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www.atslab.com 1049 Triad Court Marietta • GA 30062 • 770-423-1400

Finite Element Analysis Report

for the

PVC Pilings

for

Shoreline Plastics, LLC

300 Alton Box Rd W
Jacksonville, FL 32218

Report Date: September 17, 2019

Prepared by: ______________________ **John Loesel**
Senior Consultant

Reviewed by: ______________________ **Jeremy Orr, P.E.**
Principal Engineer - Manager

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Attachments

Client Supplied Dimensions and Material Specifications.

Background and Finite Element Analysis Results

Background

This report contains the results of the finite element analysis (FEA) performed on one design of a PVC piling in four (4) different sizes, which were provided by Shoreline Plastics LLC (client). The client requested the analysis to compare the deflection of various piling designs when subjected to a lateral load of 200lbs, as well as a buckling analysis to determine an estimated buckling load limit. Per the requested scope of work, a linear static analysis was performed. Frequency, transient, thermal, or other types of loading were not considered in the analysis. The maximum resultant displacements and theoretical buckling limit for the four sizes were estimated with the FEA analysis and are presented below.

Finite Element Analysis - Setup

The finite element models consisting of solid elements were constructed from the client provided cross section drawings. Five(5) sizes of one (1) piling design cross section were submitted for analysis and were named EP10, EP12, EP14, EP16 in reference to their outer diameter. Refer to the charts below for dimesions of each size. The models were based on the client provided dimensions with direction from the client. ATS did not modify or simplify the designs for the analysis. Loading was assumed to be steady state, and did not include analysis of any acceleration, deceleration, or transient effects. The material was a client specified Rigid PVC with Stranded FIberglass Blend and the client provided the relevant material properties which are located in the attachments.

A representative 10' section of piling was modeled for each cross section. The base of the piling was fixed (to simulate/approximate the bottom of the pipe being buried). A 200lb lateral load was applied to the very top of the pilings. A linear static analysis was then performed using the specified loads and restraints to determine a lateral displacement for comparison.

Component	Material	Yield Strength (MPa)	UTS (psi)	Youngs Modulus (MPa)	Shear Modulus (MPa)	Poisson's Ratio
Pilings (5x)	Rigid PVC w/ Stranded Fiberglass Blend (Client Spec)	103	N/A	9,650	3,644	0.324

The following loads were considered in the analysis:

Load	Value	Notes
Lateral Load	200 lbs	Load applied at the top face of the pilings.

Background and Finite Element Analysis Results

Finite Element Analysis - Results

The following results were obtained using the above linear static analysis, restraints, and loads. Solidworks 2017 was also used to calculate the area moment of inertia. Follow-up hand calculations using cantilever beam formulas matched the results of the FEA study to within 0.005". The estimated stresses for all beams were less than 11% of the stated yield strength of 103 MPa and all simulations were determined to be within the linear elastic range and non-linear anaylsis was not performed (as well as being outside the requested scope of work).

Piling Design	O.D. (in)	O.D. Thick. (in)	Int. Thick. (in)	Area Moment Of Inertia (lowest) in^4	FEA Estimated Deflection @10ft Length (in)	Beam Calculation Deflection (in)
10	10.000	0.300	0.175	152.9	**0.543**	0.538
12	12.000	0.340	0.230	315.4	**0.264**	0.261
14	14.000	0.350	0.250	533.0	**0.157**	0.154
16	16.000	0.360	0.300	873.2	**0.097**	0.094

The design with the least amount of deflection was determined to be EP16 as seen in the above chart. ATS did not perform factor of safety, stress, thermal, or frequency analysis on these parts. This analysis does not constitute an engineering review or evaluation for use of the piling or overall system design. The analysis was limited to determining the least amount of lateral deflection to the subjected load.

Maximum displacement plots for each design are located in "Finite Element Analysis Plots" that immediately follows.

Background and Finite Element Analysis Results

Finite Element Analysis - Buckling Results

Solidworks 2017 was used to determine a theoretical Buckling Load Factor (BLF) when the client specified length of piling (which differed for each size) was subjected to a vertical 10,000 lb load. Per the client, 30% of the span length is buried. The buried portion of the piping was fixed in place and vertical load was applied to the very top of the pilings. Refer to the attached images for a visual representation of the buckling FEA setup.

The theoretical estimated buckling load factor and buckling limit are listed below. It is important to note that the numbers shown below are estimates based on simple linear buckling analysis. The approach that was followed for this analysis (using a linear elastic buckling model without bifurcation analysis) should be heavily scrutinized and likely results in non-conservative values. This is due to the assumed perfect geometries as compared to reality where geometric nonlinearities exist. Discretization errors also effect the results. In general, such an approach should be used as a first screening in a complete buckling study which was outside the requested scope of work.

Piling Design	O.D. (in)	O.D. Thick. (in)	Int. Thick. (in)	Overall Length Of Column (ft)	Buried Length (30%) (ft)	Unsupporte d Cumn Length (ft)	Buckling Load Factor at 10,000 lbs	FEA Estimated Buckling Limit (lbs)
10	10.000	0.300	0.175	20.0	6.0	14.0	2.03	**20,300**
12	12.000	0.340	0.230	30.0	9.0	21.0	1.73	**17,300**
14	14.000	0.350	0.250	40.0	12.0	28.0	1.62	**16,237**
16	16.000	0.360	0.300	50.0	15.0	35.0	1.70	**17,024**

Finite Element Analysis Plots

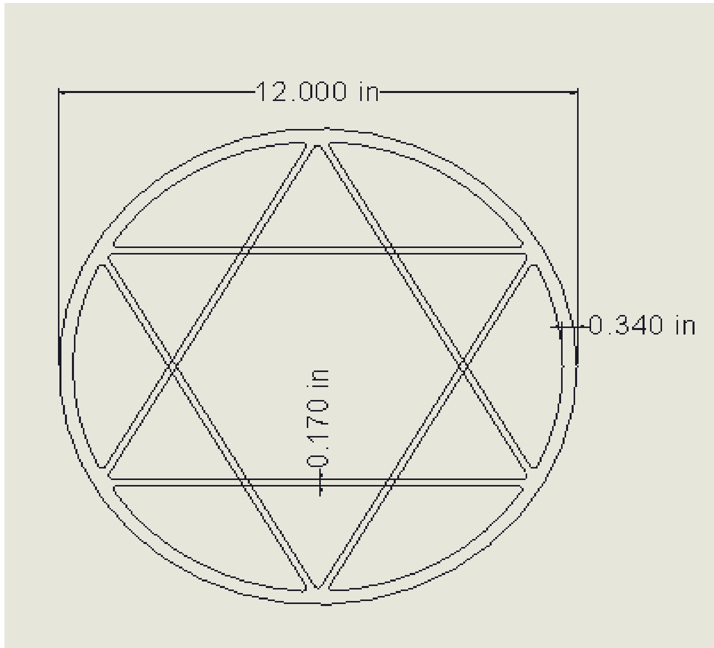

Photo 1: Typical client supplied piling cross section (sizes and thickness vary per size).

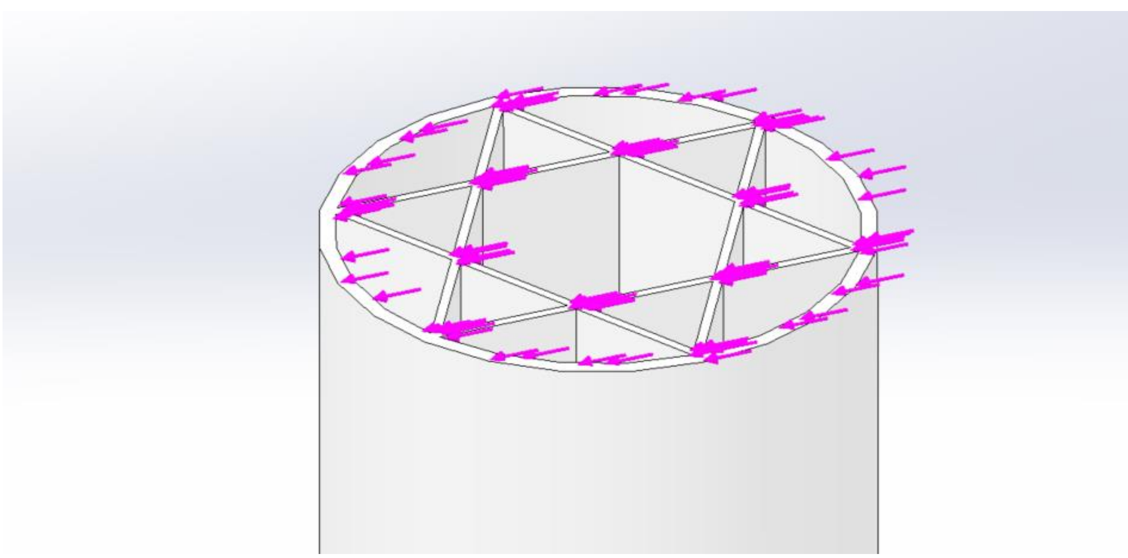

Photo 2: Typical view of 200lb lateral load applied to the top face of the pilings.

Finite Element Analysis Plots

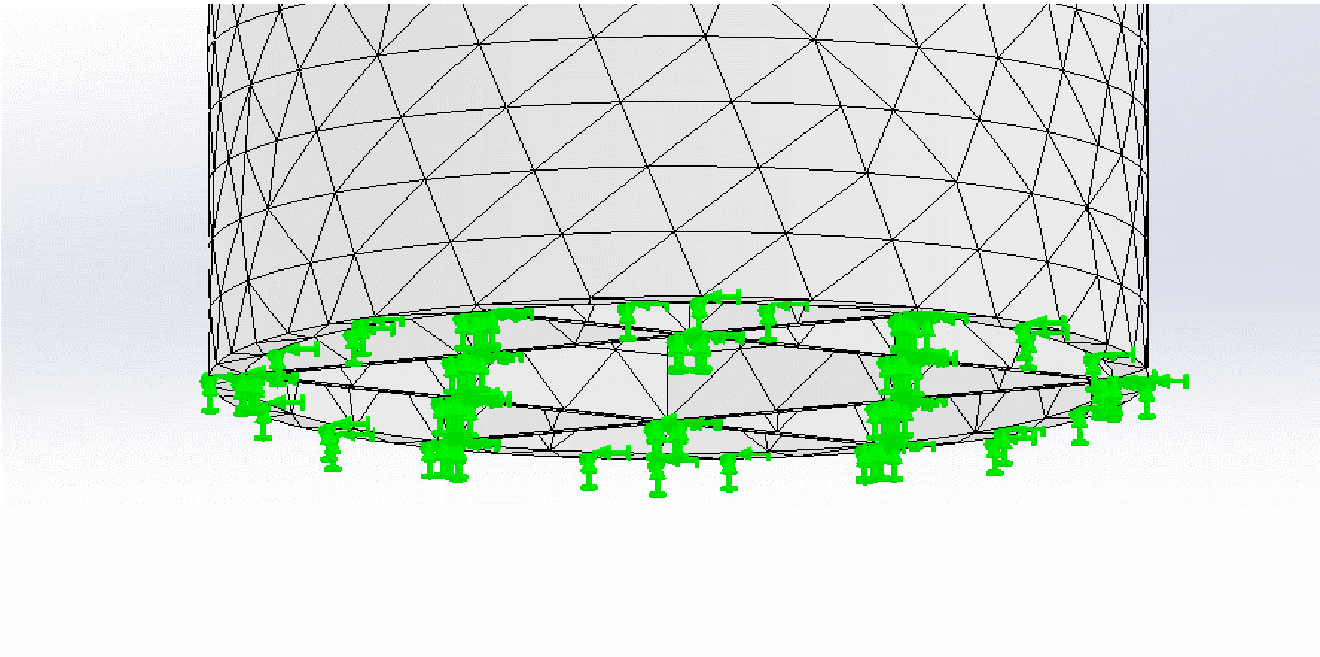

Photo 3: Typical view of the fixed restraint to the bottom of the pilings.

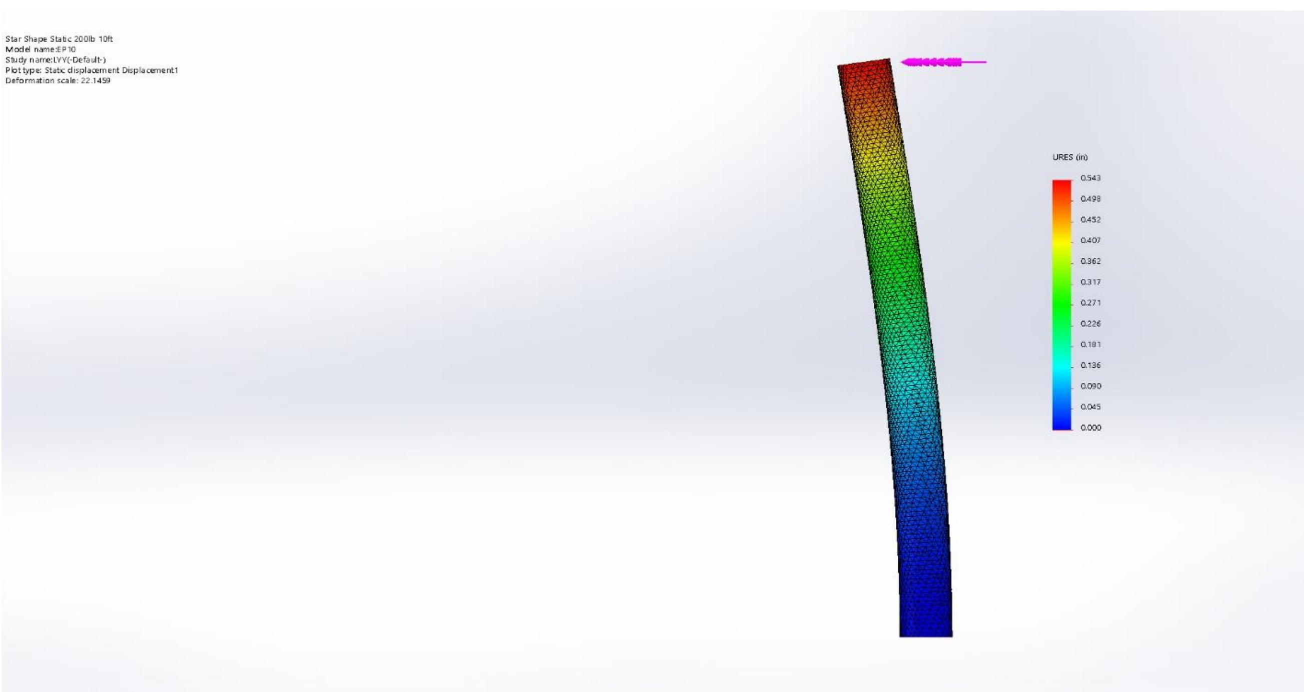

Photo 4: "EP10" resulting displacement plot. Maximum displacement=0.543".

Finite Element Analysis Plots

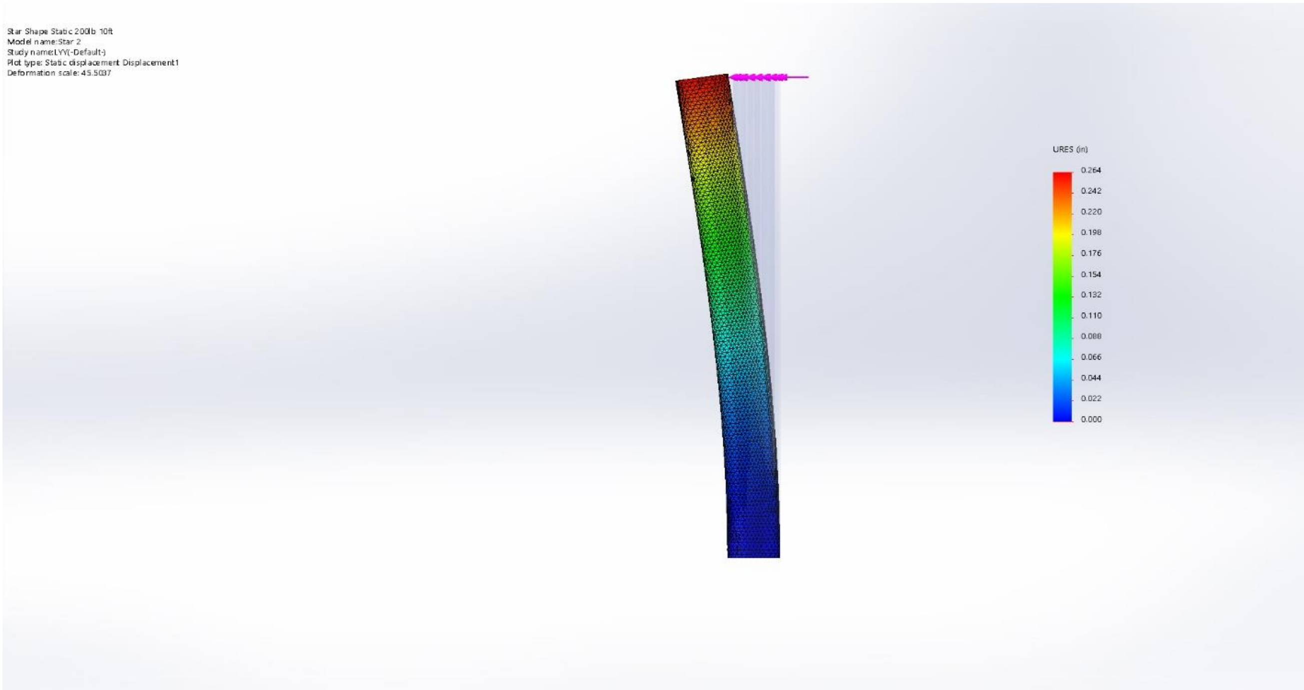

Photo 5: "EP12" resulting displacement plot. Maximum displacement=0.264".

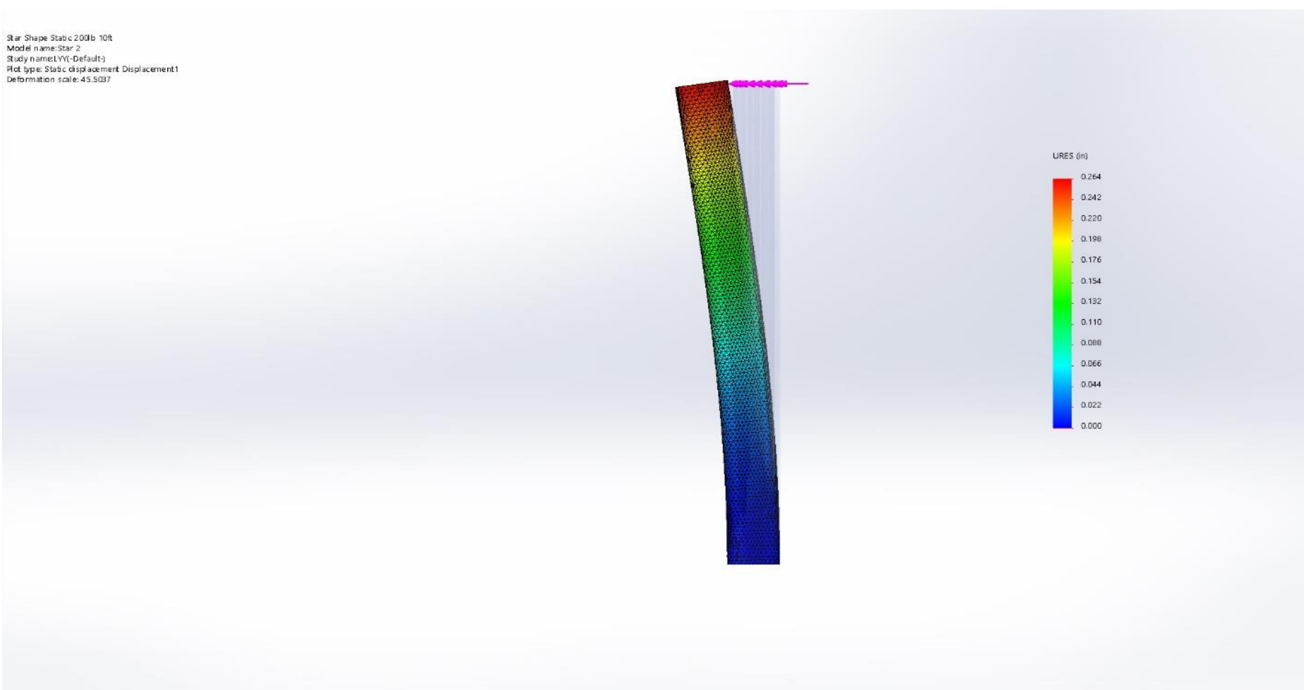

Photo 6: "EP14" resultant displacement plot. Maximum displacement=0.157".

Finite Element Analysis Plots

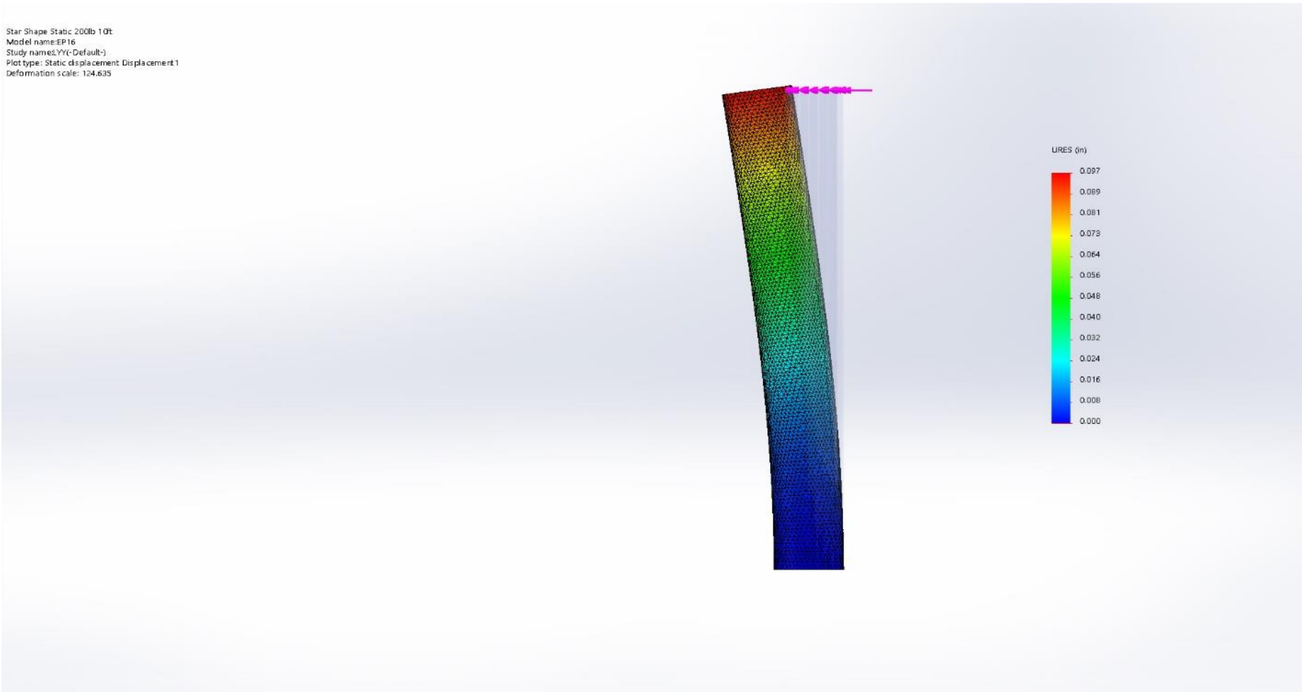

Photo 7: "EP16" resultant displacement plot. Maximum displacement=0.097".

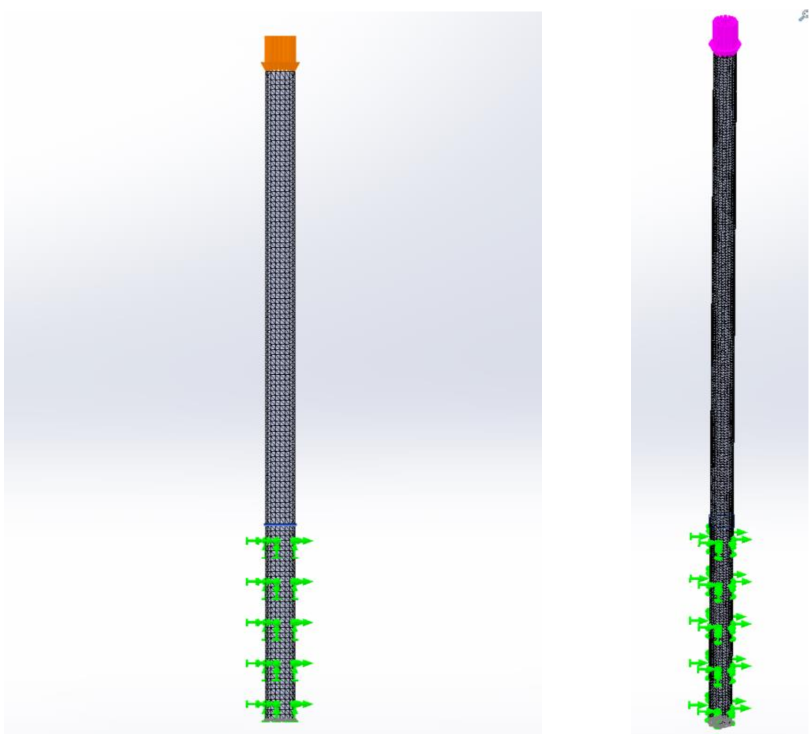

Photo 8: Typical FEA simulation set-up for buckling analysis. Note the "buried" portion of the piling has been fixed and a vertical load applied at the top of the piling.

Finite Element Analysis Plots

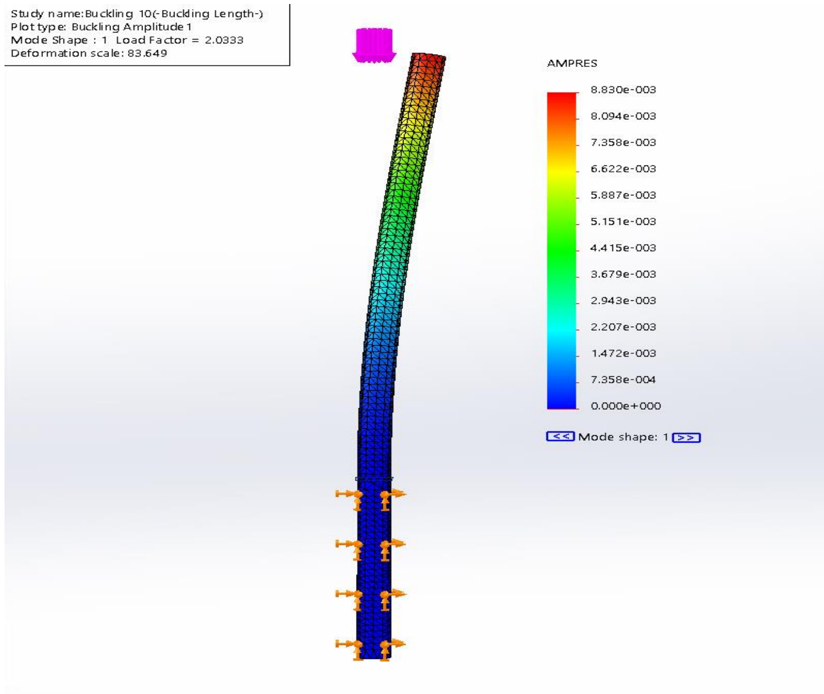

Photo 9: "EP10" under 10,000lb load. Resultant Buckling Load Factor = 2.03.

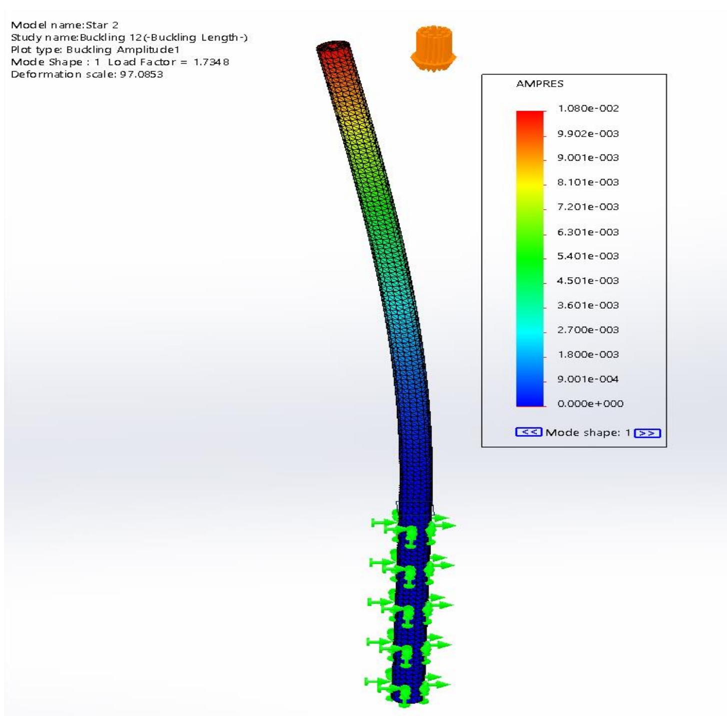

Photo 10: "EP12" under 10,000lb load. Resultant Buckling Load Factor = 1.73.

Finite Element Analysis Plots

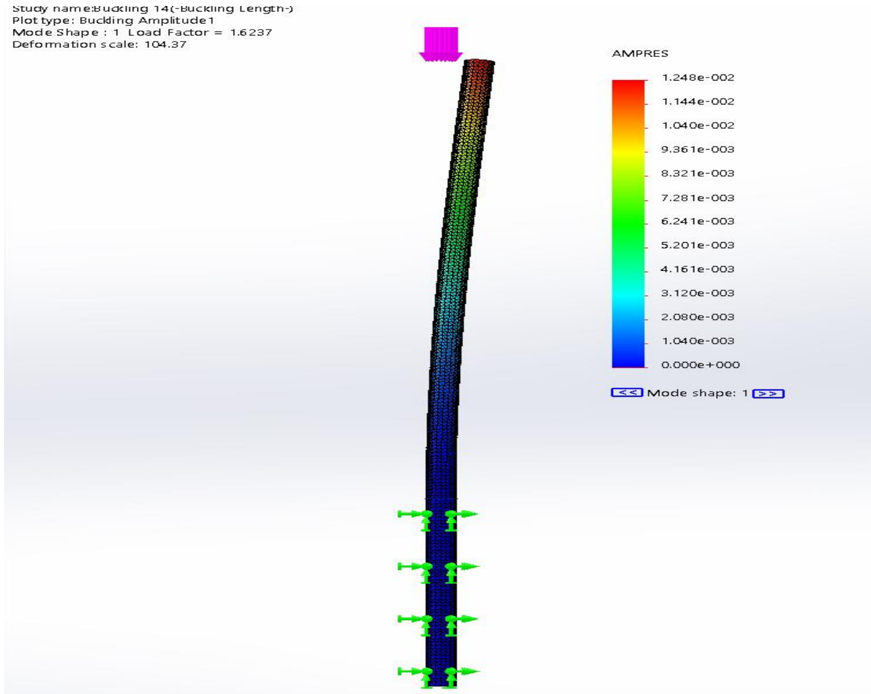

Photo 11: "EP14" under 10,000lb load. Resultant Buckling Load Factor = 1.62.

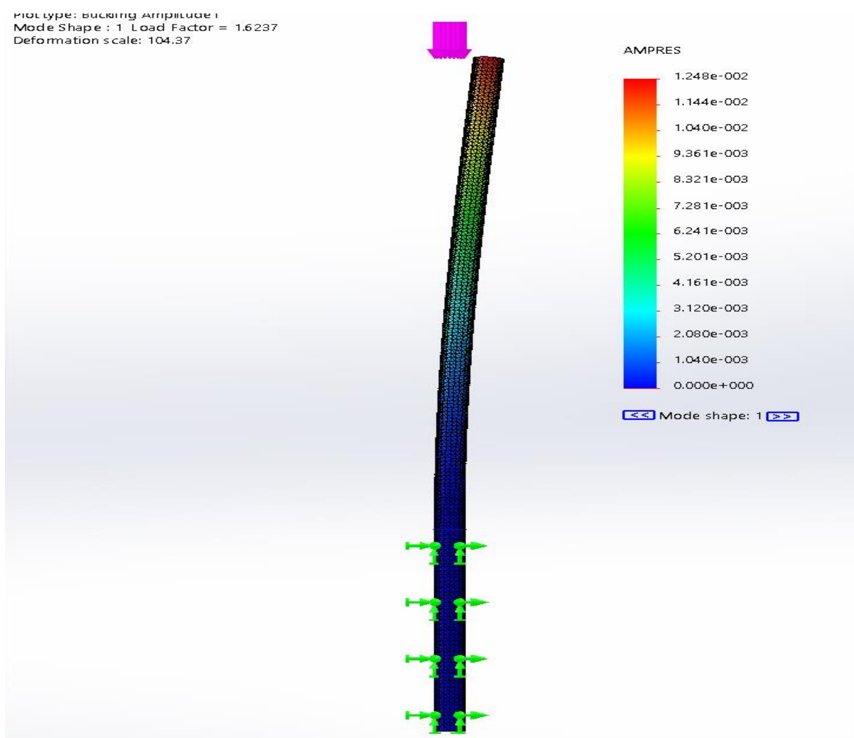

Photo 12: "EP16" under 10,000lb load. Resultant Buckling Load Factor = 1.70.

Client Supplied Dimensions and Material Specifications

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ECOPILE MATERIAL PERFORMANCE DATA

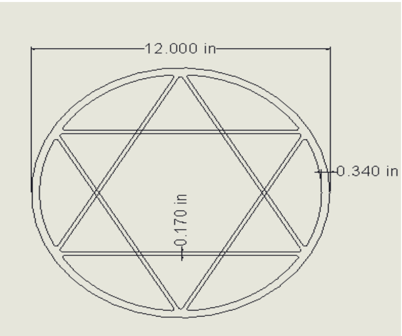
SHORELINEPLASTICS.COM

FIBER REINFORCED PVC COMPOSITE MARINE PILE

J2I3:J4

ECOPILE	ECOPILE DIAMETER		ECOPILE YIELD STRENGTH		ECOPILE MODULUS OF ELASTICITY		ECOPILE BEARING CAPACITY		ECOPILE FLEXURAL MODULUS		ECOPILE WEIGHT	
	INCH	mm	LB/IN²	Mpa	PSI	Mpa	PSI	Mpa	PSI	Mpa	LB/FT	KG/M
EP8	8.00	203.20									10.64	1.47
EP10	10.00	254.00									12.69	1.75
EP12	12.00	304.80	15,000	103.00	1.40E + 6 PSI	9,650	208,000	1,434	1.35E+6 PSI	9310	16.33	2.26
EP14	14.00	355.60									17.87	2.47
EP17	17.00	431.80									21.75	3.01

ECOPILE



Product Data Sheet

ECOPILE			
Manufacturer	Shoreline Plastics LLC		
Product	PVC/FIBERGLASS COMPOSITE MARINE PILING		
MATERIAL			
Raw Material	Polyvinyl chloride (PVC),		
Extruded Material	Ridged PVC compounded with Stranded Fiberglass blend		
Co-Extruded Material	UV protected PVC Capstock		
Molecular Weight (resin)	65	K value	
Relative Viscosity	2.15	dL/gm	
Inherent Viscosity	0.91	dL/gm	
Relative Density	1.47		
Cell Classification	N/A		
MECHANICAL PROPERTIES:			
Impact Strength: Notched Izod	110 J/m 23 deg C		ASTM D-256A
Impact strength: Unnotched Izod	270 J/m 23 deg C		ASTM D-256
Tear strength:	750-1000 lb ft/in ASTM D-624		
Hardness:	88	Shore D durometer	
Coefficient of Friction:	0.3 μs	PVC to PVC	
Tensile Strength @ Break: %	2%		ASTM-D 638
Tensile Stress @ Yield:	103	103 MPa	ASTM D 638
Tensile Modulus:	9650	MPa	ASTM D638
Flexural Modulus:	9310	MPa	ASTM D790
THERMAL PROPERTIES:			
Softening Point:	120 C		
Max continuous service Temp:	65 C		
FIRE PERFORMANCE:			
Flammability: Oxygen index	0.45	ASTM D 2863	
Ignitability index	2	AS 1530 (tested as a tube)	
Smoke produced index	8	AS 1530 (tested as a tube)	
Flame spread index	0	Does not support combustion	

ELECTRIC PROPERTIES:	
Dielectric strength (Breakdown)	14-20 kV/mm
Volume resistivity	10^{16} Ohm.cm (60% RH)
Surface resistivity	10^{13} – 10^{14} Ohm
Dielectric constant	3.4-3.6 at 25^0 C (60Hz)
Dissipation factor	0.015-0.020 at 20^0C
NOTES:	

Ultra Violet Weathering: ECOPILE maintains the same level of UV protection as Vinyl siding and Vinyl windows with an exposure rating in excess of 50 years.

ECOPILE is a two layered product, the inner layer is a PVC/Fiberglass composite, the outer layer is an impervious, heavy, PVC coating that is an accepted medium for the containment of potable water.

PVC is immune to Microbiological and Macrobiological attack.

- Testing conducted by Technical University of Darmstadt Germany

Sources	DATA SHEET NO.

Shoreline Plastics LLC

300 Alton Box Rd W. Jacksonville, FL 32218

904-696-2981 • www.durosleeve.com