STATE OF FLORIDA

FIELD CONDITIONING OF SUPERPAVE ASPHALT MIXES

Research Report
FL/DOT/SMO/99-435

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INTRODUCTION

Over the last several years, a number of Superpave projects under construction in Florida have experienced failing volumetrics (low VMA and air voids) during the initial production of the mix. In order to compensate for this reduction in air voids, contractors frequently request that the design binder content in the mix be reduced to bring the voids back into an acceptable range. Since reducing the binder content in the mix can have an adverse affect on the pavement's durability, the Department has been reluctant to approve many of these requests. Consequently, Contractors either have had to adjust the mix by making changes in the gradation, redesign the mix, or produce the mix with marginal air voids. In some cases where the Department has approved a reduction in binder content, achieving the specified density on the roadway has become more difficult, due to the reduction in lubrication in the mix.

This problem has also occurred nationally and a number of possible causes have been identified for this problem. The majority of them focus on reduced VMA due to aggregate degradation, rounding of the aggregate, or excess fines (P-200). Other possible causes have included high aggregate moisture contents (resulting in less asphalt absorption), as well as increased aggregate specific gravities (again resulting in less asphalt absorption).

It has recently been hypothesized in Florida that when a Superpave mix is sampled and tested at the plant immediately following production, that there is insufficient time for the aggregate to absorb the asphalt binder to the same extent that occurs during the mix design process. This would result in a higher effective binder content, and consequently lower air voids for the compacted plant produced mix. This is significant in Florida, where highly absorptive limestone materials are frequently used. Ideally, the best scenario would be to simulate at design and at the plant the conditions that could be expected of the mix at the roadway.

BACKGROUND

The current AASHTO Standard Practice for the Superpave Volumetric Design for Hot Mix Asphalt (PP28-95 Edition 1A) requires that the asphalt mix be conditioned during the mix design process in accordance with the Standard Practice for Short and Long Term Aging of Hot Mix Asphalt (AASHTO PP2-94 Edition 1A) in order to ". . .simulate the aging the mixture will undergo during plant mixing and construction". This conditioning involves placing the uncompacted mixture in a force-draft oven for two hours at 135°C, prior to performing any of the required mixture tests. This conditioning results in 1) age hardening of the asphalt binder and 2) absorption of the asphalt binder into the aggregate. PP-2 also states that "The short term aging procedure applies to laboratory prepared loose mix only", which basically prohibits aging or conditioning plant produced mix. This issue was further amplified through a 1998 AASHTO Lead State Guidance document with the following statement:

> **Field Aging of Asphalt Mixtures** - The purpose of the short-term oven aging (STOA) procedure included in Superpave was to account for mixture aging and binder absorption during production and the first years of the pavement's life. No additional STOA is necessary, or recommended, except to bring the mixture to the appropriate compaction temperature.

Currently, Quality Control and Acceptance tests are performed on the mixture immediately after it is sampled at the plant without any conditioning beyond what has occurred during production.

OBJECTIVE

The objective of this study was to investigate the properties of the mix after conditioning at design and after various conditioning times with plant produced mix, and comparing those properties with the properties of mixture as it is placed at the roadway. An attempt was made to determine 1) if the two hour force-draft oven conditioning adequately simulates actual roadway conditions, and 2) how can actual roadway conditions best be simulated when the asphalt mix is sampled and tested immediately following production at the plant.

Seven separate mixes were evaluated during the course of this study: three of the mixes used exclusively central Florida limestone, two of the mixes used predominantly granite, one mix used predominantly southeast Florida limestone, and one mix used predominantly north Florida limestone. A description of the mixes is shown in **Table 1**. As detailed below, several scenarios with respect to conditioning times were analyzed for the laboratory and plant produced mixes, with the ultimate goal being to identify the correct conditioning time(s) for design in the laboratory and for the plant produced mix that will simulate actual roadway mixture conditions.

SAMPLING AND TESTING

In order to correlate the design conditioning with post-production conditioning, the aggregate and binder was sampled from the plant at three of the projects under evaluation. Aggregate gradations and bulk specific gravities were determined in accordance with FM 1-T 027, FM 1-T 084, and FM 1-T 085, respectively. The mixture was then fabricated in the laboratory with a gradation and binder content based on the actual plant produced mix. The laboratory fabricated mix was then conditioned in accordance with AASHTO PP2 with a force-draft oven at the standard compaction temperature of 295°F, for 0, 1, 2, 4 & 8 hours. Specimens were then tested for maximum specific gravity (G_{mm}) in accordance with FM 1-T 209. Gyratory specimens were also compacted to N_{max} with the Superpave Gyratory Compactor (SGC) in accordance with AASHTO TP4, and the bulk specific gravities (G_{mb}) were determined in accordance with FM 1-T 166. The binder was also recovered from each of the mixes and the absolute viscosity at 60°C (140°F) was determined in accordance with AASHTO T202. Results from these tests are shown in **Table 2** and **Figures 1 thru 4**.

In order to correlate post-production conditioning with actual roadway conditions, samples were obtained at all seven project locations. At the plant, samples were obtained for G_{mm}, G_{mb}, viscosity, moisture content, and extraction with the following conditioning times: 0, haul time, 1, & 2 hours. The samples for conditioning were placed in a covered container in a force- draft oven at 295°F for the appropriate conditioning period prior to testing, while the samples that were tested for the "haul time" duration were placed in a closed container and heated in an oven at 295°F to maintain temperature. They were not exposed to the air flow in the oven. Results from these tests are shown in **Table 3** and **Figures 5 thru 9**.

At the roadway, samples were obtained and tested for G_{mm}, G_{mb}, viscosity, and extraction. The mix at the roadway was sampled from the same truck that was sampled at the plant. The G_{mb} specimens were compacted using the Department's mobile SGC trailer that was present at the roadway. The samples were not conditioned prior to testing. Results from these tests are shown in **Table 4** and **Figures 1 thru 9**.

ANALYSIS OF RESULTS

Conditioning at Design:

The first phase of this study focused on establishing the relationship between design conditioning and actual field conditions. Samples of the aggregate and asphalt binder were obtained from the plant at three of the projects under review. In addition, samples of the as-produced mix were obtained at the plant and on the roadway, with the samples taken from the same truck load of mix. These samples were then extracted with an ignition oven, and the results are shown in **Tables 5 thru 7**. The mix was then fabricated in the laboratory based on the extracted gradation/binder content from the plant, and conditioned and tested as described above.

Review of the G_{mm} data relating the aging/absorption that occurs during the mix design process to actual field conditions (**Figure 1**) indicates that a three hour conditioning at design seems to correlate the most effectively. G_{mb} data of the compacted specimens (**Figure 2**) is fairly erratic due to the variations in temperature that occurred at the roadway (roadway samples were compacted at approximately 265°F due to the lack of a heat source, while laboratory fabricated specimens were compacted at 295°F), however, conditioning appears to have somewhat of an insignificant effect on them. Air void data (**Figure 3**), seems to show that a two hour conditioning period best matches actual roadway conditions, although this data is influenced by the variations in G_{mb} values described above. Viscosity data generally shows that two hour conditioning is most representative of field conditions (**Figure 4**). It should be noted that the data on the design conditioning versus actual roadway conditions is very limited.

<u>Post Production Conditioning</u>:

The second phase of this study was to evaluate the relationship between post-production conditioning with actual roadway conditions. Four additional mixes were tested besides the three mixes previously mentioned. Of the seven total mixes, five were composed of primarily Florida limestone. Since the maximum specific gravity (G_{mm}) of the mix appeared to be affected the most by conditioning, this portion of the study primarily focused on this area.

Analysis of the average G_{mm} value for the seven mixes (**Table 8** and **Figure 5**), indicates that a post-production conditioning time that was closest to the actual haul time of the mix appears to correlate very well with roadway data. This generally corresponds to between one and two hours. However, since the two hour conditioning yielded values that were generally greater than those found at the roadway, it would appear that the one hour conditioning does a better job of simulating roadway conditions, and is at the same time conservative. It is also a good approximation of the average haul time for these projects, which was 67 minutes. The zero hour conditioning (which is currently the AASHTO requirement) was the furthest away from actual roadway conditions.

Looking at the data based on the absorption of the aggregate, the lack of post-production conditioning would underestimate the air voids of absorptive mixes by approximately 0.5%, while it would underestimate non-absorptive materials by approximately 0.25%.

Data indicated that conditioning had minimal effect on the G_{mb} values, as seen in **Figure 7**.

In order to evaluate the effects that a conditioning period would have on production testing, two current construction projects added a one hour conditioning period to the basic Quality Control testing requirements at the plant. Results from this testing confirmed that one hour conditioning seemed to match the roadway results very closely (**Tables 9 & 10**) .

CONCLUSIONS

This investigation has looked at mix properties with respect to various conditioning times at design and following field plant production, then compared them to mix properties at the roadway. Specifically, an attempt was made to determine 1) if the two hour force-draft oven conditioning adequately simulates actual roadway conditions, and 2) how can actual roadway conditions best be simulated when the asphalt mixture is sampled and tested immediately following production at the plant. From this analysis of the data, the following conclusions can be drawn:

1) The data relating design conditioning to actual roadway conditions generally indicated that an approximate conditioning time of three hours, appears to best correlate with actual field conditions in terms of G_{mm}. However, G_{mb}, air void (V_a), and viscosity data seemed to correlate best at two hours.

2) Post-production conditioning for a period of between one and two hours best matched roadway conditions. Two hour conditioning typically resulted in G_{mm} values slightly higher than those found on the roadway, while one hour conditioning resulted in G_{mm} values slightly lower. As such, two hour conditioning would result in air voids (at the plant) that are "artificially" higher than what would be expected of the mix had it been sampled at the roadway, whereas one hour conditioning would result in air voids that are slightly lower. It was of interest to note that the one hour conditioning closely matched the average haul time of 67 minutes.

3) The addition of a one hour conditioning time would typically increase the air voids of a mix with absorptive materials by 0.5%. Non-absorptive materials would experience an increase of approximately 0.25%.

4) Testing the samples immediately after production without any additional conditioning resulted in G_{mm} values that were consistently lower than those measured at the roadway.

5) Conditioning had minimal effect on compacted G_{mb} values.

RECOMMENDATIONS

Based on the analysis of the data collected during the course of this study and the previous conclusions, the following recommendations are made:

1) The Department should continue to utilize a two hour aging/conditioning period during the mix design process. Although three hours may be slightly more accurate, two hours would tend to be more conservative, and would result in less situations where the binder content of the mix would have to be reduced during production.

2) The Department should implement a one hour conditioning period prior to testing during production. Samples should be taken, reduced to the appropriate sample size, placed in a container, covered with aluminum foil, and placed in a force-draft or convection oven at the compaction temperature for one hour prior to testing. Although conditioning had a minimal effect on G_{mb} values, compaction samples should be conditioned also, in order to be consistent. However, samples for extraction and gradation do not need to be conditioned prior to testing.

3) Since lack of conditioning of plant produced mix is only one possible cause of low VMA during production, the Department should follow up this study with one that looks at aggregate degradation and rounding.

Table 1 - Project Information

Contractor	**Anderson Columbia**		**Grubbs #1**		**DAB**		**Anderson Columbia**		**Milestone**		**White Construction**		**Grubbs #2**	
Plant Location	Maxville		Brooksville		Brooksville		Lake City		Jacksonville		Gainesville		Brooksville	
Mix Design #	SP99-0290C		SP98-0203A		SP99-0272A		SP97-0091A		SP99-0252B		SP99-0341A		SP98-204B	
Mix Type	12.5 C Recycle		9.5 C		9.5 C		12.5 F Recycle		12.5 F Recycle		12.5 F Recycle		12.5 C	
Ndes	96		96		96		86		86		86		96	
AC Type	AC-30		AC-30		AC-30		AC-30		RA-15		AC-30		AC-30	
Gsb, measured	2.366		2.419		2.433		NA		NA		NA		NA	
Gsb, mine	2.377		2.378		2.378		2.526		2.616		2.432		2.382	
Aggregate	Component	%	Component	%	Component	%	Component	%	Component	%	Component	%	Component	%
Type	Tarmac S1A	13	Fl. Cr. Stn. 3/8" Stn.	40	Fl. Cr. Stn. 3/8" Stn.	40	M.M. GA-185 #7 Stn.	18	M.M. NS-315 #7 Stn.	20	M.M. NS-315 #67-A Stn.	20	Fl. Cr. Stn. #67 Stn.	14
	Tarmac S1B	52	Fl. Cr. Stn. 130A Scrns.	60	Fl. Cr. Stn. 130C Scrns.	60	M.M. GA-185 #89 Stn.	12	M.M. NS-315 #89 Stn.	10	Limerock Ind. #200 Scrns.	20	Fl. Cr. Stn. 3/8" Stn.	38
	And. Col. Screenings	15					And. Col. Screenings	30	M.M. NS-315 W-10 Scrns.	40	Limerock Ind. #210 Scrns.	30	Fl. Cr. Stn. 130A Scrns.	48
	R.A.P.	20					M.M. GA-185 W-10 Scrns.	20	Milestone Local Sand	10	R.A.P.	30		
							R.A.P.	20	R.A.P.	20				

Table 2 - Mixture Data for Laboratory Produced Specimens

Conditioning Time (minutes)	Gmm	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
Anderson Columbia, Maxville - Lab Data					
0	2.274	2.195	3.49	13.2	7282
60	2.295	2.199	4.17	13.0	11925
120	2.302	2.182	5.20	13.7	16897
240	2.318	2.165	6.59	14.4	41607
480	2.318	2.165	6.60	14.4	NA
Grubbs #1, Brooksville - Lab Data					
Conditioning Time (minutes)	Gmm	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.273	2.274	-0.02	13.5	2414
60	2.299	2.256	1.89	14.1	3160
120	2.303	2.263	1.74	13.9	4085
240	2.325	2.267	2.50	13.7	8372
480	2.337	2.264	3.12	13.8	NA
DAB, Brooksville - Lab Data					
Conditioning Time (minutes)	Gmm	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.315	2.278	1.60	13.1	2873
60	2.319	2.263	2.41	13.7	4416
120	2.329	2.271	2.47	13.4	6331
240	2.340	2.287	2.25	12.8	11451
480	2.352	2.286	2.80	12.8	NA

Table 3 - Mixture Data for Plant Produced Specimens

Anderson Columbia, Maxville - Plant Data

Conditioning Time (minutes)	Gmm	% Absorption By Agg. Wt.	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.285	2.22	2.191	4.10	13.3	6818
20	2.307	2.68	2.190	5.06	13.4	8592
60	2.310	2.75	2.198	4.87	13.1	8745
120	2.319	2.93	2.190	5.58	13.4	13523

Grubbs #1, Brooksville - Plant Data

Conditioning Time (minutes)	Gmm	% Absorption By Agg. Wt.	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.292	2.37	2.265	1.19	13.8	2900
60	2.321	2.98	2.257	2.74	14.1	4553
70	2.318	2.92	2.271	2.04	13.6	4017
120	2.331	3.19	2.272	2.52	13.5	5811

DAB, Brooksville - Plant Data

Conditioning Time (minutes)	Gmm	% Absorption By Agg. Wt.	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.330	2.48	2.263	2.89	13.7	5721
55	2.337	2.62	2.264	3.13	13.7	5536
60	2.324	2.35	2.260	2.77	13.8	6892
120	2.337	2.62	2.258	3.39	13.9	19152

Anderson Columbia, Lake City - Plant Data

Conditioning Time (minutes)	Gmm	% Absorption By Agg. Wt.	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.398	2.11	2.329	2.89	14.3	NA
60	2.405	2.25	2.332	3.03	14.1	NA
120	2.415	2.44	2.324	3.75	14.4	NA
240	2.429	2.70	NA	NA	NA	NA
480	2.431	2.74	NA	NA	NA	NA

Milestone, Jacksonville - Plant Data

Conditioning Time (minutes)	Gmm	% Absorption By Agg. Wt.	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.433	0.58	*Plant gyratory compactor was broken*			NA
60	2.441	0.73	*Plant gyratory compactor was broken*			NA
120	2.440	0.71	2.394	1.89	13.8	NA
240	2.449	0.88	NA	NA	NA	NA
480	2.455	0.99	NA	NA	NA	NA

White, Gainesville - Plant Data

Conditioning Time (minutes)	Gmm	% Absorption By Agg. Wt.	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.301	2.40	2.203	4.24	16.7	NA
60	2.309	2.57	2.202	4.63	16.7	NA
120	2.339	3.19	2.201	5.90	16.7	NA
240	2.337	3.15	NA	NA	NA	NA
480	2.344	3.29	NA	NA	NA	NA

Grubbs #2, Brooksville - Plant Data

Conditioning Time (minutes)	Gmm	% Absorption By Agg. Wt.	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
0	2.336	2.83	2.252	3.60	11.3	NA
60	2.342	2.95	2.246	4.09	11.5	NA
120	2.351	3.13	2.243	4.59	11.6	NA
240	2.360	3.31	NA	NA	NA	NA
480	2.378	3.66	NA	NA	NA	NA

Table 4 - Mixture Data for Roadway Prepared Specimens

Project	Roadway Haul Time	Gmm	% Absorption By Agg. Wt.	Gmb at Ndes	Air Voids at Ndes	VMA at Ndes	Viscosity (Poises)
And. Col., Maxville	20	2.312	2.87	2.186	5.47	13.7	7667
Grubbs #1, Brkvle.	70	2.313	3.12	2.246	2.91	14.9	4012
DAB, Brooksville	55	2.319	2.35	2.265	2.33	13.8	6849
And. Col., Lake City	128	2.416	2.39	2.333	3.44	14.0	NA
Milestone, Jax.	35	2.437	0.77	2.382	2.24	14.4	NA
White, G'ville	120	2.345	2.26	2.201	6.15	15.3	NA
Grubbs #2, Brkvle.	43	2.362	3.39	2.224	5.85	12.5	NA

Table 5 - Gradation and AC Content Data for Anderson Columbia, Maxville Project

Anderson Columbia, Maxville Plant, Roadway, and Design Comparison Sieve	Plant	Roadway	*Difference Plant-Road*	Design	*Difference Design-Plant*
3/4	100.0	100.0	***0.0***	100	***0.0***
1/2	98.3	98.8	***-0.5***	98	***-0.3***
3/8	94.6	95.5	***-0.9***	90	***-4.6***
#4	58.3	61.5	***-3.2***	56	***-2.3***
#8	26.5	27.5	***-1.0***	28	***1.5***
#16	20.2	20.7	***-0.5***	22	***1.8***
#30	17.1	17.5	***-0.4***	18	***0.9***
#50	13.6	14.0	***-0.4***	13	***-0.6***
#100	8.9	9.2	***-0.3***	7	***-1.9***
#200	5.8	6.2	***-0.4***	4.5	***-1.3***
% AC	6.42	6.55	***-0.1***	6.7	***0.3***

Table 6 - Gradation and AC Content Data for Grubbs #1, Brooksville Project

Grubbs #1, Brooksville Plant, Roadway, and Design Comparison Sieve	Plant	Roadway	*Difference Plant-Road*	Design	*Difference Design-Plant*
3/4	100.0	100.0	***0.0***	100	***0.0***
1/2	99.9	99.9	***0.0***	100	***0.1***
3/8	98.0	98.7	***-0.7***	100	***2.0***
#4	68.0	73.0	***-5.0***	70	***2.0***
#8	41.0	44.0	***-3.0***	44	***3.0***
#16	25.0	25.6	***-0.6***	26	***1.0***
#30	16.5	16.5	***0.0***	14	***-2.5***
#50	11.4	11.1	***0.3***	8	***-3.4***
#100	9.1	8.7	***0.4***	7	***-2.1***
#200	7.8	7.4	***0.4***	5.0	***-2.8***
% AC	7.91	8.37	***-0.5***	8.5	***0.6***

Table 7 - Gradation and AC Content Data for DAB, Brooksville Project

DAB, Brooksville Plant, Roadway, and Design Comparison Sieve	Plant	Roadway	***Difference Plant-Road***	Design	***Difference Design-Plant***
3/4	100.0	100.0	***0.0***	100	***0.0***
1/2	99.9	99.9	***-0.1***	100	***0.1***
3/8	97.8	97.3	***0.4***	98	***0.3***
#4	68.7	68.6	***0.1***	77	***8.3***
#8	39.9	40.5	***-0.5***	46	***6.1***
#16	23.8	24.8	***-1.0***	29	***5.2***
#30	15.5	16.5	***-1.0***	18	***2.5***
#50	10.7	11.7	***-1.0***	10	***-0.7***
#100	8.0	9.0	***-1.0***	6	***-2.0***
#200	6.6	7.5	***-0.9***	4.0	***-2.6***
% AC	7.23	7.39	***-0.2***	8.5	***1.3***

Table 8 - Maximum Specific Gravity (G_{mm}) Summary for Plant and Roadway Mixtures

	Gmm				Actual
	Conditioning Time				Haul Time
Contractor	Plant - 0 hour	Plant - 1 hour	Plant - 2 hour	Roadway	(minutes)
A.C., Maxville	2.285	2.310	2.319	2.312	20
Grubbs#1, Brk'vle	2.292	2.321	2.331	2.313	70
DAB, Brk'vle	2.330	2.324	2.337	2.319	55
A.C., Lake City	2.398	2.405	2.415	2.416	128
Milestone, Jax	2.433	2.441	2.440	2.437	35
White, G'ville	2.301	2.309	2.339	2.345	120
Grubbs#2, Brk'vle	2.336	2.342	2.351	2.362	43
Average	2.339	2.350	2.362	2.358	67
Std. Dev.	0.056	0.052	0.047	0.051	42

Difference (0 hour - Roadway)	-0.018
Difference (1 hour - Roadway)	-0.007
Difference (2 hour - Roadway)	0.004

Table 9 - Maximum Specific Gravity Data (G_{mm}) for Anderson Columbia Pilot Project #1

Date	No Aging (QA)	Rdwy (Dist.)	1 Hr (QC)	1 Hr (Dist.)	Haul Time (min)
6/29/99	2.263	2.265	2.271	NA	25
7/1/99	2.253	2.263	2.274	2.280	25
7/6/99	2.271	2.306	2.278	2.295	25
7/8/99	2.250	2.271	2.273	2.272	25
Average	2.259	2.276	2.274	2.282	
Std. Dev.	0.010	0.020	0.003	0.012	

Notes:

1. Maxville Plant, Project Location: US301, Mix Design # SP99-290B
2. "No aging" samples tested by QA technician at plant
3. Roadway samples tested by District at District Lab
4. 1 Hour aging samples tested by QC technician at plant and separate samples run by District at District Lab

Table 10 - Maximum Specific Gravity Data (G_{mm}) for Anderson Columbia Pilot Project #2

Date	No Aging (QA)	Rdwy (Dist.)	1 Hr (QC)	1 Hr (Dist.)	Haul Time (min)
7/14/99	2.265	2.288	2.271	2.278	30
7/15/99	2.258	2.281	2.284	2.281	30
Average	2.262	2.285	2.278	2.280	
Std. Dev.	0.005	0.005	0.009	0.002	

Notes:

1. Hawthorne Plant, Project Location: US301, Mix Design # SP99-291A
2. "No aging" samples tested by QA technician at plant
3. Roadway samples tested by District at District Lab
4. 1 Hour aging samples tested by QC technician at plant and separate samples run by District at District Lab

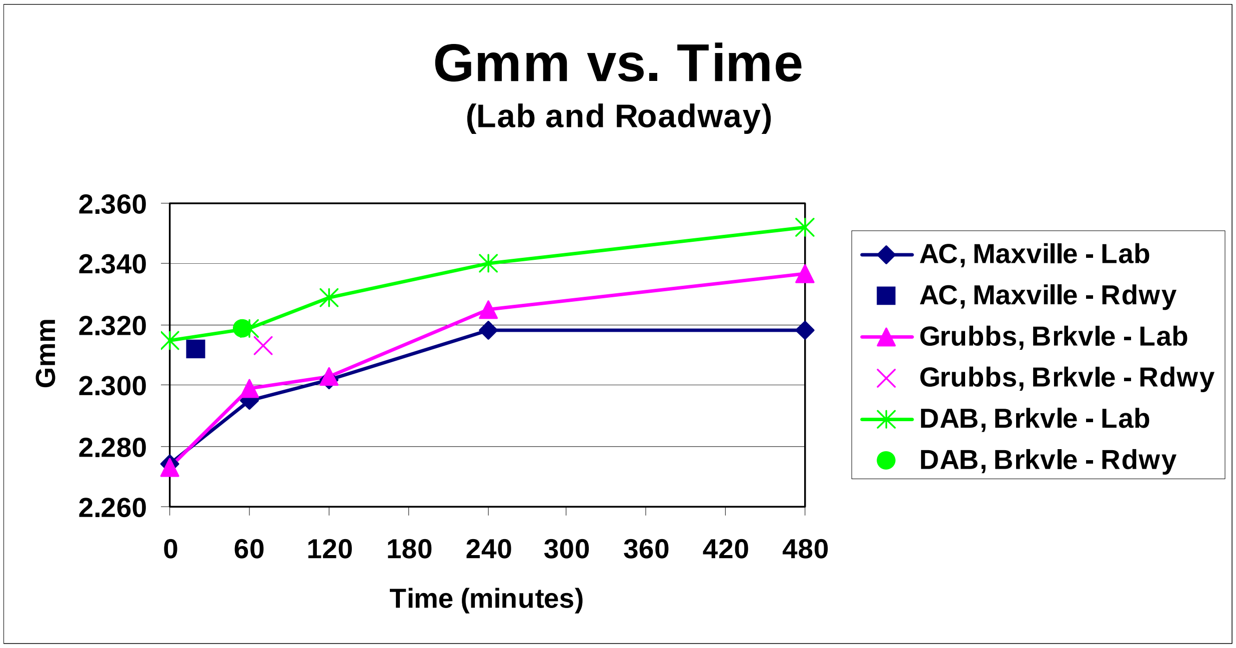

Figure 1 - Maximum Specific Gravity (Gmm) Data for Laboratory Produced and Roadway Sampled Mixtures

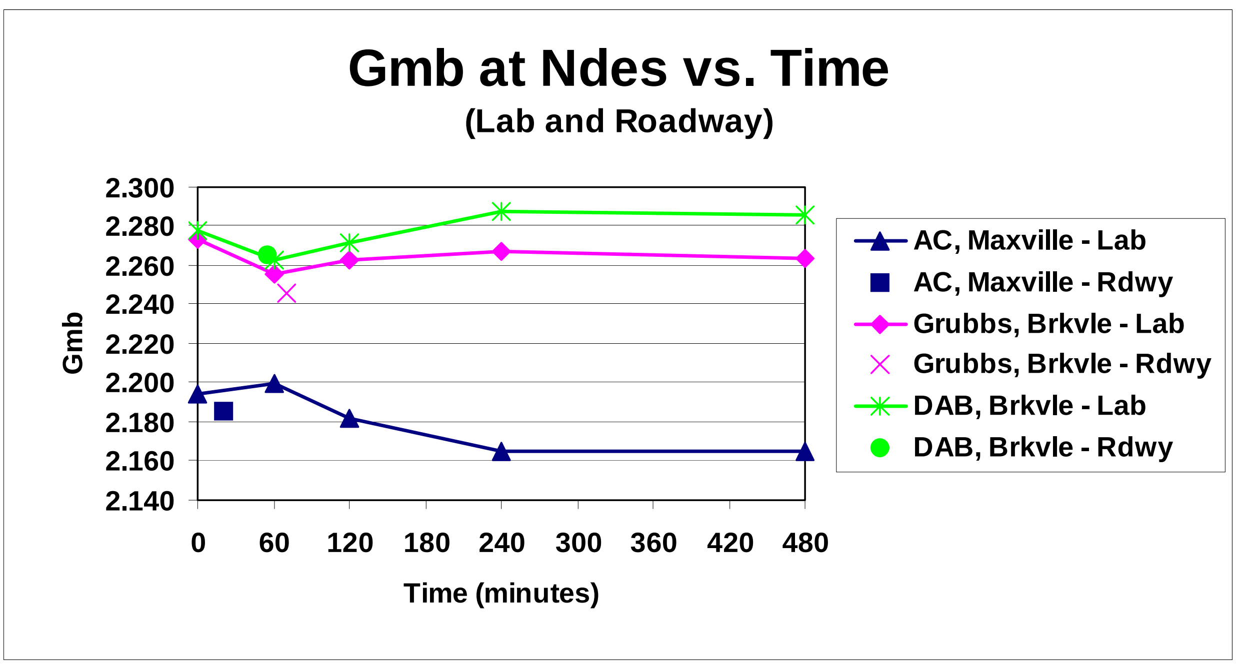

Figure 2 - Bulk Specific Gravity (Gmb) Data for Laboratory Produced and Roadway Sampled Mixtures

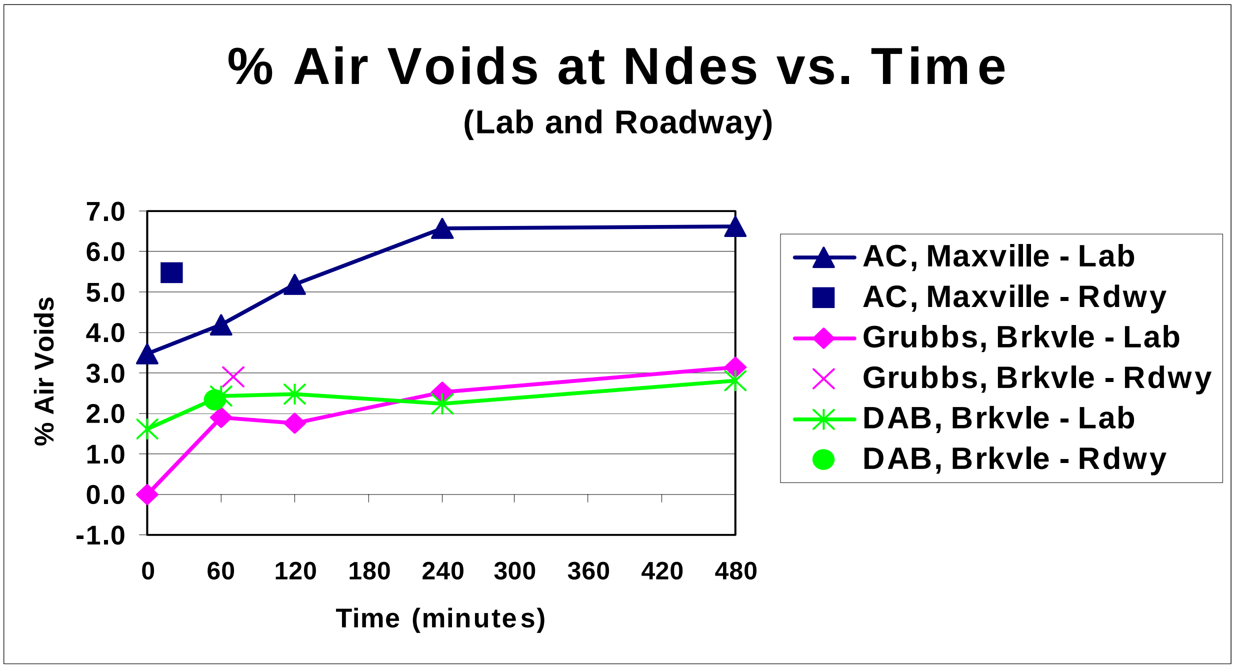

Figure 3 - % Air Voids Data for Laboratory Produced and Roadway Sampled Mixtures

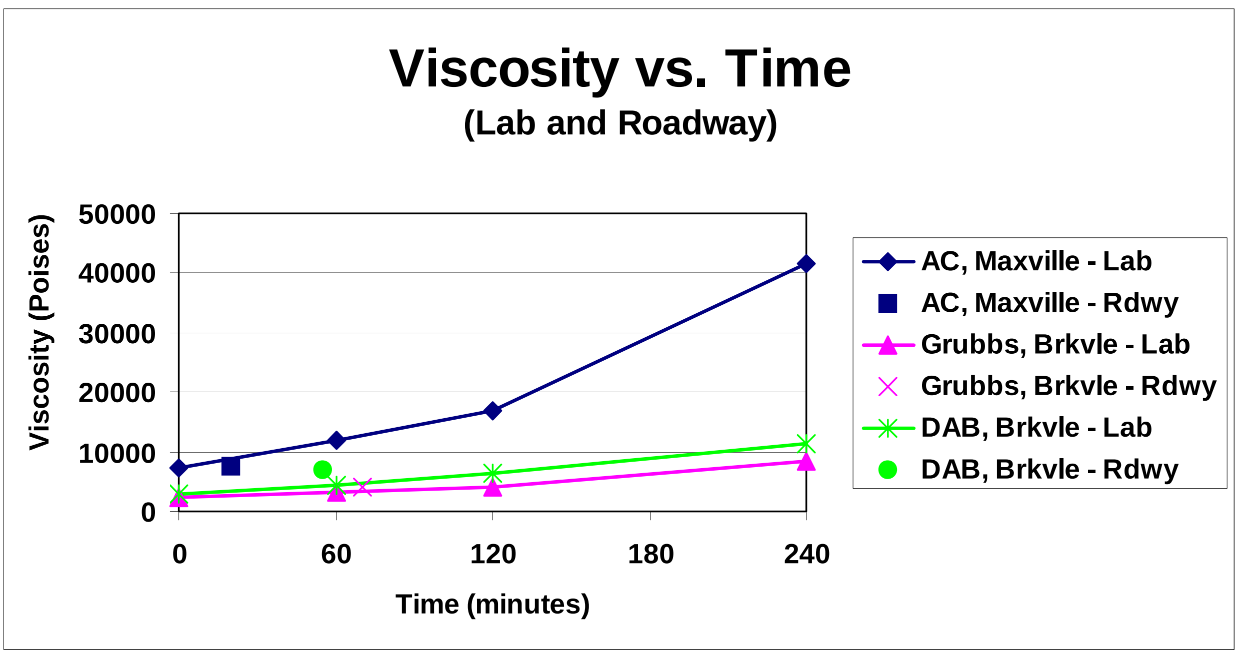

Figure 4 - Viscosity Data for Laboratory Produced and Roadway Sampled Mixtures

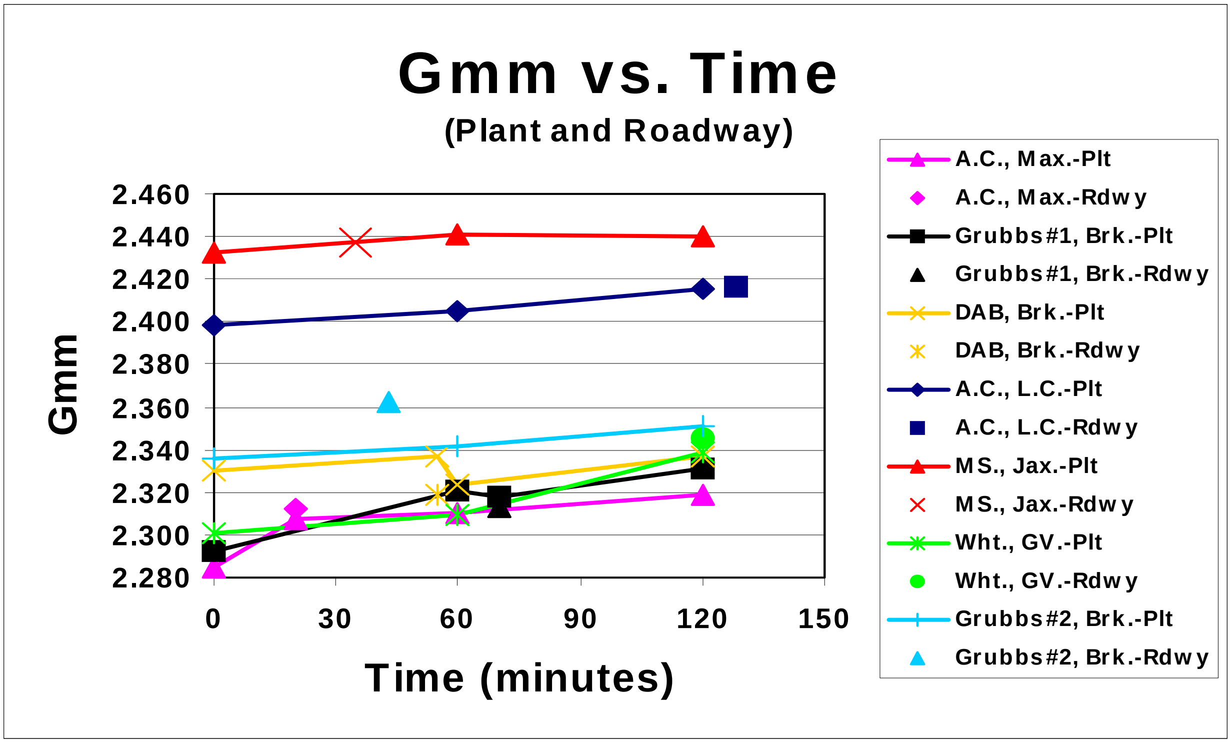

Figure 5 - Maximum Specific Gravity (Gmm) Data for Plant Produced and Roadway Sampled Mixtures

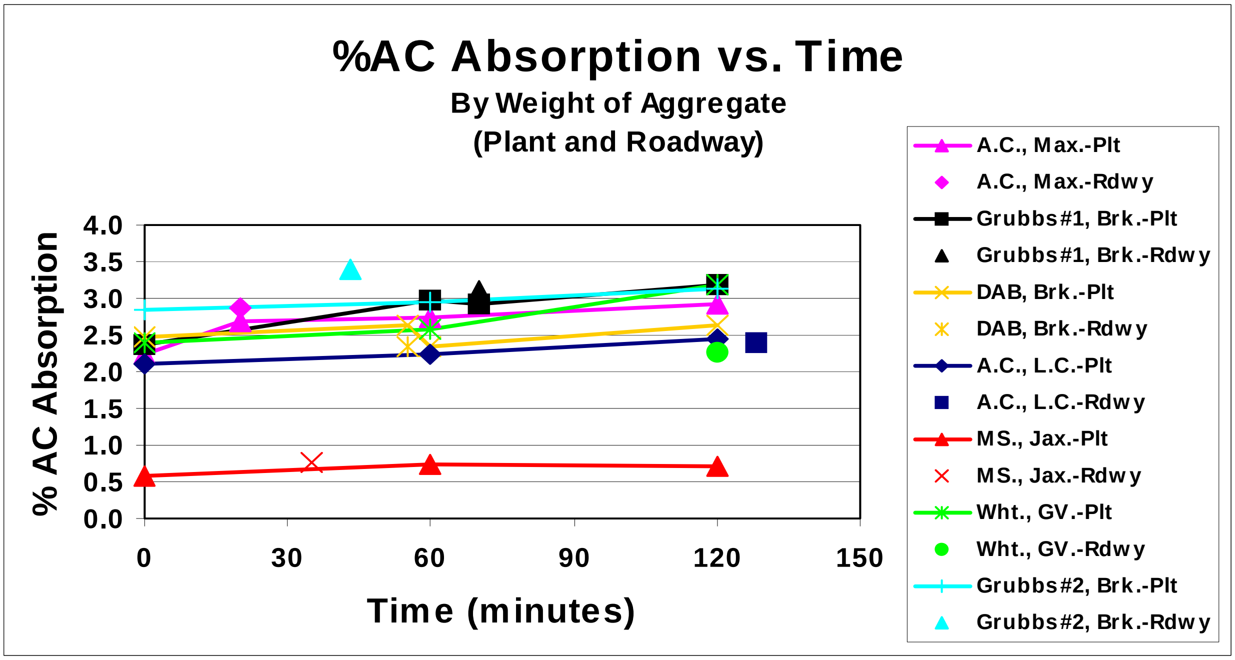

Figure 6 - % AC Absorption Data for Plant Produced and Roadway Sampled Mixtures

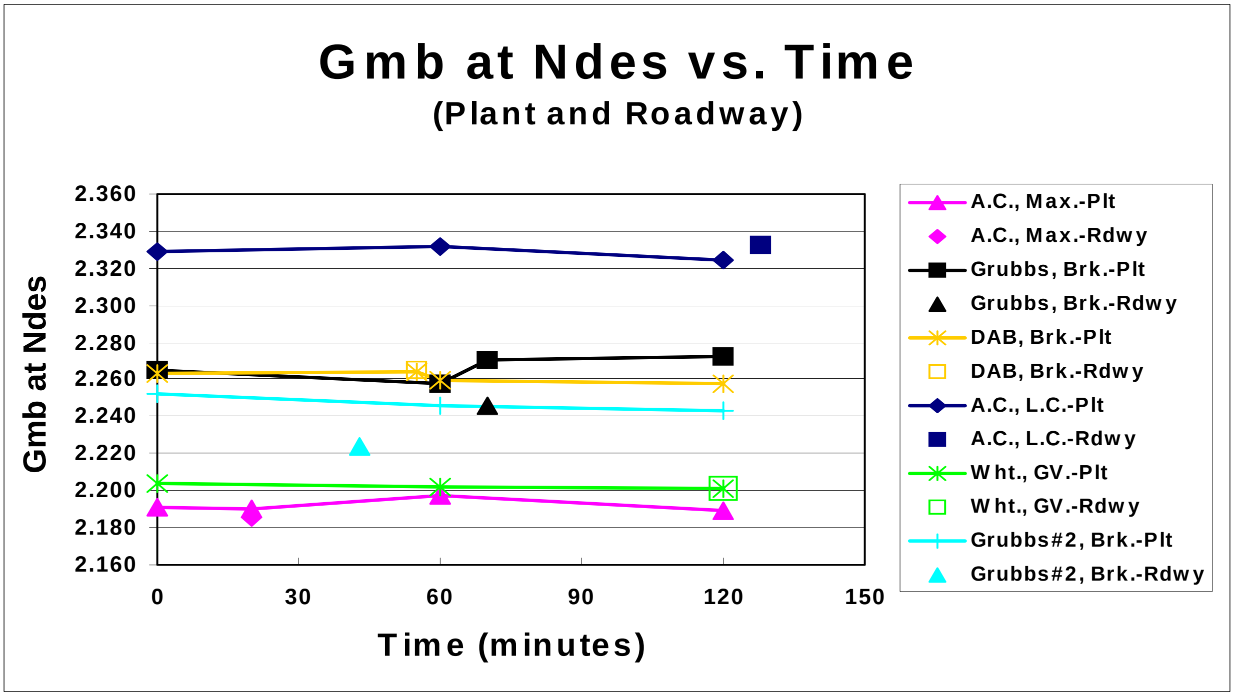

Figure 7 - Bulk Specific Gravity (Gmb) Data for Plant Produced and Roadway Sampled Mixtures

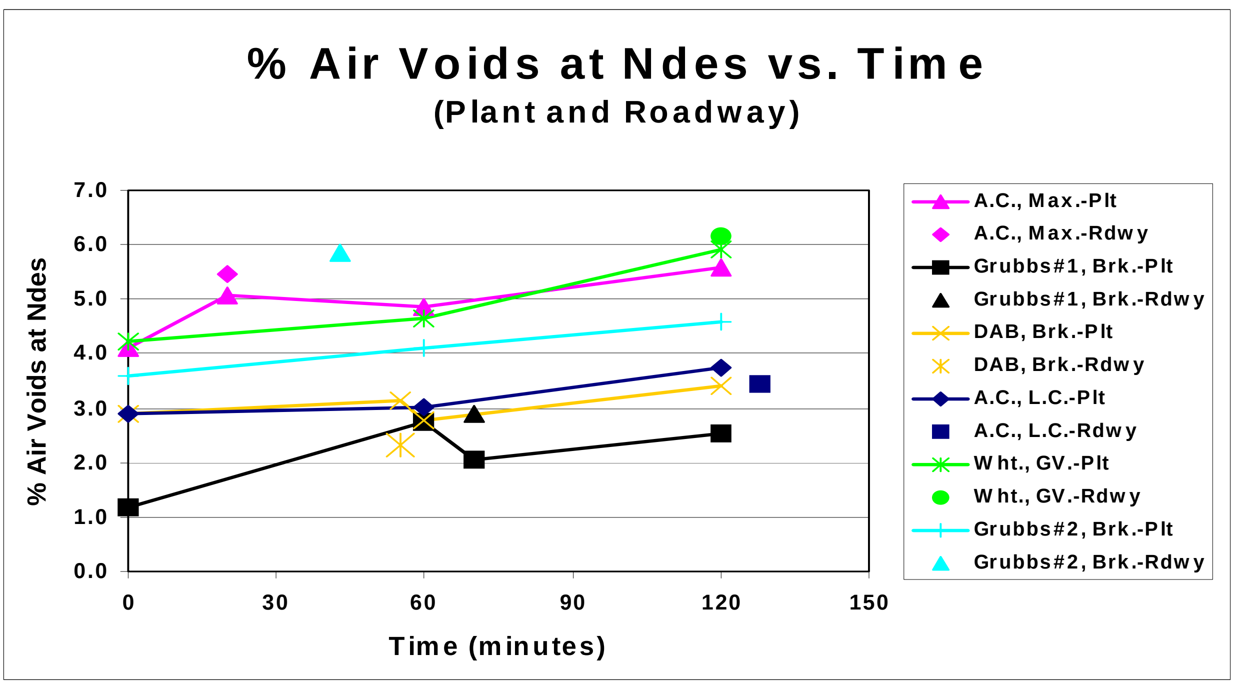

Figure 8 - % Air Voids Data for Plant Produced and Roadway Sampled Mixtures

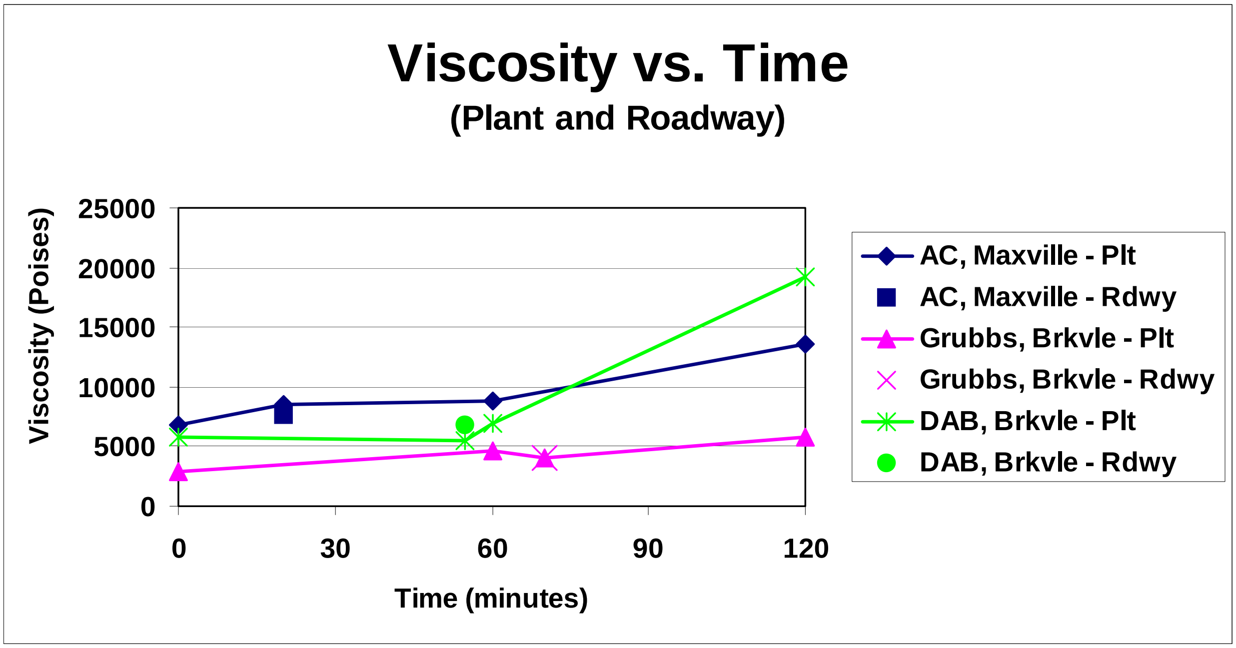

Figure 9 - Viscosity Data for Plant Produced and Roadway Sampled Mixtures