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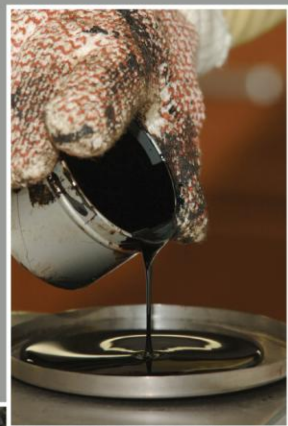

MISSOURI FIELD TRIAL OF WARM MIX ASPHALT TECHNOLOGIES: CONSTRUCTION SUMMARY

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June 2010

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ABSTRACT

Warm mix asphalt (WMA) mixtures produced using several different WMA technologies were evaluated in a field project located in St. Louis, MO. The technologies evaluated were Aspha-min® zeolite, Sasobit®, and Evotherm™ ET (emulsion technology). A control section was also produced so comparisons could be made between WMA and conventional Hot Mix Asphalt (HMA). Mixture volumetrics, rutting resistance, moisture susceptibility, and dynamic modulus were conducted to evaluate field performance. In-place field performance data was also collected. Laboratory tests indicated all three WMA technologies performed statistically equal or better than the control mixture, except for the dynamic modulus results for the Aspha-min®, which resulted in significantly lower values. Field performance for all technologies has been good, with no rutting and minimal cracking after two years of heavy traffic.

INTRODUCTION

Several new processes have been developed in recent years that will reduce the mixing and compaction temperatures of hot mix asphalt (HMA), improve compaction, or both. Generically, these technologies are referred to as warm mix asphalt (WMA). Three processes were initially developed in Europe, namely Aspha-min® zeolite, Sasobit®, and WAM Foam® in response to a variety of concerns. Beginning in 2002, as a result of a study tour sponsored by the National Asphalt Pavement Association (NAPA), interest in these technologies has grown in the United States. Since that time, a number of new processes have been developed, including U.S.-based processes such as the various Evotherm processes.

All of these processes work to lower the mixing and compaction temperatures. However, the mechanism by which they work varies from process to process. Processes that introduce small amounts of water to hot asphalt, either via a foaming nozzle or a hydrophilic material such as zeolite, or damp aggregate, rely on the fact that when a given volume of water turns to steam at atmospheric pressure, it expands by a factor of 1,673 (*1*). When the water is dispersed in hot asphalt and turns to steam (from contact with the hot asphalt), it results in an expansion of the binder phase and increase in workability. The amount of expansion varies depending on a number of factors, including the amount of water added and the temperature of the binder (*2*).

Wax-like additives, such as Sasobit®, reduce the viscosity of the binder when heated above the melting point of the wax (*3*). Sasobit® has a congealing temperature of about 216 °F (102 °C) and is completely soluble in asphalt binder at temperatures higher than 248 °F (120 °C). At temperatures below its melting point, Sasobit® reportedly forms a crystalline network structure in the binder that leads to increased stiffness of the binder (*3–4*).

Emulsions have long been used to produce cold mixes. First generation Evotherm™ ET is an emulsion-based technology used to produce WMA. The core of the Evotherm™ ET technology is a chemistry package that includes additives to improve coating and workability, adhesion promoters, and emulsification agents. Bulk properties of the emulsion, such as viscosity and storage stability, and particle size distributions, are typical of those found in conventional asphalt emulsions. The total Evotherm™ ET chemistry package is typically 0.5% by weight of emulsion. Since this field project, several additional Evotherm™ products have been developed and evaluated. These include Evotherm™ Dispersed Asphalt Technology (DAT) and Evotherm™ Third Generation (3G).

Beginning in 2003, laboratory studies were conducted to evaluate the effect of three WMA processes on mixture performance and evaluate their suitability for U.S. paving practices: Aspha-min® zeolite, Sasobit®, and Evotherm™ ET (*5–7*). The laboratory studies confirmed that the WMA processes provided adequate compaction, even at reduced temperatures. Two concerns were identified with some of the WMA process/aggregate combinations: 1) potential for increased rutting and 2) potential for increased moisture susceptibility. The former was believed to be related to the decreased aging of the binder at lower production temperatures. The latter was believed to be related to incomplete drying of the aggregates at lower production temperatures (*8*). However, it was believed that these potential concerns could be mitigated, so field trials progressed.

In 2006, a number of WMA field trials were constructed, including three that utilized multiple technologies. One of these three multiple-technology field projects, located in Missouri, is presented in this report.

PURPOSE AND SCOPE

The main purpose of this study was to evaluate the field performance of three different WMA technologies. A secondary purpose was to evaluate the potential of WMA to prevent pavement roughness due to underlying crack/joint sealer. Three WMA processes were introduced into existing HMA designs without any mix design changes to accommodate the WMA technology. WMA sections were constructed on an in-service roadway along with HMA control sections. Sampling and testing was generally conducted using the data-collection guidelines developed by the WMA Technical Working Group (*9*). Field mixed, laboratory-compacted volumetric properties; laboratory-performance tests; and field-performance data are reported.

PROJECT DESCRIPTION

The field trial was conducted on Hall Street, a four-lane road with a center turn lane through a heavily trafficked commercial area. The average annual daily traffic (AADT) for Hall Street is approximately 21,000 vehicles per day, with 7% trucks. The initial pavement structure consisted of a concrete pavement that had been previously overlaid with HMA. Reflective cracks in the HMA had been sealed with a rubberized asphalt crack sealant. The project initially consisted of an HMA overlay of the existing pavement. The project included contract incentive/disincentives for pavement smoothness. HMA paving began in fall 2005. Initial smoothness results were poor, owing to the development of bumps over the previously existing sealed reflective cracks (Figure 1). Following investigations on the reflective bumps, the contractor, Pace Construction, approached the Missouri Department of Transportation (DOT) about using WMA in lieu of HMA with the belief that the lower placement temperatures for the WMA may prevent the reflective bumps from occurring. It was believed that the lower mix temperatures of the WMA would prevent the crack sealant from expanding. The expansion of the crack sealant was the cause of the bumps; therefore, if the expansion could be prevented, then the bumps in the overlay would no longer be an issue. Missouri DOT agreed, provided that all the criteria for the specified HMA were met. Three WMA processes were used on the project: Aspha-min®, Sasobit®, and Evotherm™ ET.

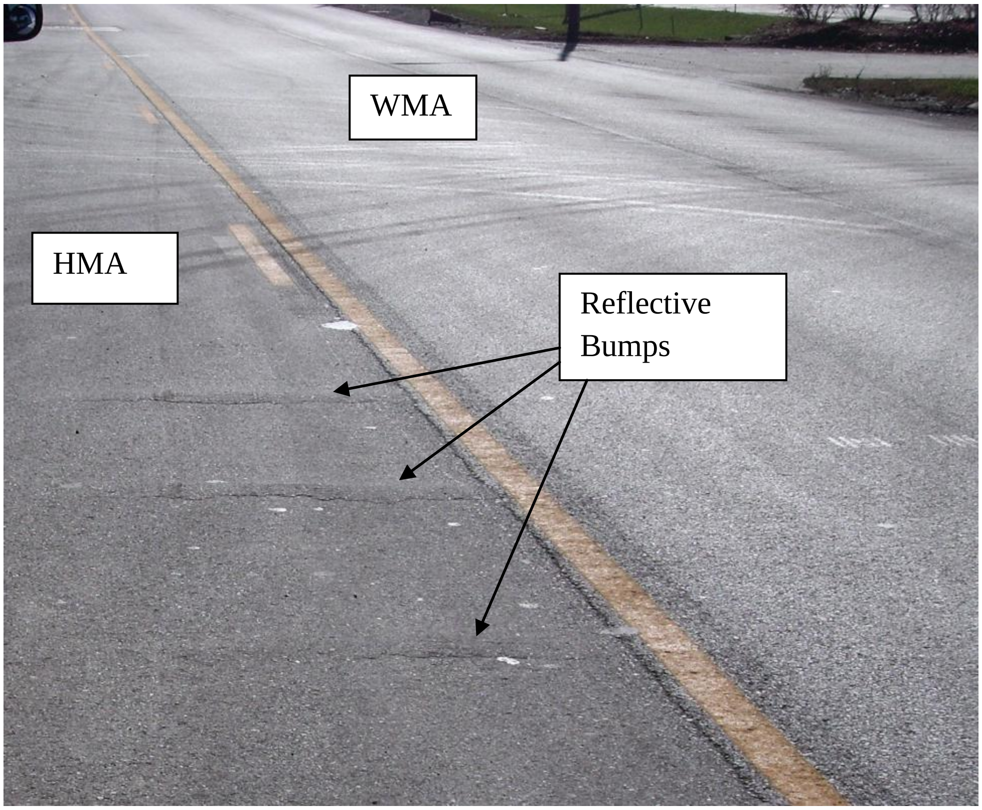

FIGURE 1 Reflective Bumps in HMA on Hall Street.

MATERIALS

The job mix formula was a 12.5 mm nominal maximum aggregate size (NMAS) Superpave mixture, designed with a compactive effort of 100 gyrations in the Superpave gyratory compactor (SGC) and can be found in Appendix A. The aggregate consisted of a blend of limestone and porphyry. The mixture used a polymer-modified PG 70-22 asphalt binder and contained 10% reclaimed asphalt pavement (RAP). An anti-stripping agent (ARR MAZ) was added at a rate of 0.25% by weight of virgin asphalt binder. Evotherm™ ET was produced using the same base binder and substituted for the liquid asphalt. The Evotherm™ ET addition rate was adjusted such that the resulting asphalt residue equaled the control mix design asphalt content. Sasobit® was added at a rate of 1.5% by total weight of asphalt binder. Aspha-min® was added at 0.3% by total weight of mix. The design aggregate gradation and optimum asphalt content are presented in Table 1.

TABLE 1 Design Aggregate Gradation and Optimum Asphalt Content

Sieve Size, mm (in.)	Percent Passing, %
19.0 (3/4")	100
12.5 (1/2")	97
9.5 (3/8")	89
4.75 (#4)	68
2.36 (#8)	49
1.18 (#16)	34
0.6 (#30)	21
0.3 (#50)	11
0.15 (#100)	7
0.075 (#200)	5.2
AC, %	5.3
G_{mm}	2.451

RESULTS AND DISCUSSIONS

Construction

Due to weather delays, the project was conducted over approximately a 10-day period in May 2006. The paving was conducted at night since the roadway was located in a heavily trafficked commercial area. A total of 2,400 tons was produced for both Sasobit® and Evotherm™ ET. For the Aspha-min®, 1,200 tons were produced during one night of production. A total of 3,600 tons of the control mixture were produced, with a portion of the control mix placed in the fall of 2005. The control test section placed in conjunction with the WMA technologies was paved on the first night. The second and third nights used Sasobit®. The addition of Sasobit® was achieved through the use of a feeder system that injected the Sasobit® pellets directly into the mix at the same point as when the asphalt binder entered the drum. Evotherm™ ET was paved on the fourth and fifth nights of paving. Aspha-min® was only used on the last night's paving. The Aspha-min® was added to the mix at approximately the same point that the asphalt was injected. Figure 2 presents that construction layout of the WMA test sections, indicating the locations of all test sections for the field study.

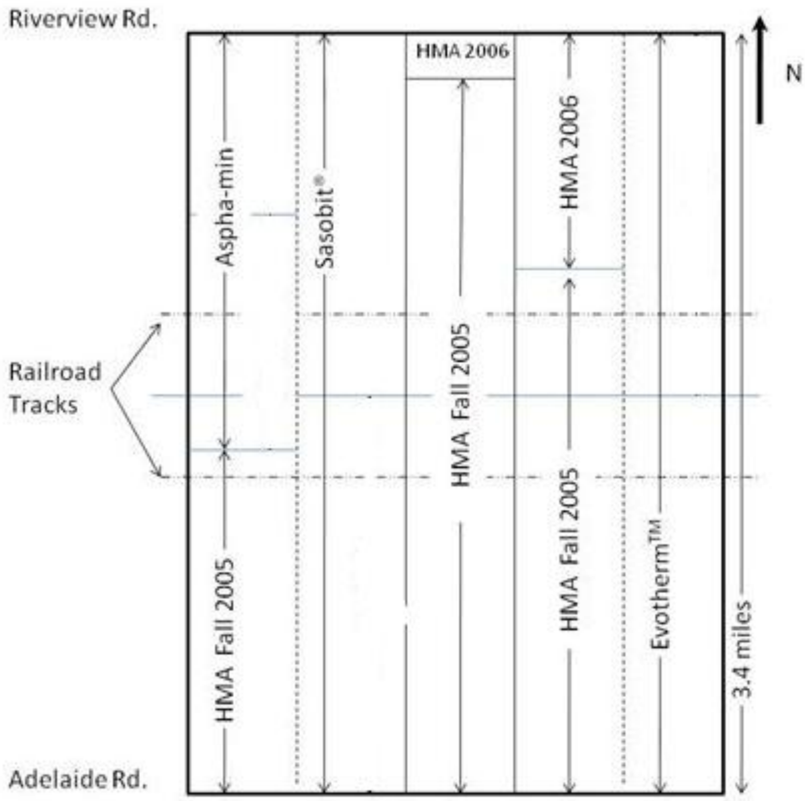

FIGURE 2 Missouri WMA Test Section Construction Layout.

During construction, the control section had a plant production temperature of 320 °F (160 °C) and was placed at a compaction temperature of 300 °F (149 °C). The Sasobit® was initially produced at 275°F. After the in-place densities and constructability proved to be acceptable, the production temperature was decreased to 240°F. The Evotherm™ ET was also originally produced at 275°F and then reduced to 250°F after the in-place densities and constructability were acceptable. A third production temperature of 225°F was employed after observing that the mix produced at 250°F was constructible. The Aspha-min was produced at 275°F. The asphalt plant that produced the mixes was a computer-operated CMI counter-flow drum plant, rated at 400 tons per hour (Figure 3). The plant operated at an actual production rate of approximately 200 to 250 tons per hour during construction of the WMA test sections. The fuel used was recycled oil.

FIGURE 3 CMI Counter-Flow Drum Mix Plant (*10*).

The asphalt mixtures were hauled to the site in end-dump trucks, with a haul distance of approximately 15 miles (roughly 20 to 25 minutes). The test sections were all placed using a Ingersoll Rand paver and a Roadtec® Material Transfer Device to minimize segregation and improve texture and pavement temperature across the mat. Compaction was achieved using four rollers: two Ingersoll Rand DD-138 steel wheel vibratory rollers for breakdown, a pneumatic rubber-tire roller for the joints, and a Hamm steel wheel roller for finish rolling (*10*).

Laboratory Testing

During construction of the test sections, samples of each asphalt mixture were obtained from the end-dump trucks as they were leaving the asphalt plant and were used to produce test specimens for performance testing. Typically, field samples were taken twice per day, once at the beginning of production (approximately after 100 tons had been produced and shipped) and once toward the end of that day's production. For the Evotherm™ ET and Sasobit® test sections, all specimens except dynamic modulus (E*) were prepared on site without reheating in the NCAT mobile laboratory (see Figure 4). For the Aspha-min® section, all specimens were prepared back in NCAT's central laboratory after reheating, due to time constraints. During the preparation of the laboratory samples at the plant for the control mixture, samples were compacted at 250 °F (121 °C) to evaluate standard HMA performance at lower compaction temperatures. For the WMA test sections, the laboratory compaction temperature ranged from 200 to 250 °F (93 to 121 °C), depending on the technology and how the pavement was performing in terms of achieving adequate density in-place. Laboratory testing included mixture volumetrics, Asphalt Pavement Analyzer (APA) rut testing (AASHTO TP 63), moisture-susceptibility testing (AASHTO T 283), Hamburg testing (AASHTO T 324), and Dynamic Modulus (E*) testing (AASHTO TP 62). These tests represent a portion of those required by the WMA Technical Working Group Material Test Framework for Warm Mix Asphalt Field Trials (*9*). Extra mix was obtained so comparisons could be made between hot compacted samples and samples that were reheated prior to compaction to simulate the comparison between the contractor's and the state DOT's expected data. Table 2 summarizes the data that were collected for this field evaluation.

TABLE 2 Hall Street, St. Louis, MO Test Samples.

Mix	Sample Day	Lab Compaction Temperature, °F	SGC Volumetrics, APA, and TSR		Reheated E*
			Hot at Plant	Reheated at NCAT	
Control	1	300	X	X	X
	1	250	X	X	X
Sasobit®	2	250	X	X	X
	2	250	X	X	X
	3	225	X	X	X
	3	225	X	X	X
Evotherm™ ET	4	250	X	X	X
	4	250	X	X	X
	5	225	X	X	X
	5	200	X	X	X
Aspha-min®	6	250		X	X

FIGURE 4 NCAT Mobile Laboratory Trailer.

Mixture Volumetric Properties

For each field sample, six specimens were compacted to determine mixture volumetric properties. The specimens were compacted using 100 gyrations of the SGC according to AASHTO T 312. Specimens were compacted at a temperature equal to the planned compaction temperature at the paver. Two sets of specimens were compacted; one set was compacted on site, and another set was compacted from mix reheated. The mix for the specimens compacted on site was placed in an oven for approximately 30 minutes to account for heat loss that occurred between sampling and splitting. Test results are illustrated in Figure 5 for both the specimens compacted hot (on site) and from reheated mix. The error bars indicate plus and minus one standard deviation of the mean. The triangles and asterisk identify the asphalt content and percent passing the No. 200 sieve (P200). Complete test results are presented in Appendix B. Figure 5 suggests that the air void contents decreased with the second sample each day. Asphalt content was determined according to the AASHTO T 164 method A and gradation analyses were performed according to AASHTO T 30. The asphalt content did decrease for several of the samples taken later in the day, which affected the air void content. The dust content, however, increased in several cases, indicating that the dust content possibly had more influence on air voids than the measured asphalt content. For the first day's Evotherm™ ET production, both the asphalt content and dust content decreased for the second sample.

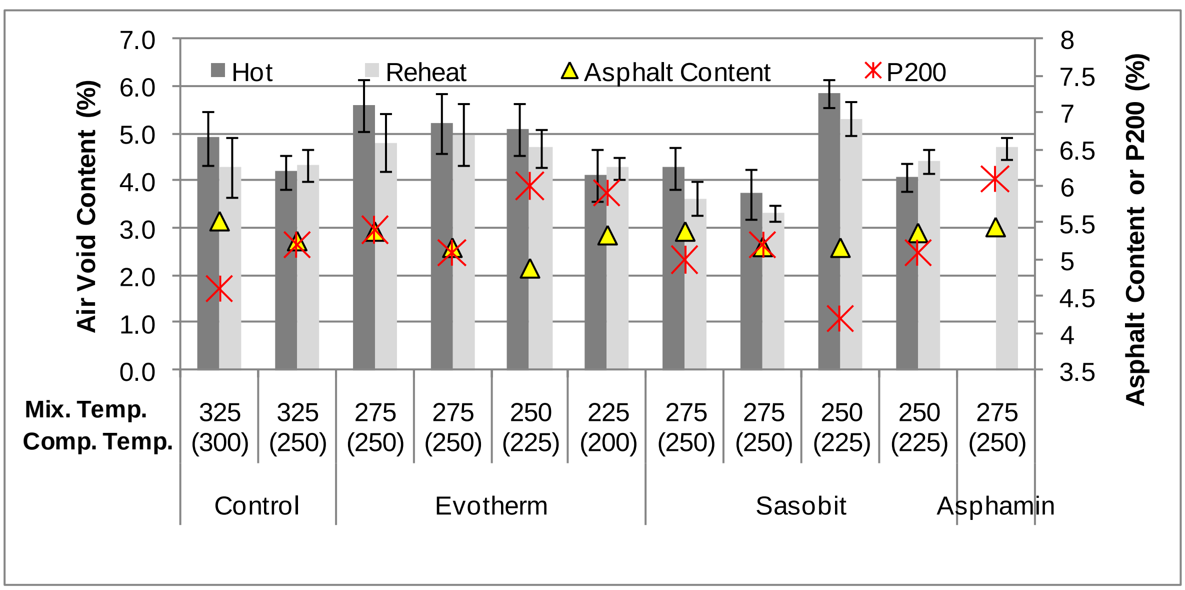

FIGURE 5 SGC Air Void Contents.

Figure 6 presents a series of box plots of the air void data. The bottom of each box represents the 25th percentile while the line in the box and the top of the box represent the 50th and 75th percentiles. The data indicate that the air void contents for the control mixture were lower at the lower compaction temperature for the specimens compacted hot. The reheated control specimens exhibited similar mean air voids for both compaction temperatures. Also, for the Evotherm™ ET emulsion samples that were compacted hot, the lower compaction temperature resulted in lower air voids. It is believed that this is due to the additional residual moisture remaining in the mixture, which is speculated to facilitate compaction. As expected, this effect is reduced for the reheated samples. The air void content for the Sasobit specimens compacted hot and, from reheated mix, is higher at the lower compaction temperature, thus suggesting that the 225°F compaction temperature was too low for the given materials. In Figure 7, the voids in mineral aggregate (VMA) results for all compaction temperatures and all technologies exceeded the minimum VMA requirement of 14%. The error bars indicate plus and minus one standard deviation of the mean.

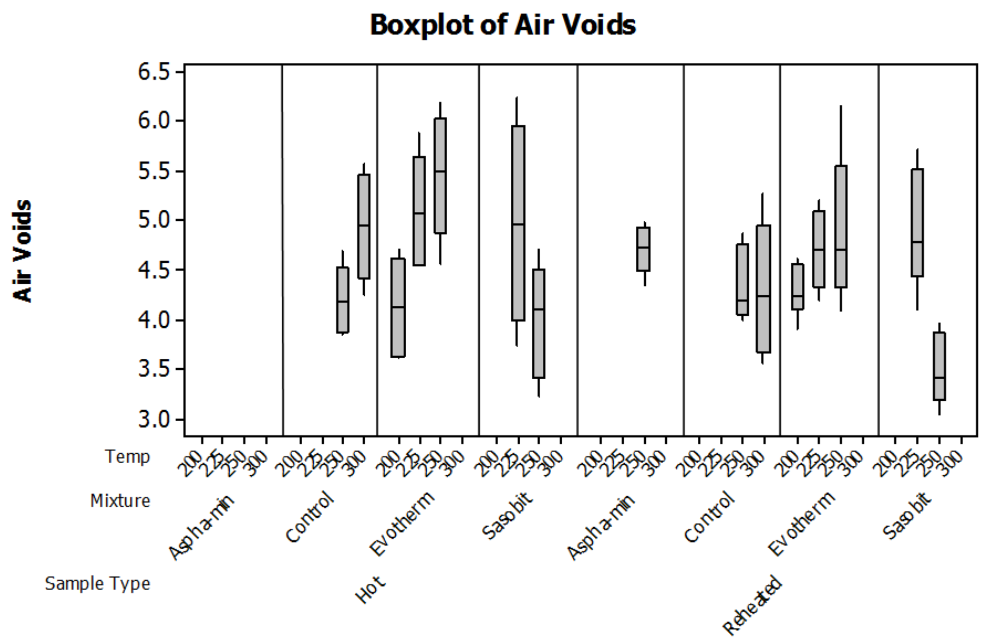

FIGURE 6 Box Plots of Air Voids.

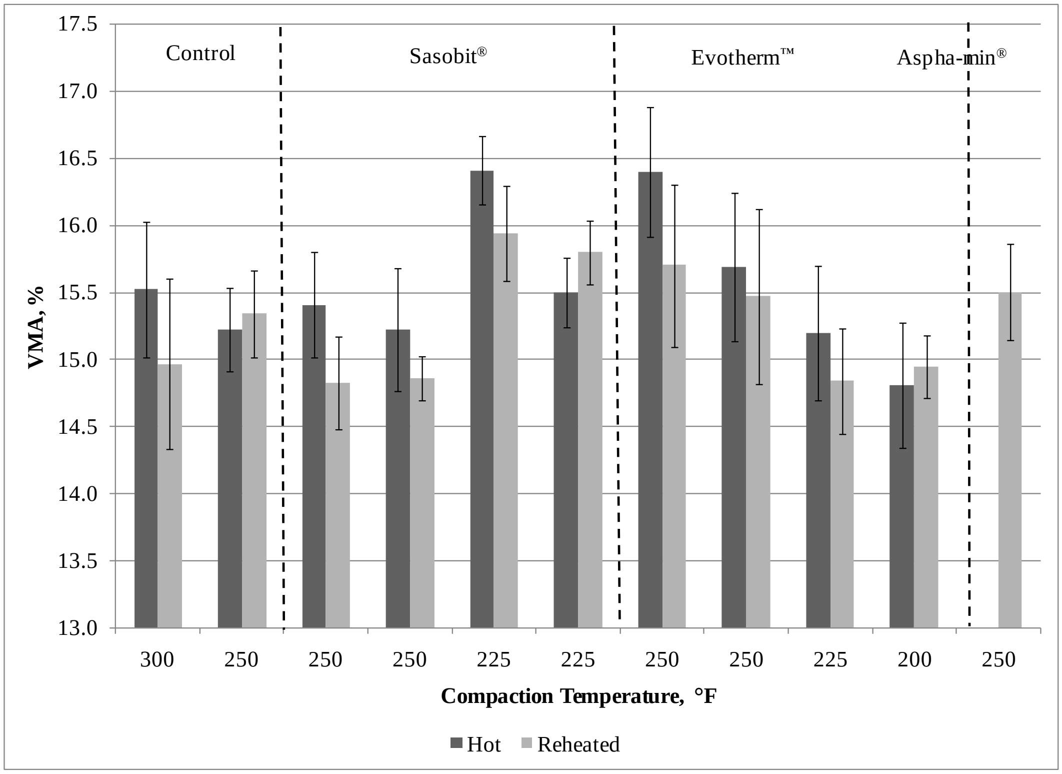

FIGURE 7 VMA Results.

An analysis of variance (ANOVA) was conducted on the compaction data to determine if the different WMA technologies had a significant effect on the compaction of samples produced in the laboratory. A General Linear Model (GLM) was used since the data set was unbalanced. The data obtained from the Aspha-min® was not included in the statistical analysis since only one set of data was obtained. Results from the analyses are presented in Table 3. It can be concluded that the WMA technology, whether the samples were compacted hot or reheated, and the time of day the sample was obtained were significant factors in the relative density of the laboratory-compacted samples.

A Dunnett's test was performed on the ANOVA results to determine how much the inclusion of the different WMA technologies reduced the void content of the compacted samples without reheating. It also determined if there was a significant difference between the air void content of the WMA technologies and the control samples. From the results, Sasobit® lowered the air void content an average of 0.9% at a compaction temperature of 250 °F (121 °C). This was compared to the control data compacted at a temperature of 300 °F (149 °C). For the Evotherm™ ET, the air voids were slightly higher than the control mixture by an average of 0.6%. The data also indicated that simply reducing the compaction temperature of the control mixture lowered the measured air void content by an average of 0.7%. This indicates that the Superpave gyratory compactor was relatively insensitive to temperature, as previous research has shown (*12*).

TABLE 3 Analysis of Variance Densification Results

Source	Degrees of Freedom	Adj. Mean Squares	F-statistic	*p*-value	Significant[1]
WMA Process	2	3.53	7.74	0.001	Yes
Reheating	1	2.77	6.07	0.015	Yes
Sample time	1	10.29	22.57	0.000	Yes
Error	108	0.46			
Total	111				

Note: [1] indicates significance at the 95% confidence interval.

Asphalt Pavement Analyzer

Specimens compacted to design gyrations were compacted using the plant-produced mix to determine if the WMA technologies affected the air voids. Once the air void contents of the design specimens were determined, specimens were tested in the APA in accordance with AASHTO TP 63 to determine the laboratory rut resistance of the asphalt mixtures. All testing was conducted at 147 °F (64 °C) using a hose pressure of 120 psi and a vertical load of 120 pounds, which were the testing parameters used in the previous laboratory evaluations (*5-7*). Test results from the APA are shown in Figure 10. The error bars indicate plus and minus one standard deviation of the mean. The data illustrates no conclusive relationship between measured rut depths and whether the sample was compacted hot or reheated prior to compaction. It is also believed that observed fuel contamination was the cause for the high measured rut depths of the second sample of Sasobit® compacted at 225 °F (121 °C) without reheating.

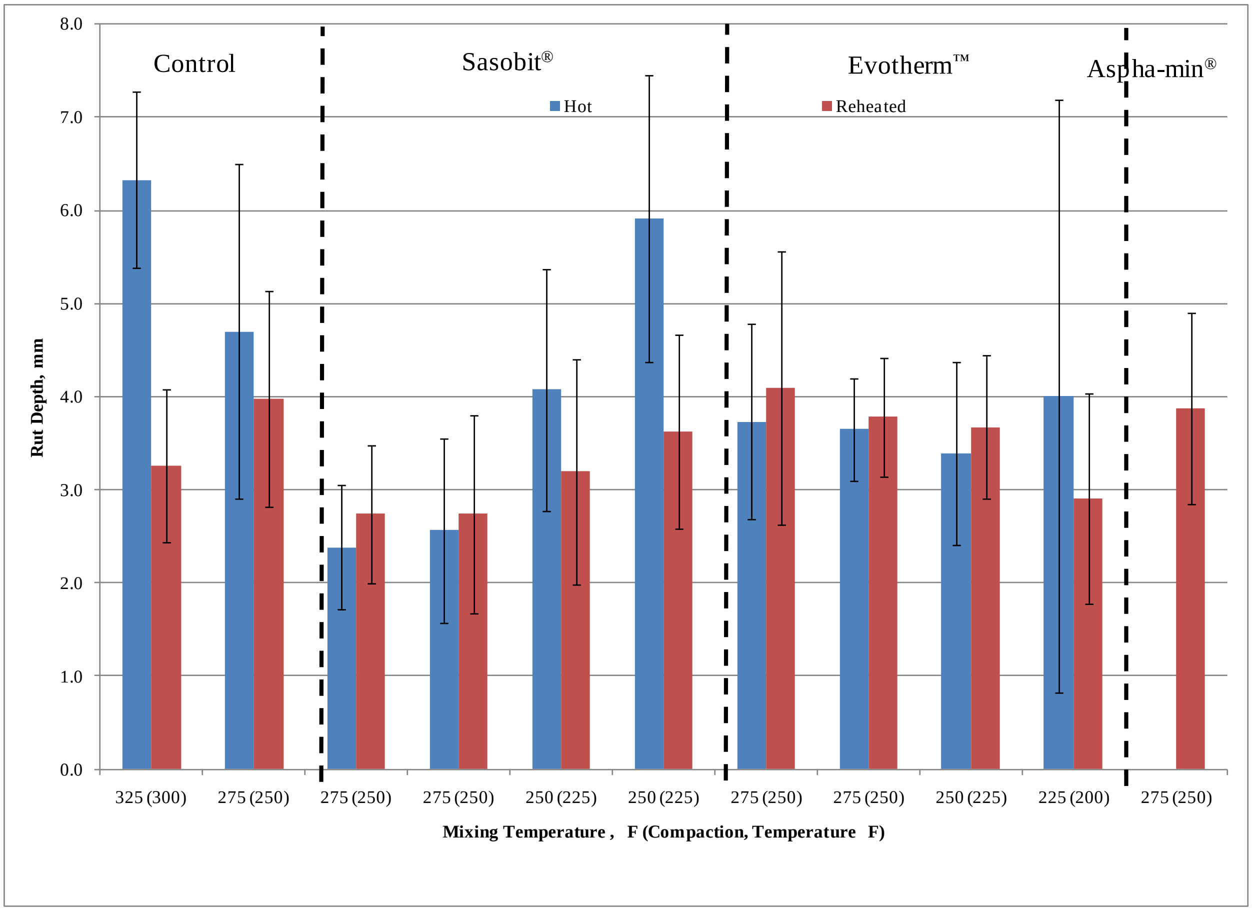

FIGURE 10 Asphalt Pavement Analyzer Rut Depth Results.

Table 4 presents the ANOVA results for the measured rut depths. Since the inclusion of the contaminated samples could potentially skew the statistical results, this data was removed from the data set prior to performing the ANOVA. The ANOVA results show that, overall, the inclusion of WMA technologies significantly affected the measured rut depths. The time of day the sample was obtained did not significantly affect the measured rut depths, as it did with the measured air void contents. A Dunnett's test was performed on the ANOVA results from the reheated samples to determine what effect each WMA technology had on the measured rut depths. The results from the Dunnett's test indicated that only the Sasobit® was statistically different (lower) than the control section APA results.

TABLE 4 Analysis of Variance Asphalt Pavement Analyzer Results

Source	**Degrees of Freedom**	**Adj. Mean Squares**	**F-statistic**	**p-value**	**Significant**[1]
WMA Process	3	8.21	4.55	0.005	Yes
Temperature	3	1.37	0.76	0.520	No
Reheating	1	6.62	3.67	0.058	No
Error	105	1.80			
Total	112				

Note: [1] indicates significant at the 95% confidence interval.

The main-effects plots for the APA rut depths are presented in Figure 8. From the plots, Sasobit® resulted in the lowest measured rut depths. This was likely due to the fact that the Sasobit® stiffens the asphalt binder, increasing its resistance to rutting. The lower measured rut depths for the reheated samples are likely because of the lower measured air voids for the reheated samples.

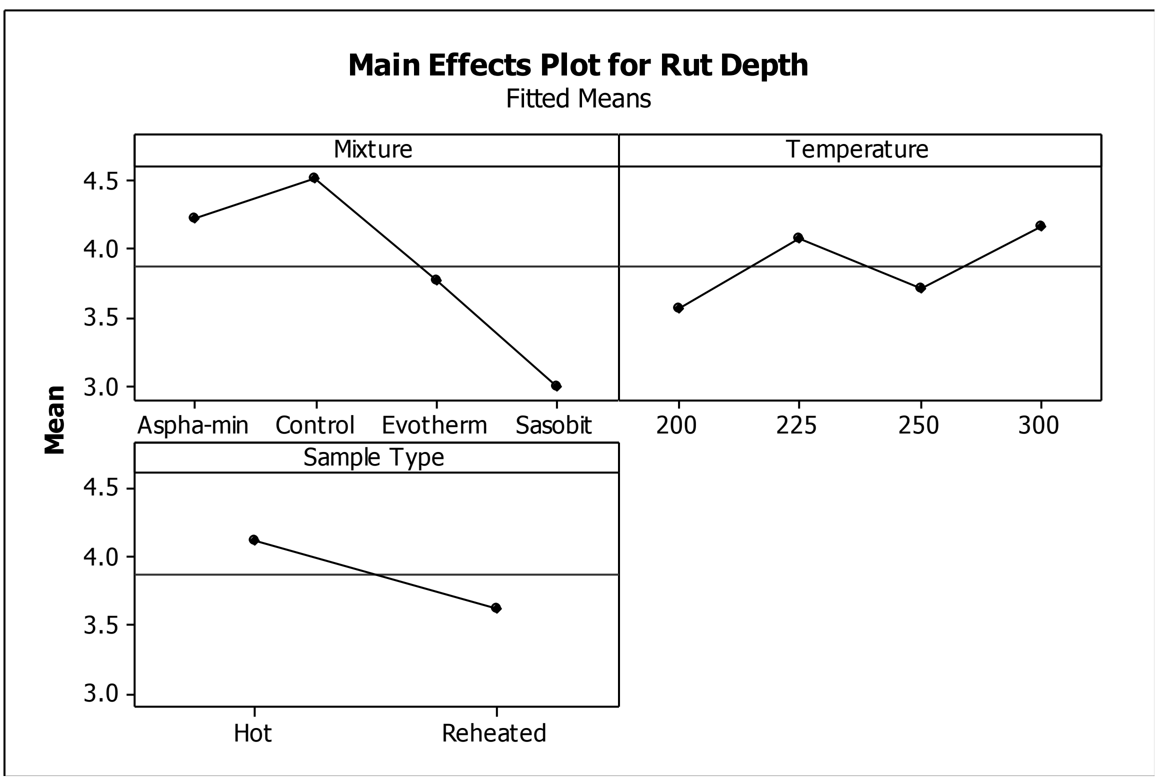

FIGURE 8 Main-Effects Plots for Measured APA Rut Depths.

Moisture Resistance

Specimens of each mixture were prepared according to AASHTO T 283 to assess moisture damage susceptibility of the asphalt mixtures. AASHTO T 283 testing was conducted on both hot compacted and reheated samples, and one freeze-thaw cycle was employed. This allowed an evaluation to see if moisture dissipation had an effect on the moisture resistance of the WMA mixtures, especially the Aspha-min® and Evotherm™ ET, which use water to deliver the technology. The testing was conducted in accordance with AASHTO T 283, with the exception of the shelf time for specimens compacted in the field. Specimens compacted in the field sat for longer than 24 hours after compaction due to the time required to ship the materials back to the main NCAT laboratory for testing from the field. It should be noted that the shelf time for all field-compacted specimens was the same. The data for each test section has been divided into the separate samples taken during the day, as well as into samples compacted hot or reheated. This data is presented in Tables 5 and 6. Complete AASHTO T 283 test results are presented in Appendix D. Figure 9 shows the averages of all the data obtained. From the data, 15 out of 22 tests had a TSR value that satisfied the Missouri DOT minimum-required TSR value of 80% (including the control mixture). It is believed that lower compaction temperatures for the second day's production for the Evotherm™ ET and Sasobit® and the possible fuel contamination for the Sasobit® were the cause of the failing TSR values. For the control mixture compacted at the lower temperatures, the lower dry tensile strengths measured were due to less binder aging.

TABLE 5 Tensile-Strength Ratio Results, Samples Compacted Hot.

Mix Type	Sample #	Mixing Temp., °F	Compaction Temp, °F	Indirect Tensile Strength, psi		TSR, %
				Uncond.	Cond.	
Control	1	325	300	166.3	126.9	76
Control	2	275	250	112.7	115.4	102
Sasobit®	1	275	250	143.3	99.5	69
Sasobit®	2	275	250	121.5	104.2	86
Sasobit®	1	250	225	142.0	97.0	68
Sasobit®	2	250	225	148.4	87.3	59
Evotherm™ ET	1	275	250	139.6	132.1	95
Evotherm™ ET	2	275	250	143.2	122.0	85
Evotherm™ ET	1	250	225	154.1	102.7	67
Evotherm™ ET	2	225	200	117.8	89.3	76

TABLE 6 Tensile-Strength Ratio Results, Samples Compacted After Reheating.

Mix Type	Sample #	Mixing Temp, °F	Compaction Temp, °F	Indirect Tensile Strength, psi		TSR, %
				Uncond.	**Cond.**	
Control	1	325	300	170.6	165.1	97
Control	2	275	250	189.4	163.6	86
Sasobit®	1	275	250	168.6	142.9	85
Sasobit®	2	275	250	116.9	101.8	87
Sasobit®	1	250	225	131.6	110.7	84
Sasobit®	2	250	225	134.7	113.9	85
Evotherm™ ET	1	275	250	153.7	123.8	81
Evotherm™ ET	2	275	250	156.6	128.8	82
Evotherm™ ET	1	250	225	147.3	119.1	81
Evotherm™ ET	2	225	200	153.3	97.6	64
Aspha-min®	1	325	250	139.3	160.3	115
Aspha-min®	2	275	250	128.1	171.3	134

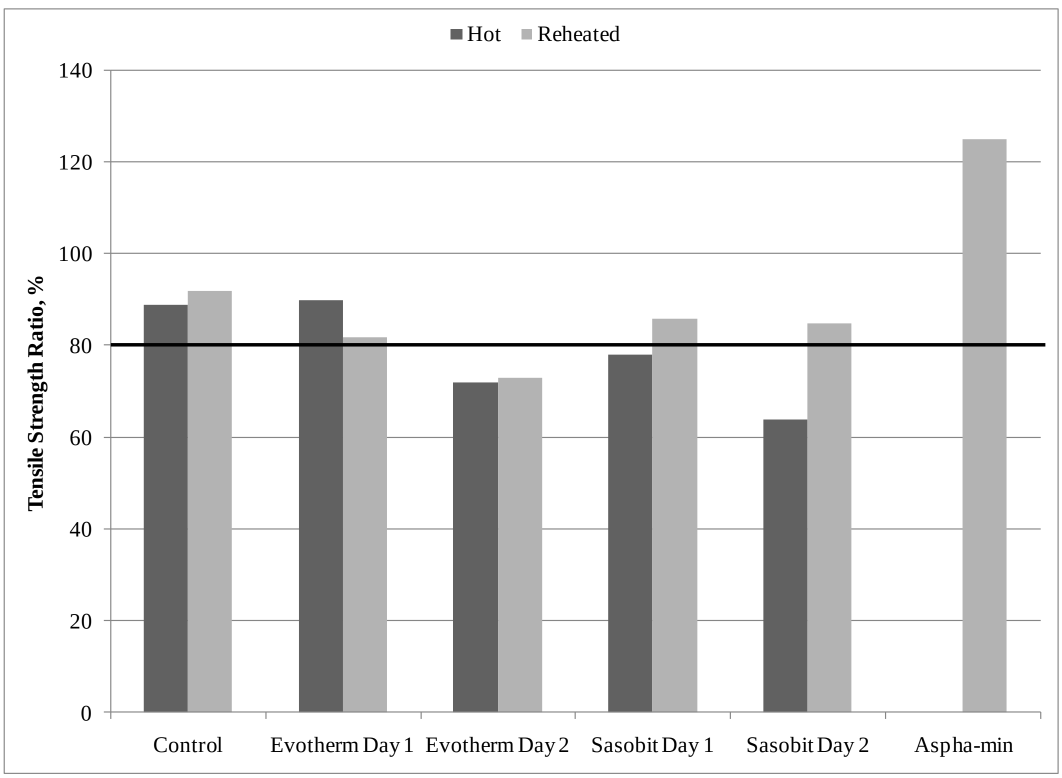

FIGURE 9 Average Tensile-Strength Ratio Results.

Hamburg Wheel Tracking

To further evaluate moisture damage susceptibility, samples were prepared and tested in accordance with AASHTO T 324 using the Hamburg wheel-tracking device. The target air voids was 7±1%, which differs from the specification that allows for 7±2% air voids. Hamburg tests were conducted on both hot-compacted and reheated mix samples. This test is typically used to predict moisture damage of HMA but has been found to be sensitive to other factors, including binder stiffness, short-term aging, compaction temperature, and anti-stripping treatments (*11*). All of these factors have been identified as potential areas of concern in the evaluation of WMA. The results from the Hamburg wheel-tracking device may provide a method of accurately establishing a good-performing WMA mixture.

Test results from the Hamburg wheel-tracking device are presented in Tables 7 and 8 (compacted hot and reheated, respectively). Figure 10 illustrates the results of Tables 7 and 8. For the Sasobit® samples compacted hot, only a single sample was evaluated for each day; this was due to compacted samples at the plant not meeting the sample air void testing requirements. In general, both stripping inflection point and rutting rate indicate whether the mixture will be prone to moisture damage or not. From these data, it can be seen that all three WMA technologies performed very well in the Hamburg, both for samples compacted hot and reheated prior to compaction. Also, as the compaction temperature dropped, the stripping inflection decreased in five of nine test pairs, indicating a slight drop in performance. The drop in performance for the second control sample is likely due to the drop in mixing and compaction temperature for the second sample.

TABLE 7 Hamburg Wheel-Tracking Device Results, Samples Compacted Hot

Mix Type	Date	Sample #	Mixing Temp., °F	Compaction Temp., °F	Stripping Inflection Point, cycles	Rutting Rate, mm/hr	Total Rutting @ 10,000 cycles, mm
Control	17-May	1	325	300	> 10,000	2.648	10.507
Control	17-May	2	275	250	5700	3.309	13.13
Sasobit®	18-May	2	275	250	8600*	1.341	5.321
Sasobit®	19-May	1	250	225	8500	0.394	1.563
Evotherm™ ET	22-May	1	275	250	> 10,000	0.825	3.274
Evotherm™ ET	22-May	2	275	250	> 10,000	0.363	1.44
Evotherm™ ET	23-May	1	250	225	9400*	0.932	3.698
Evotherm™ ET	23-May	2	225	200	9350*	1.039	4.123

Note: * represents the average of two samples, one with a determined stripping inflection point and the other with a stripping inflection point greater than 10,000 cycles.

TABLE 8 Hamburg Wheel-Tracking Device Results, Samples Compacted After Reheating

Mix Type	Date	Sample #	Mixing Temp., °F	Compaction Temp., °F	Stripping Inflection Point, cycles	Rutting Rate, mm/hr	Total Rutting @ 10,000 cycles, mm
Control	17-May	1	325	300	> 10,000	0.84	3.333
Control	17-May	2	275	250	9700*	0.655	2.599
Sasobit®	18-May	1	275	250	> 10,000	0.548	2.174
Sasobit®	18-May	2	275	250	> 10,000	0.683	2.71
Sasobit®	19-May	1	250	225	8500*	1.388	5.508
Sasobit®	19-May	2	250	225	8650*	1.194	4.738
Evotherm™ ET	22-May	1	275	250	9200*	0.827	3.282
Evotherm™ ET	22-May	2	275	250	7750	1.436	5.698
Evotherm™ ET	23-May	1	250	225	8350	0.809	3.21
Evotherm™ ET	23-May	2	225	200	7250	1.316	5.222
Aspha-min®	25-May	1	275	250	> 10,000	0.935	3.71

Note: * represents the average of two samples, one with a determined stripping inflection point and the other with a stripping inflection point greater than 10,000 cycles.

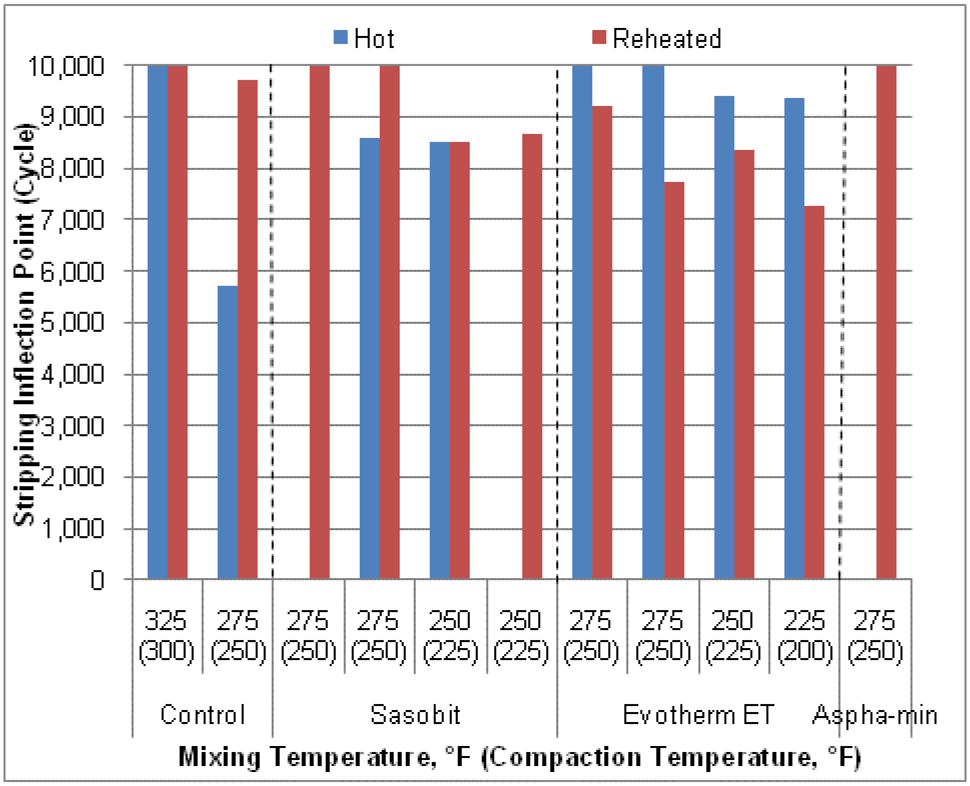

FIGURE 10 Hamburg Stripping Inflection Point – Hot and Reheated.

Dynamic Modulus

Dynamic modulus tests were conducted on field-mixed, laboratory-reheated and compacted samples using an IPC Global AMPT (Asphalt Mixture Performance Tester). Some specimens were compacted from plant-produced mix in the NCAT mobile laboratory without reheating, and others were compacted from reheated plant-produced mix at the main NCAT laboratory. Specimens were compacted to 170 mm high in a Superpave gyratory compactor and then cut and cored to 150 mm tall by 100 mm in diameter. The target air void of the cut-and-cored specimens was 7±1% air void. Testing was conducted in accordance with AASHTO TP 62, with the exception of testing at the lowest temperature of -10 °F (4 °C) because of temperature limitations of the AMPT. Three replicates were tested for each asphalt mixture sample. Testing was conducted at seven frequencies at each of three temperatures. Complete dynamic modulus data is presented in Appendix E. Testing frequencies were in accordance with AASHTO TP 62. The low temperature recommended in AASHTO TP 62 was not used due to limitations with the AMPT. Dynamic modulus master curves generated for each of the test sections are presented in Figure 11, displaying the master curves for samples that were reheated prior to compaction. The reference temperature for the master curves is 70 °F (21.1 °C).

Table 9 presents the ANOVA results performed on the dynamic modulus test data. When the data was analyzed as a whole, it was observed that the WMA technologies significantly affected the dynamic modulus results. A Tukey-Kramer's test was then performed to analyze each WMA technology separately. From the results, it was determined that there was no statistical difference between the control and Sasobit® or Evotherm™ ET, but there was for the Aspha-min®. A Dunnett's test was performed to determine how much the WMA technologies affected the measured dynamic modulus results. The Evotherm™ ET and Aspha-min® lowered the dynamic modulus an average of 5% and 24%, respectively. The Sasobit® actually increased the measured dynamic modulus by an average of 6%. These percentages are based on the dynamic modulus data recorded at 70 °F (21.1 °C) and 10 Hz. Only the Aspha-min® results were significantly different from the HMA control compacted at 300 °F.

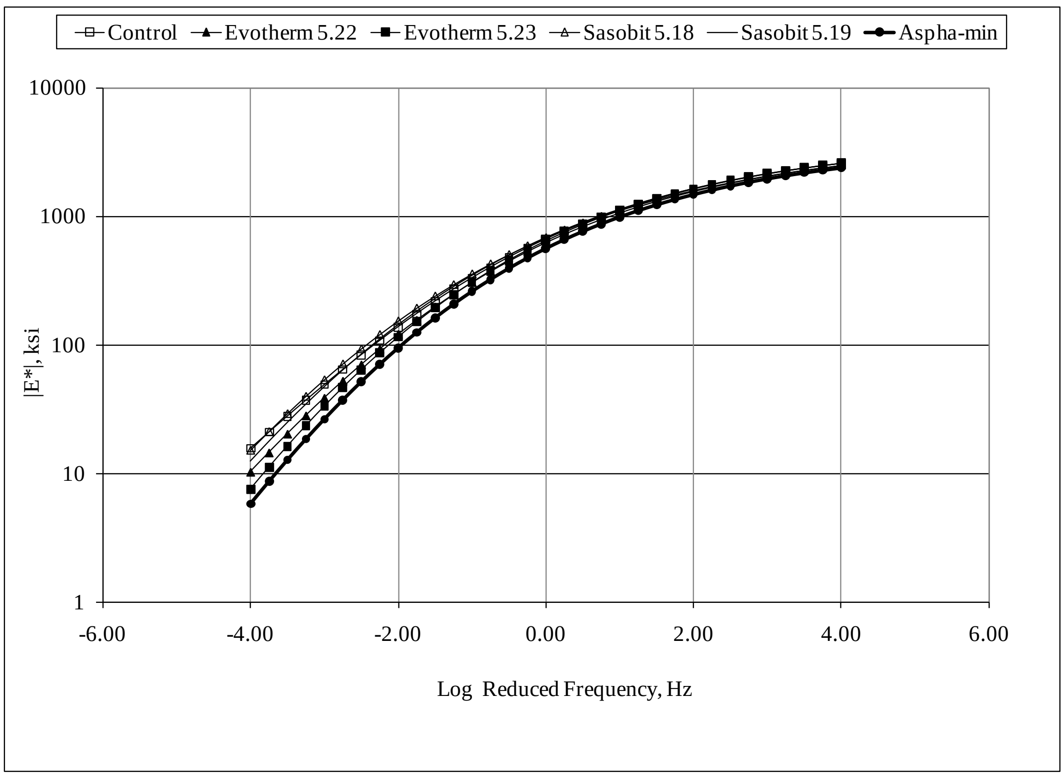

FIGURE 11 Dynamic Modulus Master Curves, Samples Compacted After Reheating.

TABLE 9 Analysis of Variance Dynamic Modulus Results.

Source	Degrees of Freedom	Adj. Mean Squares	F-statistic	p-value	Significant[1]
WMA Process	3	8.90E+4	6.16	<0.0001	Yes
Temperature	2	1.59E+8	10989.45	<0.0001	Yes
Frequency	6	5.82E+6	402.79	<0.0001	Yes
Compaction Temperature, F	3	7.31E+4	5.06	0.002	Yes
Error	615	1.44E+4			
Total	629				

Note: [1] indicates significant at the 95% confidence interval.

FIELD PERFORMANCE

Site revisits were conducted to assess the condition of the WMA and HMA pavements. During the site revisits, four cores were obtained from each section. The cores were cut in the same location of the original construction cores. Three cores were obtained from the wheelpath and one from between the wheelpaths. Rutting measurements were made using a stringline. Visual inspections were conducted to identify issues with cracking, raveling, flushing, and polished aggregate. Figure 12 presents in-place air void results for the three WMA sections as well as the control test section. The error bars indicate ± one standard deviation of the mean. Results are from construction up through two years of traffic. All of the cores were taken near the location of the original core extractions, and no construction cores were obtained from the control section. The post-construction air voids are from cores taken in the wheel path. Based on the average of three cores per WMA technology, the results suggest that densification occurred between six-months and two-years worth of traffic for two of the three WMA technologies (Sasobit® and Aspha-min®).

Figure 13 presents indirect tensile-strength (IDT) results at 77 °F (25 °C) for the different test sections. The error bars indicate ± one standard deviation of the mean. IDT results are from cores taken from each of the four test sections and are from construction through two years of service. Based on the average of three cores per WMA technology, the results suggest that indirect tensile strength generally increases with time, as would be expected unless moisture damage, cracking, or other damage are occurring. The dramatic decrease in IDT for the Aspha-min® may indicate that the Aspha-min or some other construction issue negatively affected the mix. The mean difference in the Evotherm™ ET IDT values is slight and most likely does not indicate a moisture damage issue.

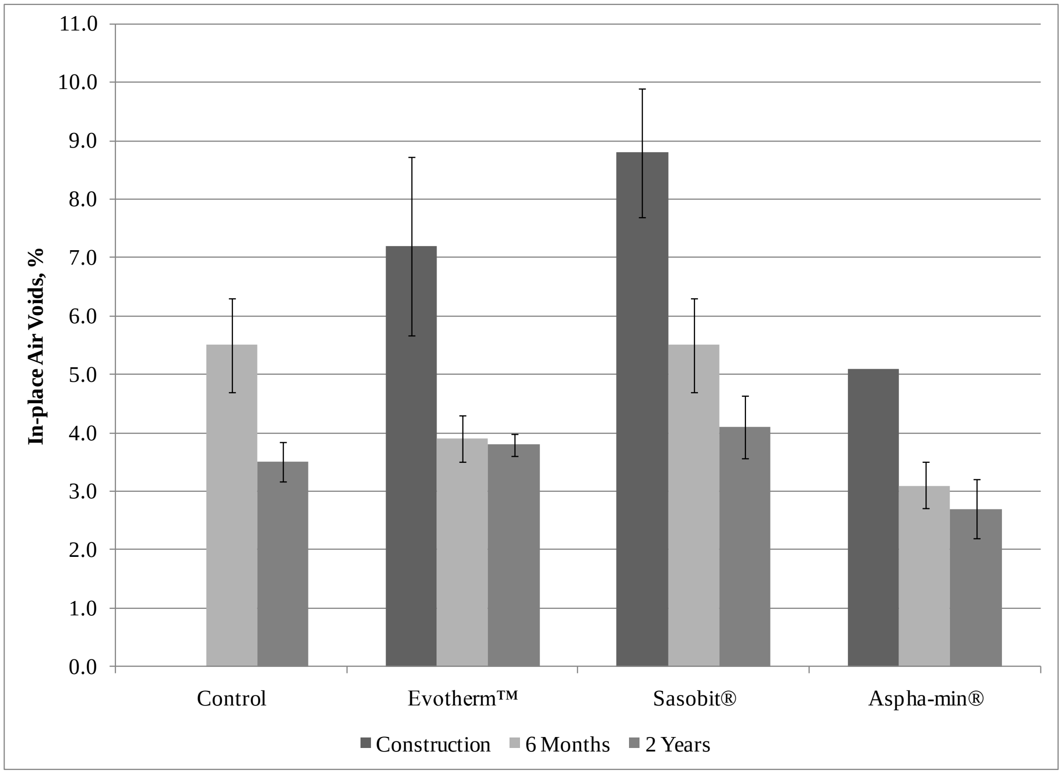

FIGURE 12 In-place Air Void Results, Construction Through Two Years.

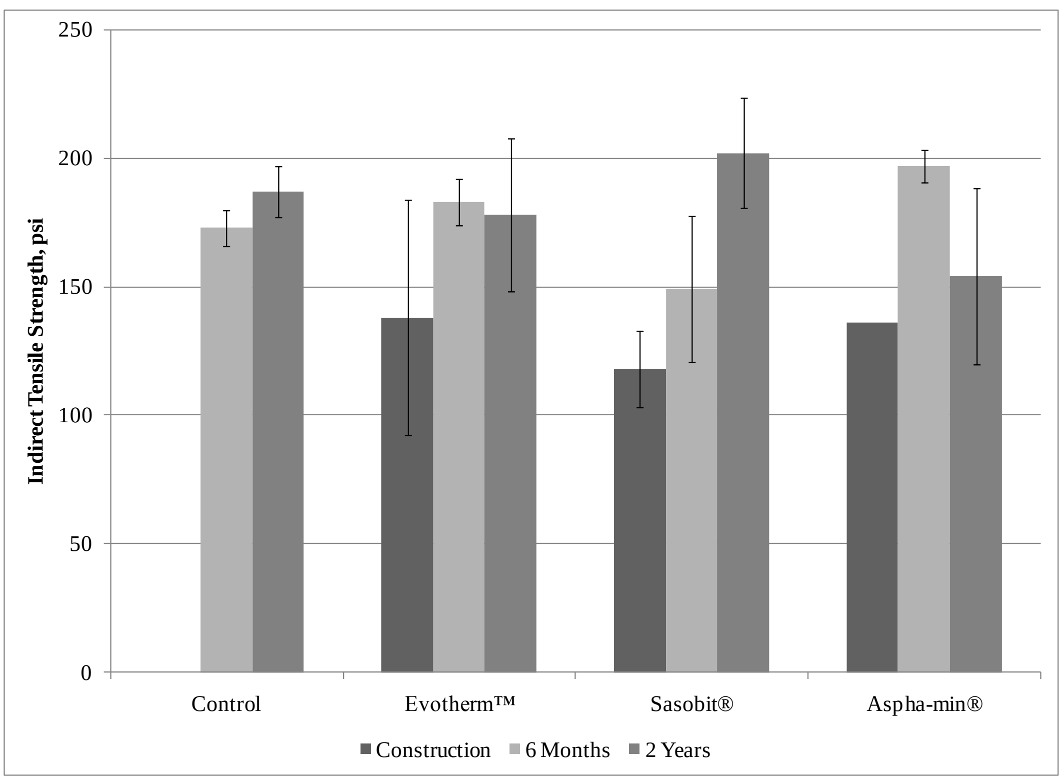

FIGURE 13 Indirect Tensile-Strength Results, Construction Through Two Years.

The most recent site visit took place in July 2008. During this visit, visual observations of the test sections, as well as rut-depth measurements using a stringline, were collected. Table 10 presents the measured field rut depths since construction. Measurements were taken at six months and 26 months after construction. From the results, no appreciable rutting has occurred in any of the test sections. Visual observation of the test sections indicated a limited number of cracks in each of the sections (Figure 14). These cracks seemed to be reflective in nature and appeared to be tight. Visual observation also indicated that there seemed to be a surface-texture difference between the center turn lane placed in 2005 and the WMA and HMA placed in 2006, with the 2006 pavement having more macrotexture. In areas, the pavement appeared to have been water or bead blasted prior to placing the line markings.

TABLE 10 Field Rut-Depth Measurements.

	6 Months	26 Months
Test Section	Rut Depth, mm	Rut Depth, mm
Control	0.4	0.5
Evotherm™ ET	1.1	1.1
Sasobit®	0.8	0.8
Aspha-min®	0.3	0.5

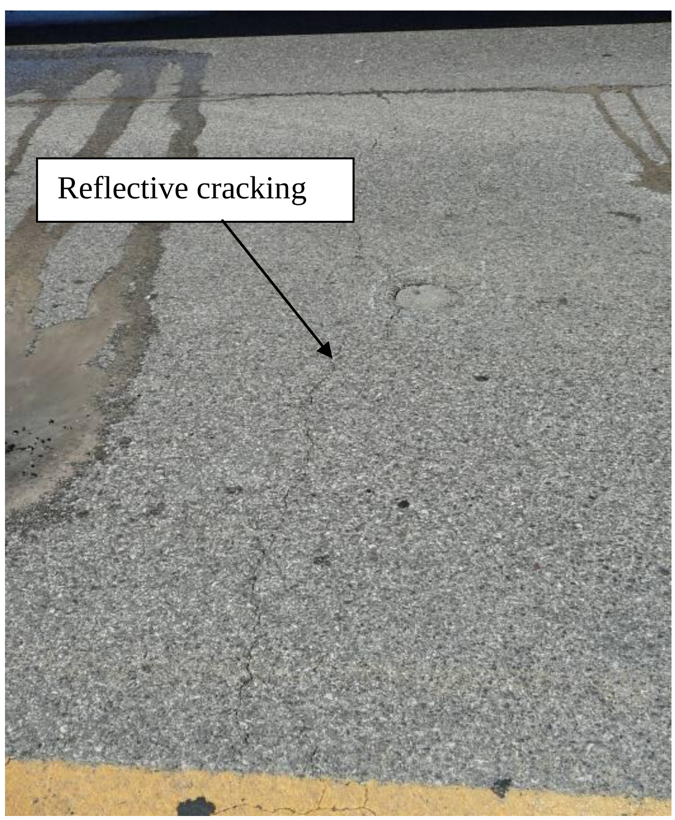

FIGURE 14 Reflective Cracking in WMA Test Section.

CONCLUSIONS

In May 2006, WMA field evaluations were conducted on Hall Street, in St. Louis, MO. These test sections were used to evaluate the field performance of three WMA technologies: Evotherm™ ET, Sasobit®, and Aspha-min®. Specific conclusions from this evaluation include:

- WMA test sections were placed at mixing temperatures ranging from 40 to 100 °F lower than the control test section. The largest reductions were obtained with the Evotherm™ ET technology.
- Laboratory air voids for the WMA sections were, on average, 0.6% higher (Evotherm™ ET) to 0.9% lower (Sasobit®) than the control section, at a mixing temperature of 275 °F (121 °C) for samples compacted at the plant without reheating. Non-reheated samples were not tested for the Aspha-min® WMA.
- Laboratory rutting-susceptibility tests conducted in the APA indicated that the Sasobit® resulted in statistically lower measured rut depths compared to the control. For the Aspha-min®, the measured APA rut depths of the reheated mix were numerically higher than the control reheated mix. The Evotherm™ ET APA results were similar to the control.
- Laboratory AASHTO T 283 tests indicate an increase in moisture-damage potential for all three WMA technologies and the control mixture at lower compaction temperatures. However, the Hamburg stripping inflection points indicate that potential for moisture damage is minimal,
- Hamburg wheel-tracking tests indicated improved rutting performance for all three WMA technologies, with all technologies having rut measurements below 10 mm after 20,000 passes. The addition of the Sasobit® most likely improved the stiffness of the mix when the wax crystallized. The Aspha-min® may have acted as additional fines to create a mastic, resulting in a stiffer binder to aid in resisting rutting. The improved rutting resistance in the laboratory for the Evotherm™ ET most likely was a result of another mix phenomenon, since Evotherm™ ET does not stiffen the binder.
- The test results for the dynamic modulus of the three different WMA technologies indicated that Sasobit® and Evotherm™ ET were not statistically different than the control mixture, whereas the Aspha-min® produced statistically lower dynamic modulus results.
- The field performance determined to date has been very promising, with minimal rutting and cracking in all WMA and HMA sections.

ACKNOWLEDGEMENTS

This work was sponsored by the FHWA under a cooperative agreement with NCAT. Mr. Hurley and Dr. Prowell were employed by NCAT when this testing was completed. The authors would like to thank the asphalt contractor, Pace Construction, for allowing this research to be conducted on their project. The authors also thank the Missouri Department of Transportation for their assistance in collecting relevant project data, and particularly for coring the pavement on three occasions.

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APPENDIX A – JOB MIX FORMULA

Dale Williams	Digitally signed by Dale Williams DN: cn=Dale Williams, c=US o=MoDOT, ou=Field Office, email=dale.williams@modot.mo.gov Reason: I am approving this document Date: 2009.08.31 07:58:44 -05'00'

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP125CLP

DATE = 04/14/06 **CONTRACTOR = PACE** **SP125 06-42**

IDENT. NO.	PRODUCT CODE	/ PRODUCER, LOCATION	BULK SP. GR.	APPAR. SP. GR.	%ABS	FORMATION	LEDGES	% CHERT
60MA0026	100207..PY2	/ Iron Mtn Trap Rock Pit #3, Iron Mountain, MO	2.610	2.648	0.6	Porphyry	1	
56B3B401	100205..LD1	/ Central Stone #31, Florissant, St. Louis, MO	2.609	2.712	1.5	St. Louis	3-9 0.6	0.6
56B3B403	1002MS..MSLD	/ Central Stone #31, Florissant, St. Louis, MO	2.606	2.709		St. Louis	3-9	
56JEC069	1002..RAP1	/ Pace Construction, Overland, MO	2.696	2.696		RAP	4.9 % AC	
60MA0002	1002MF..MF	/ Mississippi Lime Co. #2, Ste. Genevieve, MO	2.707	2.707		Min. Filler		
6MFO0006	1071APAS	/ ARR MAZ Custom Chemicals, Inc., Winter Haven, FL				AD-here HP PLUS	0.25% BY WT OF AC	
66JEC087	1015ACPG..7022	/ ConocoPhillips, Granite City, IL	1.020		PG70-22	Gyro Mold Temp. 295-305EF		

MATERIAL IDENT #	60MA0026	56B3B401	56B3B403	56JEC069	60MA0002	60MA0026	56B3B401	56B3B403	56JEC069	60MA0002	COMB. GRAD
06042	3/4"	1/2"	MAN SAND	RAP	Min. Filler	48.0	21.0	20.0	10.0	1.0	
1 1/2"	100.0	100.0	100.0	100.0	100.0	48.0	21.0	20.0	10.0	1.0	00.0
1"	100.0	100.0	100.0	100.0	100.0	48.0	21.0	20.0	10.0	1.0	100.0
3/4"	100.0	100.0	100.0	100.0	100.0	48.0	21.0	20.0	10.0	1.0	100.0
1/2"	97.5	95.0	100.0	100.0	100.0	46.8	20.0	20.0	10.0	1.0	97.8
3/8"	85.5	75.0	100.0	92.8	100.0	41.0	15.8	20.0	9.3	1.0	87.1
#4	49.2	29.0	99.8	74.7	100.0	23.6	6.1	20.0	7.5	1.0	58.1
#8	28.5	7.2	84.0	54.6	100.0	13.7	1.5	16.8	5.5	1.0	38.5
#16	17.5	4.5	54.0	41.2	100.0	8.4	0.9	10.8	4.1	1.0	25.3
#30	11.5	4.0	29.2	28.7	100.0	5.5	0.8	5.8	2.9	1.0	16.1
#50	7.2	3.5	14.5	18.6	100.0	3.5	0.7	2.9	1.9	1.0	10.0
#100	4.8	3.0	7.0	12.3	96.0	2.3	0.6	1.4	1.2	1.0	6.5
#200	4.0	2.5	5.5	9.3	75.0	1.9	0.5	1.1	0.9	0.8	5.2

LABORATORY CHARACTERISTICS AASHTO T312	Gmm =	2.451	% VOIDS =	4.0	TSR =	93	TSR Wt.		Nini =	8	MIX COMPOSITION	
	Gmb =	2.353	V.M.A. =	15.0	-200/AC =	1.1	3743		Ndes =	100	MIN. AGG.	94.6%
	Gsb =	2.618	% FILLED =	73	Gyro Wt. =	4690			Nmax =	160	VIRGIN ASPHALT CONTENT	4.9%
CALIBRATION NUMBER =		60071	MASTER GAUGE BACK CNT. =			2152			A1 =	-4.579109	ASPHALT CONTENT W/ RAP	5.4%
MASTER GAUGE SER NO. =		2502	SAMPLE WEIGHT =			7000			A2 =	3.275568		

Aggregate & Mixture Properties Based on Contractors Mix Design

APPENDIX B – VOLUMETRIC DATA

TABLE A1 Volumetric Properties, Control Mixture - Hot

	Mix Type:	Control				Asphalt Specific Gravity (Gb):		1.028		
	Ndesign:	100				Apparent Specific Gravity (Gsa):				
	Test Date:	5/17/2006				Effective Specific Gravity (Gse):		2.664		
						Bulk Specific Gravity (Gsb):		2.618		
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	300	4687.7	2684.6	4697.5	2.329	2.459	5.3	15.8	66.6
2	5.4	300	4693.0	2699.6	4699.5	2.347	2.459	4.6	15.2	69.9
3	5.4	300	4697.8	2689.1	4709.0	2.326	2.459	5.4	16.0	66.0
4	5.4	300	4693.2	2705.8	4698.8	2.355	2.459	4.2	14.9	71.6
5	5.4	300	4693.9	2685.9	4707.2	2.322	2.459	5.6	16.1	65.4
6	5.4	300	4694.2	2705.3	4703.2	2.350	2.459	4.5	15.1	70.5
Avg.						2.338	2.459	4.9	15.5	68.4
1	5.4	250	4701.2	2696.4	4710.1	2.335	2.449	4.7	15.6	70.1
2	5.4	250	4701.9	2708.1	4707.2	2.352	2.449	4.0	15.0	73.6
3	5.4	250	4703.6	2701.2	4711.6	2.340	2.449	4.5	15.5	71.1
4	5.4	250	4701.8	2711.6	4708.4	2.355	2.449	3.9	14.9	74.2
5	5.4	250	4703.4	2704.1	4712.8	2.342	2.449	4.4	15.4	71.5
6	5.4	250	4698.5	2710.7	4706.0	2.355	2.449	3.8	14.9	74.2
Avg.						2.346	2.449	4.2	15.2	72.5

TABLE A2 Volumetric Properties, Control Mixture - Reheated

	Mix Type:	Control				Asphalt Specific Gravity (Gb):		1.028		
	Ndesign:	100				Apparent Specific Gravity (Gsa):				
	Test Date:	5/17/2006				Effective Specific Gravity (Gse):		2.664		
						Bulk Specific Gravity (Gsb):		2.618		
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	300	4693.2	2686	4700.5	2.330	2.459	5.3	15.8	66.8
2	5.4	300	4677.5	2704.4	4681.2	2.366	2.459	3.8	14.5	74.0
3	5.4	300	4692.5	2715.0	4696.2	2.369	2.459	3.7	14.4	74.5
4	5.4	300	4686.4	2689.2	4691.9	2.340	2.459	4.8	15.4	68.7
5	5.4	300	4690.3	2715.6	4693.3	2.372	2.459	3.6	14.3	75.1
6	5.4	300	4692.9	2696.4	4698.7	2.344	2.459	4.7	15.3	69.4
Avg.						2.353	2.459	4.3	15.0	71.4
1	5.4	250	4689.9	2697.7	4696.9	2.346	2.449	4.2	15.2	72.4
2	5.4	250	4690.2	2698.9	4697.1	2.347	2.449	4.2	15.2	72.6
3	5.4	250	4691.8	2688.0	4701.6	2.330	2.449	4.9	15.8	69.3
4	5.4	250	4692.9	2702.9	4700.3	2.350	2.449	4.1	15.1	73.1
5	5.4	250	4692.0	2692.5	4703.1	2.334	2.449	4.7	15.7	69.9
6	5.4	250	4691.2	2702.7	4697.6	2.352	2.449	4.0	15.0	73.5
Avg.						2.343	2.449	4.3	15.3	71.8

TABLE A3 Volumetric Properties, Sasobit 5/18/2006 - Hot

	Mix Type:	Sasobit				Asphalt Specific Gravity (Gb):			1.028	
	Ndesign:	100				Apparent Specific Gravity (Gsa):				
	Test Date:	5/18/2006				Effective Specific Gravity (Gse):			2.649	
						Bulk Specific Gravity (Gsb):			2.618	
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	250	4701.1	2696.0	4709.5	2.335	2.446	4.5	15.6	70.9
2	5.4	250	4697.5	2691.1	4705.7	2.332	2.446	4.7	15.7	70.3
3	5.4	250	4703.4	2709.9	4709.7	2.352	2.446	3.8	15.0	74.4
4	5.4	250	4697.2	2690.7	4705.8	2.331	2.446	4.7	15.8	70.2
5	5.4	250	4701.5	2711.3	4706.3	2.357	2.446	3.7	14.8	75.4
6	5.4	250	4695.9	2696.7	4703.0	2.341	2.446	4.3	15.4	72.1
Avg.						2.341	2.446	4.3	15.4	72.2
1	5.4	250	4694.9	2695.5	4701.6	2.340	2.437	4.0	15.4	74.3
2	5.4	250	4702.7	2712.8	4707.8	2.357	2.437	3.3	14.8	77.9
3	5.4	250	4698.5	2692.8	4708.8	2.331	2.437	4.4	15.8	72.3
4	5.4	250	4695.1	2707.8	4698.6	2.358	2.437	3.2	14.8	78.2
5	5.4	250	4693.4	2688.6	4699.5	2.334	2.437	4.2	15.7	73.0
6	5.4	250	4693.9	2705.1	4697.0	2.356	2.437	3.3	14.8	77.8
Avg.						2.346	2.437	3.7	15.2	75.6

TABLE A4 Volumetric Properties, Sasobit 5/18/2006 - Reheated

	Mix Type:	Sasobit				Asphalt Specific Gravity (Gb):			1.028	
	Ndesign:	100				Apparent Specific Gravity (Gsa):				
	Test Date:	5/18/2006				Effective Specific Gravity (Gse):			2.662	
						Bulk Specific Gravity (Gsb):			2.618	
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	250	4691.0	2702.9	4698.6	2.351	2.446	3.9	15.1	74.1
2	5.4	250	4691.1	2704.3	4699.7	2.351	2.446	3.9	15.0	74.2
3	5.4	250	4687.8	2716.3	4692.6	2.372	2.446	3.0	14.3	78.8
4	5.4	250	4692.4	2703.6	4700.7	2.350	2.446	3.9	15.1	73.9
5	5.4	250	4683.3	2709.6	4688.8	2.366	2.446	3.3	14.5	77.5
6	5.4	250	4688.1	2702.3	4694.3	2.353	2.446	3.8	15.0	74.7
Avg.						2.357	2.446	3.6	14.8	75.5
1	5.4	250	4693.9	2710.9	4700.6	2.359	2.437	3.2	14.8	78.3
2	5.4	250	4688.0	2707.1	4692.5	2.361	2.437	3.1	14.7	78.8
3	5.4	250	4685.7	2705.3	4691.2	2.359	2.437	3.2	14.7	78.4
4	5.4	250	4687.7	2702.9	4694.4	2.354	2.437	3.4	14.9	77.2
5	5.4	250	4688.1	2704.4	4695.7	2.354	2.437	3.4	14.9	77.3
6	5.4	250	4679.9	2697.2	4689.1	2.349	2.437	3.6	15.1	76.2
Avg.						2.356	2.437	3.3	14.9	77.7

TABLE A5 Volumetric Properties, Sasobit 5/19/2006 - Hot

	Mix Type:	Sasobit				Asphalt Specific Gravity (Gb):			1.028	
	Ndesign:	100				Apparent Specific Gravity (Gsa):				
	Test Date:	5/19/2006				Effective Specific Gravity (Gse):			2.662	
						Bulk Specific Gravity (Gsb):			2.618	
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	225	4695.1	2677.2	4709.3	2.310	2.457	6.0	16.5	63.9
2	5.4	225	4692.4	2684.7	4706.3	2.321	2.457	5.5	16.1	65.7
3	5.4	225	4697.8	2681.6	4715.6	2.310	2.457	6.0	16.5	63.7
4	5.4	225	4693.8	2681.6	4710.9	2.313	2.457	5.9	16.4	64.3
5	5.4	225	4698.3	2678.1	4717.4	2.304	2.457	6.2	16.8	62.8
6	5.4	225	4701.0	2692.5	4716.9	2.322	2.457	5.5	16.1	65.9
Avg.						2.313	2.457	5.8	16.4	64.4
1	5.4	225	4696.2	2691.1	4706.4	2.330	2.438	4.4	15.8	72.0
2	5.4	225	4697.7	2701.4	4704.9	2.345	2.438	3.8	15.3	75.0
3	5.4	225	4695.9	2693.1	4705.2	2.334	2.438	4.3	15.7	72.7
4	5.4	225	4697.0	2701.8	4703.1	2.347	2.438	3.7	15.2	75.4
5	5.4	225	4690.5	2688.3	4699.5	2.332	2.438	4.3	15.7	72.4
6	5.4	225	4692.4	2695.6	4698.3	2.343	2.438	3.9	15.3	74.6
Avg.						2.339	2.438	4.1	15.5	73.7

TABLE A6 Volumetric Properties, Sasobit 5/19/2006 - Reheated

	Mix Type:	Sasobit				Asphalt Specific Gravity (Gb):			1.028	
	Ndesign:	100				Apparent Specific Gravity (Gsa):				
	Test Date:	5/19/2006				Effective Specific Gravity (Gse):			2.662	
						Bulk Specific Gravity (Gsb):			2.618	
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	225	4688.9	2687.8	4697.6	2.333	2.457	5.0	15.7	67.9
2	5.4	225	4684.6	2671.7	4692.8	2.318	2.457	5.7	16.2	65.1
3	5.4	225	4692.0	2693.9	4699.5	2.339	2.457	4.8	15.5	69.1
4	5.4	225	4689.2	2674.5	4697.1	2.318	2.457	5.6	16.2	65.2
5	5.4	225	4664.5	2666.3	4679.6	2.317	2.457	5.7	16.3	65.0
6	5.4	225	4680.6	2683.7	4690.3	2.333	2.457	5.1	15.7	67.8
Avg.						2.326	2.457	5.3	15.9	66.7
1	5.4	225	4691.9	2683.5	4701.9	2.325	2.438	4.7	16.0	70.9
2	5.4	225	4688.7	2689.9	4695.3	2.338	2.438	4.1	15.5	73.6
3	5.4	225	4686.7	2685.5	4696.5	2.331	2.438	4.4	15.8	72.1
4	5.4	225	4692.0	2687.6	4701.6	2.330	2.438	4.4	15.8	71.9
5	5.4	225	4686.5	2679.0	4697.6	2.322	2.438	4.8	16.1	70.4
6	5.4	225	4689.3	2689.5	4695.6	2.338	2.438	4.1	15.5	73.5
Avg.						2.330	2.438	4.4	15.8	72.1

TABLE A7 Volumetric Properties, Evotherm 5/22/2006 - Hot

	Mix Type:	Evotherm				Asphalt Specific Gravity (Gb):			1.028	
	Ndesign:	100				Apparent Specific Gravity (Gsa):				
	Test Date:	5/22/2006				Effective Specific Gravity (Gse):			2.673	
						Bulk Specific Gravity (Gsb):			2.618	
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	250	4672.4	2655.2	4683.9	2.303	2.451	6.0	16.8	64.0
2	5.4	250	4679.4	2672.9	4687.0	2.323	2.451	5.2	16.0	67.5
3	5.4	250	4670.8	2655.3	4683.8	2.303	2.451	6.1	16.8	64.0
4	5.4	250	4671.7	2664.9	4677.0	2.322	2.451	5.3	16.1	67.3
5	5.4	250	4677.2	2656.0	4689.8	2.300	2.451	6.2	16.9	63.5
6	5.4	250	4667.9	2670.5	4672.8	2.331	2.451	4.9	15.8	69.0
Avg.						2.314	2.451	5.6	16.4	65.9
1	5.4	250	4686.9	2695	4690.6	2.349	2.462	4.6	15.1	69.6
2	5.4	250	4689.7	2677.6	4697.8	2.321	2.462	5.7	16.1	64.6
3	5.4	250	4695.9	2695.5	4700.2	2.342	2.462	4.9	15.4	68.4
4	5.4	250	4688.9	2674.6	4699.3	2.316	2.462	5.9	16.3	63.6
5	5.4	250	4681.3	2693.7	4685.9	2.350	2.462	4.6	15.1	69.8
6	5.4	250	4703.5	2685.1	4710.9	2.322	2.462	5.7	16.1	64.6
Avg.						2.333	2.462	5.2	15.7	66.8

TABLE A8 Volumetric Properties, Evotherm 5/22/2006 - Reheated

	Mix Type:	Evotherm				Asphalt Specific Gravity (Gb):			1.028	
	Ndesign:	100				Apparent Specific Gravity (Gsa):				
	Test Date:	5/22/2006				Effective Specific Gravity (Gse):			2.685	
						Bulk Specific Gravity (Gsb):			2.618	
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	250	4687.1	2673.5	4699.1	2.314	2.451	5.6	16.4	65.9
2	5.4	250	4690.0	2695.8	4695.6	2.345	2.451	4.3	15.3	71.7
3	5.4	250	4686.2	2679.4	4697.4	2.322	2.451	5.3	16.1	67.3
4	5.4	250	4684.7	2698.9	4691.4	2.351	2.451	4.1	15.0	72.9
5	5.4	250	4692.1	2678.6	4703.1	2.318	2.451	5.4	16.3	66.5
6	5.4	250	4683.9	2695.7	4691.0	2.347	2.451	4.2	15.2	72.2
Avg.						2.333	2.451	4.8	15.7	69.4
1	5.4	250	4694.9	2706.1	4701.1	2.353	2.462	4.4	15.0	70.5
2	5.4	250	4687.6	2702.6	4693.3	2.355	2.462	4.4	14.9	70.8
3	5.4	250	4691.5	2685.9	4703.7	2.325	2.462	5.6	16.0	65.2
4	5.4	250	4685.7	2702.1	4694.3	2.352	2.462	4.5	15.0	70.2
5	5.4	250	4678.5	2668.3	4692.9	2.311	2.462	6.1	16.5	62.8
6	5.4	250	4692.3	2696.5	4701.6	2.340	2.462	4.9	15.4	68.0
Avg.						2.339	2.462	5.0	15.5	67.9

TABLE A9 Volumetric Properties, Evotherm 5/23/2006 - Hot

Mix Type:	Evotherm	Asphalt Specific Gravity (Gb): 1.028
Ndesign:	100	Apparent Specific Gravity (Gsa):
Test Date:	5/23/2006	Effective Specific Gravity (Gse): 2.673
		Bulk Specific Gravity (Gsb): 2.618

Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	225	4690.9	2706.7	4699.1	2.354	2.473	4.8	14.9	67.9
2	5.4	225	4691.4	2696.1	4704.7	2.336	2.473	5.6	15.6	64.4
3	5.4	225	4686.7	2707.4	4692.7	2.361	2.473	4.5	14.7	69.1
4	5.4	225	4685.0	2695.7	4696.6	2.341	2.473	5.3	15.4	65.4
5	5.4	225	4703.2	2716.5	4708.5	2.361	2.473	4.5	14.7	69.2
6	5.4	225	4686.7	2687.1	4700.3	2.328	2.473	5.9	15.9	63.1
Avg.						2.347	2.473	5.1	15.2	66.5
1	5.4	200	4684.5	2695.1	4691.4	2.347	2.459	4.6	15.2	69.9
2	5.4	200	4686.1	2710.7	4689.5	2.368	2.459	3.7	14.4	74.4
3	5.4	200	4692.7	2699.5	4702.0	2.343	2.459	4.7	15.3	69.3
4	5.4	200	4681.4	2710.6	4685.5	2.370	2.459	3.6	14.3	74.9
5	5.4	200	4679.2	2693.9	4687.1	2.348	2.459	4.5	15.2	70.1
6	5.4	200	4689.2	2714.3	4693.1	2.370	2.459	3.6	14.4	74.7
Avg.						2.358	2.459	4.1	14.8	72.2

TABLE A10 Volumetric Properties, Evotherm 5/23/2006 - Reheated

Mix Type:	Evotherm	Asphalt Specific Gravity (Gb): 1.028
Ndesign:	100	Apparent Specific Gravity (Gsa):
Test Date:	5/23/2006	Effective Specific Gravity (Gse): 2.685
		Bulk Specific Gravity (Gsb): 2.618

Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	225	4689.2	2713.4	4695.8	2.365	2.473	4.4	14.5	70.1
2	5.4	225	4686.1	2699.0	4694.5	2.348	2.473	5.0	15.1	66.7
3	5.4	225	4688.9	2712.4	4695.2	2.365	2.473	4.4	14.5	69.9
4	5.4	225	4686.7	2697.8	4696.9	2.344	2.473	5.2	15.3	66.0
5	5.4	225	4692.3	2718.0	4698.3	2.369	2.473	4.2	14.4	70.9
6	5.4	225	4692.4	2702.8	4700.9	2.348	2.473	5.0	15.1	66.7
Avg.						2.357	2.473	4.7	14.8	68.4
1	5.4	200	4689.8	2710.0	4694.3	2.363	2.459	3.9	14.6	73.4
2	5.4	200	4698.2	2710.8	4704.5	2.357	2.459	4.2	14.8	71.9
3	5.4	200	4695.4	2705.0	4706.7	2.346	2.459	4.6	15.2	69.8
4	5.4	200	4693.8	2709.9	4702.1	2.356	2.459	4.2	14.9	71.8
5	5.4	200	4697.0	2707.3	4708.1	2.348	2.459	4.5	15.2	70.1
6	5.4	200	4690.7	2706.1	4698.6	2.354	2.459	4.3	14.9	71.5
Avg.						2.354	2.459	4.3	14.9	71.4

TABLE A11 Volumetric Properties, Aspha-min - Reheated

	Mix Type:	Aspha-min					Asphalt Specific Gravity (Gb):		1.028	
	Ndesign:	100					Apparent Specific Gravity (Gsa):			
	Test Date:	5/25/2006					Effective Specific Gravity (Gse):		2.657	
							Bulk Specific Gravity (Gsb):		2.618	
Sample Number	Asphalt Content, %	Compaction Temperature (°F)	In Air (gms)	In Water (gms)	SSD (gms)	Bulk (Gmb)	TMD (Gmm)	VTM, %	VMA, %	VFA, %
1	5.4	250	4691.1	2685.4	4698.9	2.330	2.449	4.9	15.8	69.2
2	5.4	250	4692.6	2690.1	4698.8	2.336	2.449	4.6	15.6	70.4
3	5.4	250	4692.0	2684.1	4700.4	2.327	2.449	5.0	15.9	68.7
4	5.4	250	4686.3	2686.1	4694.3	2.334	2.449	4.7	15.7	69.9
5	5.4	250	4684.7	2691.7	4691.2	2.343	2.449	4.3	15.3	71.8
Avg.						2.334	2.449	4.7	15.7	70.0

APPENDIX C – ASPHALT CONTENT AND GRADATION DATA

TABLE B1 Measured Asphalt Content and Gradation - Control Mixture

Gradation		Sample 1				Sample 2				Overall		
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Avg.	Std Dev	Rep1	Rep2	Avg.	Std Dev	Avg.	Std Dev	JMF
37.5	5.11	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	0.00	100.0
25.0	4.26	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	0.00	100.0
19.0	3.76	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	0.00	100.0
12.5	3.12	96.9	96.6	96.8	0.2	95.2	95.0	95.1	0.1	95.9	1.17	97.8
9.5	2.75	85.9	86.2	86.1	0.2	82.2	81.4	81.8	0.6	83.9	3.01	87.1
4.75	2.02	58.1	55.8	57.0	1.6	54.3	54.1	54.2	0.1	55.6	1.94	58.1
2.36	1.47	37.2	35.9	36.6	0.9	36.4	36.8	36.6	0.3	36.6	0.04	38.5
1.18	1.08	21.9	21.4	21.7	0.4	22.3	22.4	22.4	0.1	22.0	0.49	25.3
0.6	0.8	13.9	13.5	13.7	0.3	14.2	14.1	14.2	0.1	13.9	0.32	16.1
0.3	0.58	9.0	8.8	8.9	0.1	9.4	9.3	9.4	0.1	9.1	0.32	10.0
0.15	0.43	6.2	6.0	6.1	0.1	6.7	6.6	6.7	0.1	6.4	0.39	6.5
0.075	0.31	4.6	4.5	4.6	0.1	5.4	5.0	5.2	0.3	4.9	0.46	5.2
Asphalt Content		Sample 1				Sample 2				Overall		
		Rep1	Rep2	Avg.	Std Dev	Rep1	Rep2	Avg.	Std Dev	Avg.	Std Dev	Opt. AC
		5.61	5.43	5.52	0.13	5.34	5.15	5.25	0.13	5.38	0.19	5.4

TABLE B2 Measured Asphalt Content and Gradation - Sasobit 5/18/2008

Gradation		Sample 1				Sample 2				Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.5	5.11	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
25.0	4.26	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
19.0	3.76	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
12.5	3.12	97.3	98.0	97.7	0.5	98.2	96.0	97.1	1.6	97.38	0.39	97.8
9.5	2.75	84.3	87.0	85.7	1.9	87.0	83.8	85.4	2.3	85.53	0.18	87.1
4.75	2.02	53.8	58.8	56.3	3.5	57.7	53.6	55.7	2.9	55.98	0.46	58.1
2.36	1.47	35.5	37.8	36.7	1.6	37.3	35.6	36.5	1.2	36.55	0.14	38.5
1.18	1.08	21.5	22.7	22.1	0.8	22.7	22.1	22.4	0.4	22.25	0.21	25.3
0.6	0.8	13.6	14.5	14.1	0.6	14.5	14.1	14.3	0.3	14.18	0.18	16.1
0.3	0.58	8.9	9.7	9.3	0.6	9.5	9.2	9.4	0.2	9.33	0.04	10.0
0.15	0.43	6.3	6.9	6.6	0.4	6.8	6.3	6.6	0.4	6.58	0.04	6.5
0.075	0.31	4.7	5.3	5.0	0.4	5.4	4.9	5.2	0.4	5.08	0.11	5.2
Asphalt Content		**Sample 1**				**Sample 2**				**Overall**		
		Rep1	**Rep2**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		5.44	5.32	5.38	0.08	5.56	4.78	5.17	0.55	5.28	0.15	5.4

TABLE B3 Measured Asphalt Content and Gradation - Sasobit 5/19/2008

Gradation		Sample 1				Sample 2				Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.5	5.11	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
25.0	4.26	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
19.0	3.76	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
12.5	3.12	95.4	96.6	96.0	0.8	96.4	95.4	95.9	0.7	96.0	0.1	97.8
9.5	2.75	78.5	86.3	82.4	5.5	87.3	82.9	85.1	3.1	83.8	1.9	87.1
4.75	2.02	47.2	55.9	51.6	6.2	58.7	54.8	56.8	2.8	54.2	3.7	58.1
2.36	1.47	30.5	34.7	32.6	3.0	37.5	35.4	36.5	1.5	34.5	2.7	38.5
1.18	1.08	18.7	20.1	19.4	1.0	22.2	21.0	21.6	0.8	20.5	1.6	25.3
0.6	0.8	11.6	12.3	12.0	0.5	13.8	13.2	13.5	0.4	12.7	1.1	16.1
0.3	0.58	7.5	7.9	7.7	0.3	9.1	8.7	8.9	0.3	8.3	0.8	10.0
0.15	0.43	5.4	5.5	5.5	0.1	6.5	6.2	6.4	0.2	5.9	0.6	6.5
0.075	0.31	4.2	4.1	4.2	0.1	5.1	5.0	5.1	0.1	4.6	0.6	5.2
Asphalt Content		**Sample 1**				**Sample 2**				**Overall**		
		Rep1	**Rep2**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		5.03	5.29	5.16	0.18	5.64	5.08	5.36	0.40	5.26	0.14	5.4

TABLE B4 Measured Asphalt Content and Gradation - Evotherm™ ET
5/22/2008

Gradation		Sample 1				Sample 2				Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.5	5.11	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
25.0	4.26	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
19.0	3.76	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
12.5	3.12	99.0	99.4	99.2	0.3	98.0	98.3	98.2	0.2	98.68	0.74	97.8
9.5	2.75	91.7	90.0	90.9	1.2	87.1	86.3	86.7	0.6	88.78	2.93	87.1
4.75	2.02	61.9	62.1	62.0	0.1	57.1	58.1	57.6	0.7	59.80	3.11	58.1
2.36	1.47	38.4	38.5	38.5	0.1	36.8	37.6	37.2	0.6	37.83	0.88	38.5
1.18	1.08	22.6	22.6	22.6	0.0	22.3	22.5	22.4	0.1	22.50	0.14	25.3
0.6	0.8	14.2	14.2	14.2	0.0	14.1	14.2	14.2	0.1	14.18	0.04	16.1
0.3	0.58	9.4	9.4	9.4	0.0	9.3	9.3	9.3	0.0	9.35	0.07	10.0
0.15	0.43	6.9	6.9	6.9	0.0	6.6	6.6	6.6	0.0	6.75	0.21	6.5
0.075	0.31	5.4	5.4	5.4	0.0	5.1	5.1	5.1	0.0	5.25	0.21	5.2
Asphalt Content		**Sample 1**				**Sample 2**				**Overall**		
		Rep1	**Rep2**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		5.33	5.43	5.38	0.07	5.19	5.13	5.16	0.04	5.27	0.16	5.4

TABLE B5 Measured Asphalt Content and Gradation - Evotherm™ ET
5/23/2008

Gradation		Sample 1				Sample 2				Overall		
Sieve Size (mm)	**Sieve^0.45**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**JMF**
37.5	5.11	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
25.0	4.26	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
19.0	3.76	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.00	0.00	100.0
12.5	3.12	96.7	95.5	96.1	0.8	97.3	97.1	97.2	0.1	96.65	0.78	97.8
9.5	2.75	82.6	79.3	81.0	2.3	82.3	82.8	82.6	0.4	81.75	1.13	87.1
4.75	2.02	50.7	49.2	50.0	1.1	51.8	53.2	52.5	1.0	51.23	1.80	58.1
2.36	1.47	35.0	33.1	34.1	1.3	34.1	34.7	34.4	0.4	34.23	0.25	38.5
1.18	1.08	21.5	20.8	21.2	0.5	21.4	21.2	21.3	0.1	21.23	0.11	25.3
0.6	0.8	14.4	13.6	14.0	0.6	14.1	13.7	13.9	0.3	13.95	0.07	16.1
0.3	0.58	10.1	9.1	9.6	0.7	9.8	9.1	9.5	0.5	9.53	0.11	10.0
0.15	0.43	7.9	6.4	7.2	1.1	7.7	6.5	7.1	0.8	7.13	0.04	6.5
0.075	0.31	6.9	5.1	6.0	1.3	6.7	5.1	5.9	1.1	5.95	0.07	5.2
Asphalt Content		**Sample 1**				**Sample 2**				**Overall**		
		Rep1	**Rep2**	**Avg.**	**Std Dev**	**Rep1**	**Rep2**	**Avg.**	**Std Dev**	**Avg.**	**Std Dev**	**Opt. AC**
		5.11	4.65	4.88	0.33	5.44	5.21	5.33	0.16	5.10	0.31	5.4

TABLE B6 Measured Asphalt Content and Gradation - Aspha-min

Gradation		Sample 1				
Sieve Size (mm)	Sieve^0.45	Rep1	Rep2	Avg.	Std Dev	JMF
37.5	5.11	100.0	100.0	100.0	0.0	100.0
25.0	4.26	100.0	100.0	100.0	0.0	100.0
19.0	3.76	100.0	100.0	100.0	0.0	100.0
12.5	3.12	95.1	97.0	96.1	1.3	97.8
9.5	2.75	80.8	83.5	82.2	1.9	87.1
4.75	2.02	50.3	52.7	51.5	1.7	58.1
2.36	1.47	32.6	34.6	33.6	1.4	38.5
1.18	1.08	20.8	22.0	21.4	0.8	25.3
0.6	0.8	13.9	14.8	14.4	0.6	16.1
0.3	0.58	9.5	10.4	10.0	0.6	10.0
0.15	0.43	7.0	7.9	7.5	0.6	6.5
0.075	0.31	5.6	6.5	6.1	0.6	5.2
Asphalt Content		Sample 1				
		Rep1	Rep2	Avg.	Std Dev	Opt. AC
		5.39	5.48	5.44	0.06	5.4

APPENDIX D – TENSILE-STRENGTH RATIO DATA

Project: WMA: St. Louis Date: 6/7/2006

Tested By: G. Hurley Calculated By: G. Hurley

Sample Identification: Control Mixture, Sample #1 5/17/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2	5	3	4	
(A) Diameter, in	5.918	5.926	5.914	5.912	5.921	
(B) Height, in	3.721	3.713	3.713	3.728	2.719	
(C) Weight in Air, gm	3715.3	3711.8	3715.4	3709.3	3708.5	
(D) SSD Weight, gm	3734.3	3724.5	3728.8	3727.8	3719.5	
(E) Submerged Weight, gm	2104.5	2103.5	2104.1	2097.4	2099.8	
(F) Bulk Specific Gravity [A/(D - E)]	2.280	2.290	2.287	2.275	2.290	
(G) Theoretical Maximum Gravity	2.459	2.459	2.459	2.459	2.459	
(H) % Air Voids [100*(1-F/G)]	7.3	6.9	7.0	7.5	6.9	
(I) Volume of Air Voids [H*(D - E)/100]	118.901	111.525	113.761	121.941	111.567	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3800.8	3790.2	3794.6	N / A		
ye(K) Vol. Of Absorbed Water, cc [J - C]	85.50	78.40	79.20			
(L) % Saturation [100*(K/I)]	71.9	70.3	69.6			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	4400	4200	4550	4600	5050	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	132.9	199.7	
(R) Conditioned S_T, psi [2P/(A*B*□)]	127.2	121.5	131.9	N/A	N/A	N/A
(S) Average S_T, psi	126.9			166.3		

Project: WMA: St. Louis Date: 7/11/2006

Tested By: D. Ford Calculated By: D. Ford

Sample Identification: Control Mixture, Sample #1 5/17/2006 Reheated

	Conditioned Samples			Unconditioned Samples		
Sample Number	2	5	6	1	3	4
(A) Diameter, in	5.920	5.936	5.924	5.931	5.934	5.941
(B) Height, in	3.704	3.687	3.689	3.693	3.698	3.692
(C) Weight in Air, gm	3706.2	3718.8	3701.8	3705.7	3705.9	3708.9
(D) SSD Weight, gm	3726.9	3736.1	3720.0	3721.6	3723.2	3723.3
(E) Submerged Weight, gm	2093.7	2106.3	2104.3	2094.9	2096.7	2098.0
(F) Bulk Specific Gravity [A/(D - E)]	2.269	2.282	2.291	2.278	2.278	2.282
(G) Theoretical Maximum Gravity	2.449	2.449	2.449	2.449	2.449	2.449
(H) % Air Voids [100*(1-F/G)]	7.3	6.8	6.4	7.0	7.0	6.8
(I) Volume of Air Voids [H*(D - E)/100]	119.848	111.303	104.144	113.552	113.270	110.845
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3794.4	3803.5	3779.1	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	88.20	84.70	77.30			
(L) % Saturation [100*(K/I)]	73.6	76.1	74.2			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	5600	5700	5575	6450	6525	6600
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	187.5	189.3	191.6
(R) Conditioned S_T, psi [2P/(A*B*□)]	162.6	165.8	162.4	N/A	N/A	N/A
(S) Average S_T, psi	163.6			189.4		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.86		

Project: WMA: St. Louis   Date: 6/5/2006

Tested By: G. Hurley   Calculated By: G. Hurley

Sample Identification: Control Mixture, Sample #2 5/17/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	4	5	6	2	3	
(A) Diameter, in	5.897	5.895	5.883	5.894	5.902	
(B) Height, in	3.716	3.715	3.716	3.715	3.729	
(C) Weight in Air, gm	3717.1	3712.2	3716.6	3717.8	3726.3	
(D) SSD Weight, gm	3726.8	3729.6	3727.0	3727.0	3738.7	
(E) Submerged Weight, gm	2100.3	2090.7	2104.1	2100.0	2100.8	
(F) Bulk Specific Gravity [A/(D - E)]	2.285	2.265	2.290	2.285	2.275	
(G) Theoretical Maximum Gravity	2.449	2.449	2.449	2.449	2.449	
(H) % Air Voids [100*(1-F/G)]	6.7	7.5	6.5	6.7	7.1	
(I) Volume of Air Voids [H*(D - E)/100]	108.697	123.098	105.301	108.911	116.340	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3794.4	3805.5	3794.1	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	77.30	93.30	77.50			
(L) % Saturation [100*(K/I)]	71.1	75.8	73.6			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3925	3775	4200	4000	3775	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	116.3	109.2	
(R) Conditioned S_T, psi [2P/(A*B*□)]	114.0	109.7	122.3	N/A	N/A	N/A
(S) Average S_T, psi	115.4			112.7		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				1.02		

Project: WMA: St. Louis Date: 7/11/2006

Tested By: D. Ford Calculated By: D. Ford

Sample Identification: Control Mixture, Sample #2 5/17/2006 Reheated

	Conditioned Samples			Unconditioned Samples		
Sample Number	2	5	6	1	3	4
(A) Diameter, in	5.920	5.936	5.924	5.931	5.934	5.941
(B) Height, in	3.704	3.687	3.689	3.693	3.698	3.692
(C) Weight in Air, gm	3706.2	3718.8	3701.8	3705.7	3705.9	3708.9
(D) SSD Weight, gm	3726.9	3736.1	3720.0	3721.6	3723.2	3723.3
(E) Submerged Weight, gm	2093.7	2106.3	2104.3	2094.9	2096.7	2098.0
(F) Bulk Specific Gravity [A/(D - E)]	2.269	2.282	2.291	2.278	2.278	2.282
(G) Theoretical Maximum Gravity	2.449	2.449	2.449	2.449	2.449	2.449
(H) % Air Voids [100*(1-F/G)]	7.3	6.8	6.4	7.0	7.0	6.8
(I) Volume of Air Voids [H*(D - E)/100]	119.848	111.303	104.144	113.552	113.270	110.845
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3794.4	3803.5	3779.1	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	88.20	84.70	77.30			
(L) % Saturation [100*(K/I)]	73.6	76.1	74.2			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	5600	5700	5575	6450	6525	6600
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	187.5	189.3	191.6
(R) Conditioned S_T, psi [2P/(A*B*□)]	162.6	165.8	162.4	N/A	N/A	N/A
(S) Average S_T, psi	163.6			189.4		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.86		

Project: WMA: St. Louis Date: 6/15/2006

Tested By: G. Hurley Calculated By: G. Hurley

Sample Identification: Sasobit Mixture, Sample #1 5/18/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	3		5	6	
(A) Diameter, in	5.930	5.934		5.924	5.925	
(B) Height, in	3.697	3.692		3.700	3.687	
(C) Weight in Air, gm	3638.0	3635.1		3636.5	3638.9	
(D) SSD Weight, gm	3661.4	3658.3		3657.9	3662.2	
(E) Submerged Weight, gm	2046.1	2048.1		2043.5	2049.7	
(F) Bulk Specific Gravity [A/(D - E)]	2.252	2.258		2.253	2.257	
(G) Theoretical Maximum Gravity	2.446	2.446		2.446	2.446	
(H) % Air Voids [100*(1-F/G)]	7.9	7.7		7.9	7.7	
(I) Volume of Air Voids [H*(D - E)/100]	127.974	124.059		127.687	124.806	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3727.4	3729.5		N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	89.40	94.40				
(L) % Saturation [100*(K/I)]	69.9	76.1				
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3300	3550		4850	5000	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	140.9	145.7	
(R) Conditioned S_T, psi [2P/(A*B*□)]	95.8	103.2		N/A	N/A	N/A
(S) Average S_T, psi	99.5			143.3		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.69		

Project: WMA: St. Louis

Date: 7/11/2006

Tested By: D. Ford

Calculated By: D. Ford

Sample Identification: Sasobit Mixture, Sample #1 5/18/2006 Reheated

	Conditioned Samples			Unconditioned Samples		
Sample Number	3	4		5	6	
(A) Diameter, in	5.935	5.938		5.926	5.935	
(B) Height, in	3.664	3.669		3.650	3.675	
(C) Weight in Air, gm	3652.5	3656.5		3655.6	3654.3	
(D) SSD Weight, gm	3668.8	3674.1		3668.5	3672.1	
(E) Submerged Weight, gm	2056.2	2061.9		2065.9	2055.6	
(F) Bulk Specific Gravity [A/(D - E)]	2.265	2.268		2.281	2.261	
(G) Theoretical Maximum Gravity	2.446	2.446		2.446	2.446	
(H) % Air Voids [100*(1-F/G)]	7.4	7.3		6.7	7.6	
(I) Volume of Air Voids [H*(D - E)/100]	119.346	117.310		108.078	122.510	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3737.1	3741.8		N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	84.60	85.30				
(L) % Saturation [100*(K/I)]	70.9	72.7				
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	4775	5000		6025	5475	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	177.3	159.8	
(R) Conditioned S_T, psi [2P/(A*B*□)]	139.8	146.1		N/A	N/A	N/A
(S) Average S_T, psi	142.9			168.6		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.85		

Project: WMA: St. Louis   Date: 6/12/2006

Tested By: G. Hurley   Calculated By: G. Hurley

Sample Identification: Sasobit Mixture, Sample #2 5/18/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	2	3		4	6	
(A) Diameter, in	5.912	5.912		5.909	5.905	
(B) Height, in	3.698	3.712		3.693	3.692	
(C) Weight in Air, gm	3666.4	3666.8		3670.4	3664.7	
(D) SSD Weight, gm	3680.8	3689.5		3688.6	3677.8	
(E) Submerged Weight, gm	2060.6	2064.2		2075.3	2060.0	
(F) Bulk Specific Gravity [A/(D - E)]	2.263	2.256		2.275	2.265	
(G) Theoretical Maximum Gravity	2.431	2.431		2.431	2.431	
(H) % Air Voids [100*(1-F/G)]	6.9	7.2		6.4	6.8	
(I) Volume of Air Voids [H*(D - E)/100]	112.014	116.950		103.469	110.313	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3753.4	3760.1		N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	87.00	93.30				
(L) % Saturation [100*(K/I)]	77.7	79.8				
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile Strength (S_T) Calculations						
(P) Failure Load, lbs	3625	3550		4025	4300	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	117.4	125.6	
(R) Conditioned S_T, psi [2P/(A*B*□)]	105.6	103.0		N/A	N/A	N/A
(S) Average S_T, psi	104.3			121.5		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.86		

Project: WMA: St. Louis Date: 7/20/2006

Tested By: G. Hurley Calculated By: G. Hurley

Sample Identification: Sasobit Mixture, Sample #2 5/18/2006 Reheated Samples

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2	4	3	5	6
(A) Diameter, in	5.910	5.910	5.910	5.900	5.900	5.910
(B) Height, in	3.650	3.650	3.650	3.650	3.640	3.640
(C) Weight in Air, gm	3656.9	3653.2	3660.9	3653.4	3657.4	3625.2
(D) SSD Weight, gm	3669.6	3660.7	3675.9	3667.6	3668.0	3649.6
(E) Submerged Weight, gm	2066.2	2062.1	2079.6	2071.1	2073.1	2053.0
(F) Bulk Specific Gravity [A/(D - E)]	2.281	2.285	2.293	2.288	2.293	2.271
(G) Theoretical Maximum Gravity	2.437	2.437	2.437	2.437	2.437	2.437
(H) % Air Voids [100*(1-F/G)]	6.4	6.2	5.9	6.1	5.9	6.8
(I) Volume of Air Voids [H*(D - E)/100]	102.826	99.544	94.084	97.362	94.120	109.033
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3737.3	3731.2	3734.7	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	80.40	78.00	73.80			
(L) % Saturation [100*(K/I)]	78.2	78.4	78.4			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3325	3525	3500	3950	4100	3800
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	116.8	121.5	112.5
(R) Conditioned S_T, psi [2P/(A*B*□)]	98.1	104.0	103.3	N/A	N/A	N/A
(S) Average S_T, psi	101.8			116.9		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.87		

Project: WMA: St. Louis | Date: 6/15/2006

Tested By: G. Hurley | Calculated By: G. Hurley

Sample Identification: Sasobit Mixture, Sample #1 5/19/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	3	5		1	Trial 1	
(A) Diameter, in	5.932	5.925		5.934	5.898	
(B) Height, in	3.711	3.709		3.703	3.723	
(C) Weight in Air, gm	3708.9	3712.1		3709.2	3716.3	
(D) SSD Weight, gm	3728.1	3734.2		3728.2	3728.2	
(E) Submerged Weight, gm	2115.0	2108.5		2112.1	2100.2	
(F) Bulk Specific Gravity [A/(D - E)]	2.299	2.283		2.295	2.283	
(G) Theoretical Maximum Gravity	2.457	2.457		2.457	2.457	
(H) % Air Voids [100*(1-F/G)]	6.4	7.1		6.6	7.1	
(I) Volume of Air Voids [H*(D - E)/100]	103.576	114.874		106.454	115.464	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3786.2	3795.8		N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	77.30	83.70				
(L) % Saturation [100*(K/I)]	74.6	72.9				
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3350	3350		4875	4925	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	141.2	142.8	
(R) Conditioned S_T, psi [2P/(A*B*□)]	96.9	97.0		N/A	N/A	N/A
(S) Average S_T, psi	97.0			142.0		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.68		

Project: WMA: St. Louis Date: 7/18/2006

Tested By: L. McInnis Calculated By: L. McInnis

Sample Identification: Sasobit Mixture, Sample #1 5/19/2006 Reheated Samples

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2	3	4	5	6
(A) Diameter, in	5.926	5.926	5.931	5.919	5.928	5.920
(B) Height, in	3.674	3.663	3.673	3.661	3.667	3.661
(C) Weight in Air, gm	3702.5	3689.8	3690.5	3696.8	3692.3	3701.0
(D) SSD Weight, gm	3716.7	3702.4	3708.3	3707.1	3708.7	3711.0
(E) Submerged Weight, gm	2104.6	2097.4	2097.7	2103.5	2096.8	2110.3
(F) Bulk Specific Gravity [A/(D - E)]	2.297	2.299	2.291	2.305	2.291	2.312
(G) Theoretical Maximum Gravity	2.457	2.457	2.457	2.457	2.457	2.457
(H) % Air Voids [100*(1-F/G)]	6.5	6.4	6.7	6.2	6.8	5.9
(I) Volume of Air Voids [H*(D - E)/100]	105.181	103.250	108.565	99.001	109.132	94.391
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3780.2	3768.3	3773.3	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	77.70	78.50	82.80			
(L) % Saturation [100*(K/I)]	73.9	76.0	76.3			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3800	3800	3750	4450	4350	4650
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	130.7	127.4	136.6
(R) Conditioned S_T, psi [2P/(A*B*□)]	111.1	111.4	109.6	N/A	N/A	N/A
(S) Average S_T, psi	110.7			131.6		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.84		

Project: WMA: St. Louis Date: 6/15/2006

Tested By: G. Hurley Calculated By: G. Hurley

Sample Identification: Sasobit Mixture, Sample #2 5/19/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2	3	4	5	6
(A) Diameter, in	5.928	5.918	5.924	5.915	5.928	5.918
(B) Height, in	3.701	3.696	3.712	3.688	3.716	3.702
(C) Weight in Air, gm	3733.3	3710.8	3718.1	3709.9	3713.1	3712.0
(D) SSD Weight, gm	3746.5	3722.7	3734.5	3723.5	3728.0	3722.9
(E) Submerged Weight, gm	2115.1	2106.4	2108.8	2107.6	2099.1	2106.2
(F) Bulk Specific Gravity [A/(D - E)]	2.288	2.296	2.287	2.296	2.280	2.296
(G) Theoretical Maximum Gravity	2.438	2.438	2.438	2.438	2.438	2.438
(H) % Air Voids [100*(1-F/G)]	6.1	5.8	6.2	5.8	6.5	5.8
(I) Volume of Air Voids [H*(D - E)/100]	100.104	94.233	100.638	94.202	105.889	94.141
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3810.5	3782.2	3793.0	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	77.20	71.40	74.90			
(L) % Saturation [100*(K/I)]	77.1	75.8	74.4			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3050	3025	2950	5100	5000	5225
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	148.8	144.5	151.8
(R) Conditioned S_T, psi [2P/(A*B*□)]	88.5	88.0	85.4	N/A	N/A	N/A
(S) Average S_T, psi	87.3			148.4		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.59		

Project: WMA: St. Louis Date: 6/15/2006

Tested By: G. Hurley Calculated By: G. Hurley

Sample Identification: Sasobit Mixture, Sample #2 5/19/2006 Reheated

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	3	5	2	4	6
(A) Diameter, in	5.920	5.920	5.910	5.910	5.910	5.910
(B) Height, in	3.680	3.660	3.670	3.670	3.670	3.660
(C) Weight in Air, gm	3688.5	3694.0	3688.3	3685.0	3697.7	3686.8
(D) SSD Weight, gm	3702.4	3708.4	3705.1	3699.9	3709.6	3703.6
(E) Submerged Weight, gm	2083.6	2091.1	2089.7	2078.7	2094.5	2091.3
(F) Bulk Specific Gravity [A/(D - E)]	2.279	2.284	2.283	2.273	2.289	2.287
(G) Theoretical Maximum Gravity	2.438	2.438	2.438	2.438	2.438	2.438
(H) % Air Voids [100*(1-F/G)]	6.5	6.3	6.3	6.8	6.1	6.2
(I) Volume of Air Voids [H*(D - E)/100]	105.880	102.124	102.562	109.715	98.406	100.077
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3771.6	3772.8	3769.9	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	83.10	78.80	81.60			
(L) % Saturation [100*(K/I)]	78.5	77.2	79.6			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3725	3900	4025	4425	4625	4700
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	129.9	135.7	138.3
(R) Conditioned S_T, psi [2P/(A*B*□)]	108.9	114.6	118.1	N/A	N/A	N/A
(S) Average S_T, psi	113.9			134.7		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.85		

Project: WMA: St. Louis   Date: 6/12/2006

Tested By: G. Hurley   Calculated By: G. Hurley

Sample Identification: Evotherm™ ET Mixture, Sample #1 5/22/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	2	6		3	4	
(A) Diameter, in	5.926	5.922		5.936	5.919	
(B) Height, in	3.695	3.686		3.711	3.714	
(C) Weight in Air, gm	3679.8	3677.2		3678.3	3691.3	
(D) SSD Weight, gm	3697.8	3691.8		3704.8	3703.5	
(E) Submerged Weight, gm	2081.9	2073.7		2077.0	2085.0	
(F) Bulk Specific Gravity [A/(D - E)]	2.277	2.273		2.260	2.281	
(G) Theoretical Maximum Gravity	2.451	2.451		2.451	2.451	
(H) % Air Voids [100*(1-F/G)]	7.1	7.3		7.8	6.9	
(I) Volume of Air Voids [H*(D - E)/100]	114.554	117.814		127.066	112.462	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3771.0	3769.9		N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	91.20	92.70				
(L) % Saturation [100*(K/I)]	79.6	78.7				
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	4475	4600		4725	4925	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	136.6	142.6	
(R) Conditioned S_T, psi [2P/(A*B*□)]	130.1	134.2		N/A	N/A	N/A
(S) Average S_T, psi	132.1			139.6		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.95		

Project: WMA: St. Louis

Date: 7/27/2006

Tested By: L. McInnis

Calculated By: L. McInnis

Sample Identification: Evotherm Mixture, Sample #1 5/22/2006 Reheated Samples

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2	3	4	5	6
(A) Diameter, in	5.910	5.910	5.920	5.910	5.910	5.900
(B) Height, in	3.660	3.650	3.670	3.650	3.660	3.650
(C) Weight in Air, gm	3676.9	3676.2	3676.5	3675.8	3680.4	3677.6
(D) SSD Weight, gm	3696.6	3685.7	3693.5	3685.4	3696.9	3688.1
(E) Submerged Weight, gm	2082.1	2081.6	2074.4	2081.4	2077.1	2082.7
(F) Bulk Specific Gravity [A/(D - E)]	2.277	2.292	2.271	2.292	2.272	2.291
(G) Theoretical Maximum Gravity	2.451	2.451	2.451	2.451	2.451	2.451
(H) % Air Voids [100*(1-F/G)]	7.1	6.5	7.4	6.5	7.3	6.5
(I) Volume of Air Voids [H*(D - E)/100]	114.337	104.222	119.100	104.286	118.209	104.951
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3763.7	3750.1	3761.2	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	86.80	73.90	84.70			
(L) % Saturation [100*(K/I)]	75.9	70.9	71.1			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	4025	4500	4100	5300	4800	5525
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	156.4	141.3	163.3
(R) Conditioned S_T, psi [2P/(A*B*□)]	118.5	132.8	120.1	N/A	N/A	N/A
(S) Average S_T, psi	123.8			153.7		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.81		

Project: WMA: St. Louis   Date: 6/12/2006

Tested By: G. Hurley   Calculated By: G. Hurley

Sample Identification: Evotherm Mixture, Sample #2 5/22/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2		3	5	
(A) Diameter, in	5.936	5.919		5.931	5.945	
(B) Height, in	3.707	3.691		3.705	3.708	
(C) Weight in Air, gm	3730.6	3746.4		3745.5	3739.3	
(D) SSD Weight, gm	3748.8	3754.8		3762.9	3756.8	
(E) Submerged Weight, gm	2123.3	2130.3		2131.1	2130.6	
(F) Bulk Specific Gravity [A/(D - E)]	2.295	2.306		2.295	2.299	
(G) Theoretical Maximum Gravity	2.462	2.462		2.462	2.462	
(H) % Air Voids [100*(1-F/G)]	6.8	6.3		6.8	6.6	
(I) Volume of Air Voids [H*(D - E)/100]	110.228	102.810		110.476	107.394	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3815.0	3819.0		N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	84.40	72.60				
(L) % Saturation [100*(K/I)]	76.6	70.6				
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	4100	4300		4900	5000	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	142.0	144.4	
(R) Conditioned S_T, psi [2P/(A*B*□)]	118.6	125.3		N/A	N/A	N/A

(S) Average S_T, psi	122.0	143.2
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:		0.85

Project: WMA: St. Louis Date: 7/27/2006

Tested By: B. Burmester Calculated By: B. Burmester

Sample Identification: Evotherm Mixture, Sample #2 5/22/2006 Reheated Samples

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2	4	5	6	
(A) Diameter, in	5.920	5.937	5.934	5.916	5.932	
(B) Height, in	3.665	3.673	3.685	3.653	3.671	
(C) Weight in Air, gm	3718.9	3710.3	3720.6	3718.3	3718.6	
(D) SSD Weight, gm	3727.0	3722.2	3734.1	3725.7	3730.7	
(E) Submerged Weight, gm	2122.0	2098.9	2114.7	2120.0	2110.9	
(F) Bulk Specific Gravity [A/(D - E)]	2.317	2.286	2.298	2.316	2.296	
(G) Theoretical Maximum Gravity	2.462	2.462	2.462	2.462	2.462	
(H) % Air Voids [100*(1-F/G)]	5.9	7.2	6.7	5.9	6.8	
(I) Volume of Air Voids [H*(D - E)/100]	94.480	116.273	108.190	95.424	109.402	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3786.2	3796.0	3800.8	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	67.30	85.70	80.20			
(L) % Saturation [100*(K/I)]	71.2	73.7	74.1			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	4625	4250	4350	5400	5275	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	159.1	154.2	
(R) Conditioned S_T, psi [2P/(A*B*□)]	135.7	124.1	126.6	N/A	N/A	N/A

(S) Average S_T, psi	128.8	156.6
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:		0.82

Project: WMA: St. Louis　　Date: 6/15/2006

Tested By: G. Hurley　　Calculated By: G. Hurley

Sample Identification: Evotherm Mixture, Sample #1 5/23/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2	3	4	6	
(A) Diameter, in	5.921	5.937	5.920	5.927	5.939	
(B) Height, in	3.690	3.709	3.689	3.703	3.695	
(C) Weight in Air, gm	3710.6	3741.0	3739.4	3749.6	3734.4	
(D) SSD Weight, gm	3724.8	3758.2	3750.8	3764.4	3751.5	
(E) Submerged Weight, gm	2110.4	2130.2	2132.8	2135.3	2127.4	
(F) Bulk Specific Gravity [A/(D - E)]	2.298	2.298	2.311	2.302	2.299	
(G) Theoretical Maximum Gravity	2.473	2.473	2.473	2.473	2.473	
(H) % Air Voids [100*(1-F/G)]	7.1	7.1	6.5	6.9	7.0	
(I) Volume of Air Voids [H*(D - E)/100]	113.955	115.262	105.909	112.885	114.031	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3792.2	3823.1	3819.9	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	81.60	82.10	80.50			
(L) % Saturation [100*(K/I)]	71.6	71.2	76.0			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3450	3600	3550	5375	5250	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	155.9	152.3	
(R) Conditioned S_T, psi [2P/(A*B*□)]	100.5	104.1	103.5	N/A	N/A	N/A

(S) Average S_T, psi	102.7	154.1
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:		0.67

Project: WMA: St. Louis Date: 8/1/2006

Tested By: B. Burmester Calculated By: B. Burmester

Sample Identification: Evotherm Mixture, Sample #1 5/23/2006 Reheated Samples

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	2	4	3	5	6
(A) Diameter, in	5.931	5.936	5.919	5.951	5.912	5.923
(B) Height, in	3.648	3.656	3.652	3.652	3.648	3.639
(C) Weight in Air, gm	3697.9	3699.8	3692.2	3691.0	3693.5	3692.0
(D) SSD Weight, gm	3715.6	3709.6	3706.8	3710.6	3711.6	3707.0
(E) Submerged Weight, gm	2108.6	2112.9	2108.1	2101.5	2120.2	2108.3
(F) Bulk Specific Gravity [A/(D - E)]	2.301	2.317	2.310	2.294	2.321	2.309
(G) Theoretical Maximum Gravity	2.473	2.473	2.473	2.473	2.473	
(H) % Air Voids [100*(1-F/G)]	7.0	6.3	6.6	7.2	6.1	
(I) Volume of Air Voids [H*(D - E)/100]	111.691	100.622	105.696	116.581	97.870	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3780.2	3770.5	3768.0	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	82.30	70.70	75.80			
(L) % Saturation [100*(K/I)]	73.7	70.3	71.7			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3850	4200	4100	4700	5250	5050
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	137.7	155.0	149.2
(R) Conditioned S_T, psi [2P/(A*B*□)]	113.3	123.2	120.7	N/A	N/A	N/A

(S) Average S_T, psi	119.1	147.3
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:		0.81

Project: WMA: St. Louis Date: 6/7/2006

Tested By: G. Hurley Calculated By: G. Hurley

Sample Identification: Evotherm Mixture, Sample #2 5/23/2006

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	Trial 1		4	6	
(A) Diameter, in	5.913	5.911		5.912	5.921	
(B) Height, in	3.701	3.716		3.728	3.719	
(C) Weight in Air, gm	3697.3	3714.5		3702.4	3713.5	
(D) SSD Weight, gm	3724.0	3725.7		3718.1	3728.8	
(E) Submerged Weight, gm	2100.4	2101.4		2104.9	2112.2	
(F) Bulk Specific Gravity [A/(D - E)]	2.277	2.287		2.295	2.297	
(G) Theoretical Maximum Gravity	2.459	2.459		2.459	2.459	
(H) % Air Voids [100*(1-F/G)]	7.4	7.0		6.7	6.6	
(I) Volume of Air Voids [H*(D - E)/100]	120.021	113.727		107.547	106.433	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3794.3	3798.4		N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	97.00	83.90				
(L) % Saturation [100*(K/I)]	80.8	73.8				
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3025	3125		4000	4150	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	115.5	120.0	
(R) Conditioned S_T, psi	88.0	90.6		N/A	N/A	N/A

[2P/(A*B*□)]						
(S) Average S_T, psi	89.3			117.8		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				0.76		

Project: WMA: St. Louis

Date: 8/22/2006

Tested By: B. Burmester

Calculated By: B. Burmester

Sample Identification: Evotherm Mixture, Sample #2 5/23/2006 Reheated Samples

	Conditioned Samples			Unconditioned Samples		
Sample Number	2	4	5	1	2	3
(A) Diameter, in	5.934	5.935	5.930	5.930	5.930	5.930
(B) Height, in	3.637	3.642	3.634	3.630	3.630	3.630
(C) Weight in Air, gm	3612.8	3618.2	3610.9	3689.4	3695.1	3696.6
(D) SSD Weight, gm	3629.1	3646.5	3628.4	3720.8	3725.7	3730.7
(E) Submerged Weight, gm	2040.0	2045.0	2034.9	2100.0	2098.4	2108.6
(F) Bulk Specific Gravity [A/(D - E)]	2.273	2.259	2.266	2.276	2.271	2.279
(G) Theoretical Maximum Gravity	2.459	2.459	2.459	2.459	2.459	2.459
(H) % Air Voids [100*(1-F/G)]	7.5	8.1	7.8	7.4	7.7	7.3
(I) Volume of Air Voids [H*(D - E)/100]	119.885	130.089	125.058	120.434	124.616	118.806
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3702.9	3714.8	3702.4	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	90.10	96.60	91.50			
(L) % Saturation [100*(K/I)]	75.2	74.3	73.2			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	3425	3200	3300	5100	5200	5250
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	150.8	153.8	155.3
(R) Conditioned S_T, psi [2P/(A*B*□)]	101.0	94.2	97.5	N/A	N/A	N/A

(S) Average S_T, psi	97.6	153.3
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:		0.64

Project: WMA: St. Louis Date: 10/26/2006

Tested By: D. Ford Calculated By: D. Ford

Sample Identification: Aspha-min Mixture, Sample #1, Reheated Samples

	Conditioned Samples			Unconditioned Samples		
Sample Number	4	8		2	6	
(A) Diameter, in	5.918	5.919		5.923	5.918	
(B) Height, in	3.751	3.762		3.743	3.743	
(C) Weight in Air, gm	3759.8	3758.4		3765.0	3759.6	
(D) SSD Weight, gm	3774.5	3774.5		3777.4	3774.1	
(E) Submerged Weight, gm	2134.4	2138.3		2140.3	2138.4	
(F) Bulk Specific Gravity [A/(D - E)]	2.292	2.297		2.300	2.298	
(G) Theoretical Maximum Gravity	2.448	2.448		2.448	2.448	
(H) % Air Voids [100*(1-F/G)]	6.4	6.2		6.1	6.1	
(I) Volume of Air Voids [H*(D - E)/100]	104.234	100.906		99.110	99.916	
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3831.7	3829.4		N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	71.90	71.00				
(L) % Saturation [100*(K/I)]	69.0	70.4				
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	5550	5650		4575	5125	
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	131.4	147.3	
(R) Conditioned S_T, psi	159.2	161.5		N/A	N/A	N/A

[2P/(A*B*□)]						
(S) Average S_T, psi	160.3			139.3		
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:				1.15		

Project: WMA: St. Louis Date: 11/10/2006

Tested By: D. Ford Calculated By: D. Ford

Sample Identification: Aspha-min Mixture, Sample #2, Reheated Samples

	Conditioned Samples			Unconditioned Samples		
Sample Number	1	3	6	2	4	5
(A) Diameter, in	5.914	5.916	5.929	5.922	5.920	5.913
(B) Height, in	3.738	3.714	3.738	3.737	3.741	3.727
(C) Weight in Air, gm	3695.5	3696.9	3693.0	3694.6	3698.5	3695.2
(D) SSD Weight, gm	3724.4	3714.4	3715.4	3723.6	3720.8	3714.1
(E) Submerged Weight, gm	2106.1	2097.1	2085.0	2100.8	2095.2	2094.2
(F) Bulk Specific Gravity [A/(D - E)]	2.284	2.286	2.265	2.277	2.275	2.281
(G) Theoretical Maximum Gravity	2.440	2.440	2.440	2.440	2.440	2.440
(H) % Air Voids [100*(1-F/G)]	6.4	6.3	7.2	6.7	6.8	6.5
(I) Volume of Air Voids [H*(D - E)/100]	103.751	102.177	116.875	108.620	109.821	105.474
Initial Vacuum Saturation Conditioning						
(J) SSD Weight, gm	3774.9	3771.4	3783.3	N / A		
(K) Vol. Of Absorbed Water, cc [J - C]	79.40	74.50	90.30			
(L) % Saturation [100*(K/I)]	76.5	72.9	77.3			
Second Vacuum Saturation Conditioning (If required)						
(M) SSD Weight, gm				N / A		
(N) Vol. Of Absorbed Water, cc [M - C]						
(O) % Saturation [100*(N/I)]						
Tensile-Strength (S_T) Calculations						
(P) Failure Load, lbs	5725	6100	6000	4550	4700	4100
(Q) Dry S_T, psi [2P/(A*B*□)]	N/A	N/A	N/A	130.9	135.1	118.4
(R) Conditioned S_T, psi [2P/(A*B*□)]	164.9	176.7	172.3	N/A	N/A	N/A

(S) Average S_T, psi	171.3	128.1
Tensile-Strength Ratio [Avg Conditioned S_T / Avg Dry S_T]:		1.34

APPENDIX E – DYNAMIC MODULUS DATA

TABLE D1 Dynamic Modulus Data, Control After Reheating

			Sample 1						Sample 2								
Conditions			Specimen 1		Specimen 2		Specimen 3		Specimen 1		Specimen 2		Specimen 3		Average	Average	Average
Test Temp.	Test Temp.	Frequency	Modulus	Phase Angle	Modulus	Phase Angle	Modulus	Phase Angle	Modulus	Phase Angle	Modulus	Phase Angle	Modulus	Phase Angle	Modulus	Modulus	Modulus
°C	°K	Hz	MPa	Degrees	MPa	Degrees	MPa	Degrees	MPa	Degrees	MPa	Degrees	MPa	Degrees	MPa	psi	ksi
4.4	277.4	0.5	10337	13.2	11485	14.46	9968	15.28	10860	11.65	11583	13.22	10372	12.62	10768	1561718	1562
		1	11340	12.0	12728	13.16	11072	13.89	11789	10.67	12713	12.03	11309	11.67	11825	1715122	1715
		2	12345	11.0	13930	11.99	12184	12.63	12701	9.79	13867	10.61	12264	10.54	12882	1868381	1868
		5	13666	9.8	15507	10.65	13655	11.13	13891	8.77	15325	9.77	13551	9.51	14266	2069116	2069
		10	14641	9.0	16703	9.7	14752	10.16	14771	8.05	16394	8.92	14416	8.9	15280	2216139	2216
		20	15587	8.2	17903	8.83	15847	9.27	15622	7.44	17562	7.95	15219	8.18	16290	2362702	2363
		25	15899	8.0	18317	8.57	16187	9.1	15850	7.18	17853	7.4	15571	7.93	16613	2409525	2410
21.1	294.1	0.5	3575	26.39	4183	26.46	3271	28.83	3764	24.74	4322	25.64	3949	24.54	3844	557534	558
		1	4279	24.81	5027	24.99	4023	27.06	4471	23.25	5127	24.05	4659	22.92	4598	666846	667
		2	5062	23.07	5956	23.35	4832	25.24	5223	21.72	5986	22.4	5429	21.22	5415	785343	785
		5	6193	20.82	7334	21.1	6050	22.73	6322	19.65	7267	20.17	6552	19.22	6620	960116	960
		10	7131	19.19	8481	19.37	7064	20.87	7204	18.11	8338	18.5	7497	17.67	7619	1105084	1105
		20	8147	17.53	9640	17.65	8155	18.99	8144	16.58	9523	16.86	8458	15.87	8678	1258633	1259
		25	8500	17.01	10032	17.14	8494	18.47	8420	16.1	9908	16.4	8806	15.52	9027	1309228	1309
37.8	310.8	0.5	821.9	33.9	924.9	34.34	643.6	35.32	870.8	34.05	1073	33.25	913.6	34.44	875	126857	127
		1	1072	34.28	1236	34.68	867.2	36.11	1141	33.72	1380	33.4	1180	34.35	1146	166221	166
		2	1427	33.43	1679	33.81	1215	35.21	1509	32.54	1793	32.64	1547	33.27	1528	221669	222
		5	1989	32.29	2384	32.59	1791	34.12	2084	31.09	2461	31.4	2124	31.74	2139	310216	310
		10	2517	31.03	3042	31.32	2347	32.94	2610	29.87	3077	30.21	2638	30.39	2705	392357	392
		20	3117	29.62	3816	29.84	3016	31.38	3208	28.39	3814	28.67	3239	28.8	3368	488543	489
		25	3303	29.41	4087	29.79	3217	31.21	3372	28.18	4023	28.46	3410	28.45	3569	517599	518

TABLE D2 Dynamic Modulus Data, Evotherm 5/22/2006 After Reheating

			Sample 1						Sample 2								
Conditions			Specimen 1		Specimen 2		Specimen 3		Specimen 1		Specimen 2		Specimen 3		Average	Average	Average
Test Temp. °C	Test Temp. °K	Frequency Hz	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Modulus psi	Modulus ksi
4.4	277.4	0.5	10218	12.9	11161	13.59	9440	14.27	10957	12.75	11583	13.22	9026	14.64	10398	1508053	1508
		1	11162	11.77	12302	12.36	10454	12.94	11984	11.54	12713	12.03	10000	13.32	11436	1658653	1659
		2	12105	10.76	13465	11.26	11465	11.78	12999	10.5	13867	10.61	10990	12.15	12482	1810365	1810
		5	13342	9.56	14960	10	12782	10.44	14305	9.29	15325	9.77	12293	10.76	13835	2006556	2007
		10	14256	8.75	16036	9.3	13770	9.55	15266	8.48	16394	8.92	13261	9.83	14831	2151016	2151
		20	15155	8.07	17214	8.37	14739	8.72	16208	7.72	17562	7.95	14204	8.96	15847	2298449	2298
		25	15457	7.81	17652	8.12	15034	8.46	16519	7.49	17853	7.4	14494	8.68	16168	2345031	2345
21.1	294.1	0.5	3525	25.75	3815	26.96	3250	27.82	3480	27.8	4322	25.64	3219	27.92	3602	522410	522
		1	4233	24.3	4599	25.2	3948	26.05	4201	25.96	5127	24.05	3874	26.1	4330	628072	628
		2	5001	22.79	5480	23.48	4709	24.23	5009	24.12	5986	22.4	4612	24.25	5133	744466	744
		5	6111	20.67	6774	21.15	5836	21.75	6181	21.57	7267	20.17	5695	21.7	6311	915299	915
		10	7018	19.06	7852	19.44	6742	19.91	7103	19.72	8338	18.5	6589	19.84	7274	1054973	1055
		20	7969	17.47	8979	17.73	7707	18.11	8105	17.96	9523	16.86	7527	18.05	8302	1204074	1204
		25	8263	17.02	9390	17.27	8008	17.57	8482	17.81	9908	16.4	7854	17.48	8651	1254717	1255
37.8	310.8	0.5	777.8	33.81	883	35.36	683.7	36.13	743.7	36.49	1073	33.25	643.8	37	801	116153	116
		1	1040	33.78	1168	35.3	918.3	36.41	986.4	36.89	1380	33.4	857	37.31	1058	153493	153
		2	1423	32.48	1573	34.16	1249	35.57	1339	35.82	1793	32.64	1170	36.4	1425	206609	207
		5	2025	31.15	2227	32.63	1801	34.13	1923	34.33	2461	31.4	1696	34.92	2022	293295	293
		10	2584	29.92	2829	31.17	2306	32.71	2473	32.92	3077	30.21	2189	33.55	2576	373671	374
		20	3227	28.47	3554	29.48	2906	30.99	3130	31.21	3814	28.67	2763	31.76	3232	468818	469
		25	3458	28.3	3790	29.35	3113	30.58	3341	30.94	4023	28.46	3001	31.97	3454	501017	501

TABLE D3 Dynamic Modulus Data, Evotherm 5/23/2006 After Reheating

			Sample 1						Sample 2								
Conditions			Specimen 1		Specimen 2		Specimen 3		Specimen 1		Specimen 2		Specimen 3		Average	Average	Average
Test Temp. °C	Test Temp. °K	Frequency Hz	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Modulus psi	Modulus ksi
4.4	277.4	0.5	11709	14.14	10208	13.84	12212	12.95	11053	13.94	10166	13.16	11118	13.85	11078	1606705	1607
		1	12888	12.54	11231	12.56	13361	11.78	12164	12.65	11146	12.18	12249	12.58	12173	1765596	1766
		2	14074	11.35	12255	11.4	14503	10.7	13276	11.53	12156	11	13363	11.45	13271	1924850	1925
		5	15619	10	13608	10.07	15966	9.51	14725	10.15	13208	10.59	14821	10.14	14658	2125972	2126
		10	16769	9.09	14606	9.16	17063	8.68	15788	9.27	14249	8.92	15903	9.25	15730	2281431	2281
		20	17927	8.25	15572	8.28	18140	7.85	16835	8.43	15124	8.13	16969	8.41	16761	2431040	2431
		25	18294	7.99	15878	7.94	18530	7.6	17138	8.15	15367	7.83	17438	7.97	17108	2481272	2481
21.1	294.1	0.5	4051	27.54	3396	28.31	4206	26.53	3496	28.03	3267	27.79	3843	27.45	3710	538074	538
		1	4900	25.85	4097	26.53	5031	24.87	4258	26.34	3987	26.03	4648	25.76	4487	650770	651
		2	5835	24.09	4876	24.76	5938	23.17	5096	24.7	4745	24.26	5504	24.06	5332	773402	773
		5	7194	21.69	6058	22.31	7246	20.88	6287	22.45	5872	21.81	6785	21.62	6574	953445	953
		10	8297	19.91	6977	20.43	8332	19.21	7265	20.82	6791	19.97	7815	19.82	7580	1099331	1099
		20	9469	18.05	7993	18.52	9477	17.44	8336	19.22	7772	18.19	8938	18.02	8664	1256651	1257
		25	9847	17.56	8328	17.88	9827	16.91	8678	18.92	8105	17.98	9287	17.52	9012	1307100	1307
37.8	310.8	0.5	792.3	35.39	661.3	35.79	840.9	34.49	747	34.46	662.9	35.66	730.8	35.32	739	107214	107
		1	1069	35.72	881.7	36.18	1128	34.81	1007	34.93	888.3	36.06	989.6	35.7	994	144160	144
		2	1477	34.76	1219	35.42	1550	33.95	1388	34.26	1230	35.01	1375	34.71	1373	199164	199
		5	2150	33.54	1765	34.37	2223	32.94	2016	33.16	1786	33.72	2009	33.44	1992	288847	289
		10	2795	32.32	2284	33.24	2855	31.78	2604	32.01	2309	32.48	2606	32.19	2576	373551	374
		20	3562	30.8	2906	31.72	3597	30.38	3286	30.58	2928	30.87	3311	30.63	3265	473556	474
		25	3783	30.7	3128	31.79	3792	30.42	3504	30.54	3112	30.61	3528	30.56	3475	503941	504

TABLE D4 Dynamic Modulus Data, Sasobit 5/18/2006 After Reheating

			Sample 1						Sample 2								
Conditions			Specimen 1		Specimen 2		Specimen 3		Specimen 1		Specimen 2		Specimen 3		Average	Average	Average
Test Temp. °C	Test Temp. °K	Frequency Hz	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Modulus psi	Modulus ksi
4.4	277.4	0.5	10670	12.07	11411	12.27	11461	11.91	11742	12.46	10319	11.88	10445	12.87	11008	1596600	1597
		1	11626	11.05	12475	11.27	12471	10.92	12829	11.37	11227	10.91	11423	11.78	12009	1741713	1742
		2	12580	10.16	13538	10.36	13482	10.09	13892	10.46	12127	10.04	12401	10.78	13003	1886003	1886
		5	13796	9.11	14865	9.21	14803	9.09	15199	9.41	13282	9.04	13688	9.6	14272	2070035	2070
		10	14697	8.36	15928	8.23	15795	8.39	16036	8.64	14143	8.36	14650	8.82	15208	2205792	2206
		20	15567	7.69	16904	8.07	16758	7.68	16859	7.89	14976	7.67	15601	8.07	16111	2336715	2337
		25	15844	7.46	17293	7.79	17089	7.45	17035	7.62	15207	7.43	15894	7.85	16394	2377737	2378
21.1	294.1	0.5	3853	24.71	4065	25.4	4178	24.06	4095	25.13	3753	24.34	3715	25.76	3943	571917	572
		1	4564	23.02	4839	23.7	4939	22.5	4879	23.48	4454	22.7	4427	24.1	4684	679319	679
		2	5329	21.4	5676	22.04	5751	20.96	5728	21.83	5223	21.12	5219	22.45	5488	795931	796
		5	6420	19.25	6902	19.8	6949	18.9	6950	19.63	6323	19.05	6382	20.25	6654	965145	965
		10	7323	17.63	7923	18.22	7931	17.44	7958	18.04	7204	17.56	7335	18.6	7612	1104093	1104
		20	8274	16.08	9004	16.67	8967	15.98	8993	16.44	8132	16.09	8327	16.93	8616	1249689	1250
		25	8588	15.6	9381	16.21	9318	15.57	9317	15.96	8434	15.63	8635	16.44	8946	1297455	1297
37.8	310.8	0.5	1018	33.9	980.5	34.97	1120	33.06	928.2	33.77	1027	32.87	831.9	34.38	984	142758	143
		1	1324	33.44	1262	34.84	1442	32.8	1206	33.91	1325	32.55	1095	34.5	1276	185023	185
		2	1728	32.23	1638	33.85	1868	31.8	1592	32.99	1731	31.27	1474	33.42	1672	242483	242
		5	2359	30.52	2258	32.13	2536	30.19	2212	31.48	2354	29.54	2073	32.03	2299	333399	333
		10	2923	29	2837	30.61	3137	28.78	2787	30.11	2905	28.13	2626	30.66	2869	416144	416
		20	3580	27.33	3506	28.85	3853	27.03	3458	28.48	3548	26.41	3251	28.99	3533	512378	512
		25	3789	26.98	3772	28.45	4069	26.65	3686	28.3	3738	26.06	3443	28.72	3750	543827	544

TABLE D5 Dynamic Modulus Data, Sasobit 5/19/2006 After Reheating

			Sample 1						Sample 2						
Conditions			Specimen 1		Specimen 2		Specimen 3		Specimen 1		Specimen 3		Average	Average	Average
Test Temp. °C	Test Temp. °K	Frequency Hz	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Phase Angle Degrees	Modulus MPa	Modulus psi	Modulus ksi
4.4	277.4	0.5	10781	12.87	13200	12.43	10754	12.69	10214	12.55	10790	12.96	11148	1616877	1617
		1	11808	11.93	14408	11.38	11775	11.56	11168	11.4	11810	11.82	12194	1768589	1769
		2	12756	10.77	15616	10.38	12767	10.67	12092	10.43	12832	10.81	13213	1916356	1916
		5	14094	9.67	17200	9.24	14050	9.52	13325	9.21	14166	9.65	14567	2112798	2113
		10	15103	8.86	18421	8.41	15000	8.73	14229	8.47	15166	8.82	15584	2260274	2260
		20	16097	8.16	19612	7.64	15948	7.99	15085	7.75	16151	8.09	16579	2404560	2405
		25	16411	7.99	20033	7.43	16213	7.79	15356	7.45	16473	7.82	16897	2450770	2451
21.1	294.1	0.5	3964	24.91	4809	24.71	3815	25.59	3545	25.42	3644	26.6	3955	573691	574
		1	4684	23.28	5682	23.2	4538	24	4234	23.86	4386	24.88	4705	682384	682
		2	5478	21.69	6626	21.73	5303	22.42	4977	22.26	5168	23.17	5510	799228	799
		5	6676	19.64	8022	19.68	6441	20.25	6053	20.16	6318	20.83	6702	972058	972
		10	7655	18.13	9182	18.16	7385	18.62	6929	18.56	7273	19.11	7685	1114603	1115
		20	8675	16.61	10425	16.61	8398	16.97	7863	17.01	8309	17.44	8734	1266779	1267
		25	9044	16.25	10850	16.19	8715	16.49	8144	16.52	8642	16.95	9079	1316818	1317
37.8	310.8	0.5	1011	33.78	1201	32.42	855.3	34.29	781.6	34.6	807.9	34.78	931	135084	135
		1	1319	33.58	1569	32.28	1134	34.23	1039	34.54	1064	35.05	1225	177674	178
		2	1744	32.42	2067	31.34	1523	33.14	1413	33.21	1438	34.03	1637	237430	237
		5	2415	31.26	2851	30.07	2136	31.79	2004	31.61	2037	32.61	2289	331939	332
		10	2983	29.47	3564	28.67	2681	30.46	2547	30.21	2599	31.23	2875	416961	417
		20	3679	27.8	4413	27.57	3304	28.83	3165	28.62	3232	29.56	3559	516139	516
		25	3864	27.52	4607	27.14	3492	28.7	3330	28.46	3432	29.32	3745	543175	543

TABLE D6 Dynamic Modulus Data, Aspha-min After Reheating

Conditions		Specimen 1		Average	Average	Average
Test Temp. °C	Frequency Hz	Modulus MPa	Phase Angle Degrees	Modulus MPa	Modulus psi	Modulus ksi
4.4	0.5	10032	13.65	10032	1455041	1455
4.4	1	11041	12.43	11041	1601387	1601
4.4	2	12034	11.33	12034	1745411	1745
4.4	5	13360	10.03	13360	1937734	1938
4.4	10	14354	9.17	14354	2081904	2082
4.4	20	15330	8.36	15330	2223463	2223
4.4	25	15647	8.11	15647	2269441	2269
21.1	0.5	3202	27.8	3202	464418	464
21.1	1	3910	25.96	3910	567106	567
21.1	2	4680	24.39	4680	678787	679
21.1	5	5808	21.97	5808	842392	842
21.1	10	6748	20.22	6748	978730	979
21.1	20	7750	18.45	7750	1124060	1124
21.1	25	8058	17.98	8058	1168732	1169
37.8	0.5	559.8	36.19	559.8	81193	81
37.8	1	750.5	36.83	750.5	108853	109
37.8	2	1056	35.75	1056	153162	153
37.8	5	1560	34.6	1560	226262	226
37.8	10	2051	33.39	2051	297477	297
37.8	20	2661	31.91	2661	385951	386
37.8	25	2862	31.74	2862	415104	415