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Final Report

On

Evaluation of Spraywall Structural Coating

To

Evan Rothblatt, EIT

Program Manager for Engineering

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AASHTO
THE VOICE OF TRANSPORTATION

By

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Introduction

TRI/Environmental was commissioned by the AASHTO APEL program to test a new product submitted for use by state Department of Transportation's (DOTs) in the United States. The purpose of the project was to characterize basic properties of a polyurethane structural coating used to rehabilitate underground infrastructures. The name of the product is SprayWall, produced by SprayRoq Protective Lining Systems.

APEL provided TRI a specific list of properties of interest identified by its members. The list included density, tensile, rupture, flexural, adhesion strength to steel and concrete, hardness, abrasion resistance, chemical resistance, vapor permeability, and creep response. In addition, the effect of exposure to UV light was requested. So after exposure to UV, specimens were tested for flexural, hardness, abrasion, and water vapor transmission properties. The test methods and the results obtained are described in individual sections for each. Pictures are included for the majority of the tests.

Samples

Plaques of specific thicknesses were requested from SprayRoq through APEL as required by the different test methods. Sample plaques for all but the adhesion tests were received February 17, 2017. Adhesion samples were received May 25, 2017. Due to the spray application methods used to produce the plaques, control of thickness was difficult. All the plaques had a smooth side and a side with surface undulations created by the application of the high viscosity unreacted polyurethane. All attempts were made to not polish out surface undulations in order to preserve the permeability characteristics of the coating unless the test required flat surfaces on both sides.

Specimen Preparation

Specimens were obtained from the plaques by either saw cutting or machining as required by the corresponding test methods. Critical specimens like tensile, flex, tear, and creep were precision machined to exact dimensions to minimize edge effects. Compressive creep required machining both surfaces in order to obtain as perfect as square as possible.

TEST PROCEDURES AND RESULTS

Density

The density of the sample was determined in accordance with *ASTM D 792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.* The method requires the determination of the weight of the sample and the volume. The weight is easily determined by use of a scale. The volume is determined by hanging the same specimen from a scale and then introducing it in water. Per the Archimedes principle, the change in weight observed in the scale caused by the buoyancy of the polymer represents the volume of water displaced by the specimen. Since 0.98 grams of water is the weight of 1mL of water at 23°C, the volume of the specimen is easily calculated.

The method requires that three replicate specimens be tested and the mean value reported. The results were as follows.

DENSITY (ASTM D 792)				TEST RESULTS
Test Replicate Number	1	2	3	Mean
Density (g/cm^3)	1.476	1.484	1.474	**1.478**

The results indicate that the resin is denser than water and will not float.

Tensile Properties

The tensile properties of the material were determined in accordance with ASTM D 638, *Test Method for Tensile Properties of Plastics.* Testing was performed using an Instron 5565 tension testing machine equipped with Merlin "smart" data acquisition system and scored grip faces for specimen clamping. Strain was measured using an extensometer connected at the end of the gauge area. Specimens were machined to exact specifications for a Type I specimen, and conditioned at laboratory testing environment for a minimum of thirty minutes prior to testing. The results are presented in the following table.

Figure 1 Tested Tensile Specimens

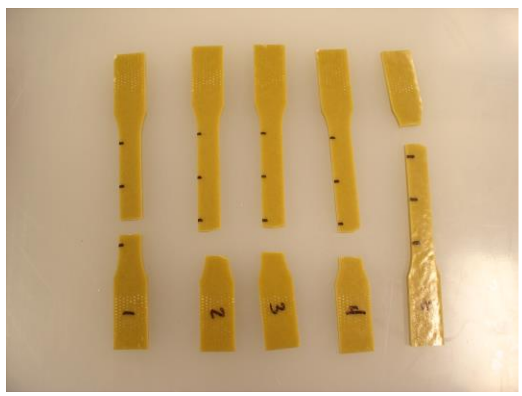
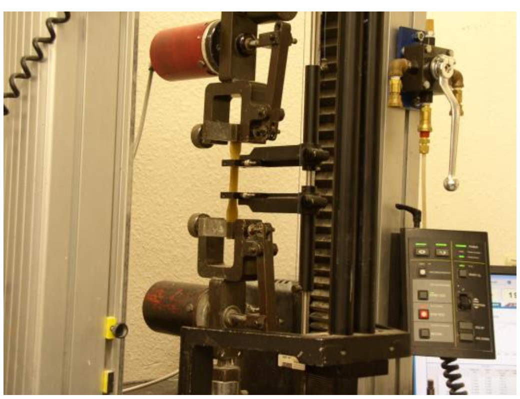


Figure 2 Untested Tensile Specimen



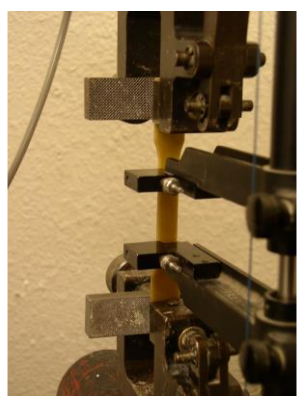


Figure 3 Specimen Under Test **Figure 4 Close up**

TENSILE PROPERTIES (ASTM D 638)						TEST RESULTS
Test Replicate Number	1	2	3	4	5	Mean
Tensile Yield Strength (psi)	8,725	7,843	6,554	7,174	7,114	**7,482**
Tensile Yield Strain (%)	1.52	1.17	0.90	1.03	1.01	**1.13**
Tensile Break Strength (psi)	8723	8657	7370	7955	8434	**8228**
Tensile Break Strain (%)	1.69	1.41	1.08	1.22	1.37	**1.35**
Young's Modulus (psi)	991,571	1,052,264	1,198,074	1,346,946	1,181,228	**1,154,016**

The results indicate the reacted polymer has a high strength relative to other polymers like HDPE, PP, or PVC. Its strain at break is very small like a brittle material and there may be little signs of incoming failure. Its Young modulus also indicates the large loads required to cause strain.

Flexural Modulus

The flexural modulus was determined in accordance to ASTM D790, *Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*. Procedure B was used according to ASTM D3350. The specimen was a bar, 0.5 in wide by 3 inches long. The thickness varied within the sample and to a certain degree within the specimen, which was saw cut from plaques provided by the manufacturer. Since the outer fiber at the center span of the specimen is the defining characteristic determining behavior, the thickness at this point was used for the calculations.

The test span was 2.0 inches and the rate of straining of the outer fiber was equal to 0.01 in/in/minute for procedure A resulting in either a crosshead rate of deflection of either 0.030 or 0.035 inches per minute. For procedure B the rate of straining of the outer fiber was equal to 0.1 in/in/minute with a crosshead rate of movement of 0.50, 0.55, or 0.70 inches per minute. A load vs. Deflection plot was obtained for each of the 5 specimens. Then, the displacement corresponding to a 1% strain in the outside surface was calculated by:

$$\mathbf{D = rL^2/6d}$$

Where:
D = Deflection of center at 1% strain (in),
r = strain (in/in),
L = support span (in), and
d = specimen thickness.

The required displacement varies with the thickness of the specimen. Therefore, each of the 5 test replicates will likely have a different displacement representing 1% strain. Once the displacement is determined, the corresponding load is found and the flexural stress at 1 % strain calculated by:

$$= \mathbf{3PL/2bd^2}$$

Where:
S = stress at 1 % strain (psi),
P = load at 1 % strain (lbf),
L = support span (in),
b = specimen width (in), and
d = specimen thickness.

The secant modulus at 1% strain is the ratio of stress to strain i.e. S/0.01. The results are shown in the following table.

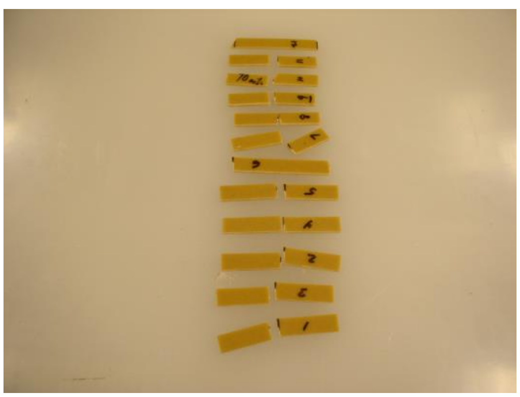


Figure 5 Flex Specimens

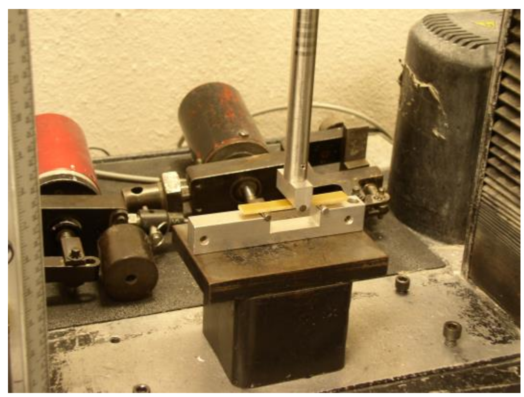


Figure 6 Flex Specimen Under Test

FLEXURAL MODULUS (ASTM D 790) **Procedure A**						TEST RESULTS
Test Replicate Number	1	2	3	4	5	Mean
Flexural Modulus (psi)	749,041	752,861	691,740	781,775	769,082	**748,900**
Flexural Secant modulus at 1% strain (psi)	741,302	740,536	679,665	765,743	751,914	**735,832**

FLEXURAL MODULUS (ASTM D 790) Procedure B						TEST RESULTS
Test Replicate Number	1	2	3	4	5	Mean
Flexural Modulus (psi)	737,272	797,082	786,411	775,298	755,815	**770,376**
Flexural Secant modulus at 1% strain (psi)	736,727	784,366	775,381	770,364	746,482	**762,573**

Rupture - Tear Strength

The tear strength was determined in accordance to ASTM D624, *Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers*. The tear strength of the material is evaluated by applying a tearing strength by means of a tensile testing machine. Type C (right angle) specimens were machined to exact specification as described in the test method. Type C specimen's main characteristic is a right angle within the specimens. Type C measures rupture, or tear initiation strength at the stress concentration located at the 90° apex. If tear initiation does not occur at the apex, the results are more indicative of tensile strength than tear strength. Specimens were machined to eliminate the edge effects usually caused by die cutting of semi-brittle or brittle materials. Prior to application of load, specimens were conditioned for a minimum of 3 hours at 23°C. As for the flexural modulus test, no attempt was made to sand the specimens to a precise thickness so as to not change the surface nature of the material and any contribution it may lend to the tear strength. The thickness was measured at 3 locations across the width near the center of the specimen. The maximum load to cause the tear was recorded for all five specimens. The results are as follows.

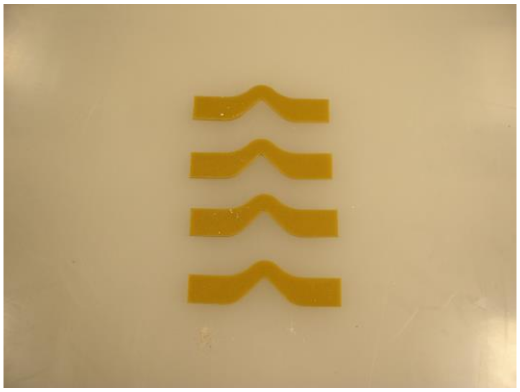


Figure 7 Untested Tear Strength Specimens

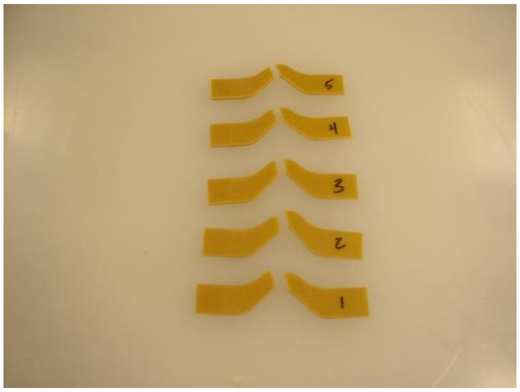


Figure 8 Tested Tear Strength Specimens

Tear Strength						TEST RESULTS
Test Replicate Number	1	2	3	4	5	Mean
Average Specimen Thickness (Inches)	0.1262	0.1044	0.1044	0.1079	0.1100	0.1106
Max Load (lbf)	79.04	57.65	49.85	43.50	46.26	55.26
Tear Strength (lbf/in)	626	552	477	403	421	**496**

The results above illustrate both the variability of the thickness and also that although the tear strength is directly proportional to thickness; it is also affected by either specimen preparation or imperfections in the specimen that contribute to determine the maximum load.

Durometer Hardness

The hardness of the material was determined in accordance with ASTM D2240, *Test Method for* Rubber Property—Durometer Hardness. This test method permits hardness measurements based on initial indentation caused by a specific indentor. Indentor type D was used which has a 0.1 mm radius tip and a 2.5 mm length. A manual (hand held) digital durometer was used to take 5 measurements in different locations of the specimen.

The results were as follows:

DUROMETER HARDNESS						TEST RESULTS
Test Replicate Number	1	2	3	4	5	Mean
Hardness	85	85	86	86	86	**86**

Taber Abrasion

The abrasion of the material was determined in accordance with ASTM D4060, *Test Method for Abrasion Resistance of Organic Coatings by the Taber Abrader*. This test method uses the rotation of the specimen surface under a pair of weighted abrasive wheels. CS-17 wheels were used with a weight of 1000 grams. Initial weight was measured and also after 1000, 2000, 3000, 4000, and 5000 cycles. The amount of mass lost after every 1000 cycles was calculated as well as the wear index per 1000 cycles of wear. The results were as follows:

Figure 10 Taber Abrasion Specimens

Figure 11 Taber Abrasion Test

TABER ABRASION							TEST RESULTS
	Weight (mg)			Weight Loss/Wear Index (mg/1000 cycles)			Wear Index (mg/1000 cycles)
Test Replicate Number	1	2	3	1	2	3	Mean
Initial	83.7737	95.4960	98.0389	0	0	0	0
Weight at 1000 Cycles	83.7075	95.4011	97.9879	0.0662	0.0949	0.0510	0.0707
Weight at 2000 Cycles	83.6467	95.3274	97.9409	0.0608	0.0737	0.0470	0.0605
Weight at 3000 Cycles	83.5810	95.2519	97.8975	0.0657	0.0755	0.0434	0.0615
Weight at 4000 Cycles	83.5200	95.1850	97.8540	0.0610	0.0669	0.0435	0.0571
Weight at 5000 Cycles	83.4576	95.1120	97.7986	0.0624	0.0730	0.0554	0.0636
Wear Index							**0.0627**

The wear index test suffers from large variability as demonstrated by the data and these results should be used cautiously in specification development.

Adhesion to Concrete

The adhesion of the coating material was determined in accordance with ASTM D7234, *Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers*. This test method uses a portable pull-off adhesion tester. Small metal coupons (dolly) are glued to the surface coating applied to a flat piece of concrete meeting the requirements of ASTM C14. The perimeter of the area under the dolly is scored all the way to the concrete to isolate the coating under test. A PosiTest AT-M Manual Adhesion Tester with digital display was used to pull the dolly which automatically stores the highest pull strength per dolly lifted. The test device is attached to the dolly and this in turn applies a pulling force to the dolly which puts in tension the material right under the dolly. The tension is felt by both the bond between the dolly and the coating, as well as the bond between the coating and the concrete. The material used to glue the dolly is intentionally chosen to exceed the tensile strength of the concrete used in the test as this strength defines the maximum strength achievable. Ten 20 mm diameter dollies were glued to the coating on the concrete and nine were pulled. Results of dollies that failed during preparation or that fail between the dolly and the coating are not reported. The results obtained for those specimens that failed between the bond of the applied coating and the concrete are as follows:

Figure 12 Coated Concrete Plate

Figure 13 Concrete Plate after Test

Adhesion to Concrete										TEST RESULTS
Test Replicate Number	1	2	3	4	5	6	8	9	10	Mean
Adhesion Strength (psi)	388	112	461	257	364	373	394	370	361	**342**

The tensile strength of concrete can be estimated to be 10% of its compressive strength so the adhesion strength of this material exceeds the typical tensile strength of concretes used in underground structures for the conveyance of water per ASTM C14. It must be mentioned that ASTM C14 doesn’t specify a compressive strength required for the concrete used as substrate.

Adhesion to Galvanized Steel

The adhesion of the coating material was determined in accordance with ASTM D4541, *Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.* This test method uses a portable pull-off adhesion tester. Small metal coupons (dolly) are glued to the surface coating applied to a flat metal plate. The perimeter of the area under the dolly is scored all the way to the metal to isolate the coating under test. A PosiTest AT-M Manual Adhesion Tester with digital display was used to pull the dolly which automatically stores the highest pull strength per dolly lifted. The test device is attached to the dolly and this in turn applies a pulling force to the dolly which puts in tension the material right under the dolly. The tension is felt by both the bond between the dolly and the coating, as well as the bond between the coating and the metal. The material used to glue the dolly is intentionally chosen to have as large as possible adhesion tensile strength as the maximum needed is unknown. Ten 20 mm diameter dollies were glued to the coating on the metal and seven were pulled. Results of dollies that failed during preparation or failed between the dolly and the coating are not reported. The results obtained for those specimens that failed between the bond of the applied coating and the metal are as follows:

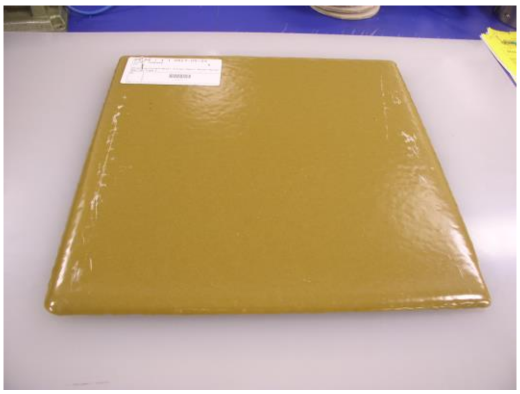


Figure 14 Coated Steel Plate

Figure 15 Steel Plate after Test

Adhesion to Metal								TEST RESULTS
Test Replicate Number	4	5	6	7	8	9	10	Mean
Adhesion Strength (psi)	382	594	493	452	399	412	382	**445**

All the dollies reported failed by the disbondment of the zinc layer. So these results are not as high as they could be if the material had been applied directly to steel.

Water Vapor Transmission

The water vapor transmission of the material was determined in accordance with ASTM E96, *Test Method for Water Vapor Transmission of Materials*. This test method permits water vapor permeability measurements based on actual water use. The method consists of placing specimen under test as the lid to a water tight container. The specimen is the only means for the water vapor produced in the container to escape. The whole container is weight initially and periodically to detect the amount of water vapor transmitted through the specimen. A numerical or graphical analysis is used to calculate the water vapor transmission over the duration of the test by fitting a straight line to the time vs. mass data pairs by use of a regression analysis.

Due to the low permeability of the material several sampling events were needed to generate specimens that were flat enough, big enough for large exposure surface, and thin enough to get meaningful results. The material is very brittle and as it is gets thinner during machining it fractures very easily.

The results were as follows:

WATER VAPOR TRANSMISSION			TEST RESULTS
Test Replicate Number	1	2	Mean
Water Vapor Transmission (cm/s)	6.76E-14	7.02E-14	**6.89E-14**

Chemical Resistance

The chemical resistance of the material was determined in accordance with ASTM G20, *Chemical Resistance of Pipeline Coatings*. This test method is a simple jar submersion test. The sample is simply submerged half way in the chemical of interest. This exposes the specimen to three different conditions that can attack the specimen as they represent three methods of chemical attack. The first condition is the fully submerged exposure which can lead to reactions in solution. The second condition is the evaporation zone which occurs right above the solution where the specimen will see solution, air, and vapor. This condition can also lead to higher concentrations of salts for some chemicals that are ionic like table salt. The availability of solution, air, and vapor can lead to accelerated degradation of the specimen. The third condition is the exposure to the water and chemical vapor. This condition allows both the water and the chemical to travel farther into the specimen due to the single molecule being able to move within the interstitials of the specimen. Eight different chemicals were used as identified by APEL. The chemicals used were gasoline, 10% hydrochloric acid, methyl ethyl ketone, 10% sodium chloride, 10% sodium hydroxide, 30% sulfuric acid, toluene, and 10% magnesium chloride. Since the specimens were flat and not pipe shape, 2 specimens per jar were used. Three jars per chemical were used for a total of 6 specimens per chemical. One jar per chemical was removed every 30 days and the specimens were visually compared to the original samples received. The results obtained are as follows:

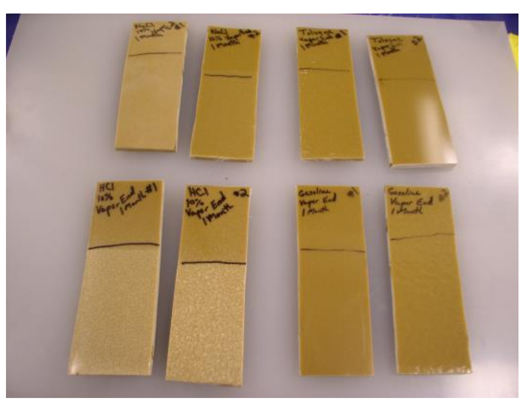


Figure 16 One month exposure

Figure 17 One Month Exposure

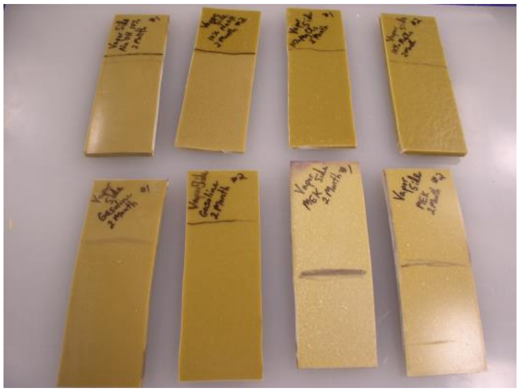


Figure 18 Two Month Exposure

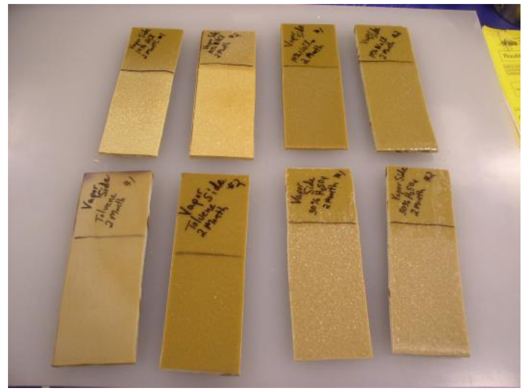


Figure 19 Two Month Exposure

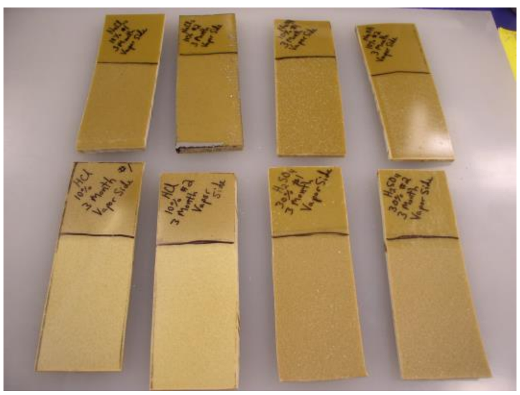


Figure 20 Three Month Exposure

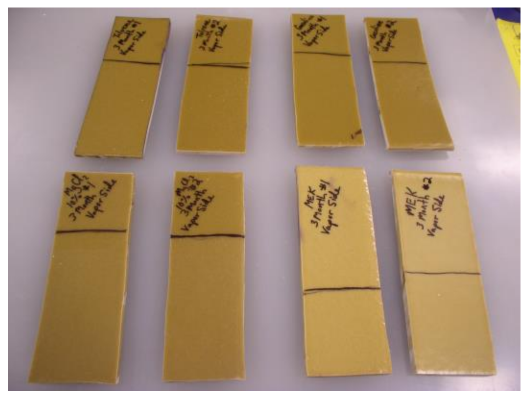


Figure 21 Three Month Exposure

Chemical Resistance						
Test Replicate Number	1	2	1	2	1	2
Chemical	30 Days		60 days		90 Days	
Gasoline	OK	OK	OK	OK	OK	OK
10% Hydrochloric Acid	SS Color SS Gloss	SS Color SS Gloss	SS Color SS Gloss	SS Color SS Gloss	SS Color SS Gloss	SS Color SS Gloss

Methyl Ethyl Ketone	OK	OK	OK	OK	OK	OK
10% Sodium Chloride	S Color	S Color	S Color	S Color	S Color	S Color
10% Sodium Hydroxide	S Color	S Color	S Color	S Color	S Color	S Color
30% Sulfuric Acid	SS Color SS Gloss	SS Color SS Gloss	SS Color SS Gloss	SS Color SS Gloss	SS Color SS Gloss	SS Color SS Gloss
Toluene	OK	OK	OK	OK	OK	OK
10% Magnesium Chloride	OK	OK	OK	OK	OK	OK

S Color = Slight change in color
SS Color = Severe change in color
SS Gloss = Severe loss of gloss

Creep

The creep properties of the coating material were determined in accordance with ASTM D6992, *Test Method for accelerated tensile creep and creep-rupture of geosynthetic materials based on time temperature superposition using the stepped isothermal method (SIM).* This test method is being used as a replacement for ASTM D2990 in order to produce results in the short amount of time required by the contract. In addition, single specimen tests were conducted using conventional creep to demonstrate that both methods provide the same information. Figure 22 shows the curves obtained from both tests at 1000 and 2000 psi indicating that for this material the tests are equivalent. SIM shows a full curve while conventional creep only a portion for the shortest exposure time.

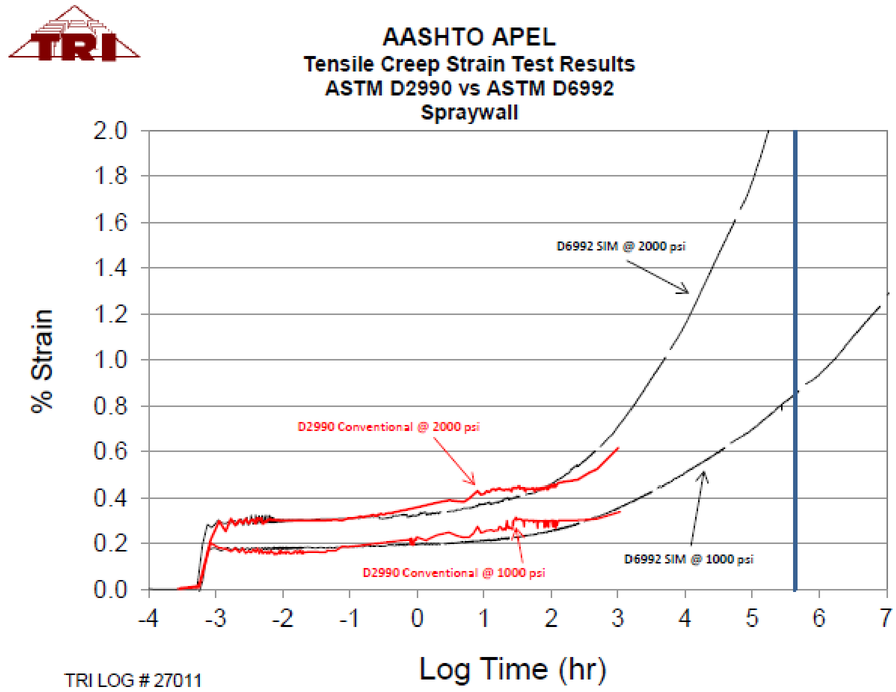


Figure 22 – Conventional and SIM Graphs

Every material responds to a constant load by deforming to accommodate the load and reduce the local stresses cause by the load. By measuring the deflection cause by the constant load one can determine the creep behavior of the material. The response to the load depends on the type of load applied. The loads can be applied in tension, compression, and flexure. Each type of load has to be treated separately. In addition, the amount of load provides a different strain response leading to different parameters to use for design at different ages. Measurement of the deflection caused by each type of load over time is critical.

The test consists of loading a specimen at room temperature for 10,000 seconds as the deflection is recorded. At the end of the 10,000 seconds, the temperature is increased by 7°C instantly in the chamber by use of high volumes of heated air to allow the specimen to reach the new temperature, all while recording deflection. The specimen sits for 10,000 seconds at this temperature before the temperature is increased again by 7°C. This process is repeated for several cycles to obtain enough data to make mathematical predictions of properties at a specific temperature and age of interest.

The specimen used for tensile creep is an ASTM D638, type I dog bone. The specimen used for compression creep is a 1” cube made of multiple machined layers of material made from 0.5” plaques. Testing of compression requires flat surfaces and complete contact between testing surfaces. Machining of both sides of the specimen was necessary in order to produce a perfect cube. The specimen used for flexural creep was a half inch wide, three inch long, and as close to 0.125’ thick as possible. The minimum span to thickness ratio of 16 was met by selecting specimens of this thickness.

Tensile Creep Properties

The results obtained for 50 year tensile creep tests are as follows:

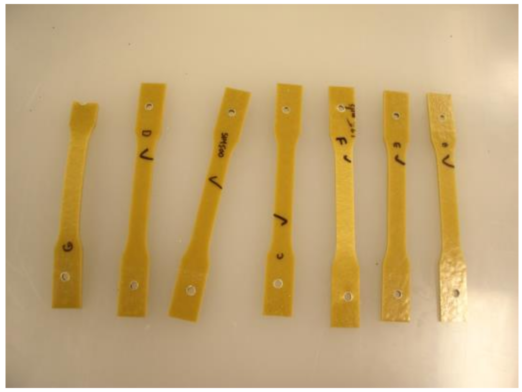


Figure 23 Tensile Creep Tested Specimens

50 Year Tensile Creep Properties								
Stress Applied (psi)	400	500	600	700	1000	1250	1500	2000
Strain (%)	0.334	0.411	0.501	0.604	0.853	1.21	1.72	2.39
Modulus (psi)	119,896	121,573	119,662	115,840	117,292	102,902	87,272	83,696

For stresses less than 1000 psi, the modulus tends to be constant within the variability of the test system. However, the amount of strain is significant and attention needs to be paid to it in any design. Using this data designers can chose the load appropriate for their specific needs.

Compressive Creep Properties

The results obtained for 50 year compressive creep tests are as follows:

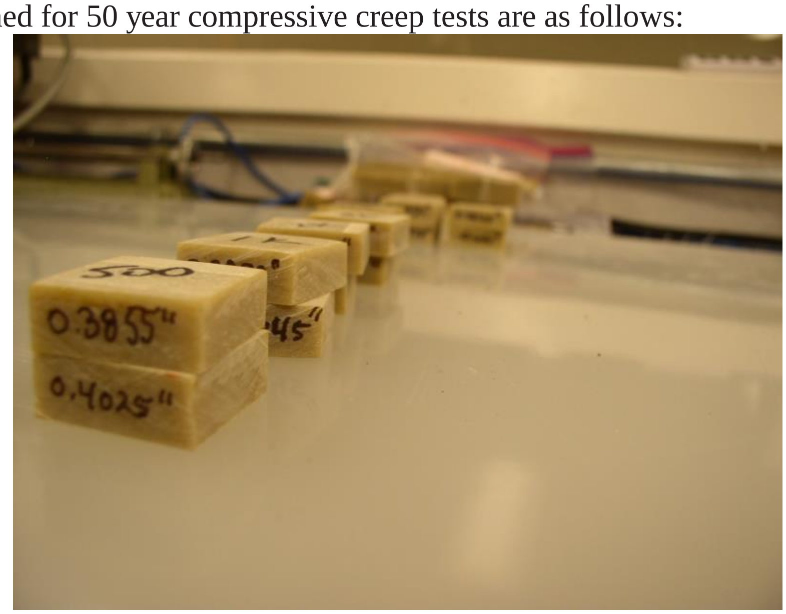


Figure 24 Tensile Creep Tested Specimens

50 Year Compressive Creep Properties									
Stress Applied (psi)	500	1000	2000	3000	4000	6000	7000	8000	10000
Strain (%)	0.730	1.173	1.590	2.430	3.238	3.853	5.040	8.274	12.630
Modulus (psi)	68,677	85,528	126,643	123,477	124,228	157,305	138,513	97,954	80,003

Using this data designers can chose the load appropriate for their specific needs. Special attention needs to be paid to the amount of strain caused by these loads as this can greatly influence the behavior of any design.

Flexural Creep Properties

The results obtained for 50 year Flexural creep tests are as follows:

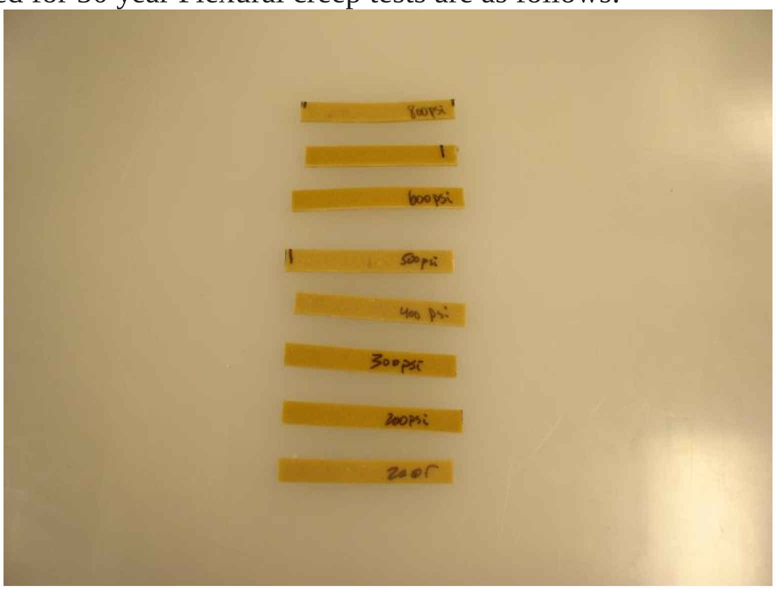


Figure 25 Flexural Creep Specimens

Stress Applied (psi)	200	300	400	500	600	800
Strain (%)	0.108	0.200	0.319	0.475	0.657	0.850
Modulus (psi)	184,480	150,072	125,507	105,320	91,367	94,640

Using this data designers can chose the load appropriate for their specific needs. For stresses greater than 400 psi, the modulus is greatly reduced and the amount of strain is large.

Ultraviolet Light Effect

The material was exposed to Ultraviolet Light (UV) in accordance with ASTM D4329, *Standard Practice for Fluorescent UV Exposure of Plastics*. Exposure was performed using a Q-Lab QUV/se accelerated weathering chamber. Cycle A of ASTM D4329 was used as requested by APEL. Exposure lasted 1000 hours. Whole plaques were exposed and cutting of the test specimens was conducted after to prevent exposure of the edges to the UV. After exposure, best fit specimens were tested for flexural properties, hardness, abrasion resistance, and water vapor permeability. Flexural specimens were machined to exact specifications for a half inch bar wide specimen. The results are presented in the following table along with the base material for easy comparison.

FLEXURAL MODULUS (ASTM D 790)						TEST RESULTS
Test Replicate Number	1	2	3	4	5	Mean
Flexural Modulus (psi)	749,041	752,861	691,740	781,775	769,082	**748,900**
UV Flexural Modulus (psi)	769,204	801,197	789,785	791,317	762,551	**782,811**
Flexural Secant modulus at 1% strain (psi)	741,302	740,536	679,665	765,743	751,914	**735,832**
UV Flexural Secant modulus at 1% strain (psi)	755,805	788,761	779,997	781,770	753,408	**771,948**

DUROMETER HARDNESS						TEST RESULTS
Test Replicate Number	1	2	3	4	5	Mean
Hardness	85	85	86	86	86	**86**
UV Hardness	85	83	86	88	88	**86**

TABER ABRASION		
Cycles	Wear Index (mg/1000 cycles)	UV Wear Index (mg/1000 cycles)
1000	0.0707	0.0939
2000	0.0605	0.0798
3000	0.0615	0.0539
4000	0.0571	0.0568
5000	0.0636	0.0513

WATER VAPOR TRANSMISSION			TEST RESULTS
Test Replicate Number	1	2	Mean
Water Vapor Transmission (cm/s)	6.76E-14	7.02E-14	**6.89E-14**
UV Water Vapor Transmission (cm/s)	2.25E-13	1.22E-13	**1.73E-13**

The effect of UV exposure is minimal but this is mainly to the high thickness of the material used for testing

Short Form Report

All the results from these tests are summarized in the following short form report for the convenience of use by State DOTs.

SprayRoq Spraywall Test Results			
Test	**ASTM**	**Result**	**Units**
Density	D792	1.474	g/cm3
Tensile Yield Strength	D638	7,482	psi
Tensile Yield Strain		1.13	%
Tensile Break Strength		8,228	psi
Tensile Break Strain		1.35	%
Young's Modulus		1,154,016	psi
Flexural Modulus	D790	748,900	psi
UV Flexural Modulus		782,811	
Flexural Modulus (1%)		735,832	
UV Flexural Modulus (1%)		771,948	
Tear Strength	D624	496	lbf/in
Durometer Hardness	D2240	86	
UV Durometer Hardness		86	
Taber Abrasion	D4060	0.0627	mg/1000 Cycles
UV Taber Abrasion		0.0611	
Concrete Adhesion	D7234	342	psi
Steel Adhesion	D4541	445	psi
Water Vapor Transmission	E96	1.14E-13	cm/s
UV Water Vapor Transmission		1.13E-13	cm/s
Chemical Resistance - Gasoline	G20	Pass	Pass/Fail, Days
Chemical Resistance – 10% HCl		30	
Chemical Resistance – MEK		Pass	
Chemical Resistance – 10% NaCl		30	
Chemical Resistance – 10% $Na(OH)_2$		30	
Chemical Resistance – 30% H_2SO_4		30	
Chemical Resistance – Toluene		Pass	
Chemical Resistance – 10% $MgCl_2$		Pass	
50 Year Creep Modulus – Tensile – 500 psi	D6992 /D2990	121,573	psi
50 Year Creep Modulus – Tensile – 1000 psi		117,292	
50 Year Creep Modulus – Tensile – 1500 psi		87,272	
50 Year Creep Modulus – Tensile – 2000 psi		83,696	
50 Year Creep Modulus – Compressive – 500 psi	D6992 /D2990	68677	psi
50 Year Creep Modulus – Compressive – 1000 psi		85528	
50 Year Creep Modulus – Compressive – 2000 psi		126643	
50 Year Creep Modulus – Compressive – 4000 psi		124228	
50 Year Creep Modulus – Compressive – 6000 psi		157305	
50 Year Creep Modulus – Compressive – 8000 psi		97954	
50 Year Creep Modulus – Compressive – 10000 psi		80003	
50 Year Creep Modulus – Flexural – 200 psi	D6992 /D2990	184,480	psi
50 Year Creep Modulus – Flexural – 300 psi		150,072	
50 Year Creep Modulus – Flexural – 400 psi		125,507	
50 Year Creep Modulus – Flexural – 500 psi		105,320	
50 Year Creep Modulus – Flexural – 600 psi		91,367	
50 Year Creep Modulus – Flexural – 800 psi		94,640	

Comparison of TRI results versus SprayRoq Data

The following report compares the data obtained in this project versus data reported by SprayRoq. For some test results reported by SprayRoq, unit conversions were necessary in order to be able to compare side by side.

SprayRoq Spraywall Test Results – TRI vs. SprayRoq				
Test	**ASTM**	**TRI**	**Spray**	**Units/Comments**
Density	D792	1.474	1.396	g/cm3
Tensile Yield Strength	D638	7,482	7450	psi
Tensile Yield Strain		1.13	<4%	%
Flexural Modulus	D790	748,900	735,000	psi
Tear Strength	D624	496	NA	lbf/in
Durometer Hardness	D2240	86	85	
Concrete Adhesion	D7234	342	>200	psi
Steel Adhesion	D4541	445	>1,600	psi, Zn vs. Steel
Water Vapor Transmission	E96	1.14E-13		cm/s
Chemical Resistance - Gasoline	G20	Pass	Pass	
Chemical Resistance – 10% HCl		30	Pass	Severe Color, Gloss
Chemical Resistance – MEK		Pass	Fail	
Chemical Resistance – 10% NaCl		30	NA	Slight Color
Chemical Resistance – 10% $Na(OH)_2$		30	NA	Slight Color
Chemical Resistance – 30% H_2SO_4		30	NA	Severe Color, Gloss
Chemical Resistance – Toluene		Pass	Pass	
Chemical Resistance – 10% $MgCl_2$		Pass	NA	

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