8.0	1.9	9.7	2.2	9.7	2.5	11.4	2.5
sublot 1	8.4	2.4	10.6	2.5	10.4	2.9	12.3	2.7
sublot 2	7.5	1.4	8.8	1.7	9.0	2.1	10.4	2.1

The construction in-place air voids for the project averaged 8.0 percent, ranging from 5.5 percent to 11.6 percent, based on AASHTO T166 bulk specific gravity measurements. For sublot 1, the average in-place air void content was 8.4 percent, and was 7.5 percent for sublot 2.

Lift thickness, field, and lab permeability results for cores are presented in Table 96. The design lift thickness for Project 16 was 38.1 mm; the actual thickness averaged 43.8 mm, 5.7 mm higher than the target value. Lift thickness ranged from 38.0 mm to 48.9 mm, or from a t/NMAS ratio of 3.0:1 to 3.9:1. PQI density results for Project 16 are presented in Table 97.

The relationship between lift thickness and in-place air voids is illustrated in Figure 38. Analysis of the data indicated little correlation between in-place air voids and lift thickness (R^2 = 0.16). An ANOVA conducted on the regression confirmed that the relationship was not significant (p-value = 0.245). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 96: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 16

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	43.6	72	70
2	1	48.9	805	499
3	1	44.5	58	45
4	1	45.7	1712	1048
5	1	44.2	725	372
6	2	38.0	266	189
7	2	45.2	2345	697
8	2	43.8	125	83
9	2	42.8	126	77
10	2	40.8	677	292

Table 97: Pavement Quality Indicator In-place Density Results, Project 16

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	119.2	118.8	118.6	118.9
2	1	117.1	117.9	117.8	117.4
3	1	119.6	119.3	119.4	119.3
4	1	115.6	115.3	114.9	115.2
5	1	118.3	117.9	117.5	116.9
6	2	120.2	120.5	121.3	120.2
7	2	118.0	117.8	118.7	118.1
8	2	120.4	120.5	120.2	120.6
9	2	120.9	121.2	120.4	120.9
10	2	119.3	118.3	118.7	119.3

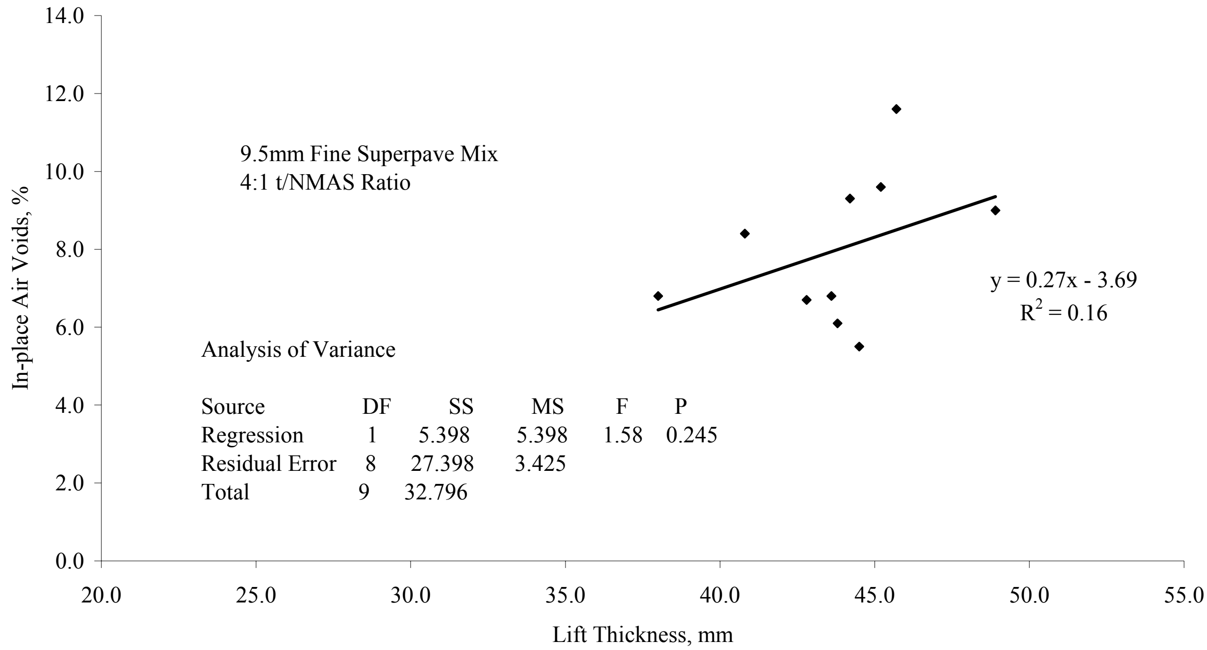

Figure 38: Relationship Between Lift Thickness and In-place Air Voids, Project 16

Figure 39 illustrates the relationship between permeability and air voids for Project 16. In Figure 39, three relationships are shown. They include field permeability and lab permeability results versus in-place air voids and lab permeability results versus in-place air voids for the lab compacted samples. The results for the lab compacted samples are presented in Table 98. In Figure 39, strong R^2 values were found for all three trendlines (0.87 for field permeability, 0.92 for lab permeability on cores, and 0.94 for lab permeability on lab samples). From observation of Figure 39, lab permeability values for the cores were generally lower than the field permeability and the lab permeability values for the lab compacted samples for a given air void content. This is presented by the regression line equations from Figure 39 and a permeability value of $125x10^{-5}$ cm/s. The three regression line equations suggested that the mix became permeable between 5 and 7 percent air voids.

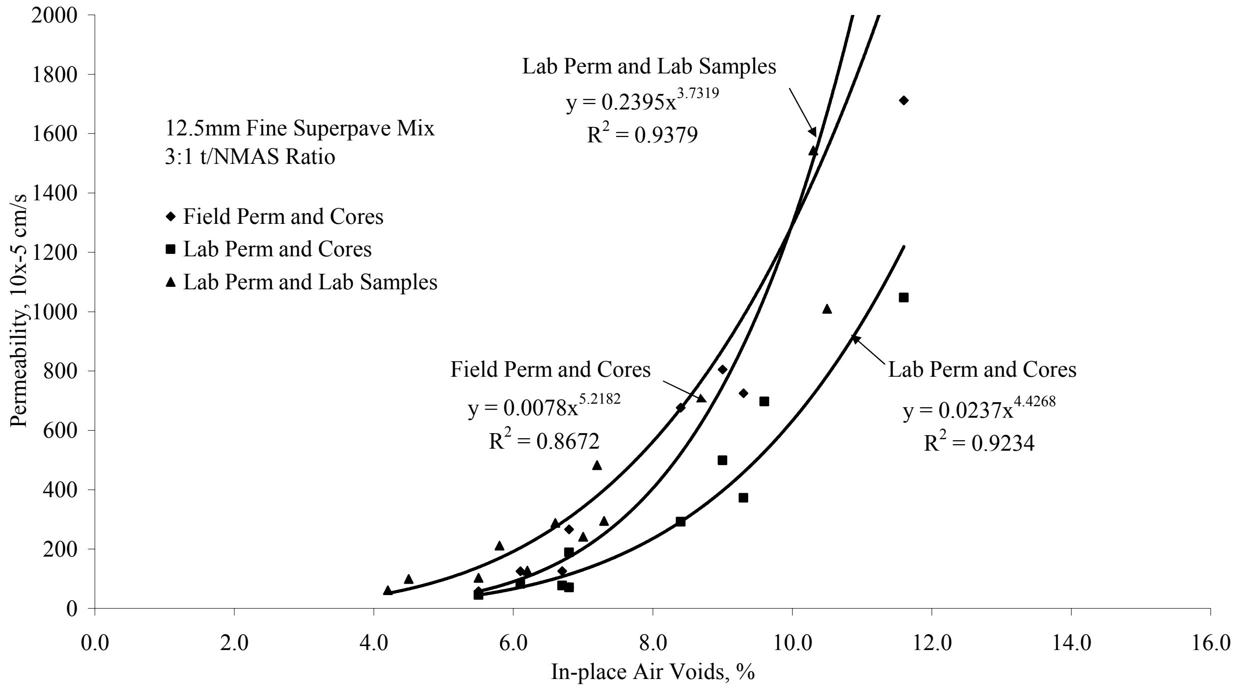

Figure 39: Relationship Between Permeability and In-place Air Voids, Project 16

Table 98: Lab Permeability Results for Lab Compacted Samples, Project 16

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	4.2	61
2	1	4.5	99
3	1	6.2	127
4	1	5.8	211
5	1	6.6	288
6	1	7.0	241
7	1	7.2	483
8	1	10.3	1543
9	2	7.3	294
10	2	5.5	103
11	2	10.5	1010
12	2	11.2	3021
13	2	12.9	3343
14	2	12.3	2240
15	2	14.0	3330
16	2	12.4	6642

5.17 Project 17:

Project 17 was the placement of new HMA in the resurfacing of a county highway. The mix consisted of a 12.5 mm NMAS fine-graded blend designed at an N_{design} of 75 gyrations, which resulted in a design asphalt content of 4.8 percent. The asphalt binder used was a PG 64-22 (unmodified).

Average gradation and binder content (solvent extraction) test results are presented in Table 99. The overall average binder content from the obtained samples for the project was 4.4 percent, 0.4 percent below the design binder content. For sublot 1, the average binder content was 0.4 percent low, and for sublot 2 the average binder content was 0.3 percent below the job mix formula. The average gradation was close to the job mix formula.

Table 99: Average Gradation and Binder Content per Sublot, Project 17

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	99.3	0.7	99.6	0.4	98.9	1.1
12.5	94.0	97.2	-3.2	97.9	-3.9	96.5	-2.5
9.5	85.0	88.7	-3.7	89.6	-4.6	87.8	-2.8
4.75	59.0	56.2	2.8	56.5	2.5	55.9	3.1
2.36	44.0	46.0	-2.0	47.0	-3.0	45.0	-1.0
1.18	40.0	39.7	0.3	40.8	-0.8	38.6	1.4
0.6	33.0	30.9	2.1	32.0	1.0	29.7	3.3
0.3	17.0	18.2	-1.2	18.7	-1.7	17.8	-0.8
0.15	6.0	7.4	-1.4	7.3	-1.3	7.5	-1.5
0.075	4.5	3.7	0.8	3.6	0.9	3.7	0.8
Asphalt Content	4.8	4.4	0.4	4.4	0.4	4.5	0.3

Table 100 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for

individual cores obtained for Project 17. In Table 101, average in-place air voids and standard deviations for the combined data and for each sublot are given.

Table 100: Core In-place Air Voids and Percent Absorption, Project 17

Sample ID	T166 VTM, %	Corelok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	9.1	9.3	10.3	11.0	0.5
2	9.5	10.1	13.6	13.9	0.5
3	10.8	8.1	14.5	15.7	0.7
4	6.8	6.9	7.0	7.9	0.2
5	13.0	13.9	15.2	15.8	0.8
6	8.5	9.2	12.7	11.9	1.2
7	9.9	10.6	13.6	13.5	0.3
8	13.0	13.9	16.5	18.0	1.5
9	11.0	11.8	12.6	17.1	0.6
10	8.2	8.5	10.3	11.2	0.2

Table 101: Average In-place Air Voids and Standard Deviations, Project 17

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	10.0	2.0	10.2	2.4	12.6	2.8	13.6	3.1
sublot 1	9.8	2.3	9.7	2.7	12.1	3.4	12.9	3.4
sublot 2	10.1	2.0	10.8	2.2	13.1	2.2	14.3	3.1

The in-place air voids for the project averaged 10.0 percent, ranging from 6.8 percent to 13.0 percent, based on AASHTO T166 bulk specific gravity measurements. For sublot 1, the average in-place air void content was 9.8 percent, and was 10.1 percent for sublot 2.

Lift thickness, field, and lab permeability results for cores are presented in Table 102. The design lift thickness for Project 17 was 37.5 mm; the actual thickness averaged 43.3 mm, 5.8 mm higher than the target value. Lift thickness ranged from 32.9 mm to 63.5 mm, or from a t/NMAS ratio of 2.6:1 to 5.1:1. PQI density results for Project 17 are presented in Table 103.

The relationship between lift thickness and in-place air voids is illustrated in Figure 40. Analysis of the data indicated little correlation between in-place air voids and lift thickness ($R^2 = 0.17$). An ANOVA conducted on the regression confirmed that the relationship was not significant (p-value = 0.059). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 102: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 17

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	43.9	14	0
2	1	41.9	15	0
3	1	32.9	42	405
4	1	39.7	5	14
5	1	63.5	163	2433
6	2	54.8	26	1344
7	2	36.7	22	1432
8	2	46.6	149	724
9	2	40.3	50	967
10	2	33.0	28	540

Table 103: Pavement Quality Indicator In-place Density Results, Project 17

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	122.5	122.7	121.4	121.7
2	1	121.1	121.2	120.4	120.7
3	1	120.9	121.1	121.4	120.9
4	1	122.8	122.9	122.4	122.6
5	1	118.2	117.0	119.6	118.5
6	2	118.2	120.0	117.4	119.8
7	2	121.2	120.3	120.8	120.8
8	2	117.9	118.7	118.4	118.1
9	2	120.0	119.6	119.7	119.5
10	2	120.7	120.6	121.3	120.7

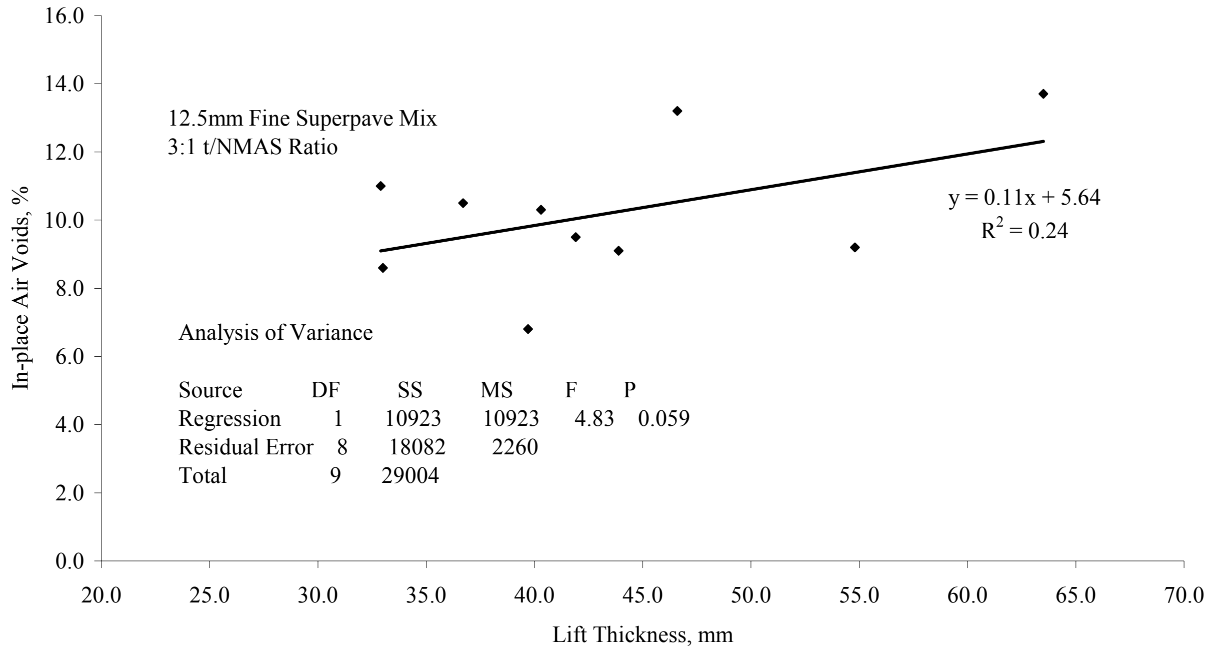

Figure 40: Relationship Between Lift Thickness and In-place Air Voids, Project 17

Figure 41 illustrates the relationship between permeability and in-place air voids for Project 17. In Figure 41, three relationships are presented. They include field permeability and lab permeability results versus in-place air voids and lab permeability results versus in-place air voids for the lab compacted samples. The results for the lab compacted samples are presented in Table 104. In Figure 41, a strong R^2 value was found for the field permeability data (0.87). A reasonable correlation was found for the lab permeability data for the cores (0.57). A low R^2 (0.10) was found for the lab permeability data for the lab compacted samples due to the permeability values being close to zero for the range of air voids From observation of Figure 41, lab permeability values for the cores were generally higher than the field permeability and the lab permeability values for the lab compacted samples for a given air void content. This is presented by the regression line equations from Figure 41 and a permeability value of 125×10^{-5} cm/s. The field permeability results suggested that the mix became permeable at an in-place air void content between 13 and 14 percent. Lab permeability test results for the cores suggested that the mix became permeable between 7 and 8 percent air voids. The lab permeability data for the lab samples was not used due to the regression line being flat.

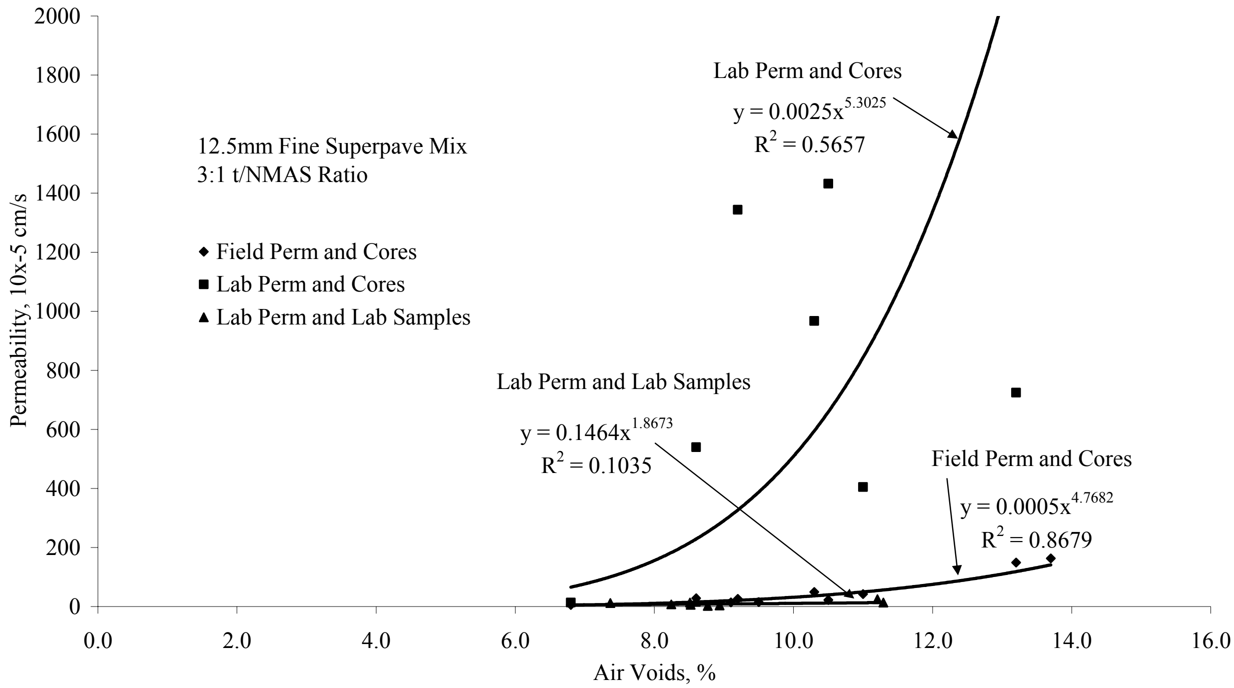

Figure 41: Relationship Between Permeability and In-place Air Voids, Project 17

Table 104: Lab Permeability Results for Lab Compacted Samples, Project 17

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	4.1	0
2	1	4.2	0
3	1	7.4	12
4	1	8.9	4
5	1	8.5	14
6	1	8.2	7
7	1	11.2	25
8	1	11.3	14
9	2	4.8	0
10	2	4.3	0
11	2	4.7	0
12	2	4.7	0
13	2	8.8	2
14	2	6.2	0
15	2	8.6	17
16	2	8.5	6

5.18 Project 18:

Project 18 was the placement of new HMA in the resurfacing of a county highway. The mix consisted of a 12.5 mm NMAS coarse-graded blend designed at an N_{design} of 75 gyrations, which resulted in a design asphalt content of 5.1 percent. The asphalt binder used was a PG 67-22.

Average gradation and binder content (solvent extraction) test results are presented in Table 105. The overall average measured binder content from the obtained samples for this project was 4.7 percent, 0.4 percent below the design binder content. For sublot 1, the average binder content was 0.5 percent low, and for sublot 2 the average binder content was 0.2 percent below the job mix formula. The average gradation was close to the job mix formula, with the majority of the sieves below than the job mix formula.

Table 105: Average Gradation and Binder Content per Sublot, Project 18

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0	100.0	0.0
12.5	98.0	98.4	-0.4	98.7	-0.7	98.1	-0.1
9.5	85.0	85.4	-0.4	85.4	-0.4	85.5	-0.5
4.75	55.0	54.9	0.1	55.3	-0.3	54.4	0.6
2.36	37.0	35.6	1.5	36.4	0.6	34.7	2.3
1.18		24.2		24.9		23.4	
0.6		17.4		18.0		16.8	
0.3	14.0	12.7	1.4	13.0	1.0	12.3	1.7
0.15		8.8		8.9		8.7	
0.075	6.5	6.0	0.5	5.9	0.6	6.0	0.5
Asphalt Content	5.1	4.7	0.4	4.6	0.5	4.9	0.2

Table 106 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for individual cores obtained for Project 18. In Table 107, average in-place air voids and standard deviations for the combined data and for each sublot are given.

Table 106: Core In-place Air Voids and Percent Absorption, Project 18

Sample ID	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	7.5	7.8	7.6	10.0	0.4
2	7.3	7.6	10.0	12.5	0.5
3	9.7	10.6	13.2	14.1	2.1
4	8.8	9.2	10.8	11.4	1.0
5	9.5	10.1	11.6	11.1	0.4
6	11.5	11.9	13.8	14.4	0.7
7	9.0	9.6	12.5	13.5	0.6
8	7.5	7.8	11.2	9.8	0.5
9	8.2	8.5	10.0	9.6	0.5
10	7.6	7.9	11.4	10.1	0.3

Table 107: Average In-place Air Voids and Standard Deviations, Project 18

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	8.7	1.3	9.1	1.4	11.2	1.8	11.7	1.9
sublot 1	8.6	1.1	9.1	1.3	10.6	2.1	11.8	1.6
sublot 2	8.8	1.6	9.1	1.7	11.8	1.4	11.5	2.3

The in-place air voids for the project averaged 8.7 percent, ranging from 7.5 percent to 11.5 percent, based on AASHTO T166 bulk specific gravity measurements. For sublot 1, the average in-place air void content was 8.6 percent, and was 8.8 percent for sublot 2.

Lift thickness, field, and lab permeability results for cores are presented in Table 108. The design lift thickness for Project 18 was 38.1 mm; the actual thickness averaged 44.5 mm, 6.4 mm higher than the target value. Lift thickness ranged from 37.9 mm to 56.7 mm, or from a t/NMAS ratio of 3.0:1 to 4.5:1. PQI density results for Project 18 are presented in Table 109.

The relationship between lift thickness and in-place air voids is illustrated in Figure 42. Analysis of the data indicated little correlation between in-place air voids and lift thickness (R^2 = 0.05). An ANOVA conducted on the regression confirmed that the relationship was not significant (p-value = 0.541). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 108: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 18

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	39.9	59	396
2	1	46.1	53	406
3	1	41.2	309	402
4	1	42.5	234	1974
5	1	56.7	105	687
6	2	45.9	244	3289
7	2	38.9	190	1551
8	2	37.9	39	405
9	2	48.3	43	773
10	2	47.5	76	391

Table 109: Pavement Quality Indicator In-place Density Results, Project 18

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	125.5	124.8	125.1	125.2
2	1	123.4	124.6	124.0	124.1
3	1	122.7	123.2	123.2	122.6
4	1	121.9	121.5	123.9	123.3
5	1	124.3	123.8	124.1	123.1
6	2	122.5	121.8	121.9	121.8
7	2	122.1	121.7	121.4	121.7
8	2	123.9	122.3	122.4	122.4
9	2	123.4	124.0	123.9	123.5
10	2	122.2	122.7	123.8	123.8

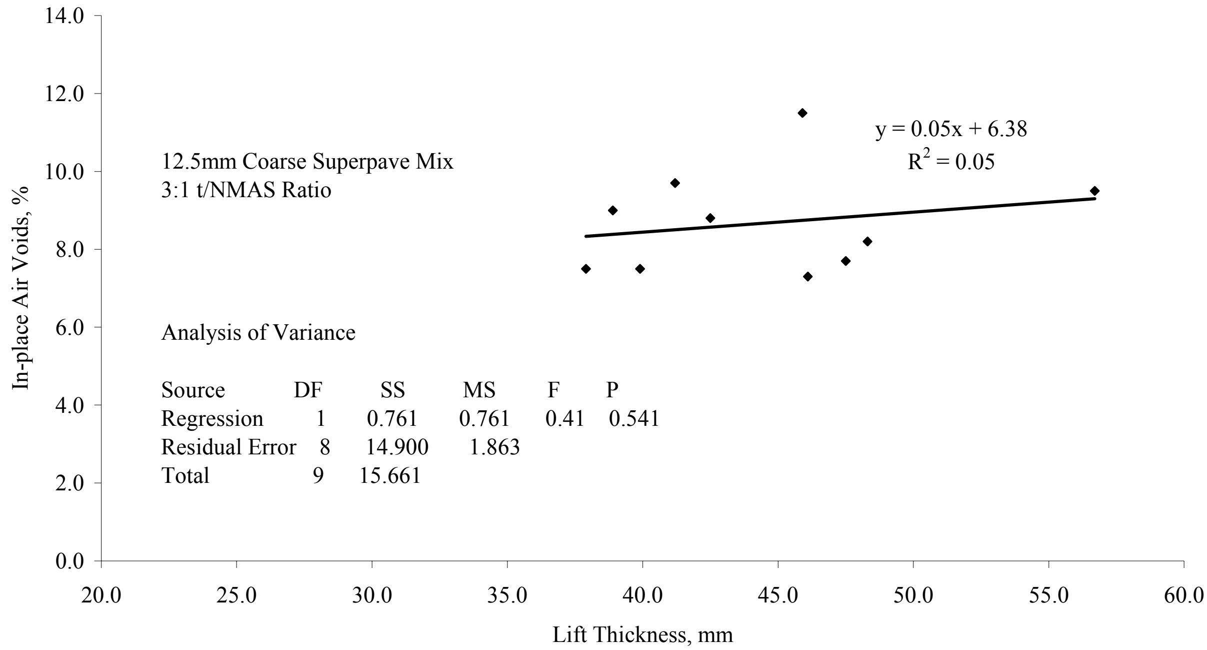

Figure 42: Relationship Between Lift Thickness and In-place Air Voids, Project 18

Figure 43 illustrates the relationship between permeability and in-place air voids for Project 18. In Figure 43, three relationships are presented. They include field permeability and lab permeability results versus in-place air voids and lab permeability results versus in-place air voids for the lab compacted samples. The results for the lab compacted samples are presented in Table 110. In Figure 43, reasonable R^2 values were found for all three trendlines (0.64 for field permeability, 0.52 for lab permeability on cores, and 0.77 for lab permeability on lab samples). From observation of Figure 43, lab permeability values for the cores were generally lower than the field permeability and higher than the lab permeability values for the lab compacted samples for a given air void content. This is presented by the regression line equations from Figure 43 and a permeability value of $125x10^{-5}$ cm/s. The field permeability results suggested that the mix became permeable at an in-place air void content between 8 and 9 percent. Lab permeability test results suggest the mix became permeable between 4 and 6 percent air voids.

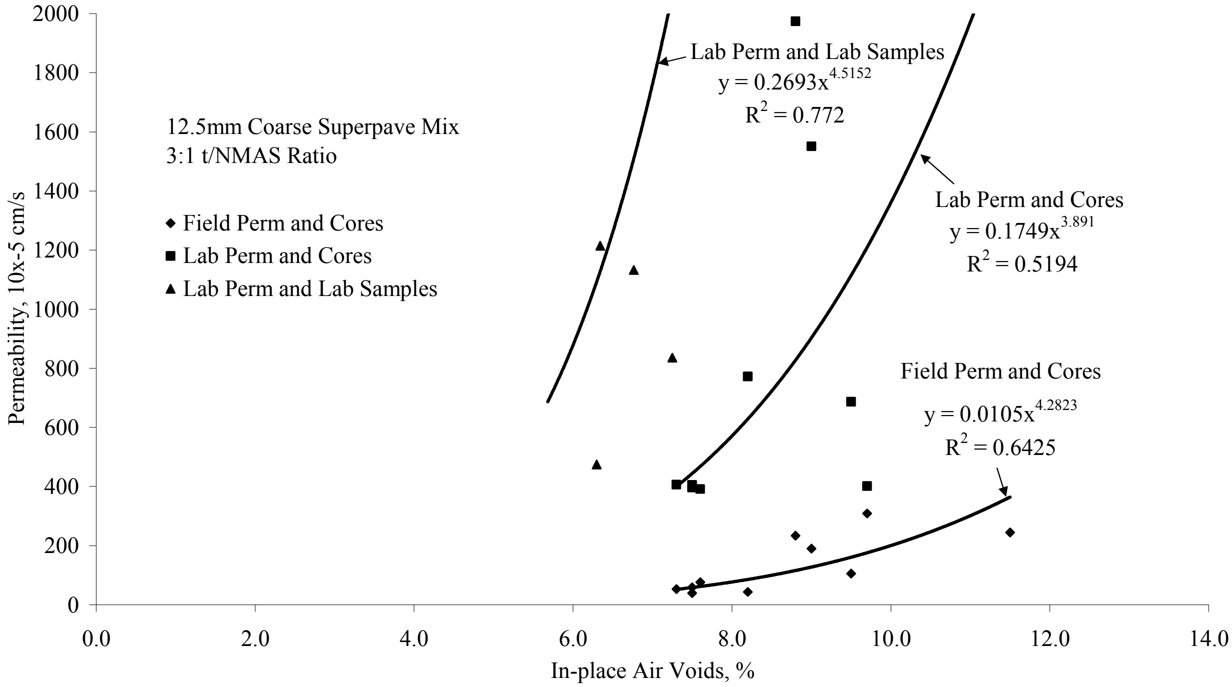

Figure 43: Relationship Between Permeability and In-place Air Voids, Project 18

Table 110: Lab Permeability Results for Lab Compacted Samples, Project 18

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	5.7	2018
2	1	6.3	474
3	1	6.3	1215
4	1	6.8	1132
5	1	9.2	7672
6	1	8.5	6819
7	1	10.6	7978
8	1	10.3	10229
9	2	7.5	3580
10	2	7.2	836
11	2	9.7	3799
12	2	8.7	4938
13	2	10.7	13167
14	2	9.7	7182
15	2	9.6	8343
16	2	11.1	25029

5.19 Project 19:

Project 19 was the placement of new HMA in the resurfacing of a county highway. The mix consisted of a 9.5 mm NMAS fine-graded blend designed at an N_{design} of 75 gyrations, which resulted in a design asphalt content of 5.5 percent. The asphalt binder used was a PG 67-22.

Average gradation and binder content (solvent extraction) test results are presented in Table 111. The overall average measured binder content from the obtained samples for the project was 5.4 percent, just 0.1 percent below the design binder content. For sublot 1, the average binder content was the design content, and for sublot 2 the average binder content was 0.2 percent below the job mix formula. The average gradation was close to the job mix formula, with the majority of the sieves above than the job mix formula.

Table 111: Average Gradation and Binder Content per Sublot, Project 19

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	100.0	0.0	100.0	0.0	100.0	0.0
12.5	100.0	100.0	0.0	100.0	0.0	100.0	0.0
9.5	98.0	98.7	-0.7	98.8	-0.8	98.7	-0.7
4.75	70.0	74.1	-4.1	74.5	-4.5	73.6	-3.6
2.36	46.0	49.6	-3.6	48.9	-2.9	50.3	-4.3
1.18		34.8		34.4		35.2	
0.6		25.1		24.9		25.3	
0.3	15.0	17.7	-2.7	17.6	-2.6	17.8	-2.8
0.15		10.3		10.2		10.3	
0.075	6.2	5.7	0.5	5.7	0.5	5.7	0.5
Asphalt Content	5.5	5.4	0.1	5.5	0.0	5.3	0.2

Table 112 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for

individual cores obtained for Project 19. In Table 113, average in-place air voids and standard deviations for the combined data and for each sublot are given.

Table 112: Core In-place Air Voids and Percent Absorption, Project 19

Sample ID	T166 VTM, %	Corelok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	12.4	14.1	11.9	15.2	0.4
2	9.1	9.8	11.6	13.1	0.2
3	9.7	9.9	10.7	12.0	0.3
4	8.5	9.0	8.4	10.3	0.3
5	10.4	10.6	10.2	12.0	0.4
6	7.7	8.1	8.3	9.2	0.2
7	10.1	10.2	9.8	12.1	0.4
8	6.2	6.3	7.2	7.6	0.2
9	5.8	5.8	7.0	7.2	0.2
10	5.9	6.2	8.3	8.7	0.2

Table 113: Average In-place Air Voids and Standard Deviations, Project 19

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	8.6	2.2	9.0	2.5	9.3	1.8	10.7	2.6
sublot 1	10.0	1.5	10.7	2.0	10.6	1.4	12.5	1.8
sublot 2	7.1	1.8	7.3	1.8	8.1	1.1	9.0	1.9

The in-place air voids for the project averaged 8.0 percent, ranging from 5.5 percent to 11.6 percent, based on AASHTO T166 bulk specific gravity measurements. For sublot 1, the average in-place air void content was 8.4 percent, and was 7.5 percent for sublot 2.

Lift thickness, field, and lab permeability results for cores are presented in Table 114. The design lift thickness for Project 19 was 31.8 mm; the actual thickness averaged 41.5 mm, 9.7 mm higher than the target value. Lift thickness ranged from 31.7 mm to 51.5 mm, or from a t/NMAS ratio of 3.3:1 to 5.4:1. PQI density results for Project 19 are presented in Table 115.

The relationship between lift thickness and in-place air voids is illustrated in Figure 44. Analysis of the data indicated a fair correlation between in-place air voids and lift thickness (R^2 = 0.52). An ANOVA conducted on the regression confirmed that the relationship was significant for this particular project (p-value = 0.025).

Table 114: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 19

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	31.7	113	756
2	1	38.2	34	781
3	1	50.9	44	868
4	1	34.7	40	360
5	1	35.4	95	438
6	2	41.8	29	456
7	2	37.6	137	310
8	2	48.3	6	957
9	2	51.5	5	0
10	2	44.4	7	0

Table 115: Pavement Quality Indicator In-place Density Results, Project 19

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	121.5	124.5	124.4	123.5
2	1	125.1	125.1	125.6	125.3
3	1	124.3	124.8	124.2	124.4
4	1	125.4	125.3	124.9	125.2
5	1	123.3	124.2	125.1	124.2
6	2	123.9	124.7	124.3	124.3
7	2	121.3	122.1	120.1	121.2
8	2	125.8	126.6	126.1	126.2
9	2	126.5	126.7	126.2	126.5
10	2	126.4	125.7	125.1	125.7

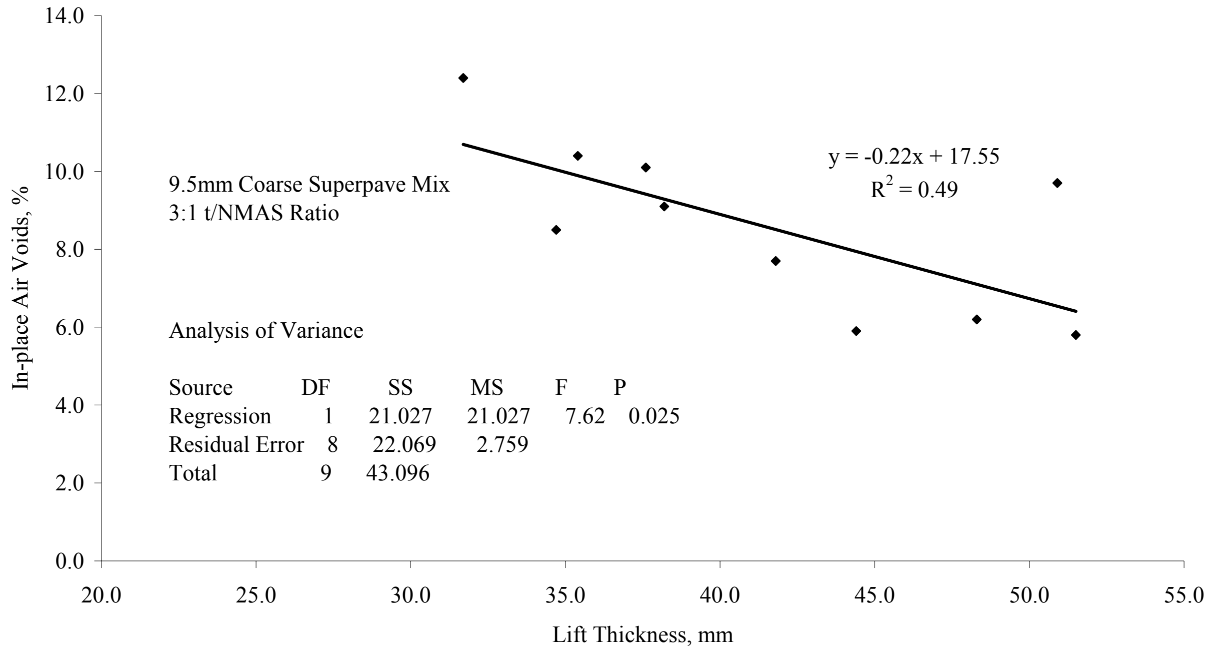

Figure 44: Relationship Between Lift Thickness and In-place Air Voids, Project 19

Figure 45 illustrates the relationship between permeability and in-place air voids for Project 19. In Figure 45, three relationships are presented. They include field permeability and lab permeability results versus in-place air voids and lab permeability results versus in-place air voids for the lab compacted samples. The results for the lab compacted samples are presented in Table 116. In Figure 45, strong R^2 values were found for two of the three trendlines (0.92 for field permeability and 0.93 for lab permeability on lab samples). A low correlation was found for the lab permeability data for the cores ($R^2 = 0.03$) due to the small range in permeability values for the range of air voids. Based on the regression line equations and a critical permeability value of $125x10^{-5}$ cm/s, the field permeability results suggested that the mix became permeable at an in-place air void content between 11 and 12 percent. Lab permeability test results for the lab samples suggested that the mix became permeable between 5 and 6 percent air voids.

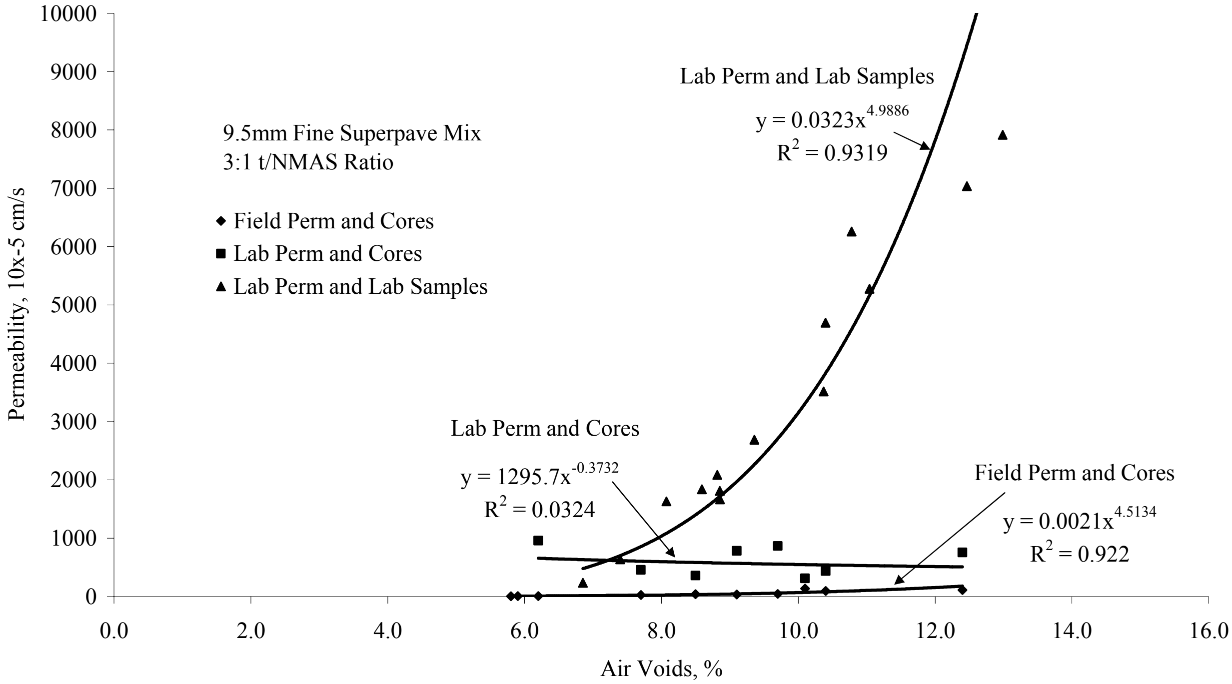

Figure 45: Relationship Between Permeability and In-place Air Voids, Project 19

Table 116: Lab Permeability Results for Lab Compacted Samples, Project 19

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	9.4	2688
2	1	8.6	1837
3	1	8.1	1632
4	1	8.8	2086
5	1	10.8	6257
6	1	10.4	4693
7	1	13.6	15409
8	1	13.4	12515
9	2	7.4	637
10	2	6.9	233
11	2	8.9	1666
12	2	8.9	1809
13	2	11.0	5276
14	2	10.4	3518
15	2	13.0	7915
16	2	12.5	7035

5.20 Project 20:

Project 20 was the placement of new HMA in the resurfacing of a United States highway. The mix consisted of a 12.5 mm NMAS fine-graded blend designed at an N_{design} of 80 gyrations, which resulted in a design asphalt content of 5.0 percent. The asphalt binder used was a PG 64-22 (unmodified).

Average gradation and binder content (solvent extraction) test results are presented in Table 117. The overall average binder content from the obtained samples for the project was 4.8 percent, 0.2 percent below the design binder content. For sublot 1, the average binder content was just 0.1 percent low, and for sublot 2 the average binder content was 0.2 percent below the job mix formula. The average gradation was close to the job mix formula, with the majority of the sieves above the job mix formula, except for the dust content, which was 0.4 percent below than the JMF.

Table 117: Average Gradation and Binder Content per Sublot, Project 20

Gradation		Overall		Sublot 1		Sublot 2	
Sieve Size (mm)	JMF	Avg	% Diff	Avg	% Diff	Avg	% Diff
37.50	100.0	100.0	0.0	100.0	0.0	100.0	0.0
25.0	100.0	100.0	0.0	100.0	0.0	100.0	0.0
19	100.0	99.8	0.2	100.0	0.0	99.7	0.3
12.5	97.0	97.7	-0.7	98.3	-1.3	97.2	-0.2
9.5	85.0	88.6	-3.6	88.8	-3.8	88.3	-3.3
4.75	55.0	59.7	-4.7	60.0	-5.0	59.3	-4.3
2.36	37.0	42.7	-5.7	43.0	-6.0	42.4	-5.4
1.18	29.0	35.7	-6.7	36.2	-7.2	35.2	-6.2
0.6	22.0	29.7	-7.7	30.3	-8.3	29.1	-7.1
0.3	11.0	12.4	-1.4	12.5	-1.5	12.3	-1.3
0.15	8.0	6.8	1.2	6.7	1.3	6.9	1.1
0.075	4.9	4.5	0.4	4.4	0.5	4.6	0.3
Asphalt Content	5.0	4.8	0.2	4.9	0.1	4.8	0.2

Table 118 contains in-place air voids (water displacement, CoreLok, CoreReader, and dimensional analysis) and water absorption values (from AASHTO T166) for

individual cores obtained for Project 20. One core was damaged being transported back to NCAT and could not be tested. In Table 119, average in-place air voids and standard deviations for the combined data and for each sublot are given.

Table 118: Core In-place Air Voids and Percent Absorption, Project 20

Sample ID	T166 VTM, %	CoreLok VTM, %	CoreReader VTM, %	Dimensional VTM, %	Water Abs., %(T166)
1	8.7	10.1	9.8	12.4	0.9
2	8.3	9.1	10.1	12.9	0.8
3	10.3	12.0	8.4	7.5	1.2
4	8.6	10.4	11.5	13.2	1.1
5			Damaged		
6	5.3	6.3	5.2	6.8	0.5
7	11.0	15.4	13.7	16.0	1.4
8	8.9	9.9	10.9	12.8	1.2
9	9.7	11.7	13.3	15.4	1.2
10	7.9	9.0	9.2	11.6	0.9

Table 119: Average In-place Air Voids and Standard Deviations, Project 20

	T166		CoreLok		CoreReader		Dimensional	
	avg	std dev	avg	std dev	avg	std dev	avg	std dev
all data	8.7	1.6	10.4	2.5	10.2	2.6	12.1	3.1
sublot 1	9.0	0.9	10.4	1.2	10.0	1.3	11.5	2.7
sublot 2	8.6	2.1	10.5	3.4	10.5	3.5	12.5	3.7

The construction in-place air voids for the project averaged 8.0 percent, ranging from 5.5 percent to 11.6 percent, based on AASHTO T166 bulk specific gravity measurements. For sublot 1, the average in-place air void content was 8.4 percent, and was 7.5 percent for sublot 2.

Lift thickness, field, and lab permeability results for cores are presented in Table 120. The design lift thickness for Project 20 was 37.5 mm; the actual thickness averaged 34.5 mm, 3.0 mm lower than the target value. Lift thickness ranged from 24.5 mm to 38.1

mm, or from a t/NMAS ratio of 2.0:1 to 3.0:1. PQI density results for Project 20 are presented in Table 121.

The relationship between lift thickness and in-place air voids is illustrated in Figure 46. Analysis of the data indicated little correlation between in-place air voids and lift thickness ($R^2 = 0.14$). An ANOVA conducted on the regression confirmed that the relationship was not significant (p-value = 0.263). The thickness only changed due to variation in the thickness caused by a number of things. To effectively estimate the effect of thickness would require that the thickness be varied by design.

Table 120: Average Lift Thickness, Field, and Lab Permeability on Cores, Project 20

Sample ID	Sublot	Avg Thickness (mm)	Avg Field Permeability (10x-5 cm/s)	Avg Lab Permeability (10x-5 cm/s)
1	1	35.0	32	626
2	1	37.6	32	623
3	1	24.5	73	301
4	1	35.6	33	444
5	1	NA	28	NA
6	2	35.5	1	0
7	2	35.7	78	2045
8	2	35.0	39	831
9	2	33.5	85	702
10	2	38.1	57	0

Table 121: Pavement Quality Indicator In-place Density Results, Project 20

Test Number	Sublot	Run 1, pcf	Run 2, pcf	Run 3, pcf	Core Avg., pcf
1	1	121.4	120.4	121.2	120.8
2	1	121.4	120.7	120.7	120.8
3	1	117.9	119.4	120.1	120.0
4	1	121.1	120.9	120.7	120.4
5	1	119.4	120.0	120.0	119.4
6	2	121.9	121.9	122.0	122.7
7	2	118.9	119.5	119.3	119.0
8	2	119.9	120.9	120.5	120.4
9	2	119.7	119.5	119.1	119.0
10	2	119.9	119.2	121.4	119.8

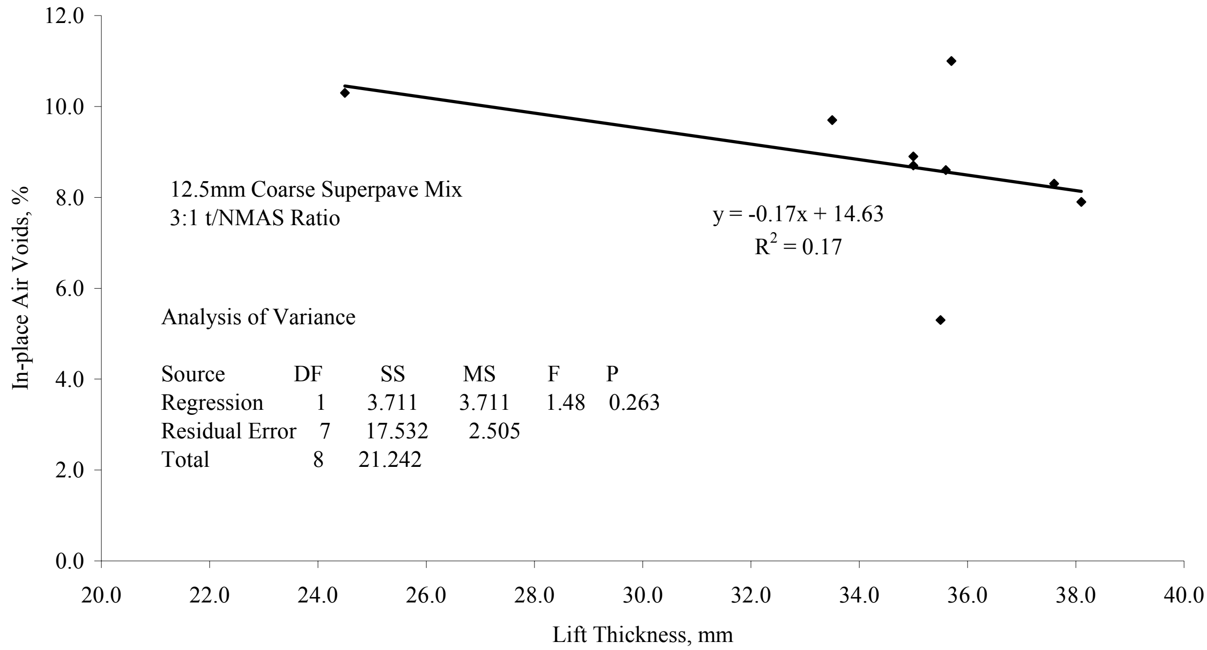

Figure 46: Relationship Between Lift Thickness and In-place Air Voids, Project 20

Figure 47 illustrates the relationship between permeability and in-place air voids for Project 20. In Figure 47, three relationships are showed. They include field permeability and lab permeability results versus in-place air voids for cores and lab permeability results versus air voids for the lab compacted samples. The results for the lab compacted samples are presented in Table 122. In Figure 47, strong R^2 values were found for two of the three trendlines (0.86 for field permeability and 0.90 for lab permeability and lab samples). A low R^2 value was found for the regression on lab permeability and cores (0.15). This may have been caused by the small range in air void contents. The field permeability results suggested that the mix became permeable at an in-place air void content between 10 and 11 percent. Lab permeability test results for both cores and lab compacted samples suggested that the mix became permeable at an air void content between 4 and 5 percent.

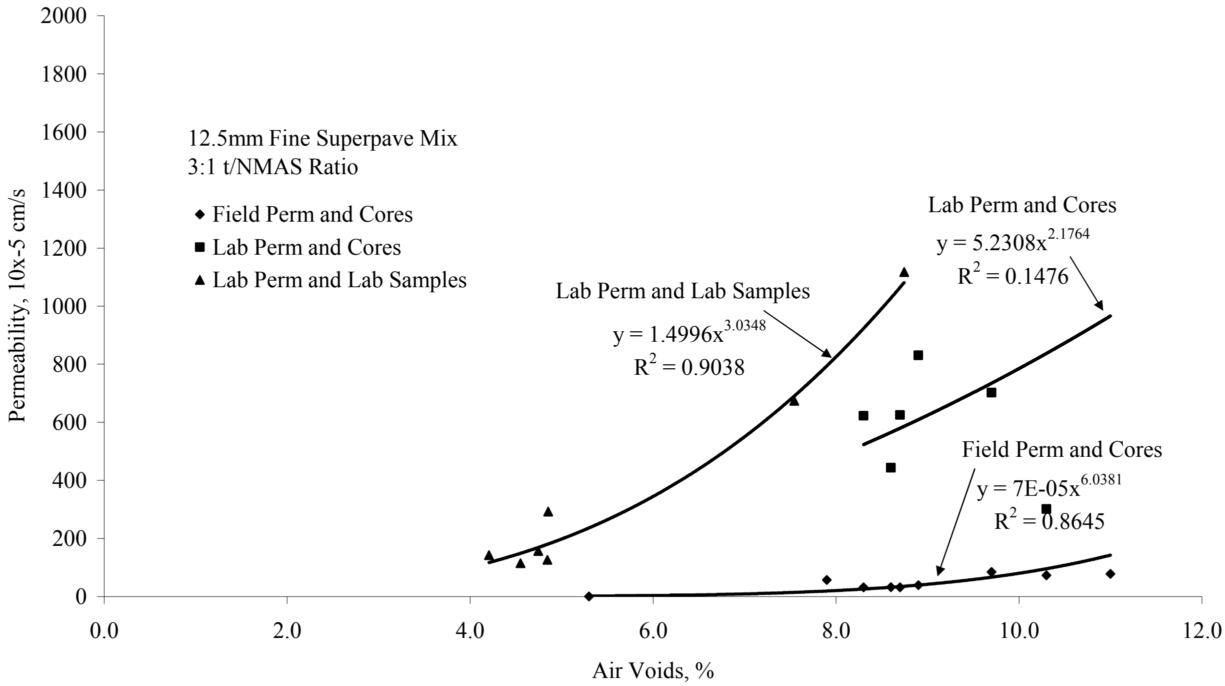

Figure 47: Relationship Between Permeability and In-place Air Voids, Project 20

Table 122: Lab Permeability Results for Lab Compacted Samples, Project 20

Sample ID	Sublot	T166 VTM, %	Avg Lab Permeability (10x-5 cm/s)
1	1	5.1	0
2	1	4.7	0
3	1	4.8	127
4	1	4.9	293
5	1	5.3	0
6	1	5.1	0
7	1	5.8	0
8	1	5.4	0
9	2	4.2	143
10	2	4.7	158
11	2	4.5	0
12	2	4.6	115
13	2	5.9	0
14	2	7.0	0
15	2	7.5	674
16	2	8.7	1117

There is a lot of variability in the permeability values for all of the projects. This is not unexpected considering that a small change in permeability can result in a 10-fold change in the coefficient of permeability. For a mix to be permeable it has to have interconnected voids. Even for the same void content the amount of interconnected voids will likely vary considerably.