Test & Evaluation Report

Flexi-Pave Pavement Performance Properties

Report Prepared for:

David May, P.E.
DMA Engineering
116 South Tennessee Avenue
Lakeland, FL 33801

Report Prepared by:

Kenneth F. Grzybowski
PRI Asphalt Technologies, Inc.
6408 Badger Drive
Tampa, FL 33610-2004

July 28, 2005

Flexi-Pave Pavement Performance Properties

July 28, 2005

-Contents-

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com

TEST & EVALUATION REPORT
FLEXI-PAVE PAVEMENT PERFORMANCE PROPERTIES

July 28, 2005

Description: Flexi-Pave is a specially formulated permeable pavement material, composed of recycled ground tire rubber, selected aggregate, a proprietary urethane-based binder, and other additives.

Sample/Data Information:

Identification	Grade/Type	Date	Source
Flexi-Pave Pavement Test Specimens	Laboratory-Prepared	Rec'd @ PRI 5/18/05	DMA Engineering
Flexi-Pave Pavement Field Samples (assorted sizes)	Field/Installed	Rec'd @ PRI 5/05	

Client: DMA Engineering Project No.: DMA-01-02-01

OBJECTIVE: Evaluate, assess, and characterize Flexi-Pave in terms of standard asphalt pavement materials and construction, specifically the wearing/fraction course and one later/lift pavement.

BACKGROUND:

Flexi-Pave is formulated on site to specific job requirements. The proprietary formulation utilized recycled ground tire rubber and other materials to provide typical asphalt pavement-type properties and enhanced performance properties, including: permeability, resilience, flexibility, and overall durability.

CONCLUSIONS:

The specimens submitted exhibited good-to-excellent performance properties for those properties selected for evaluation. The table on the next page provides a summary of the results.

Some of the applications for Flexi-Pave include: bike trails, playgrounds, parking lots, light traffic roadways, and use-areas requiring permeability.

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com

CONCLUSIONS: continued

Table 1: PROPERTY SUMMARY TABLE

Property	Test Method	Parameters	Results		Comment
Initial Scuff/Power Steering Resistance	ISSA TB 100, *Wet Track Abrasion*	@ 25°C	1 hour = 4.6 g/ft.^{2}	6 days = 8.6 g/ft.^{2}	Good - Excellent[1]
	ISSA TB 139, *Cohesion Measurement*		15 kg-cm (solid spin)[2]		Excellent
Permeability	FL DOT FM 5-565	@ 25°C	1.8 x 10^{-1} cm/sec.		Highly Permeable
Flexibility	PRI TM 025	4" w x 2" t x 36" beams @ 25°C	2 mm avg. max. deflection at center of beams – no cracks after 16 days, no permanent deformation		Highly Flexibile[3]
Hamburg Loaded Wheel Tester	TX DOT 242-F	@ 60°C to 8,000 cycles or 0.5" rut depth, which ever occurred first	2.3 mm rut depth at 8,000 cycles measured at end of test (test terminated) Full recovery after 24 hours		Excellent/Superior
Permeability	FL DOT FM 5-565	Field/Installed Sample	1.1 x 10^{-1} cm/sec.		Highly Permeable
Static Creep	TX DOT 231-F	@ 60°C	Total Strain + 2.703% Permanent Strain = 0.514%		Good - Excellent
Resilient Modulus	ASTM D 4123	@ 25°C	68,495		--
Slip Resistance	ASTM D 2047	25°C, dry	0.65		Non-slip Hazard[4]
Accelerated Weathering, ASTM 4798, 500 hours, Xenon Arc Cycle A					
Scuff/Power Steering Resistance	ISSA TB 100, *Wet Track Abrasion*	@ 25°C	1 hour = 16.5 g/ft.^{2}	6-day = 17.7 g/ft.^{2}	Excellent/Superior

1. Simulated performance test correlated to field-applied slurry seals; values $\leq$ 75 g/ft.^{2} indicates acceptable wear properties. The 6-day value (6 days of conditioning in water) indicates acceptable water resistance properties.
2. Solid Spin; no cracks, no aggregate dislodged, no tearing, equivalent to a cohesive value of 26 kg-cm.
3. Beam samples exhibited excellent flexibility and resistance to cracking and maintaining integrity, beams recovered to original shape without exhibiting permanent deformation.
4. ASTM D 2047 states, "……..laboratory testing of floor polishes with a coefficient of friction of not less than 0.5 have been traditionally recognized as providing non-hazardous walkway surfaces." A wet surface was not evaluated since material is permeable.

DATA/RESULTS:

Surface Toughness and Stress Resistance: ISSA (International Slurry Seal Association) test methods TB 100, *Wet Track Abrasion*; and TB 139, *Cohesion Measurement*, were selected to characterize Flexi-Pave's resistance to surface stress induced by vehicles (power steering) and pedestrians (skateboards, etc.). The ISSA protocols directly address these properties, the test methods are employed routinely for materials such as: slurry seals, micro-surfacing, and similar thin-lift layers placed on asphalt pavements.

Table 2: WET TRACK ABRASION, ISSA TB 100

Sample ID	Wt. Before Testing	Wt. After Testing	Mass Loss, g	Results, g/ft.^{2}
1 Hour Samples – Unaged				
1	1,712.0	1,710.4	1.6	4.9
2	1,705.3	1,703.9	1.4	4.3
			Avg.	**4.6**
6-Day Samples – Unaged				
3	1,710.4	1,707.6	2.8	8.6
4	1,703.9	1,701.1	2.8	8.6
			Avg.	**8.6**
1 Hour Samples – Aged, 500 hours Accelerated Aging (Xenon Arc with water)				
5	1,622.6	1,617.2	5.4	16.5
6-Day Samples – Aged, 500 hours Accelerated Aging (Xenon Arc with water)				
6	1,617.2	1,611.4	5.8	17.7

DISCUSSION: ISSA guidelines allow for mass losses of 50 g/ft.^{2} for 1-hour samples and losses of 75 g/ft.^{2} for 6-day samples. Flexi-Pave exhibited mass losses well below the guideline limits, which define good performance. The data suggests Flexi-Pave will exhibit a high degree of resistance to permanent surface deformation induced by vehicles and pedestrian activities.

Results, after accelerated aging, indicated an overall excellent retained resistance to scuffing and power steering induced surface damages to Flexi-Pave.

Table 3: COHESION TEST, ISSA TB 139

Sample ID	Specimen, Diameter, inches	Dimensions, Height, inches	Cohesion Value, Kg-cm	Ranked Results
1	4.038	1.574	15	Solid Spin[1]
2	4.038	1.549	15	Solid Spin[1]

1. Solid Spins = no visual cracking, no aggregate dislodged or raveled, no tearing, nor other deficiencies.

DISCUSSION: Flexi-Pave exhibited excellent cohesion properties, the specimen remained totally intact without visible deformation induced by the test procedure. Aggregates remained firmly bonded.

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com

DATA/RESULTS: continued

Table 4a: PERMEABILITY – Lab Specimen, Florida DOT FM 5-565

Sample ID	Head $_{Initial}$, cm	Head $_{Final}$, cm	Water Temp.°C	Temp. Correction	Time $_{sec.}$	Coefficient of Permeability, kg-cm/sec.
Core 1, Trial 1	83.52	20.52	28.2	0.83	1.88	1.7×10^{-1}
Core 1, Trial 2					1.72	1.9×10^{-1}
Core 1, Trial 3					1.94	1.7×10^{-1}
					Avg.	**1.77×10^{-1}**

Core Data:
Bulk Specific Gravity: 0.916
Average Core Thickness: 6.530 cm
Average Core Diameter: 15,251 cm
Average Cross-Sectional Area: 182.678 cm^2

Table 4b: PERMEABILITY – Lab Specimen, Florida DOT FM 5-565

Sample ID	Head $_{Initial}$, cm	Head $_{Final}$, cm	Water Temp.°C	Temp. Correction	Time $_{sec.}$	Coefficient of Permeability, kg-cm/sec.
Core 1, Trial 1	83.47	20.47	26.4	0.86	1.75	1.8×10^{-1}
Core 1, Trial 2					1.82	1.7×10^{-1}
Core 1, Trial 3					1.81	1.8×10^{-1}
					Avg.	**1.77×10^{-1}**

Core Data:
Bulk Specific Gravity: 0.938
Average Core Thickness: 6.180 cm
Average Core Diameter: 15,247 cm
Average Cross-Sectional Area: 182.582 cm^2

DISCUSSION: Flexi-Pave specimens exhibited a high degree of permeability. *(Note: $\leq 10^{-7}$ cm/sec. is a guideline value to define impermeability.)*

Table 4c: PERMEABILITY – Field Specimen, Florida DOT FM 5-565

Sample ID	Head $_{Initial}$, cm	Head $_{Final}$, cm	Water Temp.°C	Temp. Correction	Time $_{sec.}$	Coefficient of Permeability, kg-cm/sec.
Core 1, Trial 1	87.17	24.77	24.2	0.91	2.40	1.1×10^{-1}
Core 1, Trial 2					2.39	1.1×10^{-1}
Core 1, Trial 3					2.44	1.1×10^{-1}
					Avg.	1.1×10^{-1}

Core Data:
Bulk Specific Gravity: 1.018
Average Core Thickness: 5.411 cm
Average Core Diameter: 15.75 cm
Average Cross-Sectional Area: 180.862 cm^2

DATA/RESULTS: continued

Table 5: FLEXIBILITY, PRI Test Method #025 @ Standard Conditions

Date	Day	Deflection, mm									Sand Removed
		4L	3L	2L	1L	Center	1R	2R	3R	4R	
6/9	0	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	248 g sand 238 g sand
6/10	1	0.04 0.25	0.42 0.66	1.01 0.90	2.02 1.66	2.55 2.17	2.34 1.87	1.40 1.51	0.92 0.45	-0.07 0.26	220 g sand 186 g sand
6/11	2	-0.04 0.31	0.20 0.19	0.52 0.52	0.85 0.84	1.27 1.24	0.86 0.93	0.77 0.45	0.45 0.31	0.35 0.10	187 g sand 196 g sand
6/12	3	0.32 0.30	0.35 0.68	0.47 0.70	0.87 1.13	1.10 1.41	0.94 1.24	0.58 0.98	0.27 0.38	0.43 0.19	205 g sand 189 g sand
6/13	4	0.08 0.03	0.17 0.15	0.42 0.43	0.80 0.83	1.01 0.98	0.99 0.67	0.68 0.46	0.24 0.17	0.08 -0.07	184 g sand 192 g sand
6/14	5	-0.17 -0.02	0.31 0.56	1.16 1.00	1.86 1.60	2.09 2.05	1.89 2.00	1.28 1.34	0.54 0.64	-0.06 0.05	169 g sand 182 g sand
6/15	6	-0.31 -0.01	0.61 0.74	1.47 1.64	2.05 2.36	2.31 2.77	2.28 2.22	1.59 1.78	0.74 0.91	-0.02 0.15	158 g sand 185 g sand
6/16	7	0.04 -0.17	0.41 0.31	0.73 0.54	1.07 0.59	1.14 0.95	1.06 0.74	0.82 0.70	0.49 0.39	0.12 0.11	181 g sand 191 g sand
6/17	8	-0.02 0.09	0.51 0.42	0.94 1.15	1.34 1.63	1.39 1.93	1.26 1.86	0.88 1.26	0.45 0.66	0.02 0.17	162 g sand 162 g sand
6/18	9	-0.04 -0.25	0.41 0.27	0.85 0.59	1.07 1.11	1.21 1.36	1.15 1.11	0.85 0.77	0.48 0.46	0.12 -0.02	166 g sand 175 g sand
6/19	10	0.14 0.13	0.72 0.86	1.26 1.18	1.58 1.41	1.74 1.62	1.53 1.32	1.11 1.11	0.56 0.58	0.14 0.19	181 g sand 175 g sand
6/20	11	0.04 0.30	0.58 0.47	1.08 0.97	1.52 1.29	1.67 1.41	1.50 1.19	1.13 0.80	0.63 0.40	0.20 0.10	161 g sand 181 g sand
6/21	12	0.03 0.03	0.45 0.36	0.82 0.74	1.05 0.95	1.10 1.07	1.08 0.97	0.83 0.78	0.38 0.57	-0.05 0.15	196 g sand 190 g sand
6/22	13	0.10 -0.06	0.59 0.34	0.71 0.42	0.89 0.72	1.07 1.05	0.80 0.74	0.63 0.50	0.50 0.42	0.09 0.10	149 g sand 166 g sand
6/23	14	0.12 -0.09	0.25 0.27	0.69 0.59	0.76 0.67	1.02 1.04	0.81 0.47	0.73 0.44	0.37 0.19	0.16 0.15	155 g sand 185 g sand
6/24	15	0.22 0.01	0.49 0.38	0.85 0.95	1.30 1.10	1.38 1.25	1.27 1.18	0.85 1.03	0.52 0.72	0.11 0.09	End Test

Total Center Deflection: 22.05 mm (Replicate 1) 22.30 mm (Replicate 2)

Blue = Replicate 1 Data
Green = Replicate 2 Data

Beam Data:

	Beam 1	Beam 2
Bulk Specific Gravity:	0.910	0.903
Width Avg., inches:	4.010	3.980
Length Avg. inches:	36.060	36.020
Thickness Avg. inches:	1.980	1.950

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com

DATA/RESULTS: continued

FLEXIBILITY: Photos at 0, 7, and 15 days

Flexibility – 1.0 & 2.0: Initial

Replicate 1

Replicate 2

Flexibility – 1 – 7 & 2 – 7: 7th Day

Replicate 1

Replicate 2

Flexibility 1-15 & 2-15: 15th Day

Replicate 1

Replicate 2

DISCUSSION: Photos document minimal deflection after 15 days at center of beam.

DISCUSSION: Both beam specimens exhibited approximately 22 mm of deflection at the beam's center without cracking or other visible permanent deficiency. *(Note: conventional asphalt pavements typically do not exhibit this ability to deflect to this degree without cracking or separation.)*

Table 6: RUT RESISTANCE BY HAMBURG LOADED WHEEL TESTER, Texas DOT 242-F

Stroke Count	Replicate 1 (BSG: 0.937)		Replicate 2 (BSG: 0.939)	
	Temperature, °C	Rut Depth, mm[1.]	Temperature, °C	Rut Depth, mm[1.]
0	61	0.0	61	0.0
100	56	0.83	59	1.02
500	61	1.00	60	0.92
1,000	61	1.68	61	1.18
1,500	60	1.45	61	1.96
2,000	60	1.60	61	2.12
2,500	61	1.69	61	2.18
3,000	60	1.76	61	1.64
3,500	61	2.45	61	1.66
4,000	61	2.53	61	1.73
4,500	61	1.95	60	2.41
5,000	61	2.01	61	2.55
5,500	61	2.71	61	1.98
6,000	61	2.00	61	1.98
6,500	60	2.01	61	1.95
7,000	61	2.08	61	2.57
7,500	61	2.20	60	2.02
8,000	61	2.24	60	2.19

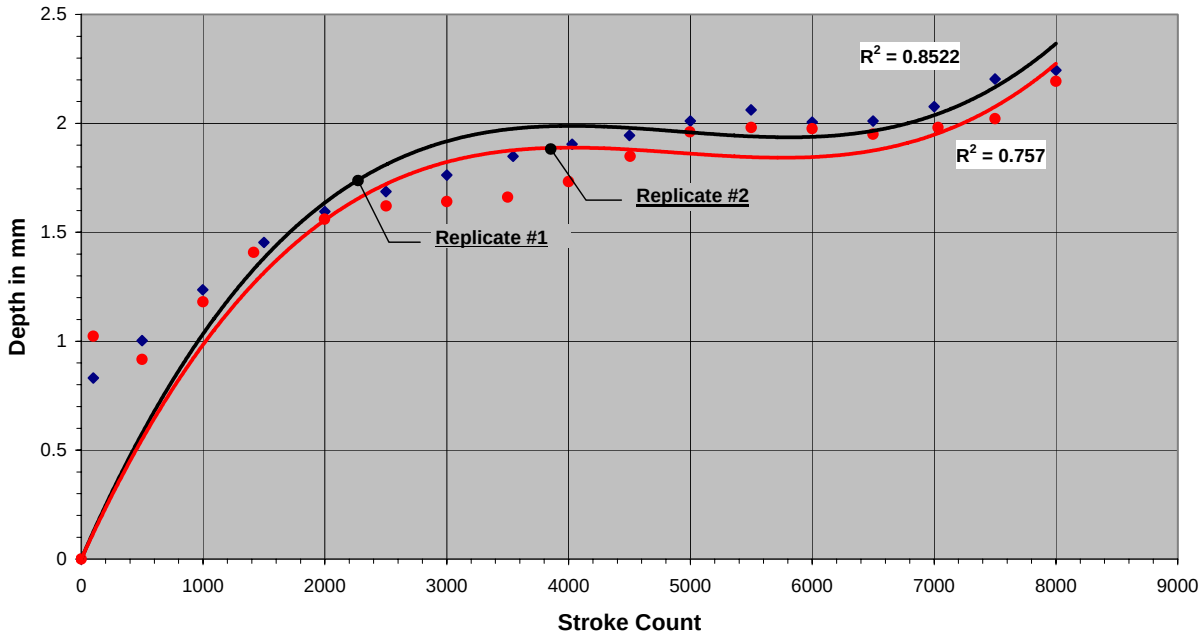
1. Depth measurement influenced by high resiliency/recovery properties of Flexi-Pave. Material, unlike conventional asphalt pavements, did not exhibit a permanent deformation, rather the material responded/deformed under immediate (passing of wheel) load, but started recovery when the load passed.

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com

DATA/RESULTS: continued

1.

HAMBURG LOADED WHEEL GRAPH
Replicates 1 & 2



Graph 1: Rut Resistance by Hamburg Loaded Wheel Tester, Texas DOT 242-F

DISCUSSION: Flexi-Pave specimens exhibited excellent rut resistance, approximately 2.2 mm of permanent deformation after 8,000 cycles (discretionary test terminated due to excellent performance – test duration pre-defined as rut depth > 12.5 mm or 8,000 cycles).

The test was conducted at 60°C, 10°C above Texas DOT's recommended parameters. Rut susceptibility is strongly correlated to temperature; higher temperatures resulting in increased susceptibility. Consequently, these Flexi-Pave specimens exhibited superior rut resistance.

The Hamburg procedure is conducted in a water environment and is also used to assess water sensitivity (adhesion of asphalt binder to aggregate in a conventional hot mix asphalt system). The Flexi-Pave specimens exhibited no adhesion loss between the binder and aggregate/particulate materials (ground tire rubber and conventional river gravel).

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com

DATA/RESULTS: continued

Hamburg Loaded Wheel Tester, 8,000 cycles @ 60°C – Replicate 1

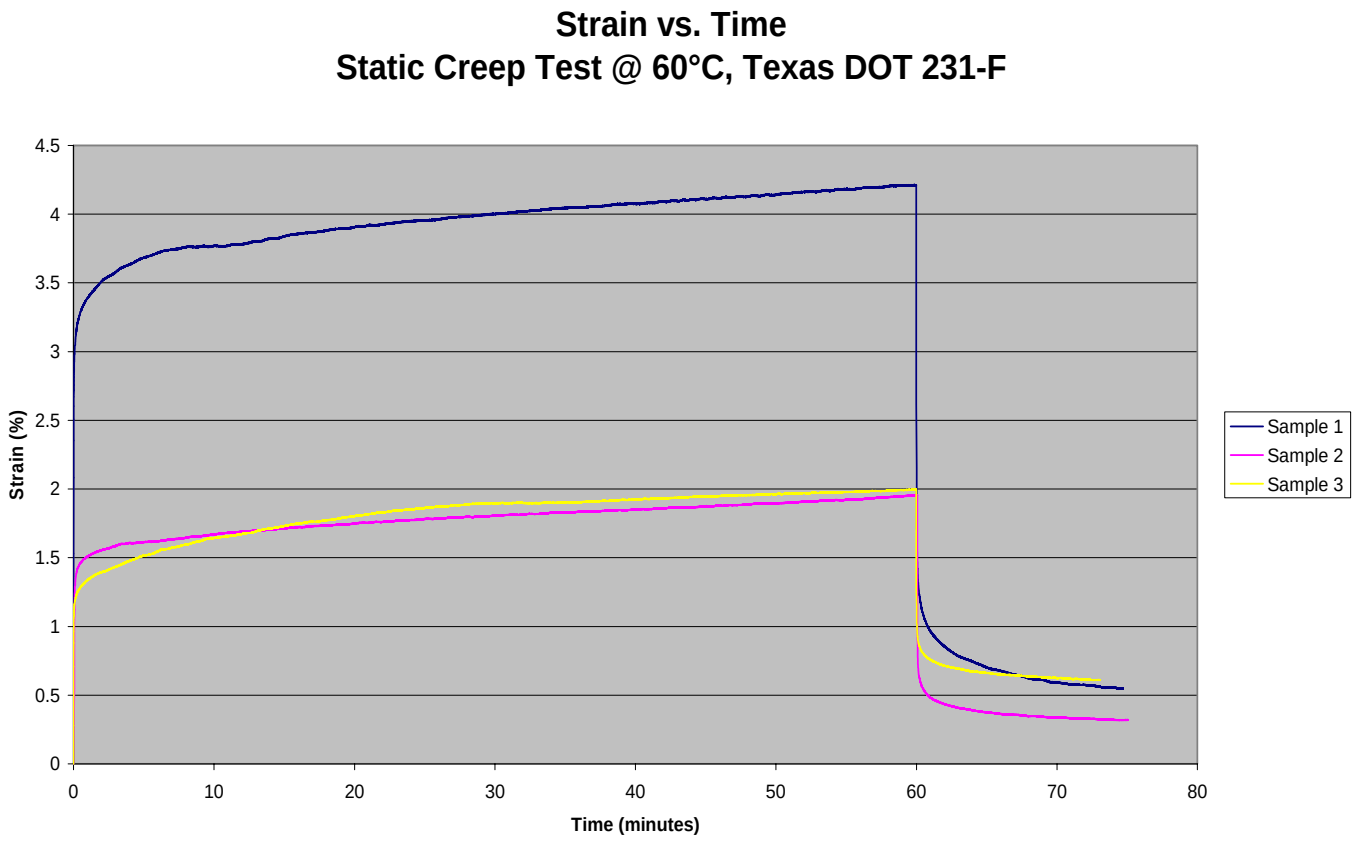
Hamburg Loaded Wheel Tester, 8,000 cycles @ 60°C – Replicate 2

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com

DATA/RESULTS: continued

Table 7: STATIC CREEP @ 60°C, Texas DOT 231-F

Sample #	Total Strain, %	Permanent Strain, %	Slope of Creep Curve, mm/mm/sec.
1	4.213	0.593	0.000117
2	1.953	0.338	0.000072
3	1.995	0.610	0.000036
Average	**2.7203**	**0.514**	**0.000201**



Graph 2: Static Creep @ 60°C – Strain % vs. Time

DISCUSSION: The Flexi-Pave specimens exhibited resiliency and recovery properties when subjected to static loading.

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com

DATA/RESULTS: continued

Table 8: RESILIENT MODULUS (RM) @ 25°C, ASTM D 4123

Sample #	RM Position A (psi)	RM Position B (psi)	Average (psi)
1	70,152	68,648	69,400
2	63,956	65,468	64,712
3	66,823	75,922	71,373
Average			**68,495**

DISCUSSION: Flexi-Pave specimens exhibited an average Resilient Modulus @ 25°C of 68,495 psi.

Table 9: SLIP RESISTANCE: ASTM D 2047 (James Machine)

Surface Condition	Results: Coefficient of Friction		
	Replicate 1 $_{4\ cycles}$	Replicate 2 $_{4\ cycles}$	Average $_{8\ cycles}$
Dry	0.65	0.65	0.65

DISCUSSION: A Coefficient of Friction values of $\geq$ 0.5 is generally accepted for classifying a walking surface as slip resistant.

The test was conducted dry, due to the high permeability of the Flexi-Pave specimens.

PRI Asphalt Technologies, Inc. 6408 Badger Drive Tampa, FL 33610 Tel: 813-621-5777 Fax: 813-621-5840 e-mail: mail@priasphalt.com Website: http://www.priasphalt.com