Appendix A

Crumb rubber Test results

Table A.1: Crumb Rubber Gradation Test Result

Sieve in (Inches)	Sieve in (mm)	Retained on each sieve (gm)	Cumulative mass of soil retained (gm)	Cumulative mass of soil passing each sieve (gm)	Percent finer %
No 8	2.36	0	0	103	100.0
No 16	1.18	0	0	103	100.0
No 30	0.6	33.8	33.8	69.2	67.2
No 50	0.3	35	68.8	34.2	33.2
No 100	0.15	32	100.8	2.2	2.1
No 200	0.075	1.8	102.6	0.4	0.4
pan		0.4	103	0	0.0

Table A.2: Specific Gravity and Water absorption of Crumb Rubber Test Result

Sample description	1	2	3
Wt. of Pycnometer **A**	55.34	63.96	64.26
Wt. of Pycnometer fille with water **B**	163.20	168.88	172.23
Wt. of Pycnometer + Rubber **C**	70.39	78.99	79.32
Wt. of Pycnometer + water + Rubber **D**	164.87	170.46	173.31
Specific gravity $\frac{C-A}{(B-A)-(D-C)}$	1.12	1.12	1.08
Rubber Specific gravity	1.11		

Appendix B

Bitumen Tests Result

Table B.1: Bitumen Specific Gravity Test Result

Sample Description		Sample
Wt. of Pycnometer	**A**	36.50
Wt. of Pycnometer fille with water	**B**	68.65
Wt. of Pycnometer + asphalt	**C**	61.2
Wt. of Pycnometer + water + asphalt	**D**	69
Specific gravity	$\frac{C-A}{(B-A)-(D-C)}$	1.03

Table B.2: Bitumen Penetration Test Result

Sample description	1	2	3	Average	Penetration grade
A-1	65	68	69	67.0	60-70
A-2	64	64	69	66.0	60-70

Table B.3: Bitumen Ductility Test Result

Sample description	1	2	3	Average	
A-1	105	105	-	105	

Table B.4: Bitumen Softening Point Test Result

Sample description	Left	Right	Average	
	47	47.4	47.2˚ C	

Table B.5: Bitumen Flash and Fire Points Test Result

Sample description	Flash point˚ F	Fire point˚ F	
	610	620	

Appendix C

Asphalt Rubber Tests Results

C.1: 15% Rubber

Table C.1: Asphalt Rubber (15% Rubber) Specific Gravity Test Result

Sample Description		Sample
Wt. of Pycnometer	**A**	38.85
Wt. of Pycnometer fille with water	**B**	66.77
Wt. of Pycnometer + asphalt	**C**	60.36
Wt. of Pycnometer + water + asphalt	**D**	67.47
Specific gravity $\frac{C-A}{(B-A)-(D-C)}$		1.03

Table C.2: Asphalt Rubber (15% Rubber) Penetration Test Result

Sample description	1	2	3	Average	Penetration grade
A-1	66	68	67	68	60-70
A-2	66	68	68	68	60-70

Table C.3: Asphalt Rubber (15% Rubber) Ductility Test Result

Sample description	1	2	3	Average	
A-1	<<105	<<105	-		

Table C.5: Asphalt Rubber (15% Rubber) Softening point Test Result

Sample description	Left	Right	Average	
	53	54	53.5˚ C	

Table C.6: Asphalt Rubber (15% Rubber) Flash and fire point Test Result

Sample description	Flash point˚F	Fire point˚ F	
	554	572	

C-2: 20% Rubber

Table C.7: Asphalt Rubber (20% Rubber) Specific Gravity Test Result

Sample description		Sample
Wt. of Pycnometer	**A**	39.39
Wt. of Pycnometer fille with water	**B**	66.73
Wt. of Pycnometer + asphalt	**C**	60.69
Wt. of Pycnometer + water + asphalt	**D**	67.63
Specific gravity $\frac{C-A}{(B-A)-(D-C)}$		1.04

Table C.8: Asphalt Rubber (20% Rubber) Penetration Test Result

Sample description	1	2	3	Average	Penetration grade
A-1	54	55	55	55	
A-2	55	56	55	55	

Table C.9: Asphalt Rubber (20% Rubber) Ductility Test Result

Sample description	1	2	3	Average	
A-1	52	54	55	54	
A-2	54	55	55	55	

Table C.10: Asphalt Rubber (20% Rubber) Softening point Test Result

Sample description	Left	Right	Average	
	58.5	59	59˚C	

Table C.11: Asphalt Rubber (20% Rubber) Flash and Fire Point Test Result

Sample description	Flash point˚ F	Fire point˚ F	
	554	581	

C-3: 25% Rubber

Table C.12: Asphalt Rubber (25% Rubber) Specific Gravity Test Result

Sample description		**Sample**
Wt. of Pycnometer	**A**	38.85
Wt. of Pycnometer fille with water	**B**	66.77
Wt. of Pycnometer + asphalt	**C**	61.78
Wt. of Pycnometer + water + asphalt	**D**	67.72
Specific gravity	$\frac{C-A}{(B-A)-(D-C)}$	1.04

Table C.13: Asphalt Rubber (25% Rubber) Penetration Test Result

Sample description	**1**	**2**	**3**	**Average**	**Penetration grade**
A-1	61	63	62	62	60-70
A-2	64	65	61	63	60-70

Table C.14: Asphalt Rubber (25% Rubber) Ductility Test Result

Sample description	**1**	**2**	**3**	**Average**	
A-1	<<105	<<105	-	cm	

Table C.15: Asphalt Rubber (25% Rubber) Softening Point Test Result

Sample description	**Left**	**Right**	**Average**	
	56.5	56.9	56.7˚ C	

Table C.16: Asphalt Rubber (25% Rubber) Flash and Fire Points Test Result

Sample description	**Flash point ˚F**	**Fire point ˚F**	
	572	590	

Appendix D
Aggregate Test Results

Table D.1: Aggregate (3/4) inches Gradation Test Result

Total weight (gm)	2415
Dry weight (gm)	2393.5

Sieve in (Inches)	**Sieve in (mm)**	**Retained on each sieve (gm)**	**Cumulative mass of soil retained (gm)**	**Cumulative mass of soil passing each sieve (gm)**	**Percent finer %**
1	25	0	0	2415	100.0
3/4	19	39	39	2376	98.4
1/2	12.5	1875.5	1914.5	500.5	20.7
3/8	9.5	421	2335.5	79.5	3.3
N0 4	4.75	58	2393.5	21.5	0.9
No 8	2.36	0	2393.5	21.5	0.9
No 16	1.18	0	2393.5	21.5	0.9
No 30	0.6	0	2393.5	21.5	0.9
No 50	0.3	0	2393.5	21.5	0.9
No 100	0.15	0	2393.5	21.5	0.9
No 200	0.075	0	2393.5	21.5	0.9
pan		21.5	2415	0	0.0

Table D.2: Aggregate (3/8) inches Gradation Test Result

Total weight (gm)	2275
Dry weight (gm)	2259.5

Sieve in (Inches)	**Sieve in (mm)**	**Retained on each sieve (gm)**	**Cumulative mass of soil retained (gm)**	**Cumulative mass of soil passing each sieve**	**Percent finer %**
1	25	0	0	2275	100.0
3/4	19	0	0	2275	100.0
1/2	12.5	0	0	2275	100.0
3/8	9.5	0	0	2275	100.0
N0 4	4.75	1455	1455	820	36.0
No 8	2.36	363	1818	457	20.1
No 16	1.18	191	2009	266	11.7
No 30	0.6	114.5	2123.5	151.5	6.7
No 50	0.3	79.5	2203	72	3.2
No 100	0.15	41	2244	31	1.4
No 200	0.075	15.5	2259.5	15.5	0.7
pan		15.5	2275	0	0.0

Table D.3: Aggregate (3/16) inches Gradation Test Result

Total weight (gm)	2415
Dry weight (gm)	2393.5

Sieve in (Inches)	**Sieve in (mm)**	**Retained on each sieve (gm)**	**Cumulative mass of soil retained (gm)**	**Cumulative mass of soil passing each sieve (gm)**	**Percent finer %**
1	25	0	0	1992	100.0
¾	19	0	0	1992	100.0
½	12.5	0	0	1992	100.0
3/8	9.5	0	0	1992	100.0
N0 4	4.75	0	0	1992	100.0
No 8	2.36	483.5	483.5	1508.5	75.7
No 16	1.18	487	970.5	1021.5	51.3
No 30	0.6	376.5	1347	645	32.4
No 50	0.3	245.5	1592.5	399.5	20.1
No 100	0.15	158	1750.5	241.5	12.1
No 200	0.075	93	1843.5	148.5	7.5
Pan		148.5	1992	0	0.0

Table D.4: Sand Gradation Test Result

Total weight (gm)	1895.9
Dry weight (gm)	1818.1

Sieve in (Inches)	**Sieve in (mm)**	**Retained on each sieve (gm)**	**Cumulative mass of soil retained (gm)**	**Cumulative mass of soil passing each sieve (gm)**	**Percent finer %**
1	25	0	0	1895.9	100.0
3/4	19	0	0	1895.9	100.0
½	12.5	0	0	1895.9	100.0
3/8	9.5	0	0	1895.9	100.0
N0 4	4.75	0	0	1895.9	100.0
No 8	2.36	115	115	1780.9	93.9
No 16	1.18	204	319	1576.9	83.2
No 30	0.6	352.4	671.4	1224.5	64.6
No 50	0.3	567.8	1239.2	656.7	34.6
No 100	0.15	474.5	1713.7	182.2	9.6
No 200	0.075	104.4	1818.1	77.8	4.1
pan		77.8	1895.9	0	0.0

Table D.5: Filler Gradation Test Result

Total weight (gm)	1108
Dry weight (gm)	167

Sieve in (Inches)	**Sieve in (mm)**	**Retained on each sieve (gm)**	**Cumulative mass of soil retained (gm)**	**Cumulative mass of soil passing each sieve (gm)**	**Percent finer %**
1	25	0	0	1108	100.0
3/4	19	0	0	1108	100.0
1/2	12.5	0	0	1108	100.0
3/8	9.5	0	0	1108	100.0
N0 4	4.75	0	0	1108	100.0
No 8	2.36	0	0	1108	100.0
No 16	1.18	0	0	1108	100.0
No 30	0.6	0	0	1108	100.0
No 50	0.3	1	1	1107	99.9
No 100	0.15	18	19	1089	98.3
No 200	0.075	148	167	941	84.9
pan		941	1108	0	0.0

Table D.6: The Summaries of Aggregate Gradation were showed below

Summary		**No(3/4)**	**No(3/8)**	**No(3/16)**	**Sand**	**Filler**
Sieve in (Inches)	**Sieve in (mm)**	**Percent finer %**	**Percent finer %**	**Percent finer %**	**Percent finer %**	**Percent finer %**
1	25	100.0	100.0	100.0	100.0	100.0
3/4	19	98.4	100.0	100.0	100.0	100.0
1/2	12.5	20.7	100.0	100.0	100.0	100.0
3/8	9.5	3.3	100.0	100.0	100.0	100.0
N0 4	4.75	0.9	36.0	100.0	100.0	100.0
No 8	2.36	0.9	20.1	75.7	93.9	100.0
No 16	1.18	0.9	11.7	51.3	83.2	100.0
No 30	0.6	0.9	6.7	32.4	64.6	100.0
No 50	0.3	0.9	3.2	20.1	34.6	99.9
No 100	0.15	0.9	1.4	12.1	9.6	98.3
No 200	0.075	0.9	0.7	7.5	4.1	84.9
pan		0.0	0.0	0.0	0.0	0.0

Table D.7: Flakiness of Aggregate (3/4) inches Test Result

Sieve Size		Weight of passing(gm)	Weight of Retained (gm)	Total (gm)	Index%
20.0	14.0	15.5	484.5	500	3.1
14.0	10.0	32	468	500	6.4
10.0	6.3	-	-	-	-
$Flakiness\ F = \frac{P}{T} \times 100$					4.8

Table D.8: Elongation of Aggregate (3/4) inches Test Result

Sieve Size		Weight of passing(gm)	Weight of Retained (gm)	Total (gm)	Index%
20.0	14.0	438.5	61.5	500	12.3
14.0	10.0	410.5	89.5	500	17.9
10.0	6.3	-	-	-	-
$Elongation\ E = \frac{R}{T} \times 100$					15.1

Table D.9: Flakiness of Aggregate (3/8) inches Test Result

Sieve Size		Weight of passing(gm)	Weight of Retained (gm)	Total (gm)	Index%
20.0	14.0	-	-	-	-
14.0	10.0	-	-	-	-
10.0	6.3	109.5	240.5	350	31
$Flakiness\ F = \frac{P}{T} \times 100$					31

Table D.10: Elongation of Aggregate (3/8) inches Test Result

Sieve Size		Weight of passing(gm)	Weight of Retained (gm)	Total (gm)	Index%
20.0	14.0	-	-	-	-
14.0	10.0	-	-	-	-
10.0	6.3	275.5	74.5	350	21.3
$Elongation\ E = \frac{R}{T} \times 100$					21.3

Table D.11: Specific Gravity and Water absorption of Aggregate (3/4) inches

Description of Sample No	Test number		Avg
	1	2	
A weight in grams of oven-dry sample in air (gm)	2500	2500	
B weight in grams of saturated surface-dry sample in air (gm)	2511	1633	
C weight in grams of saturated sample in water (gm)	1631.5	1633	
Bulk specific gravity $\frac{A}{B-C}$	2.843	2.844	2.844
Bulk specific gravity saturated surface-dry basis $\frac{B}{B-C}$	2.855	2.858	2.857
apparent specific gravity $\frac{A}{A-C}$	2.879	2.884	2.882
Water absorption $\frac{B-A}{A}\times 100\%$	0.44	0.48	0.46

Table D.12: Specific Gravity and Water absorption of Aggregate (3/8) inches

Description of Sample No	Test number		Avg
	1	2	
A weight in grams of oven-dry sample in air (gm)	2500	2500	
B weight in grams of saturated surface-dry sample in air (gm)	2516	2517	
C weight in grams of saturated sample in water (gm)	1637	1627.5	
Bulk specific gravity $\frac{A}{B-C}$	2.844	2.811	2.828
Bulk specific gravity saturated surface-dry basis $\frac{B}{B-C}$	2.862	2.830	2.846
apparent specific gravity $\frac{A}{A-C}$	2.897	2.865	2.881
Water absorption $\frac{B-A}{A}\times 100\%$	0.64	0.68	0.66

Table D.13: Specific Gravity and Water absorption of Aggregate (3/16) inches

Description of Sample No	Test number		Avg
	1	2	
A weight in grams of oven-dry sample in air (gm)	492.5	493.5	
B weight in grams of saturated surface-dry sample in air (gm)	**500**	**500**	
C weight in grams of saturated sample in water (gm)	302.5	305	
Bulk specific gravity $\frac{A}{B-C}$	2.494	2.531	2.513
Bulk specific gravity saturated surface-dry basis $\frac{B}{B-C}$	2.532	2.564	2.548
apparent specific gravity $\frac{A}{A-C}$	2.592	2.618	2.605
Water absorption $\frac{B-A}{A}\times 100\,\%$	1.52	1.32	1.42

Table D.14: Specific Gravity and Water absorption of Sand

Description of Sample No	Test number		Avg
	1	2	
A weight in grams of oven-dry sample in air (gm)	497	496.5	
B weight in grams of saturated surface-dry sample in air (gm)	**500**	**500**	
C weight in grams of saturated sample in water (gm)	311.5	312	
Bulk specific gravity $\frac{A}{B-C}$	2.637	2.641	2.639
Bulk specific gravity saturated surface-dry basis $\frac{B}{B-C}$	2.653	2.660	2.657
apparent specific gravity $\frac{A}{A-C}$	2.679	2.691	2.685
Water absorption $\frac{B-A}{A}\times 100\%$	0.604	0.7	0.652

Table D.15: Specific Gravity and Water absorption of Filler

Description of sample no	Test number		Avg
	A-1	**A-2**	
A weight in grams of oven-dry sample in air (gm)	499.5	499	
V volume in milliliters of flask (Cm^3)	**500**	**500**	
W weight in grams of volume in milliliters of water added to flask (Cm^3)	305.5	300.5	
Bulk specific gravity $\frac{A}{V-W}\ gm/cm^3$	2.568	2.501	2.535
Bulk specific gravity saturated surface-dry basis $\frac{500}{V-W}\ gm/cm^3$	2.570	2.506	2.538
apparent specific gravity $\frac{A}{(V-W)-(500-A)}\ gm/cm^3$			
Water absorption $\frac{500-A}{A}\times 100\%$	0.1	0.2	0.15

Table D.16: Aggregate Los Angeles abrasion Test Result

	Sample No	Description of sample	Grading	Spheres	Revolute	Original weight (gm)	Final weight (gm)	Loss (gm)	Loss x100 / Original weight
1		3/4	B	11	500	5000	4446	554	11.1
2		3/8	C	8	4368	632	4368	632	12.6
3									
4									
5									

Grading		**A**	**B**	**C**	**D**	**E**	**F**	**G**
Revolution		500	500	500	500	1000	1000	1000
Spheres		12	11	8	6	12	12	12
passing	**Retained on**							
3	2 .5					2500±50		
2 .5	2					2500±50		
2	1.5					5000±50	5000±50	
1.5	1	1250±25					5000±25	5000±25
1	3/4	1250±25						5000±25
3/4	1/2	1250±10	2500±10					
1/2	3/8	1250±10	2500±10					
3/8	No 4			2500±10				
No 4	No 8			2500±10				
No 8	No 16							
No 16	No 30				5000±10			
Total (gm)		5000±10	5000±10	5000±10	5000±10	10000±100	10000±100	10000±100

Table D.17: Aggregate Crashing Test Result

	Description of sample	Original weight (gm)	Final weight (gm)	Loss (gm)	Loss x100 / Original weight
ACV	3/4	3036	2727	309	10.2

Table D.18: Aggregate Impact Test Result

	Description of sample	Original weight (gm)	Final weight (gm)	Loss (gm)	Loss x100 / Original weight
Impact value	3/4	792	775.5	16.5	2.1

Table D.19: Atterberge Limits for Filler

Liquid limit		**Plastic limit**
No. of blows		
Bottle No		
Wt. of wet soil + container (gm)		
Wt. of dry soil + container (gm)		
Wt. of container (gm)		
Wt of moisture		
Wt. of dry soil		
Moisture content		

Table D.20: Sand Equivalent Test Result

Sample		
Determination	1	2
Upper level h_1	6.4	5.6
Lower level (with lunger) h_2	3.5	3.8
Lower level (visual) h^1_2	3.7	3.9
S.E. $\frac{h^2_1}{h_1} \times 100$	54.7	67.9
S.E. $\frac{h^1_2}{h_1} \times 100$	57.8	69.6
S .E .Medium (with plunger)	61.3	
S .E .Medium (visual)	63.7	

Appendix E

ARHM Design Data and Optimum Bitumen

Content of HMA & ARHM

Table E.4: Optimum Bitumen Content of HMA

Description		AC%	$OBC\% = \frac{A+B+C}{3}$
At Max Stability	**A**	4.75	
Max Density	**B**	5.2	4.90
At AV% at 4%	**C**	4.8	

Table E.5: Optimum Bitumen Content of ARHM (15% Rubber)

Description		AC%	$OBC\% = \frac{A+B+C}{3}$
At Max Stability	**A**	5.4	
Max Density	**B**	5.1	5.2
At AV% at 4%	**C**	5.2	

Table E.6: Optimum Bitumen Content of ARHM (20% Rubber)

Description		AC%	$OBC\% = \frac{A+B+C}{3}$
At Max Stability	**A**	5.3	
Max Density	**B**	5.5	5.3
At AV% at 4%	**C**	5	

Table E.7: Optimum Bitumen Content of ARHM (25%Rubber)

Description		AC%	$OBC\% = \frac{A+B+C}{3}$
At Max Stability	**A**	5.3	
Max Density	**B**	5.7	5.40
At AV% at 4%	**C**	5.25	