Hnywll-RU3086

Laboratory Evaluation of Honeywell Polymer vs SBS Polymer Modified Asphalt Mixtures

- Final Report -

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Conducted by:

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Disclaimer Statement

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16. Abstract

The scope of the study is to evaluate the laboratory performance of two asphalt mixtures; one modified with SBS polymer and the second modified with a polymer from Honeywell. Both asphalt binder and mixture properties are proposed to be evaluated in the study. Laboratory asphalt mixture tests are proposed to evaluate the overall performance of the asphalt mixtures developed using the two asphalt binders modified with the Honeywell polymer and the SBS polymer.

17. Key Words SBS Polymer Comparison, Honeywell, Laboratory Testing, Hot Mix Asphalt		18. Distribution Statement	
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Scope of Work

The scope of the project encompassed evaluating the asphalt binder and mixture performance of two PG76-22 asphalt binders modified with different polymers; 1) Styrene-Butadiene-Styrene (SBS) with Polyphosphoric Acid (PPA) and 2) Honeywell Polyethylene (PE) blended with SBS polymer. The target performance grade (PG) of the asphalt binders was a PG76-22. The asphalt binder test results provided by NuStar Asphalt can be found in Appendix A.

Asphalt binder data for these binders were provided to Rutgers University from NuStar Asphalt for the Lots supplied to Tilcon. The asphalt binders were used to produce a 12.5mm Stone Mastic Asphalt (SMA), designated by the New Jersey Department of Transportation (NJDOT) as a 12.5SMA76. Loose mix produced from a drum plant at Tilcon's Keasby facility was sampled from the delivery trucks prior to leaving the asphalt plant, placed and sealed in 5 gallon metal buckets. The Quality Control data forms from production can be found in Appendix B.

Laboratory testing consisted of mixture testing that focused on the stiffness, rutting, fatigue, and moisture damage resistance performance. The asphalt mixture testing consisted of:

- Dynamic Modulus (AASHTO TP79);
    - Short-term and long-term aged conditions
- Rutting Evaluation
    - Asphalt Pavement Analyzer (AASHTO T340)
    - Asphalt Mixture Performance Tester (AASHTO TP79)
- Fatigue Cracking Evaluation
    - Flexural Beam Fatigue (AASHTO T321)
        - Short-term and long-term aged conditions
    - Overlay Tester (NJDOT B-10)
        - Short-term and long-term aged conditions
- Moisture Susceptibility (AASHTO T283)

It should be noted that although the figures and tables noted as Honeywell PE Modified used a blend of Honeywell PE and SBS polymers. The figures and tables noted as SBS Modified used a blend of SBS polymer and polyphosphoric acid (PPA).

Volumetrics Stiffness and Composition

During production, loose mix was sampled from the back of the delivery trucks, prior to leaving the plant, to conduct Quality Control testing. Volumetrics and composition were determined for both the SBS and Honeywell polymer-modified PG76-22 asphalt binder SMA mixtures. A summary of the test results are shown in Table 1. The results indicate that the SBS modified mixture resulted in a slightly higher total and effective asphalt content when compared to the Honeywell mixture. Meanwhile, the aggregate gradation and Voids in Mineral Aggregate (VMA) of the mixtures were quite similar.

Table 1 - Summary of Volumetrics and Composition for SMA Mixtures

Property	**% Passing**	
Sieve Size	Honeywell Modified	SBS Modified
3/4" (19 mm)	100	100
1/2" (12.5 mm)	90.1	91.4
3/8" (9.5 mm)	74.4	73.1
No. 4 (4.75 mm)	31.3	28.5
No. 8 (2.36 mm)	19.9	20.1
No. 16 (1.18 mm)	16.2	16.5
No. 30 (0.600 mm)	14.0	14.3
No. 50 (0.425 mm)	12.2	12.4
No. 100 (0.15 mm)	10.3	10.2
No. 200 (0.075 mm)	7.9	8.1
Gmm (g/cm^3)	2.448	2.450
AV% @ N_{design}	4.0	3.4
Asphalt Content (%)	6.15	6.36
Effective AC (%)	5.87	6.08
VMA (%)	17.4	17.4

Asphalt Mixture Testing

The asphalt mixture produced by Tilcon consisted of a 12.5mm SMA mixture containing a PG76-22 asphalt binder. The 12.5SMA76 was placed as a surface course on U.S. Rt 1. During production, the asphalt mixtures were sampled and placed in 5-gallon metal containers. The containers were delivered to the Rutgers Asphalt Pavement Laboratory, where the sample containers were stored until sample fabrication and testing.

Prior to testing, the asphalt mixtures were reheated to compaction temperature and then compacted into the respective performance test specimens. For this study, test specimens were compacted to air void levels ranging between 6 and 7%, except for moisture damage susceptibility testing (AASHTO T283) where the samples were prepared to air voids ranging between 6.5 and 7.5%.

All mixtures reheated to compaction temperature and then immediately compacted into test specimens were considered to be Short-Term Aged (STOA). Long-Term Aging (LTOA) of the mixtures was conducted using the protocols specified in AASHTO R30, *Mixture Conditioning of Hot Mix Asphalt (HMA)*.

Dynamic Modulus (AASHTO TP79)

Dynamic modulus and phase angle data were measured and collected in uniaxial compression using the Simple Performance Tester (SPT) following the method outlined in AASHTO TP79, *Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT)* (Figure 1). The data was collected at three temperatures; 4, 20, and 45°C using loading frequencies of 25, 10, 5, 1, 0.5, 0.1, and 0.01 Hz. Test specimens were evaluated under short-term aged conditions. Since the mixtures evaluated in the study were plant produced, it was assumed that these materials already represented short-term aged conditions.

Figure 1 - Photo of the Asphalt Mixture Performance Tester (AMPT)

The collected modulus values of the varying temperatures and loading frequencies were used to develop Dynamic Modulus master stiffness curves and temperature shift factors using numerical optimization of Equations 1 and 2. The reference temperature used for the generation of the master curves and the shift factors was 20°C.

$$\log|E^*| = \delta + \frac{(Max - \delta)}{1 + e^{\beta + \gamma\left\{\log\omega + \frac{\Delta E_a}{19.14714}\left[\left(\frac{1}{T}\right) - \left(\frac{1}{T_r}\right)\right]\right\}}} \quad (1)$$

where:

$|E^*|$ = dynamic modulus, psi

ω_r = reduced frequency, Hz

Max = limiting maximum modulus, psi

δ, β, and γ = fitting parameters

$$\log[a(T)] = \frac{\Delta E_a}{19.14714}\left(\frac{1}{T} - \frac{1}{T_r}\right) \quad (2)$$

where:

a(T) = shift factor at temperature T
T_r = reference temperature, °K
T = test temperature, °K
ΔE_a = activation energy (treated as a fitting parameter)

Figure 2 shows the master stiffness curves for the short-term aged mixtures. The test results show that both mixtures have very similar stiffness properties at the short-term aged condition.

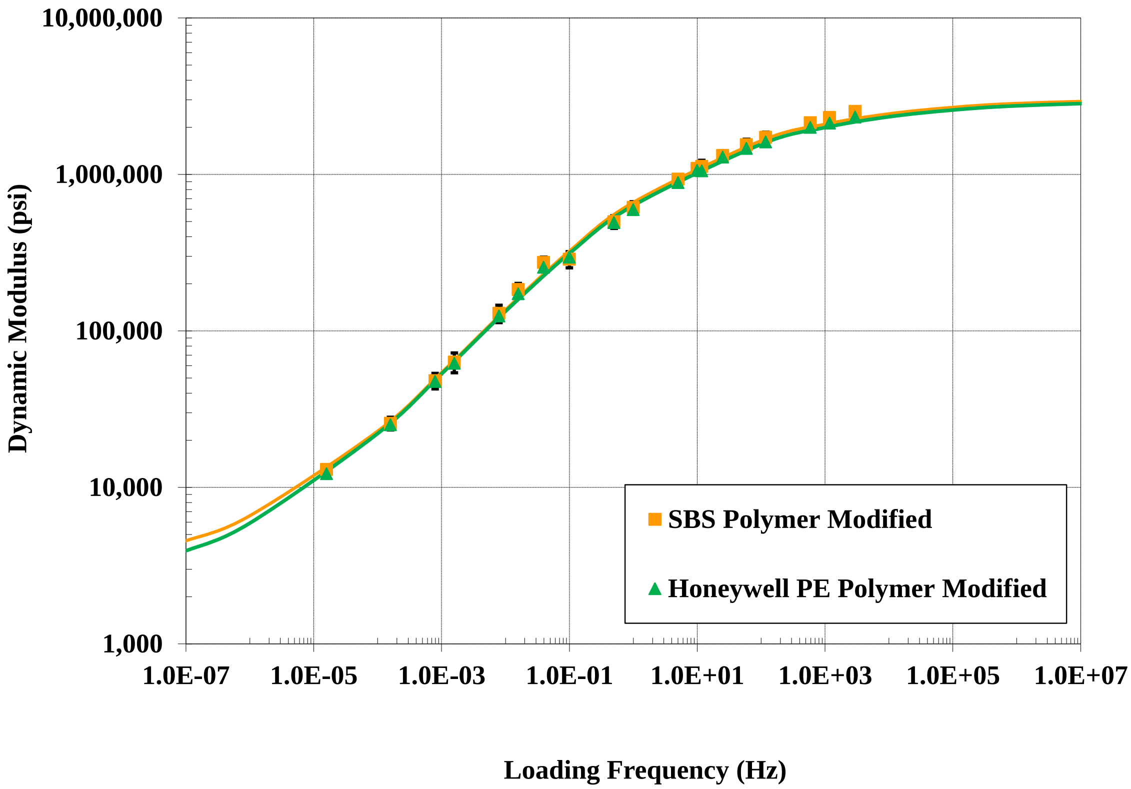

Figure 2 - Dynamic Modulus (E*) Master Stiffness Curves for Short-Term Aged (STOA) Conditions for Honeywell PE and SBS Polymer Modified PG76-22

Figures 3 through 5 show the resultant stiffness characteristics of the mixtures after LTOA conditioning. In Figures 3 and 4, both mixtures clearly stiffen as the mixture goes from the STOA condition to the LTOA condition with the magnitude of stiffening less for the SBS modified mixture. Meanwhile, Figure 5 contains both the SBS and Honeywell polymer-modified mixtures after LTOA conditioning. Comparing Figures 3 through 5, it is clear that the Honeywell modified mixture resulted in a higher level of age hardening than the SBS modified mixture.

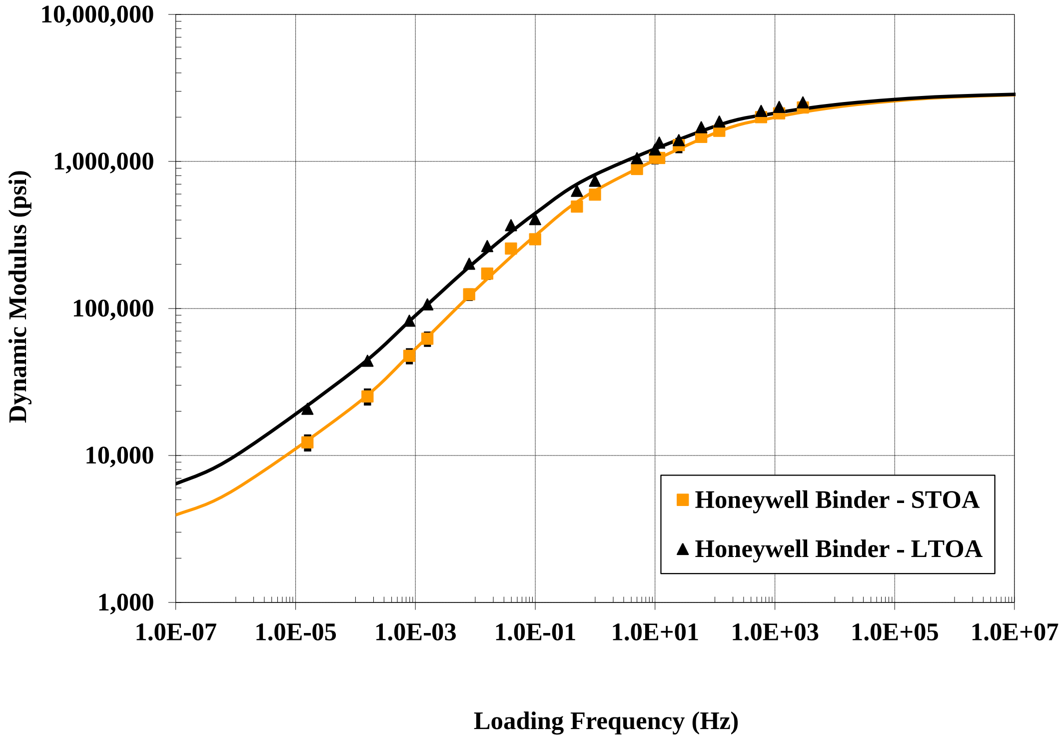

Figure 3 - Dynamic Modulus (E*) Master Stiffness Curves for STOA and LTOA Conditions – Honeywell Modified

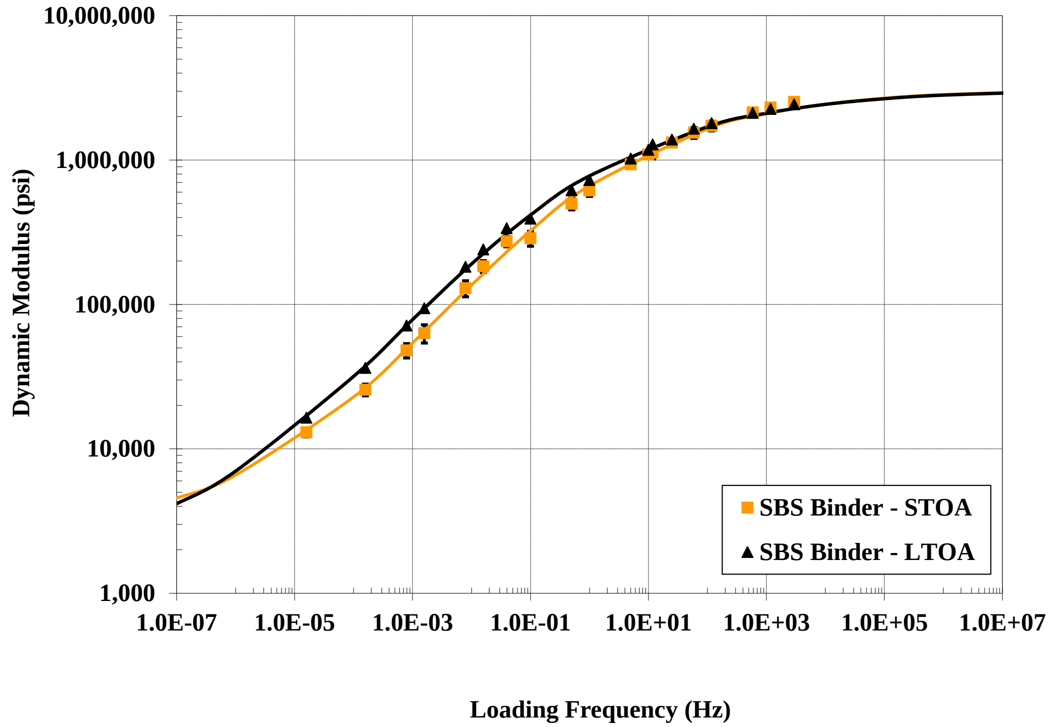

Figure 4 - Dynamic Modulus (E*) Master Stiffness Curves for STOA and LTOA Conditions – SBS Modified

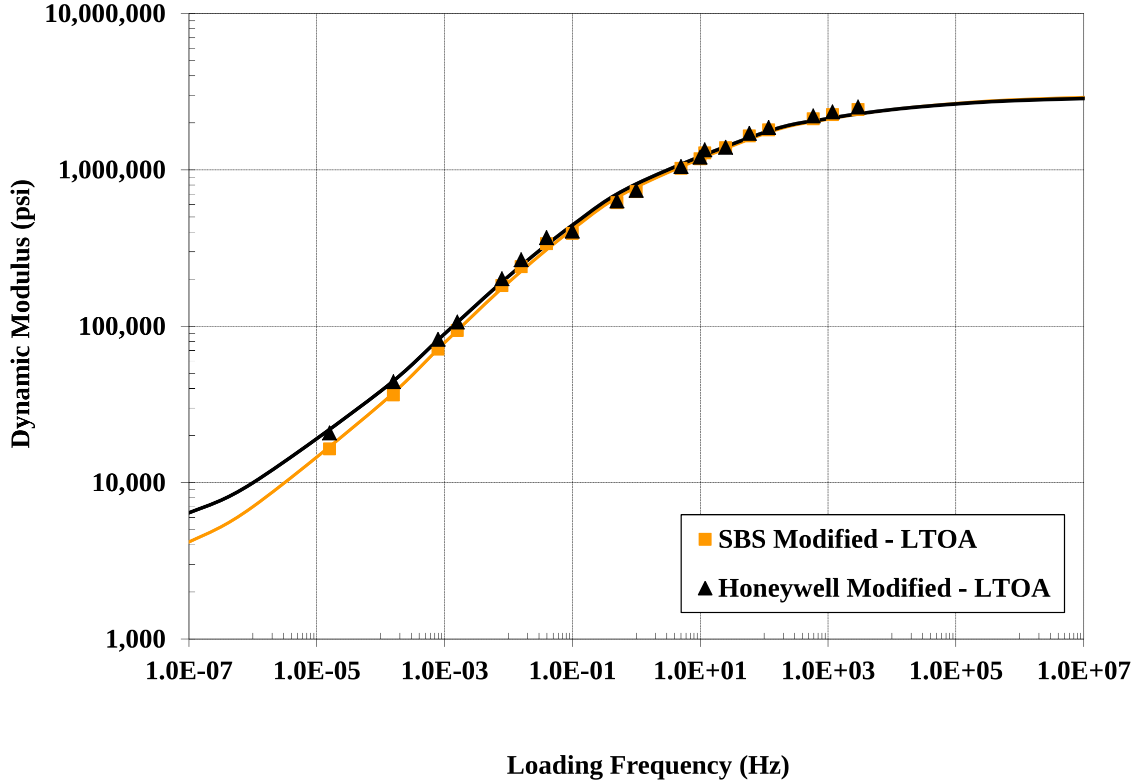

Figure 5 - Dynamic Modulus (E*) Master Stiffness Curves for LTOA Condition – SBS Modified and Honeywell Modified Mixtures

Rutting Evaluation

The rutting potential of the asphalt mixtures were evaluated in the study using two test procedures; 1) The Asphalt Pavement Analyzer (AASHTO T340) and 2) The Repeated Load – Flow Number (AASHTO TP79).

<u>Asphalt Pavement Analyzer (APA)</u>

Compacted asphalt mixtures were tested for their respective rutting potential using the Asphalt Pavement Analyzer (APA) in accordance with AASHTO T340, *Determining Rutting Susceptibility of Asphalt Paving Mixtures Using the Asphalt Pavement Analyzer (APA).* Prior to testing, the samples were conditioned for a minimum of 4 hours at the test temperature of 64°C. The samples are tested for a total of 8,000 cycles using a hose pressure of 100 psi and wheel load of 100 lbs.

The APA rutting results for the Honeywell PE and SBS modified SMA is shown in Figure 6. The results indicate that the SBS modified HMA had a slightly lower rutting potential when compared to the Honeywell PE asphalt binder.

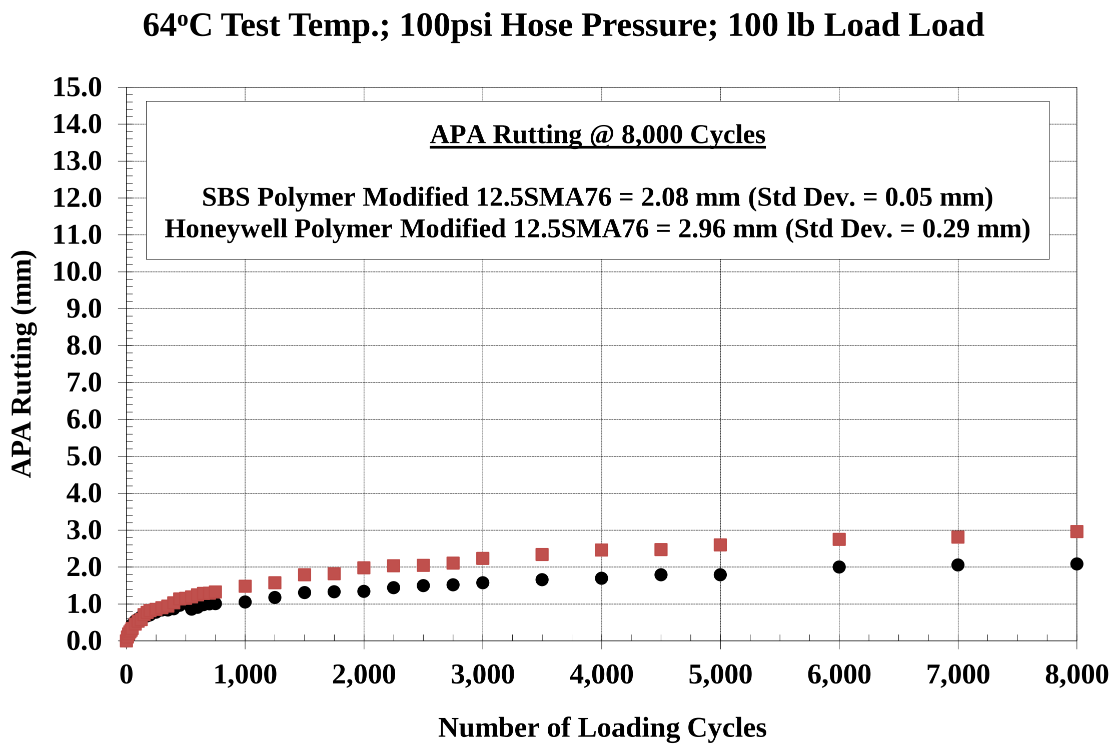

Figure 6 - Asphalt Pavement Analyzer (APA) Rutting Results)

Repeated Load – Flow Number Test

Repeated Load permanent deformation testing was measured and collected in uniaxial compression using the Simple Performance Tester (SPT) following the method outlined in AASHTO TP79, *Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT)*. The unconfined repeated load tests were conducted with a deviatoric stress of 600 kPa and a test temperature of 54.4°C, which corresponds to New Jersey's average 50% reliability high pavement temperature at a depth of 25 mm according the LTPPBind 3.1 software. These testing parameters (temperature and applied stress) conform to the recommendations currently proposed in NCHRP Project 9-33, *A Mix Design Manual for Hot Mix Asphalt*. Testing was conducted until a permanent vertical strain of 5% or 10,000 cycles was obtained.

The test results for the Honeywell PE and SBS modified SMA is shown in Table 2. The Flow Number results indicate that on average the SBS polymer modified SMA resulted in a better resistance to permanent deformation than the Honeywell PE polymer modified SMA. This is consistent with the APA results shown earlier. When evaluating the data using the Student t-test, it was found that the permanent deformation results were statistically Not Equal at a 95% confidence level.

Table 2- Repeated Load – Flow Number Test Results

Mix Type	Sample ID	Flow Number (cycles)	Cycle to Achieve 5% Strain
Honeywell Polymer Modified	1	322	761
	2	428	1,029
	3	403	903
	Average	***384***	***898***
	Std Dev	***55***	***134***
	COV %	***14***	***15***
SBS Polymer Modified	1	679	1,891
	2	482	1,400
	3	657	1,924
	Average	***606***	***1,738***
	Std Dev	***108***	***293***
	COV %	***18***	***17***

Fatigue Cracking Evaluation

The fatigue cracking properties of the mixtures were evaluated using two test procedures; 1) the Overlay Tester (NJDOT B-10) and 2) Flexural Beam Fatigue (AASHTO T321).

<u>Overlay Tester (NJDOT B-10)</u>

The Overlay Tester, described by Zhou and Scullion (2007), has shown to provide an excellent correlation to field cracking for both composite pavements (Zhou and Scullion, 2007; Bennert et al., 2009) as well as flexible pavements (Zhou et al., 2007). Figure 7 shows a picture of the Overlay Tester used in this study. Sample preparation and test parameters used in this study followed that of NJDOT B-10, *Overlay Test for Determining Crack Resistance of HMA*. These included:

- 25°C (77°F) test temperature;
- Opening width of 0.025 inches;
- Cycle time of 10 seconds (5 seconds loading, 5 seconds unloading); and
- Specimen failure defined as 93% reduction in Initial Load.

Test specimens were evaluated under both short-term and long-term aged conditions.

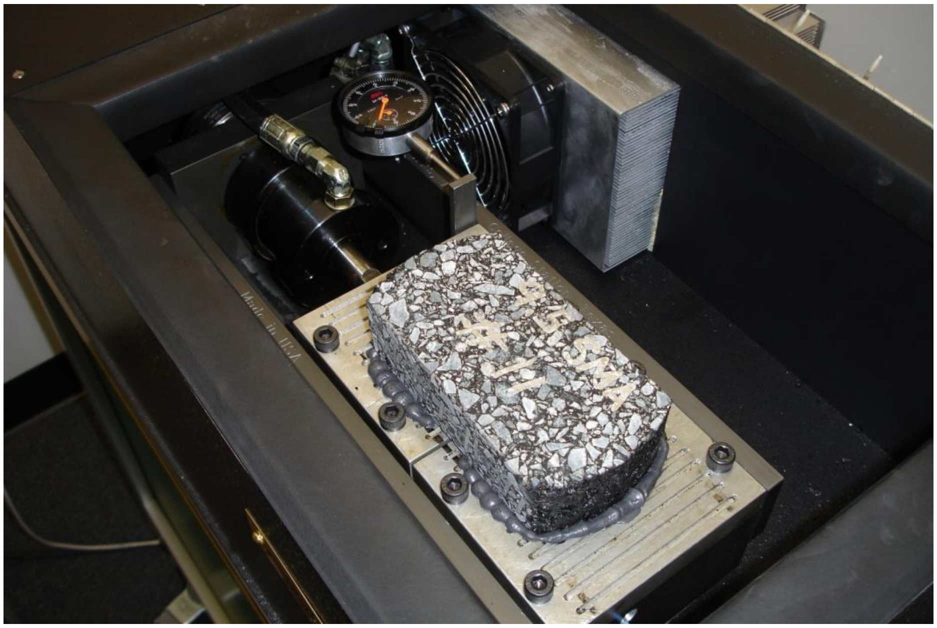

Figure 7 - Picture of the Overlay Tester (Chamber Door Open)

Figure 8 indicates that on average the Honeywell PE modified SMA has a slightly better resistance to crack propagation fatigue cracking than the SBS modified SMA when evaluated in the Overlay Tester at both the short-term and long-term aged conditions. However, when using the Student t-Test to determine if the test results were statistically equal, it was determined that the Overlay Tester performance of the two modified binders was statistically EQUAL at a 95% confidence interval at each respective aged condition. The results in Figure 8 also indicate that a reduction in fatigue crack propagation can be expected as both mixtures age.

Flexural Beam Fatigue (AASHTO T321)

Fatigue testing was conducted using the Flexural Beam Fatigue test procedure outline in AASHTO T321, *Determining the Fatigue Life of Compacted Hot-Mix Asphalt (HMA) Subjected to Repeated Flexural Bending*. The applied tensile strain levels used for the fatigue evaluation were; 300, 450, 600, 750 and 900 micro-strains. Samples were tested at short-term and long-term aged conditions as mentioned earlier.

Samples used for the Flexural Beam Fatigue test were compacted using a vibratory compactor designed to compact brick samples of 400 mm in length, 150 mm in width, and 100 mm in height. After the compaction and aging was complete, the samples were trimmed to within the recommended dimensions and tolerances specified under AASHTO T321. The test conditions utilized were those recommended by AASHTO T321 and were as follows:

- Test temperature = 15^{o}C;
- Sinusoidal waveform;
- Strain-controlled mode of loading and loading frequency of 10 Hz.

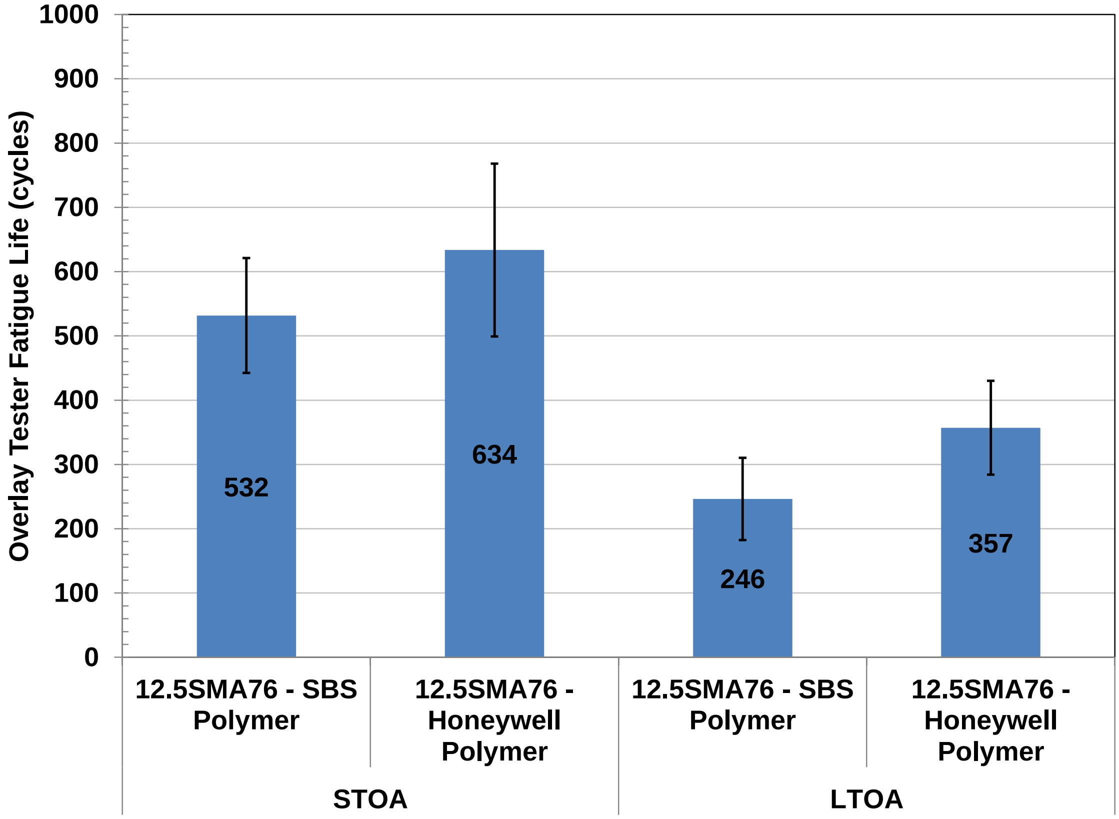

Figure 8 - Overlay Tester Results of Honeywell PE and SBS Modified SMA

The flexural beam fatigue test results for the Honeywell PE and SBS modified SMA mixes for the short-term condition is shown in Figure 9. The test results indicate that on average, the SBS polymer modified SMA had a slightly better resistance to crack initiation than the Honeywell PE polymer modified SMA at all strain levels tested for each respective aged condition.

Resistance to Moisture-Induced Damage (Tensile Strength Ratio, TSR) – Test Results

Tensile strengths of dry and conditioned asphalt samples were measured in accordance with AASHTO T283, *Resistance of Compacted Asphalt Mixtures to Moisture Induced Damage*. The results of the testing are shown in Table 3. The test results showed that the both the Honeywell PE and SBS polymer modified SMA mixtures did not meet the minimum 80% TSR specified by the NJDOT. On average, the Honeywell PE modified mixtures resulted in a slightly higher TSR value than the SBS polymer modified SMA mixture.

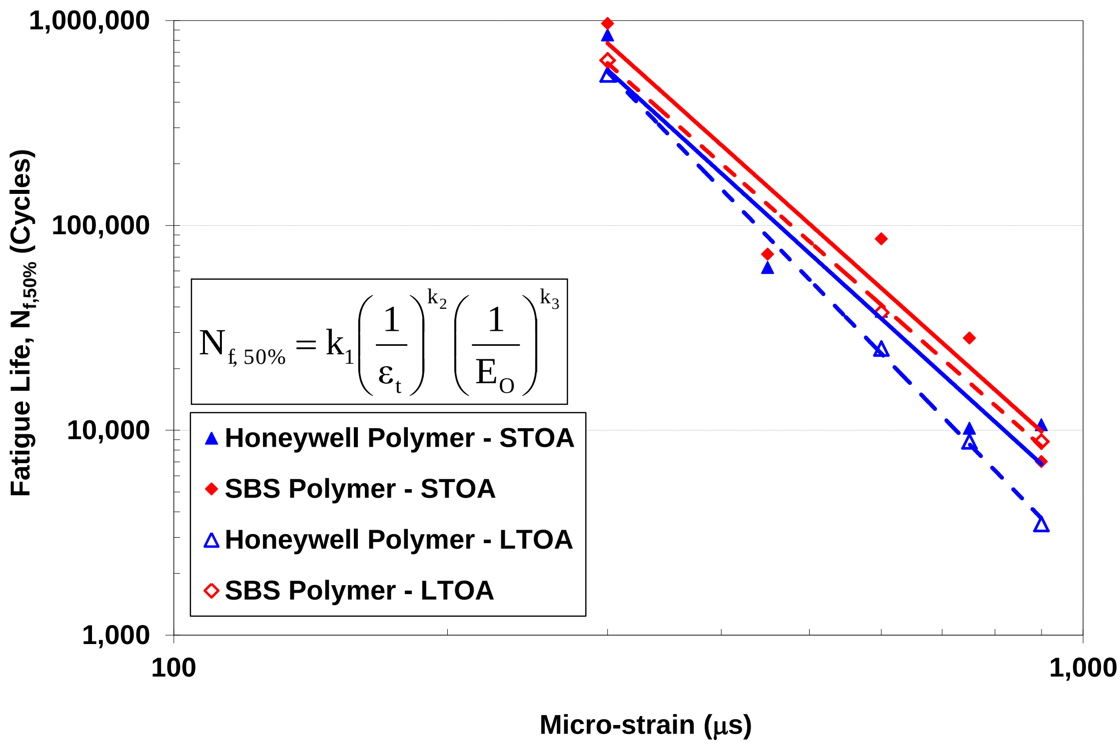

Figure 9 - Flexural Fatigue Results for Short-term Aged SBS Polymer and Honeywell PE Polymer Modified SMA

Table 3 - Tensile Strength Ratio (TSR) Results of Honeywell PE Modified and SBS Modified SMA

12.5SMA76 - Honeywell PE Polymer			
Specimen Type	Indirect Tensile Strength (psi)		Average TSR (%)
	Dry	Conditioned	
AASHTO T283 Conditioned	137.9	100.8	***76.7%***
	117.0	100.7	
	135.4	97.9	
	130.1	***99.8***	

12.5SMA76 - SBS Polymer			
Specimen Type	Indirect Tensile Strength (psi)		Average TSR (%)
	Dry	Conditioned	
AASHTO T283 Conditioned	143.8	94.7	***74.4%***
	118.1	92.7	
	119.2	96.2	
	127.1	***94.6***	

Conclusions

A research program was developed to compare the performance of Stone Matrix Asphalt (SMA) mixtures modified with Honeywell PE and SBS polymer modifiers. The test results indicate;

- Comparing the volumetric and composition of SMA mixtures, both mixtures were quite similar with the SBS polymer modified mixture having a slightly higher total and effective asphalt content. All other volumetric and composition properties were identical.
- The SBS polymer modified SMA resulted in a better rutting resistance when measured in the Asphalt Pavement Analyzer (AASHTO T340) and the AMPT Flow Number test (AASHTO TP79).
- Fatigue performance of the binders was similar with the SBS polymer modified binder showing a slightly better resistance to crack initiation, as indicated with the Flexural Fatigue test (AASHTO T321). However, on average the resistance to crack propagation was found to be slightly better in the Honeywell PE polymer modified SMA mixture. This trend was found at each aged conditioned – Short-term and Long-term conditions (AASHTO R30).
- Both the Honeywell PE and SBS polymer modified SMA mixtures resulted in very similar Tensile Strength Ratio (AASHTO T283) values. It was found both mixtures did not achieve the minimum required 80% TSR.

APPENDIX A – ASPHALT BINDER CERTIFICATE OF ANALYSIS

SBS + PPA MODIFIED PG76-22

Certificate of Analysis

Supplier:	NuStar Asphalt Refining, LLC	Phone:	856-579-5107
Terminal:	Blue Knight Energy Partners LP		
Address:	Gloucester City, NJ 08030		
Sample Grade:	PG 76-22 PPA	Specification:	AASHTO M320
Tank:	Inline	Date Sampled:	8/24/2012
Lot:	8	Date Tested:	8/29/2012
Volume:	336,000 gallons	Binder Type:	SBS Modified

Method	Test	Result	Units	Spec Limit
Unaged Binder				
AASHTO T228	Specific Gravity @ 77°F	1.035		
	Specific Gravity @ 60°F	1.041		Calculation
	API Gravity @ 60°F	4.4	°API	Calculation
	LBS/GAL	8.669		Calculation
AASHTO T48	Flash Point	274	°C	Min 230
AASHTO T316	Viscosity @ 135°C	1.162	Pa.s	Max 3.0
	Viscosity @ 165°C	0.282	Pa.s	Report
	Lab Mixing Temp °C, min	157	°C	Calculation
	Lab Mixing Temp °C, max	163	°C	Calculation
	Lab Compaction Temp °C, min	152	°C	Calculation
	Lab Compaction Temp °C, max	157	°C	Calculation
AASHTO T315	ODSR Test Temperature	76	°C	
	G*/sin delta	1.28	kPa	Min 1.00
RTFO Aged Binder				
AASHTO T240	Mass Change	-0.22	Wt%	Max +/- 1.0
AASHTO T315	RDSR Test Temperature	76	°C	
	G*/sin delta	3.08	kPa	Min 2.20
ASTM D6084	Elastic Recovery; RTFO Residue	70	%	
PAV Aged Binder				
AASHTO T315	PDSR Test Temperature	31	°C	
	G*sin delta	1900	kPA	Max 5000
AASHTO T313	BBR Test Temperature	-12	°C	
	Creep Stiffness @ 60 sec	235	MPa	Max 300
	m-value @ 60 sec	0.332		Min 0.300
Classification	PG CLASSIFICATION	PG 76-22		

By providing this data under my signature, I attest to the accuracy and validity of the data contained on the form and certify that no deliberate misrepresentation of test results, in any manner, has occurred.

Testing Laboratory:		**Responsible Technician**		**Approved By:**	
NuStar Asphalt, Paulsboro, NJ		**Signature:**	Joan Fueda	**Signature**	*Karissa Mooney*
Issue Date:	8/30/2012	**AASHTO #**	Intertek - 1009		Karissa Mooney
					Quality Manager

HONEYWELL PE MODIFIED PG76-22

Intertek

Report of Analysis

Client:	NuStar Asphalt Refining Company	**Customer Reference:**	P.O 4501333265
Sample ID:	2012-PHIL-002858-AE-001	**Date Taken:**	17-August-2012
Sample Designated As:	PG 76 - 22	**Date Submitted:**	17-August-2012
Drawn By:	Client	**Date Tested:**	19-August-2012
Sample Location:	NUSTAR BALTIMORE		
Representing:	TK 304		

Method	Test	Result	Units	Spec Limit
AASHTO T48-06	Corrected Flash Point (Conv. Calc)	277	°C	Min 230
AASHTO T228-06	Sp Gr @ 77/77 deg F	1.031		
	Sp Gr @ 60/60 deg F	1.037		
	API Gravity	4.9	°API	
	LBS./GAL.	8.640		
AASHTO T316-06	Viscosity @ 135 deg C	1080	cP	Max 3000
	Viscosity @ 165 deg C	266	cP	
AASHTO T315 OB-06	Test Temperature	76.0	°C	
	Complex Modulus (G*)	1.43	kPa	
	Phase Angle (DELTA)	77.7	deg	
	G*/Sin Delta	1.46	kPa	Min 1.00
	Test Temperature	82.0	°C	
	Complex Modulus (G*)	0.82	kPa	
	Phase Angle (DELTA)	78.6	deg	
	G*/Sin Delta	***0.83****	kPa	Min 1.00
	Pass/ Fail Temperature	80.0	°C	
AASHTO T315 RTFO-06	Test Temperature	76.0	°C	
	Complex Modulus (G*)	2.89	kPa	
	Phase Angle (DELTA)	73.3	deg	
	G*/Sin Delta	3.01	kPa	Min 2.20
	Test Temperature	82.0	°C	
	Complex Modulus (G*)	1.57	kPa	
	Phase Angle (DELTA)	75.5	deg	
	G*/Sin Delta	***1.62****	kPa	Min 2.20
	Pass / Fail Temperature	79.1	°C	
ASTM D6084	Temperature	77 deg F		
	Elastic Recovery of RTFO Residue	75	%	
AASHTO T240-08	Mass Gain + (or) Loss -	-0.248	Wt %	-1.000 - 1.000
AASHTO TP70-07	Test Temperature	64.0	°C	
	Percent Recovery of RFTO Residue @ 100 PA	44.6361	%	
	Percent Recovery of RFTO Residue @ 3200 PA	36.0746	%	
	% Difference between Average % Recovered	19.18	%	
	Non-Recoverable Creep Compliance @ 100 PA (Jnr)	0.3253	kPa	
	Non-Recoverable Creep Compliance @ 3200 PA (Jnr)	0.3873	kPa	
	% Difference between Average Non Recoverable Creep Compliance	19.06	%	
	Proposed MSCR (Jnr) specification	0.1906		
AASHTO R28-06	PAV Aging for 20hrs @ 2.1 MPa	100 °C		
AASHTO T315 PAV-06	Test Temperature	31.0	°C	
	Complex Modulus (G*)	2820	kPa	
	Phase Angle (DELTA)	52.0	deg	
	G* Sin Delta	2220	kPa	Max 5000
	Test Temperature	25.0	°C	
	Complex Modulus (G*)	6210	kPa	

Intertek

Report of Analysis

Client:	NuStar Asphalt Refining Company	**Customer Reference:**	P.O 4501333265
Sample ID:	2012-PHIL-002858-AE-001	**Date Taken:**	17-August-2012
Sample Designated As:	PG 76 - 22	**Date Submitted:**	17-August-2012
Drawn By:	Client	**Date Tested:**	19-August-2012
Sample Location:	NUSTAR BALTIMORE		
Representing:	TK 304		

Method	Test	Result	Units	Spec Limit
AASHTO T315 PAV-06	Phase Angle (DELTA)	47.6	deg	
	G* Sin Delta	4590	kPa	Max 5000
	Test Temperature	22.0	°C	
	Complex Modulus (G*)	9600	kPa	
	Phase Angle (DELTA)	44.9	deg	
	G* Sin Delta	***6780****	kPa	Max 5000
	Pass / Fail Temperature	24.3	°C	
AASHTO T313-06	Testing Temperature	-12.0	°C	
	Creep Stiffness @ S60	245	MPa	Max 300
	m-value @ S60	0.328		Min 0.300
	Testing Temperature	-18.0	°C	
	Creep Stiffness @ S60	***494****	MPa	Max 300
	m-value @ S60	***0.260****		Min 0.300
	Pass/Fail Temperature	-13.7	°C	
CLASSIFICATION	**TG CLASSIFICATION**	**PG 79.1 - 23.73**		

***** = Out of Spec Limit***

Signed: [signature] Date: 19-Aug-2012

Intertek

APPENDIX B – QC DATA

LB-XXX 98

Load 5 Pb 76.22/Honeywell PE/SBS Polymer

New Jersey Department Of Transportation

IGNITION METHOD & MARSHALL TEST FOR COMPLIANCE

Report No. 11

Date: 08/31/12

Serial No. C50DN0516

Project: Rt. 1 Resurfacing Job #

Mix No. 12.5SMA76

Producer: Tilcon / Keasbey Contractor Tilcon Plant: Drum

Lot Sample No.	24			
Starting Temp.	538 C			
Elapsed Time	49:00:00		Pan Mass = 10	
Sample Wgt.	2042.1		Wet Mass	
A-Sample Wgt. Cor. for Moist	2042.0		Dry Mass	
B-Sample Wgt. After Ignition	1906.6			
C-Wgt. Loss (A-B)	135.4			
D-% Loss (C/A*100)	6.63			
E-Temp. Compensation **	0.15			
F-Calibration Factor	0.33			
G-% Bitumen (D-E-F)	6.15			6.1 - 6.9
Sieve Size	**Wt Ret**	**% Ret.**	**% Pass**	
2"				
1 1/2"				Targets
1"	0.0	0.0	100.0	
3/4" (19.00mm)	0.0	0.0	100.0	100.0
1/2" (012.5mm)	188.5	9.9	90.1	87-97
3/8" (9.5mm)	488.6	25.6	74.4	67-77
No.4 (4.75mm)	1309.6	68.7	31.3	25-33
No.8 (2.36mm)	1528.3	80.1	19.9	18-26
No.16 (1.18mm)	1598.2	83.8	16.2	
No.30 (600mm)	1639.1	86.0	14.0	
No.50 (425mm)	1673.9	87.8	12.2	
No.100 (150mm)	1710.7	89.7	10.3	
No.200 (75mm)	1756.1	92.1	7.9	7.5-11.5
Total Aggregate Wgt./ Pan	1,906.8	7.9		
Wgt. Before Wash	1,906.8			
Wgt. After Wash	1787.1			
Difference	119.7			

Gmm @ N max	
Sample No.	
Molding Temp.	
Wt. In Air	
Wt in Water	
S.S.D.	
Gmb @ N max	
% Gmm @ N max	
Ht @ N-max	
% Voids @ N max	
Pyc Test Results	
Sample No.	
Sample Wt.	2168.5
Calibrated Pyc	1240.8
Total	3409.3
Pyc + Mix + Water	2523.5
Volume	885.8
Maximum SPG	2.448
Mass in H20 aft VAC	1282.7
(MAX)	*152.8*
(BULK)	*146.7*

Gyratory Plug	
Molding Temp	300
Eff. Spg of Agg. Blend	2.731
Bulk Spg of Agg. Blend	2.714
Wt. In Air	4716.5
Wt in Water	2718.8
S.S.D.	4725.6
Gmb @ N max	
Ht. @ N max	[redacted]
Ht. @ N des	118.4
Ht. @ N ini	132.3
% Gmm @ N max	
% Gmm @ N des	96.0
% Gmm @ N ini	85.9
% Voids @ N des	4.0
Gmb @ N des	2.350
Effective AC	5.87
Dust / Asp. Ratio	1.3
Total Volume	42.5
Volume of Binder	5.70
Binder by Volume	13.4
% VMA	17.4

I certify that the above samples were sampled by me and that all operations were performed in accordance with N.J.D.O.T. Specification and Procedures, to the best of my knowledge.

* Only for test method "B" (Without internal scale)

** Only for test method "A" (With internal scale)

DEPARTMENT OF TRANSPORTATION REPRESENTATIVE

LB-XXX 98

New Jersey Department Of Transportation

IGNITION METHOD & MARSHALL TEST FOR COMPLIANCE

Report No. 15
Date: 09/06/12
Serial No. C50DN0516

Project: Rt. 1 Resurfacing   Job #   Mix No. 12.5SMA76
Producer: Tilcon / Keasbey   Contractor Tilcon   Plant: Drum

Lot Sample No.	25			
Starting Temp.	538 C			
Elapsed Time	53:00:00		Pan Mass = 10	
Sample Wgt.	2042.1		Wet Mass	
A-Sample Wgt. Cor. for Moist	2042.0		Dry Mass	
B-Sample Wgt. After Ignition	1902.3			
C-Wgt. Loss (A-B)	139.7			
D-% Loss (C/A*100)	6.84			
E-Temp. Compensation **	0.15			
F-Calibration Factor	0.33			
G-% Bitumen (D-E-F)	6.36			6.1 - 6.9
Sieve Size	**Wt Ret**	**% Ret.**	**% Pass**	
2"				
1 1/2"				Targets
1"	0.0	0.0	100.0	
3/4" (19.00mm)	0.0	0.0	100.0	100.0
1/2" (012.5mm)	164.5	8.6	91.4	87-97
3/8" (9.5mm)	511.6	26.9	73.1	67-77
No.4 (4.75mm)	1359.9	71.5	28.5	25-33
No.8 (2.36mm)	1519.4	79.9	20.1	18-26
No.16 (1.18mm)	1587.7	83.5	16.5	
No.30 (600mm)	1630.3	85.7	14.3	
No.50 (425mm)	1666.8	87.6	12.4	
No.100 (150mm)	1708.2	89.8	10.2	
No.200 (75mm)	1748.0	91.9	8.1	7.5-11.5
Total Aggregate Wgt./ Pan	1,902.5	8.1		
Wgt. Before Wash	1,902.3			
Wgt. After Wash	1763.5			
Difference	138.8			

Gmm @ N max	
Sample No.	
Molding Temp.	
Wt. In Air	
Wt in Water	
S.S.D.	
Gmb @ N max	
% Gmm @ N max	
Ht @ N-max	
% Voids @ N max	

Pyc Test Results	
Sample No.	
Sample Wt.	2192.0
Calibrated Pyc	1240.8
Total	3432.8
Pyc + Mix + Water	2538.1
Volume	894.7
Maximum SPG	2.450
Mass in H20 aft VAC	1297.3
(MAX)	152.9
(BULK)	147.7

Gyratory Plug	
Molding Temp	300
Eff. Spg of Agg. Blend	2.731
Bulk Spg of Agg. Blend	2.714
Wt. In Air	4705.8
Wt in Water	2726.8
S.S.D.	4715.2
Gmb @ N max	
Ht. @ N max	[redacted]
Ht. @ N des	116.8
Ht. @ N ini	131.7
% Gmm @ N max	
% Gmm @ N des	96.6
% Gmm @ N ini	85.7
% Voids @ N des	3.4
Gmb @ N des	2.367
Effective AC	6.08
Dust / Asp. Ratio	1.3
Total Volume	42.3
Volume of Binder	5.90
Binder by Volume	14.0
% VMA	17.4

Load 5
Test Load

I certify that the above samples were sampled by me and that all operations were performed in accordance with N.J.D.O.T. Specification and Procedures, to the best of my knowledge.

DEPARTMENT OF TRANSPORTATION REPRESENTATIVE

* Only for test method "B" (Without internal scale)

** Only for test method "A" (With internal scale)