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TRANSMITTAL

TO: Jennifer Fitch, PE Project Manager Vermont Agency of Transportation	DATE	PROJECT NO.
	5/28/2014	Brookfield BRF FLBR (2)

XX WE ENCLOSE THE FOLLOWING: _____ UNDER SEPARATE COVER WE ARE SENDING THE FOLLOWING

COPIES	NUMBER	DESCRIPTION	CODE
1		FRP Test Sample Results	H

CODE:

A FOR INITIAL APPROVAL
B FOR FINAL APPROVAL
C APPROVED AS NOTED-RESUBMISSION REQUIRED
D APPROVED AS NOTED-RESUBMISSION NOT REQUIRED
E DISAPPROVED-RESUBMIT
F QUOTATION REQUESTED
G APPROVED
H FOR APPROVAL
I AS REQUESTED OR REQUIRED
J FOR USE IN ERECTION
K LETTER FOLLOWS
L FOR FIELD CHECK
M FOR YOUR USE

BY: Paul J. Miller

The following table is a summary of the mechanical and physical property values required by the specification, values used in design calculations, and measured values from recent testing. In one instance – coefficient of thermal expansion – the measured value was outside the range of the specification by 9.5%. There are two instances – tensile strength and shear modulus – where the measured value is slightly below the design value. In both cases, all affected calculations were checked and still pass the design criteria.

Value	Units	Required	Design	Measured	Remarks
Density	lb/in^3	±5% of Design	0.067	0.066	pass (<1.5% deviation)
Fiber Fraction	% vol	> 45%	49.1 %	48.7%	pass
Barcol Hardness	--	> 40	n/a	54	pass
Tensile Modulus	Msi	> 2.00	3.27	3.09	not used for buckling checks
Tensile Strength	ksi	> 30.0	52.3	46.69	lower strength checked in design calcs - all affected values pass
Comp. Modulus	Msi	> 1.80	3.27	3.35	pass
Compression Strength	ksi	> 30.0	34.9	56.73	pass
Shear Modulus	Msi	> 0.60	0.71	0.63	lower modulus checked in design calculations - all affected values pass
Shear Strength	ksi	> 12.0	14.3	14.45	pass
Flexural Modulus	Msi	> 1.80	n/a	2.58	pass
Flexural Strength	ksi	> 35.0	n/a	51.77	pass
Interlaminar Shear	ksi	> 3.50	n/a	5.35	pass
Bearing Strength	ksi	> 20.0	52.00	53.02	pass
Coeff. of Therm. Exp.	$x10^{-6}/°F$	8.00	n/a	8.76	CTE over spec by 9.5% - 100° change over 51' equals 0.536" ΔL vs. 0.490"
Coeff.of Friction, Wet	--	> 0.45	n/a	0.58	pass (grit blasted surface)
Water Absorption	%	< 0.70%	n/a	0.10%	pass

Physical Property Testing for Brookfield Floating Bridge

Prepared for:

Paul Holloway

Miller Construction

Prepared by:

Jacob Marquis

Kenway Corporation

May 27, 2014

On May 1, 2014 Kenway fabricated a test panel for conducting physical tests of the Brookfield floating bridge laminate. The test panel was approximately 18 in. square with half of the area made up of the nominal 0.5 in. thick layup and the other half at the nominal 1.0 in. layup. This panel was maintained at approximately 70 °F until May 27, 2014 when the following tests were conducted.

ASTM D792-13 Density and Specific Gravity of Plastics by Displacement

Per the above standard, three specimens were machined to approximately 0.5 in. cubes for weighing. The volume of each was computed by measuring the distance between parallel sides. The average density and coefficient of variation are reported in the table below.

Specimen	Length (in)	Width (in)	Height (in)	Computed Vol. (in^3)	Weight (g)	Weight ($lb \times 10^{-3}$)	Density (lb/in^3)
1	0.506	0.508	0.462	0.119	3.564	7.857	0.066
2	0.508	0.504	0.464	0.119	3.591	7.917	0.067
3	0.509	0.504	0.459	0.118	3.529	7.780	0.066
Avg	0.508	0.505	0.462	0.118	3.561	7.851	**0.066**
CV	0.3%	0.5%	0.5%	0.5%	0.9%	0.9%	0.5%

ASTM D2584-11 Ignition Loss of Cured Reinforced Resins

Per the above standard, three specimens were machined to approximately 1.0 in. cubes for weighing. The samples were placed in a muffle furnace at 1,050 °F for four hours. The residue was weighed to calculate the fiber fraction by weight. A glass density of 0.093 lb/in^3 was used along with the laminate density calculated above to compute the fiber fraction by volume.

Specimen	Length (in)	Width (in)	Height (in)	Computed Vol. (in^3)	Weight (g)	Residue Weight (g)	Fiber Wt. (%)	Fiber Vol. (%)
1	1.022	1.022	0.997	1.041	31.059	21.244	68.4%	48.8%
2	1.024	1.026	1.001	1.052	31.268	21.307	68.1%	48.6%
3	1.018	1.024	0.997	1.039	30.816	21.051	68.3%	48.7%
Avg	**1.021**	**1.024**	**0.998**	**1.044**	**31.048**	**21.201**	**68.3%**	**48.7%**
CV	0.3%	0.2%	0.2%	0.6%	0.7%	0.6%	0.2%	0.2%

ASTM D2583-13a Indentation Hardness of Rigid Plastics by Barcol Impressor

Per the above standard, ten hardness readings were taken at random locations on the test panel. The individual readings and associated average Barcol hardness are listed in the table below.

Reading	1	2	3	4	5	6	7	8	9	10	**Ave**
Hardness	57	48	46	44	62	65	56	63	48	55	**54**

Equipment

Starrett Model 799 caliper

Barber Colman Model 934-1 Barcol impressor

Intell-Lab Model PMW-320 scale

Jen-Ken Kilns Model GS muffle furnace

All remaining required testing was performed at the Advanced Structures and Composites Center at the University of Maine and those results are provided in the UMaine test report.

Material Property Testing for Vtrans Floating Bridge

Prepared for:

Jake Marquis
Kenway Corporation
Augusta, Maine

University of Maine's Advanced Structures and Composites Center
Report Number: 14-24-1267

May 27, 2014

Prepared by:
Keith A. Berube, Ph.D.
Research Engineer

Reviewed by:
Olivia Sanchez
ISO Coordinator

ACCREDITED

An ISO 17025 accredited testing laboratory, accredited by the International Accreditation Service.

Project Number: 1267
Project Date: May 20, 2014
Material: E-Glass/Interplastics 8100-50 Vinyl Ester
Date Received: April 22, 2014

Project Summary: The following material property tests were conducted:

- ASTM D3039 - *Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials*
- ASTM D6641 - *Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials Using a Combined Loading Compression (CLC) Test Fixture*
- ASTM D5379 - *Standard Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method*
- ASTM D2344 - *Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates*
- ASTM D7264 - *Standard Test Methods for Flexural Properties of Polymer Matrix Composite Materials*
- ASTM D953 - *Standard Test Method for Bearing Strength of Plastics*
- ASTM D696 - *Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer*
- ASTM D1894 - *Standard Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting*
- ASTM D570 - *Standard Test Method for Water Absorption of Plastics*

The client provided two composite panels: a 48 inch by 48 inch composite panel with nominal thickness of 0.22 inches, and an 11 inch by 45 inch composite panel with nominal thickness of 0.95 inches.

The standard pontoon laminate will consist of (1) 4008 ±45, (7) 5400 0/90, and (1) 4008 ±45. This results in a total fabric areal weight of 474 oz./yd^2 (16 oz./yd^2 stitched mat (3%), 80 oz./yd^2 ±45 (17%), 378 oz./yd^2 0/90 (80%)) and a total thickness of 0.508 inches. The laminate schedule for the 0.22 inch test panels was derived to provide a similar ratio of fiber orientations while resulting in a thickness of less than 0.250". The test laminate consists of (1) 1708, (3) 5400, and (1) 1708, which has a total areal weight of 214 oz./yd^2 (16 oz./yd^2 stitched mat (7%), 36 oz./yd^2 ±45 (17%), and 162 oz./yd^2 0/90 (76%)). Due to the test laminate having a greater percentage of stitched-mat (non-structural fiber); mechanical testing will produce strength and stiffness values that are lower than the actual pontoon laminate and therefore conservative.

The layup of the 0.95 inch panel is $[V][0/90]_{14}[+-45]_4$. This thicker laminate is required in the regions that will undergo bearing loads at the bolted connections.

The bearing specimens were cut from the 0.95 inch thick panel using a water-cooled diamond-coated wet-saw. The rest the specimens were cut from the 0.22 inch thick panel using waterjet abrasive machining. Final specimen drilling and machining was performed using a milling machine.

Prior to conducting the tests, the specimens were conditioned for a minimum of 48-hours in the laboratory's Mechanical Testing Lab at a standard environment of 70 ±3°F and 50 ±5% RH. The testing was also performed in this Lab at standard environment.

The results of the various tests are summarized in the remainder of this document.

Material Property Test: Tension
Test Method: ASTM D3039 - *Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials*
Date Tested: May 5, 2014

Test Setup: Ten specimens were obtained from the panel at various locations in an effort to capture spatial variability of the properties. The nominal specimen size was 1.0 inch wide by 10 inches long.

A servo-hydraulic Instron test frame equipped with a 22 kip load cell and hydraulic grips was used to perform the tests. The tests were conducted in position control at a cross-head rate of 0.05 inches/minute. A contact extensometer with a gage length of 2.0 inches was used to measure the strain.

Results: The specimen dimensions and results of the tensile tests are presented in Table 1. The table includes the average value and coefficient of variation (CV) for the tensile strength and modulus. The modulus was computed between 1000-3000 micro-strain.

Table 1. Tension Test Results

Specimen	Width	Thickness	Area	Max Force	Strength	Modulus
ID	*in*	*in*	*in²*	*lb*	*ksi*	*msi*
1	1.018	0.2139	0.2177	9,809	45.06	3.11
2	1.019	0.2145	0.2185	10,152	46.47	3.07
3	1.018	0.2158	0.2198	11,004	50.06	3.10
4	1.019	0.2129	0.2170	10,508	48.42	3.29
5	1.018	0.2147	0.2184	10,707	49.01	3.04
6	1.018	0.2124	0.2162	9,213	42.61	3.00
7	1.018	0.2188	0.2227	10,546	47.35	3.03
8	1.020	0.2164	0.2206	10,361	46.96	3.02
9	1.018	0.2113	0.2151	9,757	45.36	3.23
10	1.019	0.2142	0.2181	9,939	45.56	3.03
Avg	**1.018**	**0.2145**	**0.2184**	**10,200**	**46.69**	**3.09**
CV	0.1%	1.0%	1.0%	5.2%	4.7%	3.1%

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- Instron 22-kip Test Frame AS# 108
- 22-kip Load Cell AS# 269
- Instron Extensometer AS# 1092

Material Property Test: Compression
Test Method: ASTM D6641 - *Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials Using a Combined Loading Compression (CLC) Test Fixture*
Date Tested: May 10, 2014

Test Setup: Ten specimens were obtained from the panel at various locations in an effort to capture spatial variability of the properties. The nominal specimen size was 1.0 inch wide by 5.5 inches long.

A servo-hydraulic Instron test frame equipped with a 22 kip load cell and hydraulic grips was used to perform the tests. A combined shear and compression loading test fixture was used to conduct the tests. The tests were conducted in position control at a cross-head rate of 0.05 inches/minute. A GOM Aramis digital image correlation (DIC) system was used to measure the strain during the test.

Results: The specimen dimensions and results of the compression tests are presented in Table 2. The table includes the average value and CV for the compressive strength and modulus. The modulus was computed between 1000-3000 micro-strain.

Table 2. Compression Test Results

Specimen ID	Width in	Thickness in	Area in^2	Max Force lb	Strength ksi	Modulus msi
1	1.018	0.2071	0.2108	10,181	48.30	3.22
2	1.018	0.2118	0.2157	12,825	59.46	3.40
3	1.017	0.2092	0.2129	12,324	57.90	3.50
4	1.018	0.2124	0.2163	13,140	60.76	3.64
5	1.017	0.2154	0.2192	12,118	55.29	3.58
6	1.016	0.2105	0.2139	12,534	58.59	3.04
7	1.018	0.2111	0.2148	11,753	54.72	3.34
8	1.018	0.2169	0.2206	12,517	56.73	3.08
9	1.018	0.2186	0.2225	12,821	57.62	3.44
10	1.018	0.2168	0.2207	12,781	57.90	3.29
Avg	**1.018**	**0.2130**	**0.2167**	**12,299**	**56.73**	**3.35**
CV	0.1%	1.8%	1.8%	6.9%	6.1%	5.9%

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- Instron 22-kip Test Frame AS# 107
- 22-kip Load Cell AS# 268
- CLC Test Fixture AS# 293
- GOM Aramis DIC System AS# 395

Material Property Test: In-Plane Shear
Test Method: ASTM D5379 - *Standard Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method*
Date Tested: May 10, 2014

Test Setup: Ten specimens were obtained from the panel at various locations in an effort to capture spatial variability of the properties. The nominal specimen size was 0.75 inches wide by 3.0 inches long.

A servo-hydraulic Instron test frame equipped with a 5 kip load cell and hydraulic grips was used to perform the tests. An iosepescu (v-notch) test fixture was used to apply the shear loads to the test specimens. The tests were conducted in position control at a cross-head rate of 0.05 inches/minute. A GOM Aramis DIC system was used to measure the strain during the test.

Results: The specimen dimensions and results of the in-plane shear tests are presented in Table 3. The table includes the average value and CV for the in-plane shear strength and modulus. The modulus was computed using a 4000 micro-strain range starting between 2000 and 2400 micro-strain. (The exact same starting strain point was not available for every specimen.)

Table 3. In-Plane Shear Test Results

	Notch					
Specimen	***Width***	***Thickness***	***Area***	**Max Force**	**Strength**	**Modulus**
ID	*in*	*in*	*in^2*	*lb*	*ksi*	*ksi*
1	0.482	0.2123	0.1024	1560	15.24	624.5
2	0.485	0.2137	0.1037	1507	14.53	651.7
3	0.484	0.2159	0.1044	1535	14.70	677.0
4	0.484	0.2098	0.1014	1484	14.63	606.4
5	0.483	0.2126	0.1027	1447	14.09	604.3
6	0.481	0.2067	0.0994	1481	14.90	626.8
7	0.484	0.2155	0.1043	1503	14.41	655.3
8	0.483	0.2098	0.1013	1406	13.88	619.8
9	0.487	0.2168	0.1055	1480	14.03	624.8
10	0.483	0.2138	0.1033	1451	14.05	606.0
Avg	0.484	0.2127	0.1028	1485	14.45	629.7
CV	0.3%	1.5%	1.7%	3.0%	3.0%	3.8%

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- Instron 22-kip Test Frame AS# 107
- 5-kip Load Cell AS# 601
- Shear Test Fixture AS# 301
- GOM Aramis DIC System AS# 395

Material Property Test: Interlaminar Shear
Test Method: ASTM D2344 - *Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates*
Date Tested: May 7, 2014

Test Setup: Ten specimens were obtained from the panel at various locations in an effort to capture spatial variability of the properties. The nominal specimen size was 0.5 inches wide by 1.3 inches long.

A servo-hydraulic Instron test frame equipped with a 5 kip load cell and a 3-point flexure fixture with a support span of 0.85 inches was used to perform the tests. The tests were conducted in position control at a cross-head rate of 0.05 inches/minute.

Results: The specimen dimensions and results of the short-beam shear tests are presented in Table 4. The table includes the average value and CV for the short-beam strength.

Table 4. Short-Beam Strength Test Results

Specimen	Length	Width	Thickness	Area	Max Force	Strength
#	in	in	in	in^2	lb	ksi
1	1.3010	0.5173	0.2066	0.1069	705	4.95
2	1.3025	0.5168	0.2075	0.1072	778	5.44
3	1.3030	0.5163	0.2110	0.1089	756	5.20
4	1.3005	0.5155	0.2126	0.1096	752	5.15
5	1.3055	0.5180	0.2086	0.1080	762	5.29
6	1.3025	0.5165	0.2082	0.1075	762	5.31
7	1.3050	0.5175	0.2166	0.1121	794	5.31
8	1.3025	0.5175	0.2191	0.1134	823	5.44
9	1.3045	0.5165	0.2116	0.1093	863	5.92
10	1.3025	0.5178	0.2142	0.1109	804	5.44
Avg	**1.3030**	**0.5170**	**0.2116**	**0.1094**	**780**	**5.35**
CV	*0.1%*	*0.2%*	*1.9%*	*2.0%*	*5.6%*	*4.8%*

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- Instron 22-kip Test Frame AS# 107
- 5-kip Load Cell AS# 601
- Flexure Fixture AS# 298

Material Property Test: Flexure
Test Method: ASTM D7264 - *Standard Test Method for Flexural Properties of Polymer Matrix Composite Materials*
Date Tested: May 7, 2014

Test Setup: Ten specimens were obtained from the panel at various locations in an effort to capture spatial variability of the properties. The nominal specimen size was 1.0 inch wide by 8.5 inches long.

A servo-hydraulic Instron test frame equipped with a 5-kip load cell and a 3-point flexure fixture with a support span of 7.026 inches were used during the flexure tests. The tests were conducted in position control at a cross-head rate of 0.10 inches/minute.

Results: The specimen dimensions and results of the flexure tests are presented in Table 5. The table includes the average value and CV for the flexural strength and modulus. The modulus was computed between 1000-3000 micro-strain.

Table 5. Flexure Test Results

Specimen	Length	Width	Thickness	Max Force	Strength	*Modulus*
ID	*in*	*in*	*in*	*lb*	*ksi*	*Msi*
1	8.573	1.0190	0.2093	212.2	50.09	2.92
2	8.568	1.0170	0.2133	228.1	51.95	2.52
3	8.566	1.0169	0.2149	226.7	50.91	2.55
4	8.582	1.0201	0.2125	239.8	54.88	2.83
5	8.590	1.0175	0.2134	225.3	51.23	2.57
6	8.579	1.0171	0.2142	225.6	50.95	2.25
7	8.535	1.0196	0.2148	228.7	51.24	2.55
8	8.581	1.0188	0.2173	228.6	50.08	2.40
9	8.576	1.0176	0.2154	238.1	53.15	2.52
10	8.545	1.0173	0.2056	217.2	53.20	2.73
Avg	**8.5693**	**1.0181**	**0.2131**	**227.0**	**51.77**	**2.58**
CV	*0.2%*	*0.1%*	*1.6%*	*3.6%*	*3.0%*	*7.7%*

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- Instron 22-kip Test Frame AS# 107
- 5-kip Load Cell AS# 601
- Flexure Fixture AS# 298

Material Property Test: Bearing
Test Method: ASTM D953 - *Standard Test Method for Bearing Strength of Plastics*
Date Tested: May 2-5, 2014

Test Setup: Ten specimens were obtained from the panel. The nominal specimen size was 4 inches wide by 10.5 inches long.

A servo-hydraulic Instron test frame equipped with a 110-kip load cell and hydraulic grips was used to perform the tests. A pin-bearing fixture was used to support the specimen at one end while load was applied to the 15/16 inch hole via a 7/8 inch hardened steel pin at the other end. The tests were conducted in position control at a cross-head rate of 0.05 inches/minute.

Results: The specimen dimensions and results of the bearing tests are presented in Table 6. The table includes the average value and CV for the bearing strength at the first drop in load and at the ultimate load.

Table 6. Bearing Strength Test Results

				Bearing	Force		Strength	
Specimen	Length	Width	Thickness	Area	*First drop*	*Ultimate*	*First drop*	*Ultimate*
#	*in*	*in*	*in*	*in²*	*lb*	*lb*	*ksi*	*ksi*
1	10.568	3.893	0.9115	0.8546	31,612	43,884	36.99	51.35
2	10.561	3.898	0.9268	0.8689	30,560	44,687	35.17	51.43
3	10.582	3.911	0.9180	0.8607	32,528	47,172	37.79	54.81
4	10.597	3.919	0.9187	0.8613	31,094	47,435	36.10	55.07
5	10.597	3.913	0.9235	0.8658	32,300	46,844	37.31	54.10
6	10.578	3.906	0.9084	0.8516	30,893	47,596	36.27	55.89
7	10.561	3.910	0.9281	0.8701	32,271	48,100	37.09	55.28
8	10.555	3.904	0.9188	0.8613	30,582	47,051	35.51	54.63
9	10.538	3.907	0.9187	0.8613	28,811	44,843	33.45	52.07
10	10.543	3.897	0.9172	0.8598	30,876	45,465	35.91	52.88
11	10.573	3.906	0.9221	0.8645	28,654	39,486	33.14	45.67
Avg	**10.568**	**3.906**	**0.919**	**0.862**	**30,926**	**45,687**	**35.89**	**53.02**
CV	***0.2%***	***0.2%***	***0.6%***	***0.6%***	***4.2%***	***5.4%***	***4.2%***	***5.5%***

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- Instron 110-kipTest Frame AS# 270
- 110-kip Load Cell AS# 110

Material Property Test: Coefficient of Thermal Expansion
Test Method: ASTM D696 - *Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer*
Date Tested: May 8-12, 2014

Test Setup: Ten specimens were obtained from the panel at various locations in an effort to capture spatial variability of the properties. The nominal specimen size was 0.5 inches wide by 2.0 inches long.

Two constant temperature baths (-22°F and 86°F) were used with a quartz dilatometer to conduct this testing as outlined in the standard. The specimens were kept in the bath until the deflection stabilized as indicated by an attached precision measuring device.

Results: The specimen dimensions and results of the coefficient of thermal expansion (CTE) tests are presented in Table 7. The table includes the average value and CV for the CTE.

Table 7. Coefficient of Thermal Expansion Test Results

Specimen	Length at room temp	Average change in length	CTE
#	*in*	*in*	*/°F x10^{-6}*
1	2.0335	0.001917	8.73
2	2.0350	0.001950	8.88
3	2.0300	0.001950	8.88
4	2.0325	0.001925	8.77
5	2.0380	0.001925	8.77
6	2.0370	0.001875	8.54
7	2.0345	0.001900	8.65
8	2.0360	0.001950	8.88
9	2.0375	0.001950	8.88
10	2.0380	0.001900	8.65
Avg	2.0352	0.001924	8.76
CV	0.13%	1.38%	1.38%

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- VWR Scientific Bath (+30°C) AS# 226
- VWR Scientific Bath (-30°C) AS# 208
- Tinius Olsen Dilatometer AS# 609`
- Mitutoyo Digital Gage AS# 725

Material Property Test: Coefficient of Friction
Test Method: ASTM D1894 - *Standard Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting*
Date Tested: May 12-20

Test Setup: Ten specimens were obtained from the panel at various locations in an effort to capture spatial variability of the properties. The nominal specimen size was 2.5 inches by 2.5 inches for the sled attachment, while the base section was 5.0 inches wide by 10 inches long.

The testing was conducted on a servo hydraulic Instron test frame equipped with a 56 pound load cell. A test fixture with a pulley and base attachment was used during the testing. The mass of the specimen sled was 4197 grams. The specimens were tested using the mold surface as the contact surface. The specimens were tested in a wet condition by adding water to the contact surfaces. Two different tests were conducted; original surface (as received) and with a bead-blasted surface. The glass bead blasting media used to prepare the surface was a 60-120 mesh applied at 80 psi.

Results: The results of the testing are presented in Table 8. The table includes both static and kinetic friction results for the two different tests conducted. Two trials were conducted with each specimen, so the results presented are the average value of the two trials.

Table 8. Coefficient of Friction Test Results

		Original Surface, Wet				***Bead-Blasted Surface, Wet***			
		Force		**Coefficient of Friction**		**Force**		**Coefficient of Friction**	
Specimen		static	kinetic			static	kinetic		
#	mass (g)	g	g	static	kinetic	g	g	static	kinetic
1	41.083	1733	1521	0.41	0.36	2328	2154	0.55	0.51
2	40.722	1549	1489	0.37	0.35	2497	2318	0.59	0.55
3	41.157	1472	1507	0.35	0.36	2694	2339	0.64	0.55
4	41.484	1535	1388	0.36	0.33	2430	2163	0.57	0.51
5	41.693	1662	1498	0.39	0.35	2260	1950	0.53	0.46
6	40.485	1474	1534	0.35	0.36	2561	1912	0.60	0.45
7	42.103	1614	1386	0.38	0.33	2518	2280	0.59	0.54
8	41.082	1623	1541	0.38	0.36	2535	2329	0.60	0.55
9	41.125	1705	1490	0.40	0.35	2334	2208	0.55	0.52
10	40.698	1561	1572	0.37	0.37	2303	2116	0.54	0.50
Avg	41.163	1593	1493	**0.38**	**0.35**	2446	2177	**0.58**	**0.51**
CV	1.2%	5.7%	4.1%	5.7%	4.1%	5.7%	7.0%	5.7%	7.0%

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- Instron 5-kip Test Frame AS# 511
- 56 lb. Load Cell AS# 611

Material Property Test: Water Absorption
Test Method: ASTM D570 - *Standard Test Method for Water Absorption of Plastics*
Date Tested: May 12-20

Test Setup: Ten specimens were obtained from the panel at various locations in an effort to capture spatial variability of the properties. The nominal specimen size was 1.0 inch wide by 3.0 inches long. The specimens were weighed while dry and then submerged in a bath of deionized water in a standard environment. The specimens were periodically removed from the bath, dried weighed, and then returned to soak in the bath.

Results: The results of the 24-hr soak and the 1-week soak time are presented in Table 9. The table includes the mean value and CV for the water absorption of the specimens.

Table 9. Water Absorption Test Results

	Dimensions				24 Hour Soak		1 Week Soak	
Specimen	Length	Width	Thickness	Dry Weight	Weight (g)	Water	Weight (g)	Water
#	*in*	*in*	*in*	*g*	*g*	Absorption	*g*	Absorption
1	2.9775	1.0190	0.20909	19.7906	19.8003	0.05%	19.8035	0.07%
2	2.9800	1.0175	0.21157	19.6936	19.7135	0.10%	19.7099	0.08%
3	2.9920	1.0185	0.21157	20.0207	20.0402	0.10%	20.0430	0.11%
4	2.9820	1.0175	0.22018	19.8197	19.8388	0.10%	19.8383	0.09%
5	2.9805	1.0170	0.20893	19.3718	19.3891	0.09%	19.3950	0.12%
6	2.9855	1.0250	0.21673	19.9215	19.9320	0.05%	19.9427	0.11%
7	2.9845	1.0195	0.20565	19.8210	19.8419	0.11%	19.8526	0.16%
8	2.9945	1.0190	0.21005	19.9727	19.9795	0.03%	19.9889	0.08%
9	3.0665	1.0195	0.20873	20.1635	20.1745	0.05%	20.1808	0.09%
10	2.9795	1.0180	0.20752	19.7021	19.7132	0.06%	19.7155	0.07%
Avg	2.9923	1.0191	0.21100	19.8277	19.8423	0.07%	19.8470	0.10%
CV	0.9%	0.2%	2.1%	1.1%	1.1%	36.1%	1.1%	29.0%

Equipment used:

- Mitutoyo Caliper AS# 1199
- Mitutoyo Micrometer AS# 1200
- Ohaus Scale AS# 657