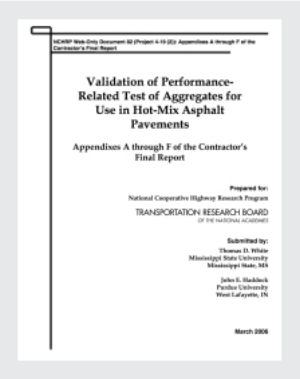

Validation of Performance-Related Test of Aggregates for Use in Hot-Mix Asphalt Pavements: Appendixes A through F

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Validation of Performance-Related Test of Aggregates for Use in Hot-Mix Asphalt Pavements

Appendixes A through F of the Contractor's Final Report

Prepared for:

National Cooperative Highway Research Program

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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March 2006

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APPENDIX A

PETROGRAPHIC ANALYSIS RESULTS

Selection of aggregates for inclusion in the experiments considered mineralogy, level of use throughout the United States, availability, and range of test properties. The goal was to maximize the range of aggregate shape, surface texture, and angularity.

Five coarse and six fine aggregates were included in the study. Coarse aggregates were from dolomite, limestone, granite, gravel, and traprock sources and fine aggregates were from granite, dolomite, gravel, traprock, and two natural sand sources. One of the natural sands has a low UVA value (Natural Sand A) and was obtained from the same source as the gravel. The second natural sand (Natural Sand B) was selected from a different source and has a higher UVA value.

Table A.1 Coarse Dolomite Analysis

Grain size, mm	Mode, mm	Grain SD	Cement, %	Matrix, %	Ground Mass, %	Voids, %	Grain Shape	Alt Grain Shape	Grains, %
0.13	0.085	9.9	7	21.5	28.4	11.7	1.7	8.9	59.9

Table A.2 Traprock Mineral Composition

Mineral Species	Crystal/Grain Size	% of Composition	Comments
Feldspar Plagioclase	Coarse	40-50	Mostly Euhedral
Pyribole highly uralized	Coarse	40-60	Subhedral
Chlorite	Coarse	<5	Irregular masses
Iron Oxides	Coarse	1-2	Irregular masses

Table A.3 Gravel and Natural Sand A

Constituent	Percent of Constituent
Clastic	5.67
Clastic (weathered)	9.55
Limestone	22.09
Dolomite	14.03
Dolomite (weathered)	7.76
Quartz	6.87
Quartzite	0.60
Chert	4.78
Mafic	15.82
Felsic	9.85
Oxidized Igneous	2.99
Total	100.00

Table A.4 Analysis for Granite

Constituent	Percent of Constituent
Granite[1]	85
Schistose rock[2]	15

Notes:

[1] The rock is of granitic composition consisting of approximately 65 percent feldspar (potash + plagioclase), 30 percent quarts, and 10 perent accessory minerals and minor components comprising biotite, muscovite, epidote, and opaque (iron) minerals. The rock is holocrystalline, hypidiomorphic granular intergrown in texture consisting of relatively larger, short, laths of plagioclase (average 1-2 mm) in a matrix of quarts intergrown with microline ina graphic, or mymekitic, texture. Quartz also occurs in finer and coarser-grained pods in which the individual grains have irregular, but not sutured, contacs and predominantly sharp extinction. The grain sizes in the coarse regions are 0.3 to 0.4 mm and in the finer regions approximately 0.03 to 0.04 mm. No fine-grained, distotrted, strined, quartzose regions of the potentially alkali-reactive type were observed.

[2] The rock is mica schist, most likely a metamorphosed, hydrothermally altered, basic igneous (metavolcanic) rock. It consists of a dense, compact, interwoven structure of micaceous minerals, chiefly biotite and muscovite with occasional grains of altered plagioclase and occasional void, or vein, filling of calcite. There is little to no quartz in the rock. The rock is predominantly fine-grained (0.8 mm) with occasional large grains up to 0.5 mm maximum dimension. No fine-grained, distorted, strained, quartzose regions of the potentially alkali-reactive type were observed.

Table A.5 Limestone Quarry

Devonian System
New Albany Shale
Shale dark brownish-gray to gray
North Vernon Limestone
Limestone, fossiliferous; upper part dark gray, dense, fossiliferous; lower part gray to tan, coarsely crystalline
Jeffersonville Limestone
Limestone, tan; upper 3,0 ft crystalline, medium bedded, fossiliferous; lower 4.4 ft mottled, fine grained, containing fossil detritus; zone of nodular chert near base
Limestone in alternating units of tan, brown, and gray color, dolomitic, dense to granular and porous in texture; in places containing breccia and black shale partings; lower part laminated;
Dolomite and limestone, alternating in few-foot intervals, light tan to brown and gray, banded, chalky, dense in places; lower 1.7 ft gray to dark gray-brown, massive to dense, containing dark-colored bands, stylolitic partings, scattered calcite crystals, and pyrite in vuggy spaces
Limestone, light-gray to light-brown, dolomitic, dense to granular; contains stromatoporoids, trilobites, brachiopoda, cup corals, and other fossils; vugs and solution cavities in lower 3.3 ft (coral zone)
Geneva Dolomite
Dolomite, brownish-gray to chocolate-brown, fine-grained to saccharoidal, massive; contains small pockets of calcite
Dolomite, medium-brown to chocolate-brown, granular to saccharoidal, massive; contains large masses of white to yellow coarsely crystalline calcite; dolomitized coral molds and casts in 2 to 3 ft zone 2.6 ft below top of unit; pyrite in places abundant
Silurian System
Louisville Limestone
Limestone, dark medium-gray, fine-grained, crystalline, massive dolomitic; stylolites common

Table A.6 Analysis for Natural Sand B

Constituent	Percent of Constituent
Quartz/Quartzite	37.3
Sandstone/Siltstone	24.8
Limestone/Dolomite	33.1
Igneous/Metamorphic	3.5
Chert	0.8
Ironstone	0.5
Total	100.0

APPENDIX B

LABORATORY HMA MIXTURE DESIGN RESULTS

B.1 MIXTURE DESIGNS

A single, unmodified asphalt binder, PG 64-22, was used in all mixtures. This binder represents a typical neat binder grade for much of the United States, and is included in most specifications. It should be noted that the experiments were designed to assess aggregate contribution to HMA mixture performance. The binder properties are summarized in Table B.1.

All mixtures were designed using the Superpave volumetric mixture design method outlined in the Asphalt Institute Manual, SP-2, *Superpave Level I Mix Design*, and subsequent addendum. The mixture design criteria used in the project are shown in Table B.2. The mixture gradations for the coarse-graded, fine-graded, and moisture susceptibility mixtures are shown in Figures B.1, B.2, and B.3, respectively.

Table B.1 Binder Properties

PG 64-22 Asphalt Binder			
Property	Test Method	Result	Specifications
Flash Point (C)	AASHTO T 48	230+	230 Min.
Rotational Viscosity @ 135C (Pa.s)	ASTM D 4402	0.40	3.0 Max.
G*/sinδ @64C (kPa)	AASHTO TP 5	1.30	1.0 Min.
Rolling Thin Film Oven (AASHTO T 230)			
Mass Loss (%)	AASHTO T 240	0.25	1.0 Max.
G*/sinδ @64C (kPa)	AASHTO TP 5	3.05	2.20 Min.
Pressure Aging Vessel Residue (AASHTO PP 1)			
Pressure Aging Temperature (C)	AASHTO PP 1	-	100
G*sinδ @25C (kPa)	AASHTO TP 5	4120	5000 Max.
Creep Stiffness @ -12C (MPa)	AASHTO TP 1	184	300 Max.
m-value @ -12C	AASHTO TP 1	0.32	0.30 Min.

Table B.2 Mixture Design Criteria

Property	Criteria
$N_{initial}$	8
N_{design}	100
$N_{maximum}$	160
Voids @ Optimum Binder Content, %	4.0
VMA, %	14.0
VFA, %	65-75
Dust/Binder Ratio	0.8-1.6
% G_{mm} @ $N_{initial}$	<89
% G_{mm} @ $N_{maximum}$	<98

B.2 HMA MIXTURE DESIGN FOR RUTTING EXPERIMENTS

B.2.1 Coarse-graded Mixtures

Table B.3 Mixture CA-1: Coarse Dolomite (IN) and Natural Sand A (IN)

Property	Criteria	Ndes					Nmax
		CA-1 (5.0)	CA-1 (5.5)	CA-1 (6.0)	CA-1 (6.5)	*AC_{des}	CA-1 (5.69)
%AC		5.0	5.5	6.0	6.5	5.7	5.7
%Air Voids (V_a)	4.0 %	5.9	4.6	2.9	1.9	4.0	3.0
%VMA	14.0 % Min.	15.2	15.1	14.7	14.9	14.9	14.1
%VFA	65.0 % Min. 75.0 % Max.	61.2	69.6	80.4	87.4	73.4	78.8
Dust/Asphalt Ratio	0.8-1.6 %	0.8	0.7	0.7	0.6	0.7	0.7
Max. Specific Gravity (G_{mm})		2.551	2.532	2.512	2.493	2.524	2.524
Bulk Specific Gravity (G_{mb})		2.401	2.415	2.440	2.446		2.449
%G_{mm} @ N_{ini}	89.0 % Max.	84.5	85.5	86.8	87.6	86.0	
%G_{mm} @ N_{max}	98.0 % Max.						97.0
Effective Sp. Gravity of Blend (G_{se})	---	2.766	2.766	2.766	2.766	2.766	2.766
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.689	2.689	2.689	2.689	2.689	2.689

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.4 Mixture CA-2: Coarse Limestone (IN) and Natural Sand A (IN)

Property	Criteria	Ndes					Nmax
		CA-2 (5.5)	CA-2 (6.0)	CA-2 (6.5)	CA-2 (7.0)	*AC_{des}	CA-2 (6.1)
%AC		5.5	6.0	6.5	7.0	6.1	6.1
%Air Voids (V_a)	4.0 %	5.5	4.1	3.1	1.9	4.0	3.1
%VMA	14.0 % Min.	14.1	13.9	14.1	14.1	14.0	13.2
%VFA	65.0 % Min. 75.0 % Max.	60.9	70.5	78.2	86.8	71.5	76.7
Dust/Asphalt Ratio	0.8-1.6 %	1.1	0.9	0.8	0.8	0.9	0.9
Max. Specific Gravity (G_{mm})		2.469	2.451	2.433	2.415	2.447	2.447
Bulk Specific Gravity (G_{mb})		2.333	2.350	2.359	2.371		2.372
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	84.1	85.4	86.2	87.1	85.4	
$\%G_{mm}$ @ N_{max}	98.0 % Max.						96.9
Effective Sp. Gravity of Blend (G_{se})	---	2.688	2.688	2.688	2.688	2.688	2.688
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.566	2.566	2.566	2.566	2.566	2.566

Table B.5 Mixture CA-3: Coarse Gravel (IN) and Natural Sand A (IN)

Property	Criteria	Ndes					Nmax
		CA-3 (3.5)	CA-3 (4.0)	CA-3 (4.5)	CA-3 (5.0)	*AC_{des}	CA-3 (3.87)
%AC		3.5	4.0	4.5	5.0	3.87	3.87
%Air Voids (V_a)	4.0 %	5.2	3.6	1.7	0.6	4.0	2.9
%VMA	14.0 % Min.	11.2	10.8	10.2	10.3	10.8	9.9
%VFA	65.0 % Min. 75.0 % Max.	53.2	66.6	83.2	94.3	63.6	70.2
Dust/Asphalt Ratio	0.8-1.6 %	1.2	1.0	0.9	0.8	1.1	1.1
Max. Specific Gravity (G_{mm})		2.525	2.506	2.488	2.469	2.511	2.511
Bulk Specific Gravity (G_{mb})		2.393	2.416	2.445	2.455		2.437
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	87.5	88.8	90.4	91.4	88.5	
$\%G_{mm}$ @ N_{max}	98.0 % Max.						97.1
Effective Sp. Gravity of Blend (G_{se})	---	2.665	2.665	2.665	2.665	2.665	2.665
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.600	2.600	2.600	2.600	2.600	2.600

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.6 Mixture CA-4: Coarse Granite (NC) and Natural Sand A (IN)

Property	Criteria	Ndes					Nmax
		CA-4 (5.0)	CA-4 (5.5)	CA-4 (6.0)	CA-4 (6.5)	*AC_{des}	CA-4 (5.8)
%AC		5.0	5.5	6.0	6.5	5.81	5.8
%Air Voids (V_a)	4.0 %	5.8	4.6	3.5	2.5	4.0	2.9
%VMA	14.0 % Min.	16.0	16.0	16.1	16.3	16.0	15.1
%VFA	65.0 % Min. 75.0 % Max.	63.5	71.0	78.1	84.5	75.1	80.8
Dust/Asphalt Ratio	0.8-1.6 %	0.8	0.7	0.6	0.6	0.7	0.6
Max. Specific Gravity (G_{mm})		2.491	2.472	2.454	2.436	2.461	2.461
Bulk Specific Gravity (G_{mb})		2.345	2.357	2.368	2.375		2.389
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	85.8	86.6	87.3	88.1	87.0	
$\%G_{mm}$ @ N_{max}	98.0 % Max.						97.1
Effective Sp. Gravity of Blend (G_{se})	---	2.691	2.691	2.691	2.691	2.691	2.691
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.652	2.652	2.652	2.652	2.652	2.652

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.7 Mixture CA-5: Coarse Traprock (VA) and Natural Sand A (IN)

Property	Criteria	Ndes					Nmax
		CA-5 (4.0)	CA-5 (4.5)	CA-5 (5.0)	CA-5 (5.5)	*AC_{des}	CA-5 (3.72)
%AC		4.0	4.5	5.0	5.5	4.8	4.8
%Air Voids (V_a)	4.0 %	6.0	4.6	3.5	1.9	4.0	3.0
%VMA	14.0 % Min.	14.3	14.3	14.4	14.2	14.3	13.6
%VFA	65.0 % Min. 75.0 % Max.	58.4	67.6	75.6	86.5	72.0	77.5
Dust/Asphalt Ratio	0.8-1.6 %	0.7	0.6	0.6	0.5	0.6	0.6
Max. Specific Gravity (G_{mm})		2.664	2.643	2.621	2.600	2.630	2.630
Bulk Specific Gravity (G_{mb})		2.506	2.520	2.529	2.550		2.549
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	86.5	87.6	88.7	89.9	88.2	
$\%G_{mm}$ @ N_{max}	98.0 % Max.						97.0
Effective Sp. Gravity of Blend (G_{se})	---	2.853	2.853	2.853	2.853	2.853	2.853
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.808	2.808	2.808	2.808	2.808	2.808

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

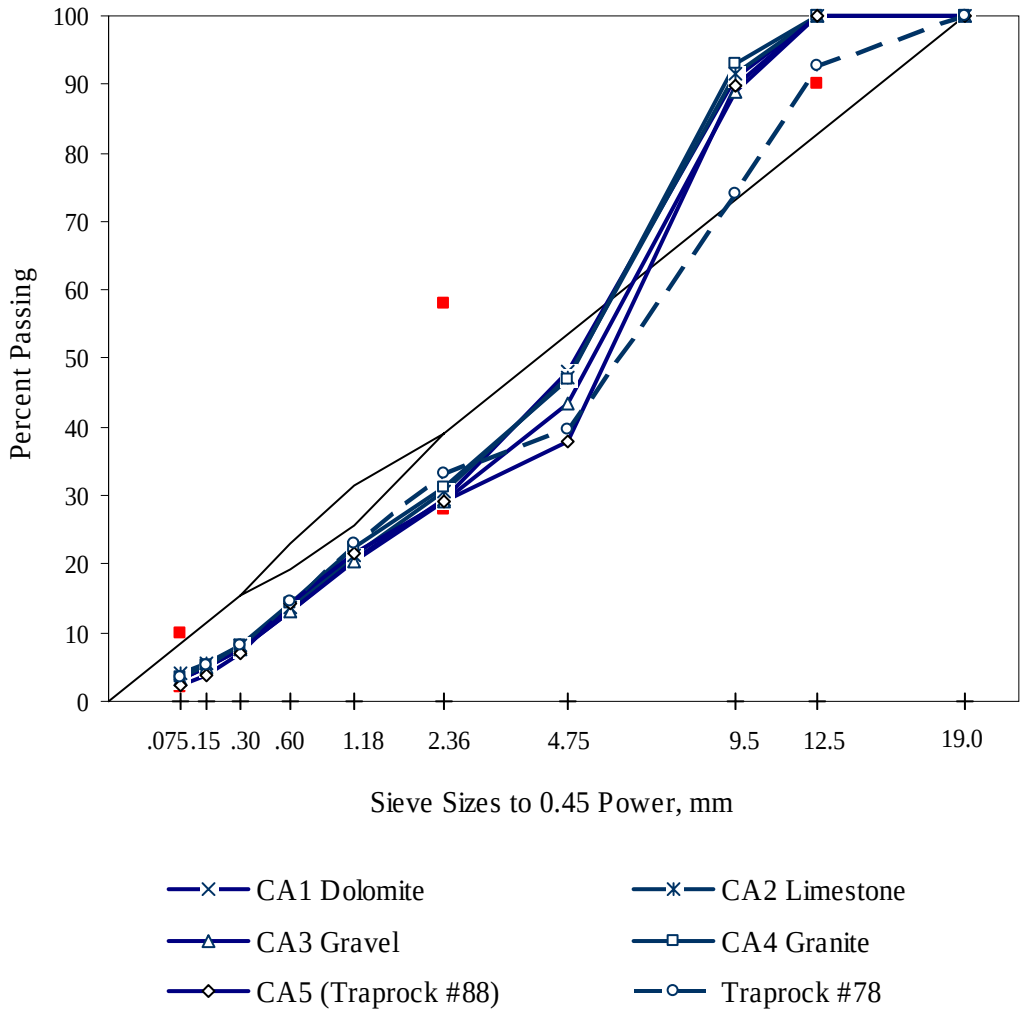

Figure B.1 Coarse-Graded Mixture Gradations

B.2.2 Fine-graded Mixtures

Table B.8 Mixture FA-1: Natural Sand A (IN) and Coarse Gravel (IN)

Property	Criteria	Ndes					Nmax
		FA-1A (5.0)	FA-1A (5.5)	FA-1A (6.5)	FA-1 (6.0)	*AC_{des}	FA-1 (6.0)
%AC		5.0	5.5	6.5	6.0	6.0	6.0
%Air Voids (V_a)	4.0 %	7.2	5.5	2.7	4.1	4.0	3.3
%VMA	14.0 % Min.	15.9	15.5	15.1	15.3	15.3	14.6
%VFA	65.0 % Min. 75.0 % Max.	55.0	64.5	82.1	73.3	74.0	77.4
Dust/Asphalt Ratio	0.8-1.6 %	0.6	0.5	0.4	0.4	0.4	0.4
Max. Specific Gravity (G_{mm})		2.474	2.455	2.420	2.438	2.438	2.438
Bulk Specific Gravity (G_{mb})		2.296	2.321	2.354	2.338		2.357
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	87.9	89.4	92.0	90.4	90.7	
$\%G_{mm}$ @ N_{max}	98.0 % Max.						96.7
Effective Sp. Gravity of Blend (G_{se})	---	2.671	2.671	2.671	2.671	2.671	2.671
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.594	2.594	2.594	2.594	2.594	2.594

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.9 Mixture FA-2: Crushed gravel sand (IN) and Coarse Gravel (IN)

Property	Criteria	Ndes					Nmax
		FA-2B (6.7)	FA-2B (5.7)	FA-2B (5.2)	FA-2B (6.2)	*AC_{des}	FA-2 (5.71)
%AC		6.7	5.7	5.2	6.2	5.71	5.7
%Air Voids (V_a)	4.0 %	1.3	4.2	5.4	2.3	4.0	3.1
%VMA	14.0 % Min.	15.8	16.2	16.2	15.6	16.2	15.2
%VFA	65.0 % Min. 75.0 % Max.	91.8	73.9	66.7	85.1	75.2	79.9
Dust/Asphalt Ratio	0.8-1.6 %	0.6	0.7	0.8	0.7	0.7	0.7
Max. Specific Gravity (G_{mm})		2.412	2.447	2.465	2.429	2.447	2.447
Bulk Specific Gravity (G_{mb})		2.381	2.343	2.332	2.373		2.372
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	90.4	88.2	87.1	89.6	88.3	
$\%G_{mm}$ @ N_{max}	98.0 % Max.						96.9
Effective Sp. Gravity of Blend (G_{se})	---	2.669	2.669	2.669	2.669	2.669	2.669
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.638	2.638	2.638	2.638	2.638	2.638

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.10 Mixture FA-3: Natural Sand B (OH) and Coarse Gravel (IN)

Property	Criteria	Ndes					Nmax
		FA-3 (5.0)	FA-3 (5.5)	FA-3 (6.0)	FA-3 (6.5)	*AC_{des}	FA-3 (5.84)
%AC		5.0	5.5	6.0	6.5	5.8	5.8
%Air Voids (V_a)	4.0 %	6.6	4.8	3.5	2.1	4.0	2.9
%VMA	14.0 % Min.	15.6	15.1	15.0	14.8	15.0	14.1
%VFA	65.0 % Min. 75.0 % Max.	57.8	68.0	76.6	85.6	73.6	79.7
Dust/Asphalt Ratio	0.8-1.6 %	0.9	0.8	0.7	0.7	0.8	0.8
Max. Specific Gravity (G_{mm})		2.475	2.456	2.439	2.421	2.444	2.444
Bulk Specific Gravity (G_{mb})		2.312	2.338	2.353	2.369		2.374
%G_{mm} @ N_{ini}	89.0 % Max.	86.8	88.2	89.2	90.4	88.9	
%G_{mm} @ N_{max}	98.0 % Max.						97.1
Effective Sp. Gravity of Blend (G_{se})	---	2.672	2.672	2.672	2.672	2.672	2.672
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.602	2.602	2.602	2.602	2.602	2.602

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.11 Mixture FA-4: Granite Sand (NC) and Coarse Gravel (IN)

Property	Criteria	Ndes					Nmax
		FA-4 (4.0)	FA-4 (4.5)	FA-4 (5.0)	FA-4 (6.0)	*AC_{des}	FA-4 (4.94)
%AC		4.0	4.5	5.0	6.0	4.9	4.9
%Air Voids (V_a)	4.0 %	7.2	5.3	3.5	0.8	4.0	2.7
%VMA	14.0 % Min.	15.4	14.7	14.2	13.9	14.3	13.3
%VFA	65.0 % Min. 75.0 % Max.	53.0	63.9	75.1	94.3	73.0	79.6
Dust/Asphalt Ratio	0.8-1.6 %	2.3	2.1	1.8	1.5	1.9	1.9
Max. Specific Gravity (G_{mm})		2.494	2.476	2.457	2.422	2.460	2.460
Bulk Specific Gravity (G_{mb})		2.314	2.344	2.370	2.403		2.393
%G_{mm} @ N_{ini}	89.0 % Max.	85.5	87.0	88.3	91.0	88.1	
%G_{mm} @ N_{max}	98.0 % Max.						97.3
Effective Sp. Gravity of Blend (G_{se})	---	2.651	2.651	2.651	2.651	2.651	2.651
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.625	2.625	2.625	2.625	2.625	2.625

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.12 Mixture FA-5: Dolomite Sand (IN) and Coarse Gravel (IN)

Property	Criteria	Ndes					Nmax
		FA-5N-03 (6.0)	FA-5N-03 (6.5)	FA-5N-03 (7.0)	FA-5N-03 (7.5)	*AC_{des}	FA5N-03 (6.3)
%AC		6.0	6.5	7.0	7.5	6.3	6.3
%Air Voids (V_a)	4.0 %	4.8	3.5	2.0	0.3	4.0	2.6
%VMA	14.0 % Min.	15.8	15.8	15.5	15.2	15.8	14.5
%VFA	65.0 % Min. 75.0 % Max.	69.8	77.6	87.4	97.8	74.7	82.3
Dust/Asphalt Ratio	0.8-1.6 %	0.7	0.7	0.6	0.6	0.7	0.7
Max. Specific Gravity (G_{mm})		2.465	2.446	2.429	2.411	2.454	2.454
Bulk Specific Gravity (G_{mb})		2.347	2.360	2.381	2.403		2.391
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	87.0	88.0	88.8	90.2	87.5	
$\%G_{mm}$ @ N_{max}	98.0 % Max.						97.4
Effective Sp. Gravity of Blend (G_{se})	---	2.705	2.705	2.705	2.705	2.705	2.705
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.620	2.620	2.620	2.620	2.620	2.620

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.13 Mixture FA-6: Traprock Sand (VA) and Coarse Gravel (IN)

Property	Criteria	Ndes					Nmax
		FA-6 (4.0)	FA-6 (4.5)	FA-6 (5.0)	FA-6 (6.0)	*AC_{des}	FA-6 (4.9)
%AC		4.0	4.5	5.0	6.0	4.9	4.9
%Air Voids (V_a)	4.0 %	7.2	5.3	3.5	0.5	4.0	2.8
%VMA	14.0 % Min.	15.4	14.8	14.3	14.0	14.4	13.4
%VFA	65.0 % Min. 75.0 % Max.	53.0	63.9	75.6	96.1	72.2	79.2
Dust/Asphalt Ratio	0.8-1.6 %	2.0	1.8	1.6	1.3	1.6	1.6
Max. Specific Gravity (G_{mm})		2.658	2.636	2.615	2.573	2.619	2.619
Bulk Specific Gravity (G_{mb})		2.466	2.496	2.524	2.559		2.546
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	85.3	86.5	87.9	90.5	87.7	
$\%G_{mm}$ @ N_{max}	98.0 % Max.						97.2
Effective Sp. Gravity of Blend (G_{se})	---	2.845	2.845	2.845	2.845	2.845	2.845
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.797	2.797	2.797	2.797	2.797	2.797

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

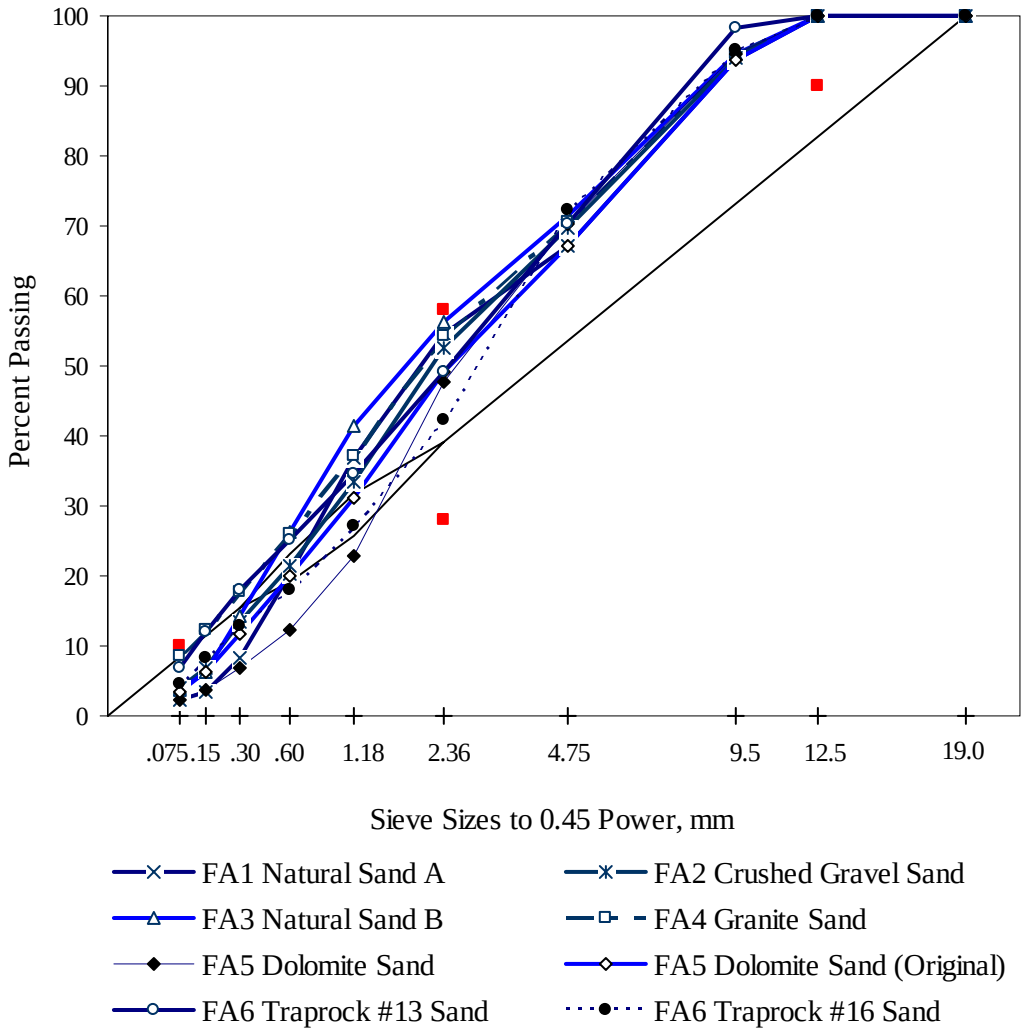

Figure B.2 Fine-Graded Mixture Gradations

B.3 HMA MIXTURE DESIGN FOR MOISTURE SUSCEPTIBILITY EXPERIMENTS

B.3.1 Fine-graded Mixtures

Table B.14 Mixture FAM-1: Natural Sand A (IN) and Coarse Dolomite (IN)

Property	Criteria	Ndes					Nmax
		FAM-1 (5.0)	FAM-1 (5.5)	FAM-1 (6.0)	FAM-1 (6.5)	*AC_{des}	FAM-1 (6.1)
%AC		5.0	5.5	6.0	6.5	6.1	6.1
%Air Voids (V_a)	4.0 %	7.3	5.7	4.3	2.6	4.0	3.1
%VMA	14.0 % Min.	16.2	15.8	15.7	15.3	15.6	14.7
%VFA	65.0 % Min. 75.0 % Max.	55.0	63.9	72.6	82.8	74.4	78.9
Dust/Asphalt Ratio	0.8-1.6 %	0.9	0.8	0.7	0.6	0.7	0.7
Max. Specific Gravity (G_{mm})		2.521	2.502	2.483	2.464	2.481	2.481
Bulk Specific Gravity (G_{mb})		2.337	2.359	2.376	2.399		2.404
%G_{mm} @ N_{ini}	89.0 % Max.	87.1	88.4	89.8	91.4	90.1	
%G_{mm} @ N_{max}	98.0 % Max.						96.9
Effective Sp. Gravity of Blend (G_{se})	---	2.728	2.728	2.728	2.728	2.728	2.728
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.648	2.648	2.648	2.648	2.648	2.648

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.15 Mixture FAM-2: Crushed gravel sand (IN) and Coarse Dolomite (IN)

Property	Criteria	Ndes					Nmax
		FAM-2 (5.5)	FAM-2 (6.0)	FAM-2 (6.5)	FAM-2 (7.0)	*AC_{des}	FAM-2 (6.4)
%AC		5.5	6.0	6.5	7.0	6.35	6.4
%Air Voids (V_a)	4.0 %	6.7	4.9	3.5	2.2	4.0	2.8
%VMA	14.0 % Min.	17.4	16.9	16.8	16.7	16.8	15.9
%VFA	65.0 % Min. 75.0 % Max.	61.7	71.0	79.1	87.0	76.4	82.3
Dust/Asphalt Ratio	0.8-1.6 %	1.1	1.0	0.9	0.8	0.9	0.9
Max. Specific Gravity (G_{mm})		2.517	2.498	2.479	2.461	2.485	2.485
Bulk Specific Gravity (G_{mb})		2.349	2.376	2.392	2.407		2.415
%G_{mm} @ N_{ini}	89.0 % Max.	85.6	87.0	87.9	88.9	87.6	
%G_{mm} @ N_{max}	98.0 % Max.						97.2
Effective Sp. Gravity of Blend (G_{se})	---	2.748	2.748	2.748	2.748	2.748	2.748
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.687	2.687	2.687	2.687	2.687	2.687

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.16 Mixture FAM-3: Granite Sand (NC) and Coarse Dolomite (IN)

Property	Criteria	Ndes					Nmax
		FAM-3 (5.0)	FAM-3 (5.5)	FAM-3 (6.0)	FAM-3 (6.5)	*AC_{des}	FAM-3 (5.4)
%AC		5.0	5.5	6.0	6.5	5.41	5.4
%Air Voids (V_a)	4.0 %	5.4	3.6	2.0	0.9	4.0	2.8
%VMA	14.0 % Min.	15.8	15.2	14.9	15.1	15.3	14.4
%VFA	65.0 % Min. 75.0 % Max.	65.7	76.7	86.8	94.0	74.3	80.3
Dust/Asphalt Ratio	0.8-1.6 %	1.9	1.7	1.5	1.4	1.7	1.7
Max. Specific Gravity (G_{mm})		2.503	2.485	2.466	2.448	2.488	2.488
Bulk Specific Gravity (G_{mb})		2.368	2.396	2.418	2.426		2.417
%G_{mm} @ N_{ini}	89.0 % Max.	86.3	87.8	89.2	90.5	87.5	
%G_{mm} @ Nmax	98.0 % Max.						97.2
Effective Sp. Gravity of Blend (G_{se})	---	2.707	2.707	2.707	2.707	2.707	2.707
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.671	2.671	2.671	2.671	2.671	2.671

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.17 Mixture FAM-4: Traprock Sand (VA) and Coarse Dolomite (IN)

Property	Criteria	Ndes					Nmax
		FAM-4(02) (5.0)	FAM-4(02) (5.5)	FAM-4(02) (6.0)	FAM-4(02) (6.5)	*AC_{des}	FAM-4(02) (5.3)
%AC		5.0	5.5	6.0	6.5	5.3	5.3
%Air Voids (V_a)	4.0 %	4.9	3.3	1.3	0.5	4.0	2.7
%VMA	14.0 % Min.	15.2	14.9	14.3	14.8	15.0	13.8
%VFA	65.0 % Min. 75.0 % Max.	67.6	77.7	91.0	96.7	73.3	80.4
Dust/Asphalt Ratio	0.8-1.6 %	1.5	1.4	1.2	1.1	1.4	1.4
Max. Specific Gravity (G_{mm})		2.662	2.640	2.618	2.597	2.650	2.650
Bulk Specific Gravity (G_{mb})		2.531	2.552	2.585	2.584		2.578
%G_{mm} @ N_{ini}	89.0 % Max.	86.1	87.1	88.7	89.9	86.7	
%G_{mm} @ N_{max}	98.0 % Max.						97.3
Effective Sp. Gravity of Blend (G_{se})	---	2.904	2.904	2.904	2.904	2.904	2.904
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.835	2.835	2.835	2.835	2.835	2.835

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

Table B.18 Mixture FAM-5: Natural Sand B (OH) and Coarse Dolomite (IN)

Property	Criteria	Ndes					Nmax
		FAM-5 (5.5)	FAM-5 (6.0)	FAM-5 (6.5)	FAM-5 (7.0)	*AC_{des}	FAM-5 (6.1)
%AC		5.5	6.0	6.5	7.0	6.1	6.1
%Air Voids (V_a)	4.0 %	5.8	4.1	2.9	1.6	4.0	3.2
%VMA	14.0 % Min.	16.3	15.9	15.9	15.8	15.9	15.2
%VFA	65.0 % Min. 75.0 % Max.	64.5	74.3	81.7	90.1	75.2	79.2
Dust/Asphalt Ratio	0.8-1.6 %	0.8	0.7	0.7	0.6	0.7	0.7
Max. Specific Gravity (G_{mm})		2.491	2.473	2.454	2.436	2.469	2.469
Bulk Specific Gravity (G_{mb})		2.347	2.372	2.383	2.398		2.394
$\%G_{mm}$ @ N_{ini}	89.0 % Max.	87.5	88.8	89.8	91.0	88.9	
$\%G_{mm}$ @ Nmax	98.0 % Max.						96.8
Effective Sp. Gravity of Blend (G_{se})	---	2.715	2.715	2.715	2.715	2.715	2.715
Sp. Gravity of Binder (G_b)	---	1.030	1.030	1.030	1.030	1.030	1.030
Sp. Gravity of Aggregate (Gs_b)	---	2.650	2.650	2.650	2.650	2.650	2.650

*The volumetric properties of mixtures with design asphalt content and compacted at N design are computed using regression analysis

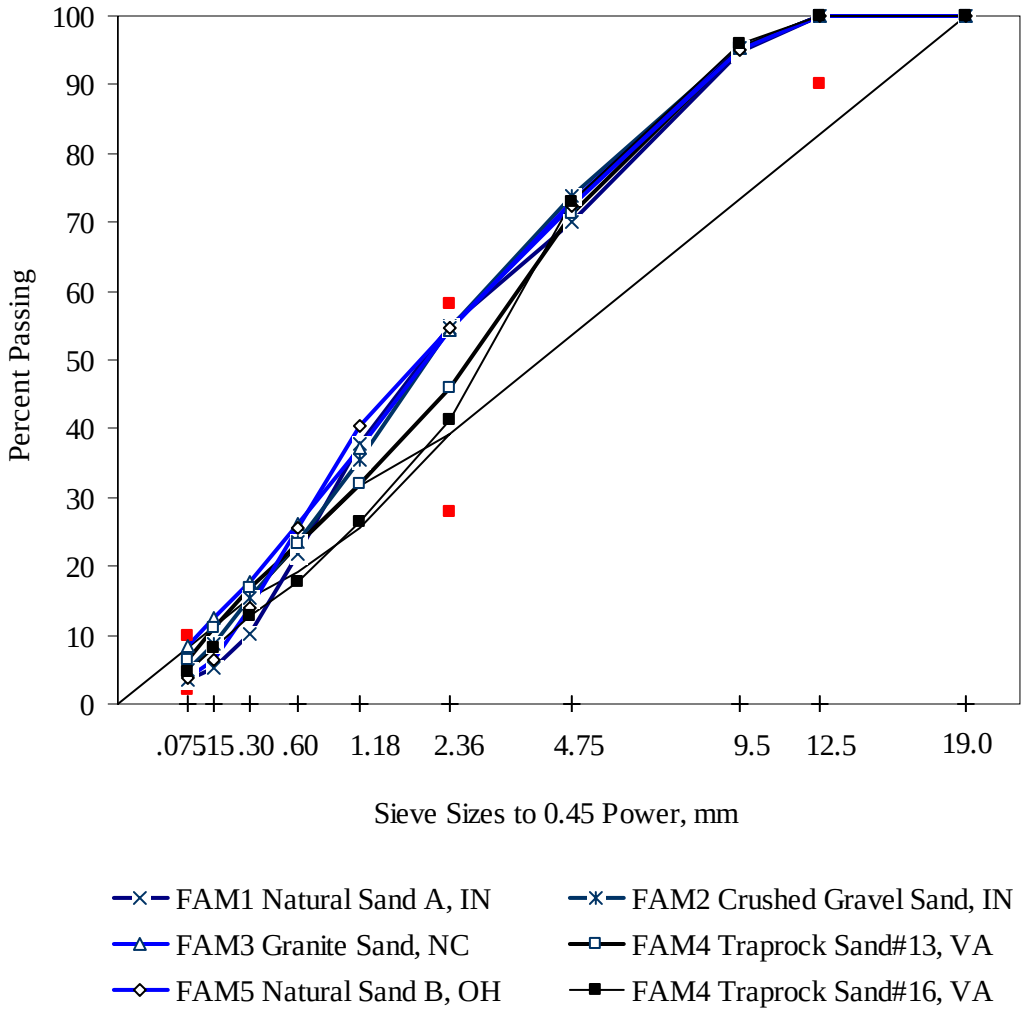

Figure B.3 Moisture Susceptibility Mixture Gradations

APPENDIX C

AGGREGATE TEST

C.1 FLAT OR ELONGATED PARTICLE TEST (ASTM D4791) – LABORATORY MIX DESIGN SOURCE

C.1.1 Dolomite Coarse Aggregate (Indiana)

Table C.1 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	94.0	43.9	336.4	474.3	19.8	9.3	29.1	70.9
	Trial 2	106.9	37.6	379.6	524.1	20.4	7.2	27.6	72.4
	Trial 3	18.1	0.0	127.1	145.2	12.5	0.0	12.5	87.5
-9.5mm + 4.75mm	Trial 1	75.2	71.4	125.8	272.4	27.6	26.2	53.8	46.2
	Trial 2	28.6	15.3	54.0	97.9	29.2	15.6	44.8	55.2
	Trial 3	28.7	16.7	45.1	90.5	31.7	18.5	50.2	49.8

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	13.4	17.6	5.5	23.0	77.0
-9.5mm + 4.75mm	61.9	29.5	20.1	49.6	50.4
Weighted Average =		27.4	17.5	44.9	55.1

Table C.2 Flat or Elongated Particle 3:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	7.3	0.0	346.2	353.5	2.1	0.0	2.1	97.9
	Trial 2	3.0	0.0	334.1	337.1	0.9	0.0	0.9	99.1
	Trial 3	2.9	0.0	342	344.9	0.8	0.0	0.8	99.2
-9.5mm + 4.75mm	Trial 1	5.6	0.0	99.6	105.2	5.3	0.0	5.3	94.7
	Trial 2	4.3	0.0	91.2	95.5	4.5	0.0	4.5	95.5
	Trial 3	12.7	0.0	191.4	204.1	6.2	0.0	6.2	93.8

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	13.4	1.3	0.0	1.3	98.7
-9.5mm + 4.75mm	61.9	5.3	0.0	5.3	94.7
Weighted Average =		4.6	0.0	4.6	95.4

Table C.3 Flat and Elongated Particle 3:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	8.7	344.8	353.5	2.5	97.5
	Trial 2	18.0	319.0	337.0	5.3	94.7
	Trial 3	21.2	323.8	345.0	6.1	93.9
-9.5mm + 4.75mm	Trial 1	28.5	76.9	105.4	27.0	73.0
	Trial 2	22.2	73.5	95.7	23.2	76.8
	Trial 3	53.3	150.8	204.1	26.1	73.9

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	13.4	4.6	95.4
-9.5mm + 4.75mm	61.9	25.5	74.5
Weighted Average =		21.7	78.3

Table C.4 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	210.4	210.4	0.0	0.0	0.0	100.0
	Trial 2	0.0	0.0	187.5	187.5	0.0	0.0	0.0	100.0
	Trial 3	0.0	0.0	198.6	198.6	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	Trial 1	4.3	0.0	229.9	234.2	1.8	0.0	1.8	98.2
	Trial 2	1.2	0.0	225.9	227.1	0.5	0.0	0.5	99.5
	Trial 3	0.0	0.0	90.5	90.5	0.0	0.0	0.0	100.0

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	13.4	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	61.9	0.8	0.0	0.8	99.2
Weighted Average =		0.7	0.0	0.7	99.3

Table C.5 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	0.9	266.3	267.2	0.3	99.7
	Trial 2	1.1	278.8	279.9	0.4	99.6
	Trial 3	2.8	269.9	272.7	1.0	99.0
-9.5mm + 4.75mm	Trial 1	7.7	102.1	109.8	7.0	93.0
	Trial 2	9.1	93.9	103	8.8	91.2
	Trial 3	6.3	87.4	93.7	6.7	93.3

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	13.4	0.6	99.4
-9.5mm + 4.75mm	61.9	7.5	92.5
Weighted Average =		6.3	93.7

C.1.2 Limestone Coarse Aggregate (Indiana)

Table C.6 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	87.0	34.6	155.0	276.6	31.5	12.5	44.0	56.0
	Trial 2	72.3	38.9	176.0	287.2	25.2	13.5	38.7	61.3
	Trial 3	96.0	41.1	244.6	381.7	25.2	10.8	35.9	64.1
-9.5mm + 4.75mm	Trial 1	54.3	39.1	78.1	171.5	31.7	22.8	54.5	45.5
	Trial 2	39.4	25.2	78.6	143.2	27.5	17.6	45.1	54.9
	Trial 3	19.8	14.4	33.2	67.4	29.4	21.4	50.7	49.3

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	12.1	27.3	12.3	39.5	60.5
-9.5mm + 4.75mm	63.2	29.5	20.6	50.1	49.9
Weighted Average =		29.2	19.3	48.4	51.6

Table C.7 Flat or Elongated Particle 3:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	7.3	0.0	285.7	293.0	2.5	0.0	2.5	97.5
	Trial 2	7.8	0.0	296.5	304.3	2.6	0.0	2.6	97.4
	Trial 3	12.1	0.0	280.3	292.4	4.1	0.0	4.1	95.9
-9.5mm + 4.75mm	Trial 1	13.6	0.0	167.0	180.6	7.5	0.0	7.5	92.5
	Trial 2	5.1	0.0	87.0	92.1	5.5	0.0	5.5	94.5
	Trial 3	6.1	0.0	85.9	92.0	6.6	0.0	6.6	93.4

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	12.1	3.1	0.0	3.1	96.9
-9.5mm + 4.75mm	63.2	6.6	0.0	6.6	93.4
Weighted Average =		6.0	0.0	6.0	94.0

Table C.8 Flat and Elongated Particle 3:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	38.5	254.6	293.1	13.1	86.9
	Trial 2	24.7	279.5	304.2	8.1	91.9
	Trial 3	35.2	257.1	292.3	12.0	88.0
-9.5mm + 4.75mm	Trial 1	63.7	116.9	180.6	35.3	64.7
	Trial 2	26.1	66.0	92.1	28.3	71.7
	Trial 3	27.6	64.4	92.0	30.0	70.0

Summary

	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	12.1	11.1	88.9
-9.5mm + 4.75mm	63.2	31.2	68.8
Weighted Average =		28.0	72.0

Table C.9 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	2.6	0.0	194.2	196.8	1.3	0.0	1.3	98.7
	Trial 2	1.9	1.0	143.0	146.2	1.3	0.9	2.2	97.8
	Trial 3	1.9	0.0	172.2	174.1	1.1	0.0	1.1	98.9

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	12.1	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	63.2	1.2	0.3	1.5	98.5
Weighted Average =		1.0	0.2	1.3	98.7

Table C.10 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	3.5	219.7	223.2	1.6	98.4
	Trial 2	6.0	216.3	222.3	2.7	97.3
	Trial 3	3.4	224.5	227.9	1.5	98.5
-9.5mm + 4.75mm	Trial 1	10.2	99.3	109.5	9.3	90.7
	Trial 2	8.0	98.0	106.0	7.5	92.5
	Trial 3	11.1	89.1	100.2	11.1	88.9

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	12.1	1.9	98.1
-9.5mm + 4.75mm	63.2	9.3	90.7
Weighted Average =		8.1	91.9

C.1.3 Gravel Coarse Aggregate (Indiana)

Table C.11 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		G	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	45.8	7.0	234.9	287.7	15.9	2.4	18.4	81.6
	Trial 2	51.9	11.4	241.7	305.0	17.0	3.7	20.8	79.2
	Trial 3	44.5	0.0	191.4	235.9	18.9	0.0	18.9	81.1
-9.5mm + 4.75mm	Trial 1	75.7	34.6	258.9	369.2	20.5	9.4	29.9	70.1
	Trial 2	97.0	33.1	339.1	469.2	20.7	7.1	27.7	72.3
	Trial 3	30.9	8.8	71.5	111.2	27.8	7.9	35.7	64.3

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	15.9	17.3	2.1	19.3	80.7
-9.5mm + 4.75mm	66.0	23.0	8.1	31.1	68.9
Weighted Average =		21.9	6.9	28.8	71.2

Table C.12 Flat or Elongated Particle 3:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		G	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	4.0	0.0	187.5	191.5	2.1	0.0	2.1	97.9
	Trial 2	2.4	0.0	204.7	207.1	1.2	0.0	1.2	98.8
	Trial 3	4.7	0.0	193.4	198.1	2.4	0.0	2.4	97.6
-9.5mm + 4.75mm	Trial 1	3.8	0.0	155.3	159.1	2.4	0.0	2.4	97.6
	Trial 2	5.5	0.0	123.1	128.6	4.3	0.0	4.3	95.7
	Trial 3	2.3	0.0	140.8	143.1	1.6	0.0	1.6	98.4

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	15.9	1.9	0.0	1.9	98.1
-9.5mm + 4.75mm	66.0	2.8	0.0	2.8	97.2
Weighted Average =		2.6	0.0	2.6	97.4

Table C.13 Flat and Elongated Particle 3:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		G	g	g	%	%
-12.5mm + 9.5mm	Trial 1	18.1	173.5	191.6	9.4	90.6
	Trial 2	10.8	196.4	207.2	5.2	94.8
	Trial 3	16.9	181.1	198.0	8.5	91.5
-9.5mm + 4.75mm	Trial 1	22.8	136.4	159.2	14.3	85.7
	Trial 2	23.5	105.0	128.5	18.3	81.7
	Trial 3	15.6	127.4	143.0	10.9	89.1

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	15.9	7.7	92.3
-9.5mm + 4.75mm	66.0	14.5	85.5
Weighted Average =		13.2	86.8

Table C.14 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	15.9	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	66.0	0.0	0.0	0.0	100.0
Weighted Average =		0.0	0.0	0.0	100.0

Table C.15 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	2.2	280.8	283	0.8	99.2
	Trial 2	2.2	249.9	252.1	0.9	99.1
	Trial 3	0.0	348.0	348.0	0.0	100.0
-9.5mm + 4.75mm	Trial 1	2.5	124.4	126.9	2.0	98.0
	Trial 2	3.4	127.5	130.9	2.6	97.4
	Trial 3	2.2	129.1	131.3	1.7	98.3

Summary

	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	15.9	0.6	99.4
-9.5mm + 4.75mm	66.0	2.1	97.9
Weighted Average =		1.8	98.2

C.1.4 Granite Coarse Aggregate (North Carolina)

Table C.16 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	81.1	16.1	174.8	272	29.8	5.9	35.7	64.3
	Trial 2	84.6	19.7	170.3	274.6	30.8	7.2	38.0	62.0
	Trial 3	133.4	52.9	357.7	544.0	24.5	9.7	34.2	65.8
-9.5mm + 4.75mm	Trial 1	101.7	70.7	164.8	337.2	30.2	21.0	51.1	48.9
	Trial 2	41.7	32.3	93.1	167.1	25.0	19.3	44.3	55.7
	Trial 3	28.2	15.0	40.4	83.6	33.7	17.9	51.7	48.3

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	9.0	28.4	7.6	36.0	64.0
-9.5mm + 4.75mm	67.0	29.6	19.4	49.0	51.0
Weighted Average =		29.5	18.0	47.5	52.5

Table C.17 Flat or Elongated Particle 3:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	4.2	0.0	380.1	384.3	1.1	0.0	1.1	98.9
	Trial 2	7.1	0.0	348.8	355.9	2.0	0.0	2.0	98.0
	Trial 3	1.6	0.0	333.6	335.2	0.5	0.0	0.5	99.5
-9.5mm + 4.75mm	Trial 1	4.7	0.0	142.3	147.0	3.2	0.0	3.2	96.8
	Trial 2	3.9	0.0	143.9	147.8	2.6	0.0	2.6	97.4
	Trial 3	6.5	0.0	129.4	135.9	4.8	0.0	4.8	95.2

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	9.0	1.2	0.0	1.2	98.8
-9.5mm + 4.75mm	67.0	3.5	0.0	3.5	96.5
Weighted Average =		3.3	0.0	3.3	96.7

Table C.18 Flat and Elongated Particle 3:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	32.8	351.5	384.3	8.5	91.5
	Trial 2	25.0	330.9	355.9	7.0	93.0
	Trial 3	18.3	316.9	335.2	5.5	94.5
-9.5mm + 4.75mm	Trial 1	31.4	115.5	146.9	21.4	78.6
	Trial 2	34.3	113.4	147.7	23.2	76.8
	Trial 3	28.4	107.5	135.9	20.9	79.1

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	9.0	7.0	93.0
-9.5mm + 4.75mm	67.0	21.8	78.2
Weighted Average =		20.1	79.9

Table C.19 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	9.0	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	67.0	0.0	0.0	0.0	100.0
Weighted Average =		0.0	0.0	0.0	100.0

Table C.20 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	2.4	249.3	251.7	1.0	99.0
	Trial 2	4.3	277.3	281.6	1.5	98.5
	Trial 3	3.3	234.6	237.9	1.4	98.6
-9.5mm + 4.75mm	Trial 1	3.0	179.7	182.7	1.6	98.4
	Trial 2	4.8	138.5	143.3	3.3	96.7
	Trial 3	4.9	132.5	137.4	3.6	96.4

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	9.0	1.3	98.7
-9.5mm + 4.75mm	67.0	2.9	97.1
Weighted Average =		2.7	97.3

C.1.5 Traprock #78 Coarse Aggregate (Virginia)

Table C.21 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-19mm + 12.5mm	Trial 1	81.6	15.5	728.0	825.1	9.9	1.9	11.8	88.2
	Trial 2	62.1	14.1	694.4	770.6	8.1	1.8	9.9	90.1
	Trial 3	14.6	5.0	343.6	363.2	4.0	1.4	5.4	94.6
-12.5mm + 9.5mm	Trial 1	138.0	95.2	541.6	774.8	17.8	12.3	30.1	69.9
	Trial 2	123.5	94.7	574.1	792.3	15.6	12.0	27.5	72.5
	Trial 3	32.0	8.5	140.8	181.3	17.7	4.7	22.3	77.7
-9.5mm + 4.75mm	Trial 1	108.2	67.3	194	369.5	29.3	18.2	47.5	52.5
	Trial 2	78.5	69.8	172.3	320.6	24.5	21.8	46.3	53.7
	Trial 3	41.0	24.3	110.6	175.9	23.3	13.8	37.1	62.9

Summary					
		Average			
	Component	Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-19mm + 12.5mm	11.0	7.3	1.7	9.0	91.0
-12.5mm + 9.5mm	29.0	17.0	9.6	26.7	73.3
-9.5mm + 4.75mm	53.0	25.7	17.9	43.6	56.4
Weighted Average =		20.8	13.4	34.2	65.8

Table C.22 Flat or Elongated Particle 3:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-19mm + 12.5mm	Trial 1	0.0	0.0	352.1	352.1	0.0	0.0	0.0	100.0
	Trial 2	0.0	0.0	331.0	331.0	0.0	0.0	0.0	100.0
	Trial 3	0.0	0.0	361.9	361.9	0.0	0.0	0.0	100.0
-12.5mm + 9.5mm	Trial 1	5.6	4.2	240.3	250.1	2.2	1.7	3.9	96.1
	Trial 2	4.3	0.0	216.0	220.3	2.0	0.0	2.0	98.0
	Trial 3	2.3	0.0	207.9	210.2	1.1	0.0	1.1	98.9
-9.5mm + 4.75mm	Trial 1	9.0	3.1	118.3	130.4	6.9	2.4	9.3	90.7
	Trial 2	7.5	1.3	118.5	127.3	5.9	1.0	6.9	93.1
	Trial 3	12.6	1.5	122.2	136.3	9.2	1.1	10.3	89.7

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-19mm + 12.5mm	11	0.0	0.0	0.0	100.0
-12.5mm + 9.5mm	29.0	1.8	0.6	2.3	97.7
-9.5mm + 4.75mm	53.0	7.3	1.5	8.8	91.2
Weighted Average =		4.7	1.0	5.8	94.2

Table C.23 Flat and Elongated Particle 3:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	G	g	%	%
-19mm + 12.5mm	Trial 1	16.3	335.8	352.1	4.6	95.4
	Trial 2	2.5	328.5	331.0	0.8	99.2
	Trial 3	13.3	348.6	361.9	3.7	96.3
-12.5mm + 9.5mm	Trial 1	29.0	221.1	250.1	11.6	88.4
	Trial 2	25.8	194.5	220.3	11.7	88.3
	Trial 3	8.0	202.2	210.2	3.8	96.2
-9.5mm + 4.75mm	Trial 1	29.0	101.4	130.4	22.2	77.8
	Trial 2	36.3	91.0	127.3	28.5	71.5
	Trial 3	41.4	94.9	136.3	30.4	69.6

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-19mm + 12.5mm	11.0	3.0	97.0
-12.5mm + 9.5mm	29.0	9.0	91.0
-9.5mm + 4.75mm	53.0	27.0	73.0
Weighted Average =		18.6	81.4

Table C.24 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-19mm + 12.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-19mm + 12.5mm	11	0.0	0.0	0.0	100.0
-12.5mm + 9.5mm	29.0	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	53.0	0.0	0.0	0.0	100.0
Weighted Average =		0.0	0.0	0.0	100.0

Table C.25 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	G	g	%	%
-19mm + 12.5mm	Trial 1	6.4	559.2	565.6	1.1	98.9
	Trial 2	0.0	573.2	573.2	0.0	100.0
	Trial 3	0.0	610.7	610.7	0.0	100.0
-12.5mm + 9.5mm	Trial 1	7.2	365.4	372.6	1.9	98.1
	Trial 2	2.2	362.7	364.9	0.6	99.4
	Trial 3	5.4	388.4	393.8	1.4	98.6
-9.5mm + 4.75mm	Trial 1	5.0	194.3	199.3	2.5	97.5
	Trial 2	6.0	176.9	182.9	3.3	96.7
	Trial 3	6.0	149.9	155.9	3.8	96.2

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-19mm + 12.5mm	11.0	0.4	99.6
-12.5mm + 9.5mm	29.0	1.3	98.7
-9.5mm + 4.75mm	53.0	3.2	96.8
Weighted Average =		2.3	97.7

C.1.6 Traprock #88 Coarse Aggregate (Virginia)

Table C.26 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	17.3	0	130	147.3	11.7	0.0	11.7	88.3
	Trial 2	14.6	0	131	145.6	10.0	0.0	10.0	90.0
	Trial 3	16.8	6.4	110.9	134.1	12.5	4.8	17.3	82.7
-9.5mm + 4.75mm	Trial 1	23.6	14	68	105.6	22.3	13.3	35.6	64.4
	Trial 2	24.5	14.0	60.0	98.5	24.9	14.2	39.1	60.9
	Trial 3	35.2	8.4	53	96.6	36.4	8.7	45.1	54.9

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	14.6	11.4	1.6	13.0	87.0
-9.5mm + 4.75mm	74.2	27.9	12.1	39.9	60.1
Weighted Average =		25.2	10.3	35.5	64.5

Table C.27 Flat or Elongated Particle 3:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	3.0	0.0	322.3	325.3	0.9	0.0	0.9	99.1
	Trial 2	0.0	0.0	253.9	253.9	0.0	0.0	0.0	100.0
	Trial 3	2.5	0.0	305.3	307.8	0.8	0.0	0.8	99.2
-9.5mm + 4.75mm	Trial 1	2.6	0.0	79.3	81.9	3.2	0.0	3.2	96.8
	Trial 2	2.1	0.0	88.9	91.0	2.3	0.0	2.3	97.7
	Trial 3	2.3	0.0	153.3	155.6	1.5	0.0	1.5	98.5

Summary					
		Average			
	Component	Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	14.6	0.6	0.0	0.6	99.4
-9.5mm + 4.75mm	74.2	2.3	0.0	2.3	97.7
Weighted Average =		2.0	0.0	2.0	98.0

Table C.28 Flat and Elongated Particle 3:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	G	g	%	%
-12.5mm + 9.5mm	Trial 1	6.0	316.3	322.3	1.9	98.1
	Trial 2	7.5	246.4	253.9	3.0	97.0
	Trial 3	5.2	302.6	307.8	1.7	98.3
-9.5mm + 4.75mm	Trial 1	9.8	72.2	82.0	12.0	88.0
	Trial 2	11.9	79.2	91.1	13.1	86.9
	Trial 3	23.7	132	155.7	15.2	84.8

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	14.6	2.2	97.8
-9.5mm + 4.75mm	74.2	13.4	86.6
Weighted Average =		11.6	88.4

Table C.29 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	14.6	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	74.2	0.0	0.0	0.0	100.0
Weighted Average =		0.0	0.0	0.0	100.0

Table C.30 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	G	g	%	%
-12.5mm + 9.5mm	Trial 1	8.0	265.5	273.5	2.9	97.1
	Trial 2	1.3	222.7	224.0	0.6	99.4
	Trial 3	2.1	249.0	251.1	0.8	99.2
-9.5mm + 4.75mm	Trial 1	3.8	170.6	174.4	2.2	97.8
	Trial 2	4.7	164.4	169.1	2.8	97.2
	Trial 3	7.7	182.7	190.4	4.0	96.0

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	14.6	1.4	98.6
-9.5mm + 4.75mm	74.2	3.0	97.0
Weighted Average =		2.7	97.3

C.2 FLAT OR ELONGATED PARTICLE TEST (ASTM D4791) – HMA PLANT STOCKPILE SOURCES

C.2.1 Dolomite Coarse Aggregate (Indiana)

Table C.31 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	55.0	22.4	223.7	301.1	18.3	7.4	25.7	74.3
	Trial 2	51.9	18.2	239.8	309.9	16.7	5.9	22.6	77.4
	Trial 3	73.0	15.9	127.1	360.5	20.2	4.4	24.7	35.3
-9.5mm + 4.75mm	Trial 1	74.4	63.6	128.1	266.1	28.0	23.9	51.9	48.1
	Trial 2	71.7	56.5	54.0	265	27.1	21.3	48.4	20.4
	Trial 3	80.8	49.6	45.1	278.2	29.0	17.8	46.9	16.2

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	12.4	18.4	5.9	24.3	62.3
-9.5mm + 4.75mm	59.9	28.0	21.0	49.0	28.2
Weighted Average =		26.4	18.4	44.8	34.1

Table C.32 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	2.5	0.0	275.8	278.3	0.9	0.0	0.9	99.1
	Trial 2	2.1	0.0	263.0	265.1	0.8	0.0	0.8	99.2
	Trial 3	2.2	0.0	263.4	265.6	0.8	0.0	0.8	99.2

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	12.4	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	59.9	0.8	0.0	0.8	99.2
Weighted Average =		0.7	0.0	0.7	99.3

Table C.33 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	6.1	294.9	301	2.0	98.0
	Trial 2	5.2	304.5	309.7	1.7	98.3
	Trial 3	5.0	355.7	360.7	1.4	98.6
-9.5mm + 4.75mm	Trial 1	17.8	260.3	278.1	6.4	93.6
	Trial 2	19.7	245.4	265.1	7.4	92.6
	Trial 3	13.0	252.9	265.9	4.9	95.1

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	12.4	1.7	98.3
-9.5mm + 4.75mm	59.9	6.2	93.8
Weighted Average =		5.5	94.5

C.2.2 Limestone Coarse Aggregate (Indiana)

Table C.34 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	40.1	5.7	144.3	190.1	21.1	3.0	24.1	75.9
	Trial 2	48.6	0.0	142.3	190.9	25.5	0.0	25.5	74.5
	Trial 3	27.0	12.6	104.5	144.1	18.7	8.7	27.5	72.5
-9.5mm + 4.75mm	Trial 1	38.1	21.6	51.1	110.8	34.4	19.5	53.9	46.1
	Trial 2	29.0	26.3	54.0	118.4	24.5	22.2	46.7	45.6
	Trial 3	26.4	16.0	53.1	95.5	27.6	16.8	44.4	55.6

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	10.0	21.8	3.9	25.7	74.3
-9.5mm + 4.75mm	56.8	28.8	19.5	48.3	49.1
Weighted Average =		27.8	17.2	44.9	52.9

Table C.35 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0	0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	2.3	0	108.5	110.8	2.1	0.0	2.1	97.9
	Trial 2	1.1	0	117.3	118.4	0.9	0.0	0.9	99.1
	Trial 3	1.7	0	115.5	117.2	1.5	0.0	1.5	98.5

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	10.0	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	56.8	1.5	0.0	1.5	98.5
Weighted Average =		1.3	0.0	1.3	98.7

Table C.36 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	3.4	186.5	189.9	1.8	98.2
	Trial 2	4.1	186.2	190.3	2.2	97.8
	Trial 3	4.0	140.1	144.1	2.8	97.2
-9.5mm + 4.75mm	Trial 1	9.6	100.8	110.4	8.7	91.3
	Trial 2	12.0	106.6	118.6	10.1	89.9
	Trial 3	6.4	89.1	95.5	6.7	93.3

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	10.0	2.3	98.0
-9.5mm + 4.75mm	56.8	8.5	90.6
Weighted Average =		7.6	91.7

C.2.3 Gravel Coarse Aggregate (Indiana)

Table C.37 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	27.3	0.0	148.8	176.1	15.5	0.0	15.5	84.5
	Trial 2	26.3	0.0	133.8	160.1	16.4	0.0	16.4	83.6
	Trial 3	25.9	0.0	115.6	141.5	18.3	0.0	18.3	81.7
-9.5mm + 4.75mm	Trial 1	37.7	21.6	100.7	160	23.6	13.5	37.1	62.9
	Trial 2	38.4	22.3	54.0	162.4	23.6	13.7	37.4	33.3
	Trial 3	45.0	34.0	169.0	248.0	18.1	13.7	31.9	68.1

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	5.7	16.7	0.0	16.7	83.3
-9.5mm + 4.75mm	84.5	21.8	13.6	35.4	54.8
Weighted Average =		21.8	13.6	35.4	54.8

Table C.38 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	5.7	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	84.5	0.0	0.0	0.0	100.0
Weighted Average =		0.0	0.0	0.0	100.0

Table C.39 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	1.4	174.7	176.1	0.8	99.2
	Trial 2	2.9	157.2	160.1	1.8	98.2
	Trial 3	0.0	141.5	141.5	0.0	100.0
-9.5mm + 4.75mm	Trial 1	0.3	159.7	160.0	0.2	99.8
	Trial 2	2.9	160.1	163.0	1.8	98.2
	Trial 3	1.6	193.3	194.9	0.8	99.2

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	5.7	0.9	98.7
-9.5mm + 4.75mm	84.5	0.9	99.0
Weighted Average =		0.9	99.0

C.2.4 Granite Coarse Aggregate (North Carolina)

Table C.40 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	51.9	17.1	157.8	226.8	22.9	7.5	30.4	69.6
	Trial 2	46.5	15.0	155.8	217.3	21.4	6.9	28.3	71.7
	Trial 3	47.3	23.7	129.1	200.1	23.6	11.8	35.5	64.5
-9.5mm + 4.75mm	Trial 1	72.5	60.0	74.9	207.4	35.0	28.9	63.9	36.1
	Trial 2	39.3	26.2	39.8	105.3	37.3	24.9	62.2	37.8
	Trial 3	35.4	23.9	44.1	103.4	34.2	23.1	57.4	42.6

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	16.2	22.6	8.8	31.4	68.6
-9.5mm + 4.75mm	64.7	35.5	25.6	61.1	38.9
Weighted Average =		32.9	22.3	55.2	44.8

Table C.41 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	g	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL

Summary

	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	16.2	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	64.7	0.0	0.0	0.0	100.0
Weighted Average =		0.0	0.0	0.0	100.0

Table C.42 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	g	g	%	%
-12.5mm + 9.5mm	Trial 1	3.8	222.9	226.7	1.7	98.3
	Trial 2	6.0	211.3	217.3	2.8	97.2
	Trial 3	0.0	200.1	200.1	0.0	100.0
-9.5mm + 4.75mm	Trial 1	16.1	191.2	207.3	7.8	92.2
	Trial 2	9.1	96.0	105.1	8.7	91.3
	Trial 3	7.0	96.4	103.4	6.8	93.2

Summary			
	Component	Average	
		Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	16.2	1.5	98.5
-9.5mm + 4.75mm	64.7	7.8	92.2
Weighted Average =		6.5	93.5

C.2.5 Traprock #88 Coarse Aggregate (Virginia)

Table C.43 Flat or Elongated Particle 2:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	17.3	0.0	130	147.3	11.7	0.0	11.7	88.3
	Trial 2	14.6	0.0	131	145.6	10.0	0.0	10.0	90.0
	Trial 3	16.8	6.4	110.9	134.1	12.5	4.8	17.3	82.7
-9.5mm + 4.75mm	Trial 1	23.6	14.0	68	105.6	22.3	13.3	35.6	64.4
	Trial 2	24.5	14.0	60.0	98.5	24.9	14.2	39.1	60.9
	Trial 3	35.2	8.4	53	96.6	36.4	8.7	45.1	54.9

Summary					
	Component	Average			
		Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	19.0	11.4	1.6	13.0	87.0
-9.5mm + 4.75mm	70.8	27.9	12.1	39.9	60.1
Weighted Average =		24.4	9.8	34.3	65.7

Table C.44 Flat or Elongated Particle 5:1 Ratio

Particle Size		Flat	Elongated	Non	Total	Flat	Elongated	FOE	Non
		g	G	g	g	%	%	%	%
-12.5mm + 9.5mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
-9.5mm + 4.75mm	Trial 1	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 2	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL
	Trial 3	0.0	0.0	ALL	ALL	0.0	0.0	0.0	ALL

Summary					
		Average			
	Component	Flat	Elongated	FOE	Non
Particle Size	%	%	%	%	%
-12.5mm + 9.5mm	19.0	0.0	0.0	0.0	100.0
-9.5mm + 4.75mm	70.8	0.0	0.0	0.0	100.0
Weighted Average =		0.0	0.0	0.0	100.0

Table C.45 Flat and Elongated Particle 5:1 Ratio

Particle Size		Flat and Elongated	Non	Total	Flat and Elongated	Non
		g	G	g	%	%
-12.5mm + 9.5mm	Trial 1	0.0	ALL	ALL	0.0	ALL
	Trial 2	0.0	ALL	ALL	0.0	ALL
	Trial 3	0.0	ALL	ALL	0.0	ALL
-9.5mm + 4.75mm	Trial 1	5.2	100.5	105.7	4.9	95.1
	Trial 2	3.6	94.4	98.0	3.7	96.3
	Trial 3	3.9	92.9	96.8	4.0	96.0

Summary			
		Average	
	Component	Flat and Elongated	Non
Particle Size	%	%	%
-12.5mm + 9.5mm	19.0	0.0	100.0
-9.5mm + 4.75mm	70.8	4.2	95.8
Weighted Average =		3.3	96.7

C.3 UNCOMPACTED VOID CONTENT (AASHTO TP56) – LABORATORY MIX DESIGN SOURCE

C.3.1 Method A – AASHTO TP56

Table C.46 Coarse Aggregate

Aggregate Type	Dolomite	Limestone	Gravel	Granite	Traprock #78	Traprock #88
Dry Bulk Specific Gravity, g/cm3	2.734	2.550	2.598	2.674	2.897	2.910
Dry Weight 1, g	3951.4	3903.1	4429.2	4021.2	4403.2	4468.3
Dry Weight 2, g	3947.7	3898.6	4437.1	4052.4	4397.5	4476.5
Dry Weight 3, g	3934.2	3907.1	4447.5	4010.5	4394.9	4481.1
Average Dry Weight, g	3944.4	3902.9	4437.9	4036.8	4398.5	4475.3
UVA, %	51.2	48.2	42.2	48.9	48.6	48.0

Note: Volume of Container = 2954.6 cm^3

C.3.2 Method B – AASHTO TP56

Table C.47 Dolomite Coarse Aggregate

Data

Size Fraction	*-12.5 +9.5mm*			*-9.5mm +4.75mm*		
	Dry Weight 1	4139.7	g	Dry Weight 1	3957.7	g
	Dry Weight 2	4174.2	g	Dry Weight 2	3973.3	g
	Dry Weight 3	4146.8	g	Dry Weight 3	3963.2	g
	Average Dry Weight	4153.6	g	Average Dry Weight	3964.7	g

Calculation

Size Fraction	*-12.5 +9.5mm*	*-9.5mm +4.75mm*
	U1 = 48.6	U2 = 50.9
	UVB = 49.8	

Table C.48 Limestone Coarse Aggregate

Data

Size Fraction	*-12.5 +9.5mm*			*-9.5mm +4.75mm*		
	Dry Weight 1	3863.7	g	Dry Weight 1	3740.1	g
	Dry Weight 2	3850.1	g	Dry Weight 2	3717.8	g
	Dry Weight 3	3875.3	g	Dry Weight 3	3738.5	g
	Average Dry Weight	3863.0	g	Average Dry Weight	3732.1	g

Calculation

Size Fraction	*-12.5 +9.5mm*		*-9.5mm +4.75mm*	
	U1 =	48.8	U2 =	50.5
	UVB =	49.6		

Table C.49 Gravel Coarse Aggregate

Data

Size Fraction	*-12.5 +9.5mm*			*-9.5mm +4.75mm*		
	Dry Weight 1	4417.1	g	Dry Weight 1	4361.8	g
	Dry Weight 2	4371.0	g	Dry Weight 2	4382.4	g
	Dry Weight 3	4418.5	g	Dry Weight 3	4373.0	g
	Average Dry Weight	4402.2	g	Average Dry Weight	4372.4	g

Calculation

Size Fraction	*-12.5 +9.5mm*		*-9.5mm +4.75mm*	
	U1 =	42.7	U2 =	43.1
	UVB =	42.9		

Table C.50 Granite Coarse Aggregate

Data

Size Fraction	*-12.5 +9.5mm*			*-9.5mm +4.75mm*		
	Dry Weight 1	4042.0	g	Dry Weight 1	3998.7	g
	Dry Weight 2	4101.0	g	Dry Weight 2	3972.4	g
	Dry Weight 3	4031.2	g	Dry Weight 3	3977.7	g
	Average Dry Weight	4058.1	g	Average Dry Weight	3982.9	g

Calculation

Size Fraction	*-12.5 +9.5mm*		*-9.5mm +4.75mm*	
	U1 =	48.7	U2 =	49.6
	UVB =	49.1		

Table C.51 Traprock #78 Coarse Aggregate

Data

Size Fraction	*-19.0+12.5mm*			*-12.5 +9.5mm*			*-9.5mm +4.75mm*		
	Dry Weight 1	4523.6	g	Dry Weight 1	4431.2	g	Dry Weight 1	4287.9	g
	Dry Weight 2	4531.6	g	Dry Weight 2	4424.2	g	Dry Weight 2	4285.5	g
	Dry Weight 3	4580.1	g	Dry Weight 3	4393.7	g	Dry Weight 3	4317.4	g
	Average Dry Weight	4545.1	g	Average Dry Weight	4416.4	g	Average Dry Weight	4296.9	g

Calculation

Size Fraction	*-12.5 +9.5mm*		*-12.5 +9.5mm*		*-9.5mm +4.75mm*	
	U1 =	46.9	U1 =	48.4	U2 =	49.8
	UVB =	48.4				

Table C.52 Traprock #88 Coarse Aggregate

Data

Size Fraction	*-12.5 +9.5mm*			*-9.5mm +4.75mm*		
	Dry Weight 1	4432.2	g	Dry Weight 1	4350.5	g
	Dry Weight 2	4456.0	g	Dry Weight 2	4357.9	g
	Dry Weight 3	4459.0	g	Dry Weight 3	4361.7	g
	Average Dry Weight	4449.1	g	Average Dry Weight	4356.7	g

Calculation

Size Fraction	*-12.5 +9.5mm*		*-9.5mm +4.75mm*	
	U1=	48.3	U2=	49.4
	UVB=	48.8		

C.4 MICRO-DEVAL TEST

Table C.53 Micro-Deval Tests (AASHTO TP58) - Coarse Aggregates

Aggregate Type	Dolomite	Limestone	Gravel	Granite	Traprock #78	Traprock #88
Source	Indiana	Indiana	Indiana	North Carolina	Virginia	Virginia
Initial Dry Weight, g	1502.6	1501.2	1500.9	1500.8	1500.7	1500.1
Final Dry Weight, g	1397.5	1338.3	1368.9	1419.0	1423.7	1430.4
Weight Loss, g	105.1	162.9	132.0	81.8	77.0	69.7
Micro Deval Value	7.0	10.9	8.8	5.5	5.1	4.6

Note: Average of 3 samples

Table C.54 Micro-Deval Tests (Ontario Test Method LS-619) - Fine Aggregates

Aggregate Type	Natural Sand A	Crushed Gravel Sand	Natural Sand B	Granite Sand	Dolomite Sand	Traprock #16	Dolomite Sand	Traprock #13
Source	Indiana	Indiana	Ohio	North Carolina	Indiana	Virginia	Indiana	Virginia
Initial Dry Weight, g	499.9	499.9	499.8	500.0	500.0	500.0	499.9	499.9
Final Dry Weight, g	449.8	415.1	397.6	446.9	471.1	439.4	409.3	427.4
Weight Loss, g	50.1	84.8	102.2	53.1	28.9	60.6	90.6	72.5
Micro Deval Value	10.0	17.0	20.4	10.6	5.8	12.1	18.1	14.5

C.5 LOS ANGELES ABRASION TEST (ASTM C96)

Table C.55 Coarse Aggregate

Aggregate	Gradation Type	Initial Dry Weight, g	Weight Retained on the 1.7 mm Sieve, g	Loss, %
Dolomite	C	5000.8	3850.6	23.0
Limestone	C	5000.3	3758.9	24.8
Gravel	C	5000.3	4060.1	18.8
Granite	C	5000.3	4057.1	18.9
Traprock #78	C	5000.5	4320.4	13.6
Traprock #88	C	4999.7	4285.6	14.3

C.6 MAGNESIUM SULFATE SOUNDNESS TEST (AASHTO T104) – 5 CYCLES

Table C.56 Dolomite Coarse Aggregate

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
19.0mm to 12.5mm					
12.5mm to 9.5mm	13.4	281.3	280.9	0.1	0.03
9.5mm to 4.75mm	61.9	320.2	315.8	1.4	1.13
Total =	75.3			Total =	1

19.0mm to 12.5mm					
12.5mm to 9.5mm	13.4	334.3	332.8	0.4	0.08
9.5mm to 4.75mm	61.9	300.3	299.2	0.4	0.30
Total =	75.3			Total =	0

19.0mm to 12.5mm					
12.5mm to 9.5mm	13.4	333.1	330.5	0.8	0.14
9.5mm to 4.75mm	61.9	302.8	300.5	0.8	0.62
Total =	75.3			Total =	1

Average Loss = **1**

Table C.57 Limestone Coarse Aggregate

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
19.0mm to 12.5mm					
12.5mm to 9.5mm	12.1	327.2	316.1	3.4	0.55
9.5mm to 4.75mm	63.2	320.3	299.1	6.6	5.56
Total =	75.3			Total =	6
19.0mm to 12.5mm					
12.5mm to 9.5mm	12.1	365.3	356.7	2.4	0.38
9.5mm to 4.75mm	63.2	329.2	309.6	6.0	5.00
Total =	75.3			Total =	5
19.0mm to 12.5mm					
12.5mm to 9.5mm	12.1	362.7	341.7	5.8	0.93
9.5mm to 4.75mm	63.2	315.6	291	7.8	6.54
Total =	75.3			Total =	7
				Average Loss =	**6**

Table C.58 Gravel Coarse Aggregate

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
19.0mm to 12.5mm					
12.5mm to 9.5mm	15.9	324.8	301.3	7.2	1.40
9.5mm to 4.75mm	66.0	300.4	283.6	5.6	4.51
Total =	81.9			Total =	6

19.0mm to 12.5mm					
12.5mm to 9.5mm	15.9	321	302.2	5.9	1.14
9.5mm to 4.75mm	66.0	297.7	272.9	8.3	6.71
Total =	81.9			Total =	8

19.0mm to 12.5mm					
12.5mm to 9.5mm	15.9	336.1	319.2	5.0	0.98
9.5mm to 4.75mm	66.0	300.4	282.1	6.1	4.91
Total =	81.9			Total =	6

Average Loss = **7**

Table C.59 Granite Coarse Aggregate

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
19.0mm to 12.5mm					
12.5mm to 9.5mm	9.0	323.5	323.3	0.1	0.01
9.5mm to 4.75mm	67.0	329.8	327.5	0.7	0.61
Total =	76.0			Total =	1
19.0mm to 12.5mm					
12.5mm to 9.5mm	9.0	353.4	353.1	0.1	0.01
9.5mm to 4.75mm	67.0	378.7	378.1	0.2	0.14
Total =	76.0			Total =	0
19.0mm to 12.5mm					
12.5mm to 9.5mm	9.0	349	348.5	0.1	0.02
9.5mm to 4.75mm	67.0	286.7	285.5	0.4	0.37
Total =	76.0			Total =	0
				Average Loss =	**0**

Table C.60 Traprock #78 Coarse Aggregate

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
19.0mm to 12.5mm					
12.5mm to 9.5mm	29.0	354.2	350.8	1.0	0.34
9.5mm to 4.75mm	53.0	398.5	394.3	1.1	0.68
Total =	82.0			Total =	1
19.0mm to 12.5mm					
12.5mm to 9.5mm	29.0	341.3	336.5	1.4	0.50
9.5mm to 4.75mm	53.0	384.8	381.2	0.9	0.60
Total =	82.0			Total =	1
19.0mm to 12.5mm					
12.5mm to 9.5mm	29.0	352.3	350.7	0.5	0.16
9.5mm to 4.75mm	53.0	384.1	380.4	1.0	0.62
Total =	82.0			Total =	1
				Average Loss=	**1**

Table C.61 Traprock #88 Coarse Aggregate

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
19.0mm to 12.5mm					
12.5mm to 9.5mm	14.6	338.7	335.5	0.9	0.16
9.5mm to 4.75mm	74.2	319.3	315.8	1.1	0.92
Total =	88.8			Total =	1

19.0mm to 12.5mm					
12.5mm to 9.5mm	14.6	336.2	333.2	0.9	0.15
9.5mm to 4.75mm	74.2	318.8	314.8	1.3	1.05
Total =	88.8			Total =	1

Average Loss = **1**

C.7 UNCOMPACTED VOID CONTENT OF FINE AGGREGATES

Table C.62 Method A – ASTM C1252

Aggregate Type	Natural Sand A	Crushed Gravel Sand	Natural Sand B	Granite Sand	Dolomite Sand	Dolomite Sand	Traprock #16	Traprock #13
Dry Bulk Specific Gravity, g/cm3	2.585	2.660	2.586	2.639	2.665	2.634	2.911	2.892
Dry Weight 1, g	153.5	142.9	149.4	133.7	146.1	138.4	149.1	145.7
Dry Weight 2, g	153.8	142.6	149.7	133.3	145.5	139.1	147.7	146.3
Dry Weight 3, g	153.3	142.3	149.2	133.8	145.5	140.0	148.1	146.0
Average Dry Weight, g	153.5	142.6	149.4	133.6	145.7	139.2	148.3	146.0
UVA, %	40.2	46.1	41.9	49.1	45.0	46.8	48.8	49.2

Table C.63 Natural Sand A (Method B – ASTM C1252)

Data

Size Fraction	*-2.36mm + 1.18mm*		*-1.18mm + 0.60mm*		*-0.60mm + 0.30mm*	
	Trial 1	150.1 g	**Trial 1**	144.6 g	**Trial 1**	143.3 g
	Trial 2	151.0 g	**Trial 2**	144.8 g	**Trial 2**	143.3 g
	Trial 3	150.3 g	**Trial 3**	144.8 g	**Trial 3**	143.4 g
	Average	150.5 g	**Average**	144.7 g	**Average**	143.3 g

Calculation

U1= 41.4 U2= 43.7 U3= 44.2

UVB = 43.1

Table C.64 Natural Sand A (VTM5)

Data

Size Fraction	*-2.36mm + 1.00mm*			*-1.00mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	413.5	g	**Trial 1**	406.2	g	**Trial 1**	405.2	g
	Trial 2	413.3	g	**Trial 2**	406.1	g	**Trial 2**	405.1	g
	Trial 3	412.7	g	**Trial 3**	405.1	g	**Trial 3**	405.1	g
	Average	413.2	g	**Average**	405.8	g	**Average**	405.1	g

Calculation

U1=	43.3	U2=	44.3	U3= 44.4
UVB =	44.0			

Table C.65 Crushed Gravel Sand (Method B – ASTM C1252)

Data

Size Fraction	*-2.36mm + 1.18mm*			*-1.18mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	136.2	g	**Trial 1**	129.2	g	**Trial 1**	127.5	g
	Trial 2	136.5	g	**Trial 2**	129.3	g	**Trial 2**	127.4	g
	Trial 3	136.5	g	**Trial 3**	129.2	g	**Trial 3**	127.5	g
	Average	136.4	g	**Average**	129.2	g	**Average**	127.5	g

Calculation

U1=	48.4	U2=	51.1	U3= 51.8
UVB =	50.4			

Table C.66 Crushed Gravel Sand (VTM5)

Data

Size Fraction	*-2.36mm + 1.00mm*			*-1.00mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	368.6	g	**Trial 1**	360.8	g	**Trial 1**	358.4	g
	Trial 2	369.3	g	**Trial 2**	360.2	g	**Trial 2**	358.3	g
	Trial 3	369.6	g	**Trial 3**	360.8	g	**Trial 3**	360.1	g
	Average	369.2	g	**Average**	360.6	g	**Average**	358.9	g

Calculation

U1=	50.8	U2=	51.9	U3= 52.1
UVB =	51.6			

Table C.67 Natural Sand B (Method B – ASTM C1252)

Data

Size Fraction	*-2.36mm + 1.18mm*			*-1.18mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	144.6	g	**Trial 1**	137.9	g	**Trial 1**	133.7	g
	Trial 2	144.5	g	**Trial 2**	137.8	g	**Trial 2**	133.7	g
	Trial 3	143.8	g	**Trial 3**	137.6	g	**Trial 3**	133.6	g
	Average	144.3	g	**Average**	137.8	g	**Average**	133.7	g

Calculation

U1=	44.1		U2=	46.7		U3=	48.3
UVB =	46.4						

Table C.68 Natural Sand B (VTM5)

Data

Size Fraction	*-2.36mm + 1.00mm*			*-1.00mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	395.3	g	**Trial 1**	386.1	g	**Trial 1**	377.9	g
	Trial 2	396.4	g	**Trial 2**	384.7	g	**Trial 2**	376.2	g
	Trial 3	394.0	g	**Trial 3**	386.5	g	**Trial 3**	375.8	g
	Average	395.2	g	**Average**	385.8	g	**Average**	376.6	g

Calculation

U1=	46.1		U2=	47.3		U3=	48.6
UVB =	47.3						

Table C.69 Granite Sand (Method B – ASTM C1252)

Data

Size Fraction	*-2.36mm + 1.18mm*			*-1.18mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	127.9	g	**Trial 1**	122.2	g	**Trial 1**	120.0	g
	Trial 2	128.6	g	**Trial 2**	122.5	g	**Trial 2**	119.8	g
	Trial 3	127.5	g	**Trial 3**	122.0	g	**Trial 3**	120.0	g
	Average	128.0	g	**Average**	122.2	g	**Average**	119.9	g

Calculation

U1=	51.2		U2=	53.4		U3=	54.3
UVB =	53.0						

Table C.70 Granite Sand (VTM5)

Data

Size Fraction	*-2.36mm + 1.00mm*			*-1.00mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	342.2	g	**Trial 1**	338.4	g	**Trial 1**	337.7	g
	Trial 2	342.4	g	**Trial 2**	336.2	g	**Trial 2**	337.9	g
	Trial 3	342.2	g	**Trial 3**	335.9	g	**Trial 3**	337.8	g
	Average	342.3	g	**Average**	336.8	g	**Average**	337.8	g

Calculation

U1=	54.0	U2=	54.7	U3=	54.6
UVB =	54.4				

Table C.71 Dolomite Sand (Method B – ASTM C1252)

Data

Size Fraction	*-2.36mm + 1.18mm*			*-1.18mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	134.7	g	**Trial 1**	131.4	g	**Trial 1**	131.4	g
	Trial 2	134.8	g	**Trial 2**	131.4	g	**Trial 2**	131.5	g
	Trial 3	134.9	g	**Trial 3**	131.7	g	**Trial 3**	131.6	g
	Average	134.8	g	**Average**	131.5	g	**Average**	131.5	g

Calculation

U1=	49.1	U2=	50.4	U3=	50.4
UVB =	49.9				

Table C.72 Dolomite Sand (VTM5)

Data

Size Fraction	*-2.36mm + 1.00mm*			*-1.00mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	365.6	g	**Trial 1**	363.9	g	**Trial 1**	370	g
	Trial 2	365.7	g	**Trial 2**	363.3	g	**Trial 2**	370.5	g
	Trial 3	365.5	g	**Trial 3**	362.2	g	**Trial 3**	370.6	g
	Average	365.6	g	**Average**	363.1	g	**Average**	370.4	g

Calculation

U1=	51.3	U2=	51.7	U3=	50.7
UVB =	51.2				

Table C.73 Traprock #16 Sand (Method B – ASTM C1252)

Data

Size Fraction	*-2.36mm + 1.18mm*			*-1.18mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	139.0	g	**Trial 1**	133.3	g	**Trial 1**	132.8	g
	Trial 2	138.8	g	**Trial 2**	133.6	g	**Trial 2**	132.7	g
	Trial 3	138.4	g	**Trial 3**	133	g	**Trial 3**	132.6	g
	Average	138.7	g	**Average**	133.3	g	**Average**	132.7	g

Calculation

U1=	52.3	U2=	54.1	U3= 54.3
UVB =	53.6			

Table C.74 Traprock #16 Sand (VTM5)

Data

Size Fraction	*-2.36mm + 1.00mm*			*-1.00mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	370.8	g	**Trial 1**	369.1	g	**Trial 1**	375.1	g
	Trial 2	371.9	g	**Trial 2**	368.6	g	**Trial 2**	375.3	g
	Trial 3	372.5	g	**Trial 3**	368.3	g	**Trial 3**	375.4	g
	Average	371.7	g	**Average**	368.6	g	**Average**	375.3	g

Calculation

U1=	54.9	U2=	55.3	U3= 54.5
UVB =	54.9			

Table C.75 Dolomite Sand (Method B – ASTM C1252)

Data

Size Fraction	*-2.36mm + 1.18mm*			*-1.18mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	131.6	g	**Trial 1**	127.5	g	**Trial 1**	126.3	g
	Trial 2	131.3	g	**Trial 2**	127.4	g	**Trial 2**	126.9	g
	Trial 3	131.6	g	**Trial 3**	127.8	g	**Trial 3**	126.6	g
	Average	131.5	g	**Average**	127.6	g	**Average**	126.6	g

Calculation

U1=	49.8	U2=	51.3	U3= 51.6
UVB =	50.9			

Table C.76 Dolomite Sand (VTM5)

Data

Size Fraction	*-2.36mm + 1.00mm*			*-1.00mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	357.3	g	**Trial 1**	356.0	g	**Trial 1**	356.7	g
	Trial 2	357.9	g	**Trial 2**	355.5	g	**Trial 2**	357.1	g
	Trial 3	358.0	g	**Trial 3**	356.4	g	**Trial 3**	357.2	g
	Average	357.7	g	**Average**	356.0	g	**Average**	357.0	g

Calculation

U1=	51.8	U2=	52.1	U3= 51.9
UVB =	51.9			

Table C.77 Traprock #13 Sand (Method B – ASTM C1252)

Data

Size Fraction	*-2.36mm + 1.18mm*			*-1.18mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	138.1	g	**Trial 1**	132.3	g	**Trial 1**	130.1	g
	Trial 2	138.1	g	**Trial 2**	132.3	g	**Trial 2**	130.2	g
	Trial 3	138.1	g	**Trial 3**	132.1	g	**Trial 3**	130.1	g
	Average	138.1	g	**Average**	132.2	g	**Average**	130.1	g

Calculation

U1=	52.0	U2=	54.0	U3= 54.7
UVB =	53.6			

Table C.78 Traprock #13 Sand (VTM5)

Data

Size Fraction	*-2.36mm + 1.00mm*			*-1.00mm + 0.60mm*			*-0.60mm + 0.30mm*		
	Trial 1	367.8	g	**Trial 1**	364.6	g	**Trial 1**	366.6	g
	Trial 2	368.0	g	**Trial 2**	364.8	g	**Trial 2**	366.1	g
	Trial 3	367.7	g	**Trial 3**	363.9	g	**Trial 3**	365.8	g
	Average	367.8	g	**Average**	364.4	g	**Average**	366.2	g

Calculation

U1=	54.9	U2=	55.3	U3= 55.1
UVB =	55.1			

C.8 METHYLENE BLUE TEST (AASHTO TP57)

Table C.79 Laboratory Mix Design Source

	Aggregate Type			Aggregate Type		
	Natural Sand A			Crushed Gravel Sand		
	Initial Reading	Final Reading	MBV	Initial Reading	Final Reading	MBV
Test 1	26.5	33.0	3.3	33.5	36.0	1.3
Test 2	16.0	22.5	3.3	29.0	31.5	1.3
Test 3	22.5	29.0	3.3	31.5	34.0	1.3
		Average MBV =	3.3		Average MBV =	1.3

	Aggregate Type			Aggregate Type		
	Granite Sand			Dolomite Sand		
	Initial Reading	Final Reading	MBV	Initial Reading	Final Reading	MBV
Test 1	35.5	51.5	8.0	32.5	33.5	0.5
Test 2	22.5	47.0	12.3	1.5	3.0	0.8
Test 3	3.0	29.0	13.0	17	18.5	0.8
		Average MBV =	11.1		Average MBV =	0.7

	Aggregate Type			Aggregate Type		
	Traprock #16			Traprock #13		
	Initial Reading	Final Reading	MBV	Initial Reading	Final Reading	MBV
Test 1	10.5	24.0	6.8	14.5	24.0	4.8
Test 2	-	-	-	13.5	24.0	5.3
Test 3	-	-	-	24	34.5	5.3
		Average MBV =	6.8		Average MBV =	5.1

	Aggregate Type			Aggregate Type		
	Natural Sand B			Dolomite Sand		
	Initial Reading	Final Reading	MBV	Initial Reading	Final Reading	MBV
Test 1	19.5	29.5	5.0	19	24.5	2.8
Test 2	3.0	12.5	4.8	24.5	30.0	2.8
Test 3	12.5	22.5	5.0	-	-	-
		Average MBV =	4.9		Average MBV =	2.8

Table C.80 HMA Plant Stockpiles

	Aggregate Type			Aggregate Type		
	Natural Sand A			Crushed Gravel Sand		
	Initial Reading	Final Reading	MBV	Initial Reading	Final Reading	MBV
Test 1	9.0	22.5	6.8	22.5	25.0	1.3
Test 2	1.5	18.0	8.3	8.0	10.5	1.3
Test 3	18.0	34.5	8.3	10.5	13.0	1.3
		Average MBV =	7.8		Average MBV =	1.3

	Aggregate Type			Aggregate Type		
	Granite Sand			Dolomite Sand		
	Initial Reading	Final Reading	MBV	Initial Reading	Final Reading	MBV
Test 1	12.5	24.0	5.8	0.5	6	2.8
Test 2	24.0	36.0	6.0	6.0	11.5	2.8
Test 3	35.0	46.5	5.8	11.5	17	2.8
		Average MBV =	5.8		Average MBV =	2.8

	Aggregate Type			Aggregate Type		
	Natural Sand B			Traprock #13		
	Initial Reading	Final Reading	MBV	Initial Reading	Final Reading	MBV
Test 1	13.0	24.0	5.5	22.5	37.0	7.3
Test 2	24.0	35.0	5.5	13.0	26.5	6.8
Test 3	2.0	13.0	5.5	26.5	40.0	6.8
		Average MBV =	5.5		Average MBV =	6.9

C.9 SAND EQUIVALENT (AASHTO T104)

Table C.81 Fine Aggregate

	Aggregate Type			Aggregate Type			Aggregate Type		
	Natural Sand A			Crushed Gravel Sand			Natural Sand B		
	Clay Reading	Sand Reading	SE	Clay Reading	Sand Reading	SE	Clay Reading	Sand Reading	SE
Test 1	4.3	4.1	96.0	4.6	4.2	92.0	5.6	4.4	79.0
Test 2	4.2	4.1	98.0	4.6	4.0	87.0	5.5	4.3	79.0
Test 3	4.0	3.9	98.0	4.7	4.2	90.0	4.5	3.9	87.0
		Average SE =	98.0		Average SE =	90.0		Average SE =	82.0

	Aggregate Type			Aggregate Type			Aggregate Type		
	Granite Sand			Dolomite Sand			Dolomite Sand		
	Clay Reading	Sand Reading	SE	Clay Reading	Sand Reading	SE	Clay Reading	Sand Reading	SE
Test 1	4.3	3.3	77.0	4.0	4.0	100.0	4.5	3.5	78.0
Test 2	5.2	3.3	64.0	3.7	3.7	100.0	4.5	3.6	80.0
Test 3	5.3	3.5	67.0	3.9	3.9	100.0	4.6	3.6	79.0
		Average SE =	70.0		Average SE =	100.0		Average SE =	79.0

	Aggregate Type			Aggregate Type		
	Traprock #16			Traprock #13		
	Clay Reading	Sand Reading	SE	Clay Reading	Sand Reading	SE
Test 1	3.9	3.4	88.0	4.5	3.7	83.0
Test 2	4.5	3.7	83.0	5.9	4.0	68.0
Test 3	-	-	-	6.9	4.0	58.0
		Average SE =	86.0		Average SE =	70.0

C.10 MAGNESIUM SULFATE SOUNDNESS TESTS (AASHTO T104) – 5 CYCLES

Table C.82 Natural Sand A

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
9.5mm to 4.75mm	0.0			0.0	0.0
4.75mm to 2.36mm	10.1	100.2	89.9	10.3	1.0
2.36mm to 1.18mm	30.7	100.2	88.4	11.8	3.6
1.18mm to .600mm	28.8	100.0	90.2	9.8	2.8
.600mm to .300mm	21.4	100.0	92.5	7.5	1.6
.300mm to .150mm	7.4				
Minus 150mm	1.6				
	Total = 100.0			Total =	9

Table C.83 Crushed Gravel Sand

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
9.5mm to 4.75mm	0.0			0.0	0.0
4.75mm to 2.36mm	18.2	100.4	89.7	10.7	1.9
2.36mm to 1.18mm	31.2	100.1	85.4	14.7	4.6
1.18mm to .600mm	19.8	100.3	80.9	19.3	3.8
.600mm to .300mm	13.6	100.7	82.6	18.0	2.4
.300mm to .150mm	9.9				
Minus 150mm	7.3				
	Total = 100.0			Total =	13

Table C.84 Natural Sand B

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
9.5mm to 4.75mm	0.0			25.8	0.0
4.75mm to 2.36mm	14.7	100.0	74.2	25.8	3.8
2.36mm to 1.18mm	23.4	100.0	71.8	28.2	6.6
1.18mm to .600mm	24.4	100.0	67.7	32.3	7.9
.600mm to .300mm	19.5	100.0	68.7	31.3	6.1
.300mm to .150mm	11.9				
Minus 150mm	6.1				
Total =	100.0			Total =	24

Table C.85 Granite Sand

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
9.5mm to 4.75mm	1.0			12.9	0.1
4.75mm to 2.36mm	16.0	100.3	87.4	12.9	2.1
2.36mm to 1.18mm	26.0	100.4	80.7	19.6	5.1
1.18mm to .600mm	17.0	100.4	79.6	20.7	3.5
.600mm to .300mm	13.0	100.3	83.3	16.9	2.2
.300mm to .150mm	8.0				
Minus 150mm	19.0				
Total =	100.0			Total =	13

Table C.86 Dolomite Sand

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
9.5mm to 4.75mm	1.6			12.1	0.2
4.75mm to 2.36mm	26.8	100	87.9	12.1	3.2
2.36mm to 1.18mm	39.9	100.0	92	8	3.2
1.18mm to .600mm	16.7	100.0	90.5	9.5	1.6
.600mm to .300mm	9.0	100.0	87.7	12.3	1.1
.300mm to .150mm	4.3				
Minus 150mm	1.7				
Total =	100.0			Total =	9

Table C.87 Dolomite Sand

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
9.5mm to 4.75mm	0.0			0	0
4.75mm to 2.36mm	18.7	100.1	56.3	43.8	8.2
2.36mm to 1.18mm	29.6	100.0	66.4	33.6	9.9
1.18mm to .600mm	18.3	100.0	61.1	38.9	7.1
.600mm to .300mm	13.9	100.0	67.6	32.4	4.5
.300mm to .150mm	9.0				
Minus 150mm	10.5				
Total =	100.0			Total =	30

Table C.88 Traprock #16 Sand

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
9.5mm to 4.75mm	5.0			3.4	0.2
4.75mm to 2.36mm	38.0	100.0	96.6	3.4	1.3
2.36mm to 1.18mm	23.0	100.0	90.9	9.1	2.1
1.18mm to .600mm	14.0	100.0	87.1	12.9	1.8
.600mm to .300mm	8.0	100.0	84.7	15.3	1.2
.300mm to .150mm	6.0				
Minus 150mm	6.0				
Total =	100.0			Total =	7

Table C.89 Traprock #13 Sand

Sieve Size	Grading of Original Fractions Sample	Mass of Test Fraction Before Test	Mass of Test Fraction After Test	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
9.5mm to 4.75mm	4.0			6.8	0.3
4.75mm to 2.36mm	25.9	100.4	93.6	6.8	1.8
2.36mm to 1.18mm	21.0	100.2	78.8	21.4	4.5
1.18mm to .600mm	13.5	100.3	72.8	27.4	3.7
.600mm to .300mm	9.9	100.5	72.7	27.7	2.7
.300mm to .150mm	8.9				
Minus 150mm	16.8				
Total =	100.0			Total =	13

APPENDIX D

TEST SECTION CONSTRUCTION AND CONTROL

D.1 TEST SECTION CONSTRUCTION

Accelerated pavement tests were conducted at the INDOT/Purdue University APT facility located at the Indiana Department of Transportation Research Division in West Lafayette, Indiana (Figure D.1). In this facility, up to four test lanes can be constructed using conventional paving equipment. Prior to test section construction, any previously tested mixtures are removed. To facilitate removal, the slab heating system is turned on for 24 hours. A backhoe is used to remove the majority of the mixture with any remaining material being removed with hand tools.

Mixtures were produced by a local HMA contractor and delivered by truck to the APT facility. Mixtures were loaded into the paving machine hopper (Figure D.2) that is then backed into the facility (Figure D.3) Paving proceeds as the machine is driven forward, out of the building (Figure D.4). The resulting lane is 3 meters wide, half the total width of the APT test pit. The mixture is then compacted with a static steel-wheeled roller to achieve the target density (Figure D.5). A second mixture is placed in the adjacent 3-meter wide lane and compacted.

A longitudinal cut is made in the center of each 3-meter wide lane and the interior 1.5-meter wide portion of each lane removed (Figure D.6). The result is two, 1.5-meter wide test lanes, one on each side of the pit. Finally, a third mixture, 3-meters wide, is placed in the middle and compacted. The process produces four, 1.5-meter test lanes with three different mixtures; the middle two test lanes are constructed of the same mixture with no longitudinal joint between

them. Figure D.7 shows the APT test lanes and the APT equipment ready for testing. The average mat thickness was 100 mm.

It takes approximately seven weeks to construct, apply accelerated load passes, collect performance data, and perform material tests for each group of three test sections. The fourth section is a duplicate and is normally not tested unless additional data is needed. Actual construction, including the removal of any previously used mixtures, takes one day. Twenty-two (11 rutting, 5 moisture susceptibility, and 6 fatigue) test lanes were constructed and tested for the project.

D.2 SAMPLING AND TESTING DURING CONSTRUCTION

During construction of each set of test lanes, samples were taken and tested to determine: 1) The effect of HMA production and construction on aggregate properties; 2) in-place mixture composition; and 3) mixture volumetric properties. Prior to the HMA mixture production, bulk samples of aggregates were collected from plant stockpiles. Plant produced HMA samples were taken during construction and used to determine binder content, theoretical maximum specific gravity, and mixture gradations. In addition, samples were compacted with the gyratory compactor to N_{des}. Tests are summarized in Table D.1.

The aggregate mixture gradations for the coarse-graded, fine-graded, and moisture susceptibility mixtures are shown in Tables D.2, D.3, and D.4, respectively. The plant mixture properties of compacted HMA mixtures are shown in Table D.5. The data show that all of the mixtures had binder contents close to their design values. Gradations are also in close agreement except fines of plant produced material are lower. This value was slightly low for both the plant

mixtures and for cores taken before traffic. The VTM values of these mixtures were high. Also, these mixtures did not meet VFA requirements because of high VTM values.

Once construction was completed cores were extracted from each lane and tested for in-place density and moisture sensitivity (for the stripping portion of the study). In addition, after binder extraction, mixture gradation, fine aggregate uncompacted voids content, and aggregate particle flat *or* elongated percentage were determined. Figure D.8 shows the approximate location of cores extracted from test lanes. Cores were extracted before and after traffic. Three cores, one each from sections four, five, and six of each test lane, were extracted prior to APT trafficking. After APT trafficking four cores were extracted from each of the three sections, i.e. section four, five, and six (12 total). In each of the three sections, two cores were extracted from outside the wheel path and two from within the wheel path. Core diameters were approximately 102 mm (4 inches). Figure D.9 shows twelve cores taken after traffic.

Table D.1 APT Material Sampling and Testing Plan

Sample Type	Test Method	Experi-ments	Use
Aggregate Samples	Aggregate Gradation (AASHTO T11 and T27)	Rutting Moisture Fatigue	Composition Performance Relationships
Loose Mixture	Binder Content (AASHTO T164)	Rutting Moisture Fatigue	Composition Performance Relationships Volumetric Properties
	Aggregate Gradation (AASHTO T11 and T27)	Rutting Moisture Fatigue	Composition Performance Relationships
	Theoretical Maximum Specific Gravity (AASHTO T209)	Rutting Moisture Fatigue	Composition Performance Relationships Volumetric Properties
	Flat *or* Elongated Particles in Coarse Aggregate, 2:1 Ratio (ASTM D4791)	Rutting	Performance Relationships
	Uncompacted Voids Content of Fine Aggregate (ASTM C1252)	Rutting Moisture	Performance Relationships
Cores	Bulk Specific Gravity of Compacted Bituminous Mixture (AASHTO T166)	Rutting Moisture	Composition Performance Relationships Volumetric Properties
	Moisture Sensitivity (AASHTO T283)	Moisture	Volumetric Properties Changes in Strength
	Flat *or* Elongated Particles in Coarse Aggregate, 2:1 Ratio (ASTM D4791)	Rutting	Performance Relationships
	Uncompacted Voids Content of Fine Aggregate (ASTM C1252)	Rutting Moisture	Performance Relationships

Table D.2 Plant Produced HMA Mixture Gradation, Coarse-Graded Mixtures

	CA-1		CA-2		CA-3	
Sieve Size, mm	Design	Plant	Design	Plant	Design	Plant
12.5	100	100.0	100.0	100.0	100.0	100.0
9.5	91.0	89.2	91.5	91.7	89.0	97.8
4.75	48.3	48.5	47.3	51.3	43.5	45.5
2.36	29.3	30.8	30.8	33.6	29.1	30.8
1.18	20.7	20.3	21.2	21.8	20.5	20.7
0.60	13.2	12.0	13.8	12.8	13.0	11.7
0.30	7.6	5.2	8.3	5.7	7.5	4.3
0.15	4.9	2.8	5.6	3.2	4.8	2.3
0.075	3.2	2.1	4.0	2.5	3.2	1.7
Pb, %	5.7	5.6	6.1	5.9	3.9	3.8

Table D.2 Continued

	CA-4		CA-5	
Sieve Size, mm	Design	Plant	Design	Plant
12.5	100.0	100.0	100.0	100.0
9.5	93.1	91.5	89.8	89.7
4.75	46.9	44.8	37.8	40.0
2.36	31.1	25.4	29.1	28.4
1.18	22.5	15.6	21.7	19.0
0.60	14.3	8.9	14.2	10.4
0.30	8.0	4.2	6.9	4.6
0.15	5.4	2.5	3.7	2.7
0.075	3.4	2.0	2.5	2.0
Pb, %	5.8	5.4	4.8	4.6

Table D.3 Plant Produced HMA Mixture Gradations, Fine-Graded Mixtures

	FA-1		FA-2		FA-3	
Sieve Size, mm	Design	Plant	Design	Plant	Design	Plant
12.5	100.0	100.0	100.0	100.0	100.0	100.0
9.5	93.6	98.2	94.1	98.1	94.4	98.3
4.75	67.2	64.8	69.7	66.1	71.3	68.1
2.36	54.7	53.9	52.5	46.5	56.3	49.7
1.18	36.8	36.5	33.4	27.7	41.4	32.4
0.60	20.4	19.8	21.6	16.7	26.3	17.3
0.30	8.2	6.4	13.4	9.9	14.2	8.6
0.15	3.6	2.4	7.0	5.3	6.4	3.9
0.075	2.2	1.7	3.9	2.9	3.8	2.4
Pb, %	6.0	6.3	5.7	5.6	5.8	5.4
Film Thickness, μm	12.75	14.37	10.33	12.65	9.04	11.88

Table D.3 Continued

	FA-4		FA-5		FA-6	
Sieve Size, mm	Design	Plant	Design	Plant	Design	Plant
12.5	100.0	100.0	100.0	100.0	100.0	100.0
9.5	94.4	97.2	93.6	98.5	98.3	99.6
4.75	70.7	70.9	67.2	64.7	70.2	76.0
2.36	54.3	51.9	49.2	48.3	49.3	49.8
1.18	37.1	33.6	31.1	31.0	34.5	32.5
0.60	26.1	23.0	20.1	18.5	25.1	22.3
0.30	17.6	16.3	11.8	10.7	18.1	15.7
0.15	12.4	10.7	6.4	6.1	11.9	10.9
0.075	8.5	6.4	3.5	4.1	6.9	7.6
Pb, %	4.9	5.2	6.3	6.1	4.9	5.2
Film Thickness, μm	5.86	7.38	11.02	11.44	6.09	6.52

Table D.4 Plant Produced HMA Mixture Gradations, Moisture Susceptibility Mixtures

	FAM1		FAM2		FAM3	
Sieve Size, mm	Design	Plant	Design	Plant	Design	Plant
12.5	100.0	99.6	100.0	100.0	100.0	100.0
9.5	94.8	93.8	95.5	95.0	95.5	94.8
4.75	70.0	63.6	73.7	67.3	73.1	70.8
2.36	55.0	51.8	54.5	46.8	54.4	50.8
1.18	37.7	35.4	35.5	27.3	37.2	32.2
0.60	21.9	20.1	23.6	16.3	26.1	21.5
0.30	10.1	7.6	15.4	10.0	17.7	15.2
0.15	5.3	3.8	8.7	5.9	12.5	10.8
0.075	3.4	3.0	5.0	3.9	8.5	7.6
Pb, %	6.1	5.7	6.35	6.25	5.4	5.4
Film Thickness, μm	10.91	11.67	9.46	12.32	6.37	7.21

Table D.4 Continued

	FAM4		FAM5	
Sieve Size, mm	Design	Plant	Design	Plant
12.5	100.0	99.7	100.0	100.0
9.5	95.5	96.4	95.2	95.1
4.75	71.2	71.7	72.3	74.6
2.36	46.1	45.0	54.7	58.2
1.18	32.1	29.4	40.3	41.3
0.60	23.3	20.6	25.6	25.0
0.30	16.8	15.3	13.9	14.3
0.15	11.0	11.0	6.3	7.0
0.075	6.4	7.5	3.7	4.4
Pb, %	5.3	5.5	6.1	5.9
Film Thickness, μm	6.81	7.13	10.01	9.03

Table D.5 Plant Produced HMA Mixture Volumetric Data

Coarse-Graded Mixtures									
Mixture ID	P_b	VTM	G_{mm}	VMA, %		VFA, %		DP	$\%G_{mm}$
	%	%		N_{des}	Req'd.	N_{des}	Req'd.	%	N_{ini}
CA-1	5.6	5.2	2.520	16.3	14.0 min.	68.4	65 to 75	0.6	86.4
CA-2	6.0	4.1	2.443	14.2		70.9		0.7	87.0
CA-3	3.8	7.1	2.507	14.0		49.1		0.5	86.8
CA-4	5.4	9.8	2.457	20.8		52.9		0.4	82.1
CA-5	4.6	7.1	2.643	16.4		57.0		0.5	85.2
Fine-Graded Mixtures									
Mixture ID	P_b	VTM	G_{mm}	VMA, %		VFA, %		DP	$\%G_{mm}$
	%	%		N_{des}	Req'd.	N_{des}	Req'd.	%	N_{ini}
FA-1	6.3	4.9	2.449	15.9	14.0 min.	68.9	65 to 75	0.4	90.1
FA-2	5.6	6.8	2.454	18.2		62.6		0.6	85.5
FA-3	5.4	5.5	2.454	16.0		65.4		0.6	87.0
FA-4	5.2	3.6	2.449	14.8		75.4		1.3	88.2
FA-5	6.1	2.9	2.457	14.5		80.1		0.9	88.3
FA-6	5.2	3.6	2.613	14.7		75.2		1.7	87.6
Moisture Susceptibility Mixtures									
Mixture ID	P_b %	VTM %	G_{mm}	VMA, %		VFA, %		DP %	$\%G_{mm}$
				N_{des}	Req'd	N_{des}	Req'd.		N_{ini}
FAM1	5.7	4.1	2.483	15.0	14.0	72.6	65-75	0.6	90.2
FAM2	6.25	5.3	2.486	17.8		70.2		0.7	85.6
FAM3	5.4	3.5	2.487	15.0		76.4		1.5	86.7
FAM4	5.5	3.2	2.633	15.1		78.7		1.6	86.2
FAM5	5.9	3.1	2.472	14.8		79.0		0.9	87.1

Figure D.1 INDOT/ Purdue Accelerated Pavement Testing Facility

Figure D.2 Loading the paver

Figure D.3 The paving machine backs into the facility

Figure D.4 Test section paving

Figure D.5 Mixture compaction

Figure D.6 Center section is removed

Figure D.7 Test sections are ready for testing

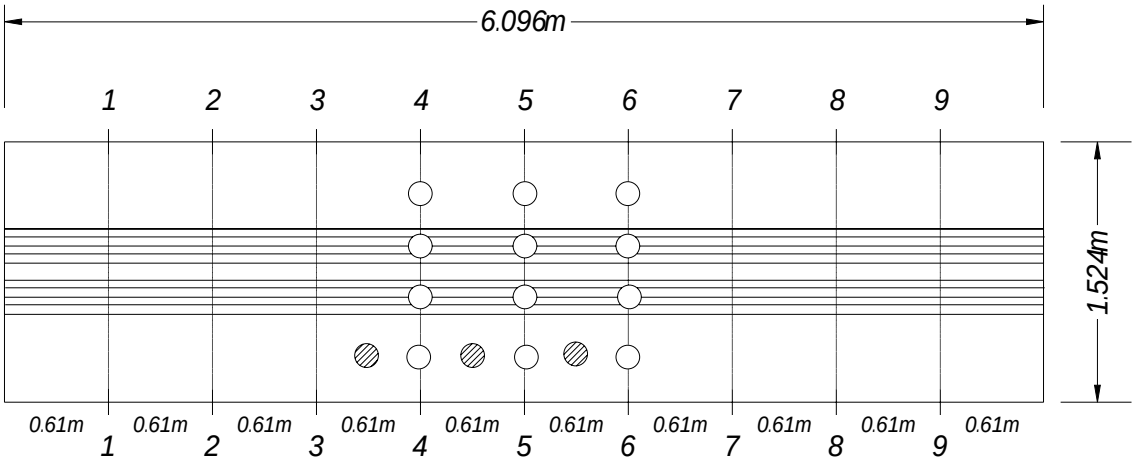

Figure D.8 APT coring locations

Figure D.9 Cores taken after traffic

APPENDIX E

MOISTURE SUSCEPTIBILITY

E.1 DRY AND CONDITIONS SPECIMEN PHOTOGRAPHS

		Dry Specimen	Conditioned Specimen
FAM1	Natural Sand A		
Tensile Strength (kPa)		452.3	499.4
TSR		1.10	

Figure E.1 Dry and conditioned specimens of FAM1 mixture

		Dry Specimen	Conditioned Specimen
FAM2	Crushed Gravel Sand, IN		
Tensile Strength (kPa)		689.6	621.2
TSR		0.90	

Figure E.2 Dry and conditioned specimens of FAM2 mixture

		Dry Specimen	Conditioned Specimen
FAM3	Granite Sand, NC		
Tensile Strength (kPa)		837.7	708.1
TSR		0.85	

Figure E.3 Dry and conditioned specimens of FAM3 mixture

		Dry Specimen	Conditioned Specimen
FAM4	Traprock Sand #13, VA		
Tensile Strength (kPa)		652.8	537.0
TSR		0.82	

Figure E.4 Dry and conditioned specimens of FAM4 mixture

		Dry Specimen	Conditioned Specimen
FAM5	Natural Sand B, OH		
Tensile Strength (kPa)		808.7	640.2
TSR		0.79	

Figure E.5 Dry and conditioned specimens of FAM5 mixture

		Internal surface	Bottom surface
FAM1	Natural Sand A		

Figure E.6 Cores from FAM1 test section after traffic

		Internal surface	Bottom surface
FAM2	Crushed Gravel Sand, IN		

Figure E.7 Cores from FAM2 test section after traffic

		Internal surface	Bottom surface
FAM3	Granite Sand, NC		

Figure E.8 Cores from FAM3 test section after traffic

		Internal surface	Bottom surface
FAM4	Traprock Sand #13, VA		

Figure E.9 Cores from FAM4 test section after traffic

		Internal surface	Bottom surface
FAM5	Natural Sand B, OH		

Figure E.10 Cores from FAM5 test section after traffic

APPENDIX F

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