PULTRUDED FENDER & BEARING PILES

Presented by Dustin Troutman

214 Industrial Lane • Alum Bank, PA 15521

www.creativepultrusions.com • 814.839.4186 • Toll Free: 888.CPI.PULL • Fax: 814.839.4276

WHERE AND HOW ARE PULTRUDED FIBER REINFORCED POLYMER (FRP) PIPE PILES BEING USED?

CREATIVE PULTRUSIONS

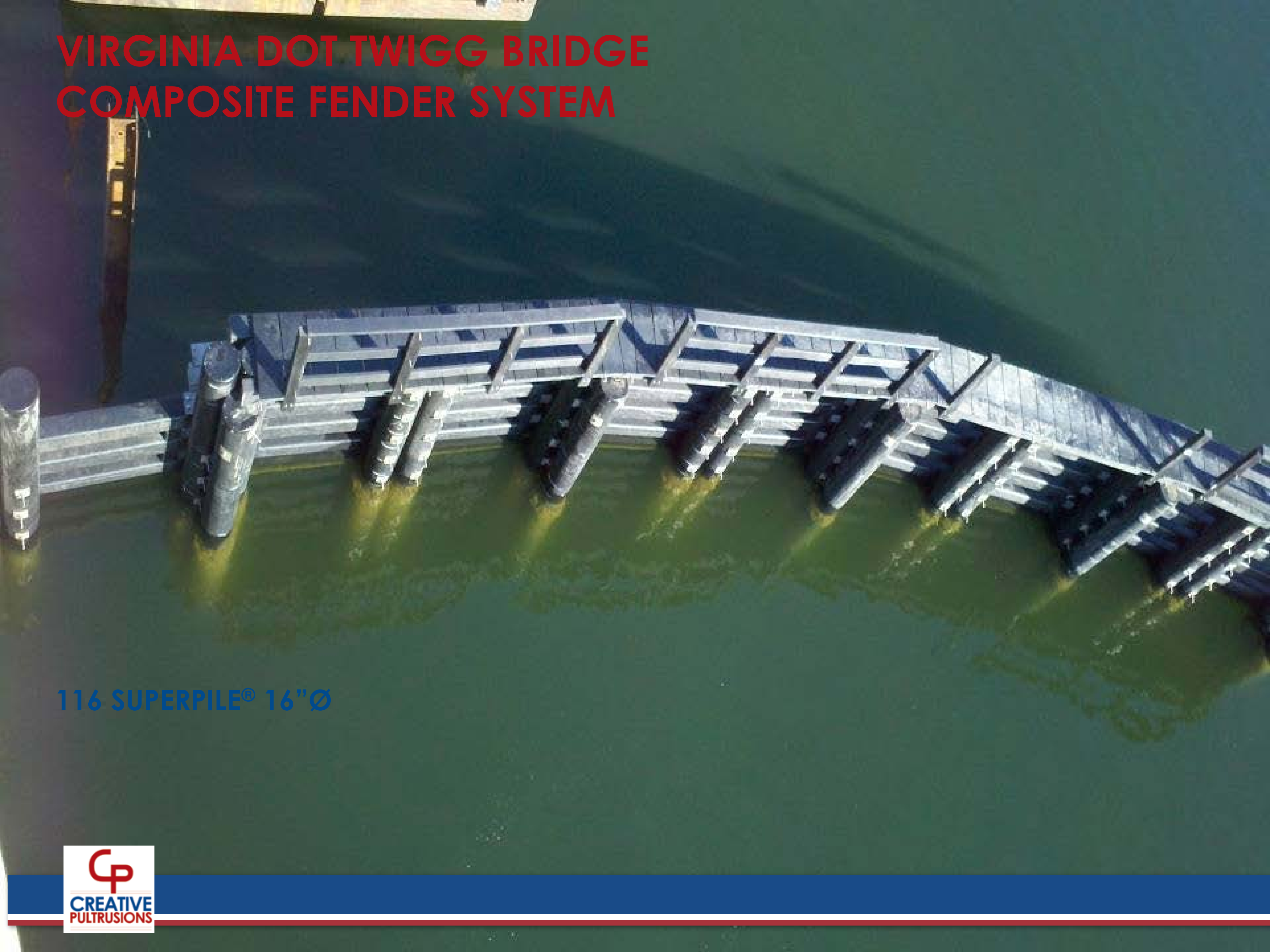
STATUE OF LIBERTY DOCK REBUILD

STATUE OF LIBERTY DOCK REBUILD

STATUE OF LIBERTY DOCK COMPLETE

VIRGINIA DOT TWIGG BRIDGE COMPOSITE FENDER SYSTEM

CREATIVE PULTRUSIONS


VIRGINIA DOT TWIGG BRIDGE
COMPOSITE FENDER SYSTEM
116 SUPERPILE® 16”Ø
CREATIVE
PULTRUSIONS

VIRGINIA DOT TWIGG BRIDGE COMPOSITE FENDER SYSTEM

PINELLAS BAYWAY BRIDGE PIPE PILE FENDER INSTALLATION

104 16"Ø 67' LONG SUPERPILE®

CREATIVE PULTRUSIONS

PINELLAS BAYWAY BRIDGE - FLORIDA DOT

PINELLAS BAYWAY BRIDGE - FLORIDA DOT

PINELLAS BAYWAY BRIDGE - FLORIDA DOT


GIBA BRIDGE PIPE PILE FENDER
CREATIVE
PULTRUSIONS

MARGATE BRIDGE, NJ

52 12" Diameter FRP Piles at 80 Foot
in Length were used to Construct the Bridge Fender

MARGATE BRIDGE, NJ

Piles Ready to Ship

Piles Delivered to the Job Site

Piles Installed with a Vulcan V5C
Vibro Hammer

MARGATE BRIDGE, NJ
COMPLETE FENDER

CRANEY ISLAND PORTSMOUTH, VA
FUEL PIER U.S. NAVY

95’ PILES, HDPE SLEEVES, FILLED WITH CONCRETE

CREATIVE PULTRUSIONS

CRANEY ISLAND PORTSMOUTH, VA
FUEL PIER U.S. NAVY

CREATIVE PULTRUSIONS

WHARF CHARLIE, MAYPORT FLORIDA
U.S. NAVY

72' PILES, HDPE SLEEVES, FRP INSERT

CREATIVE PULTRUSIONS

OCCIDENTAL PETROLEUM BARGE LANDING FENDER LONG BEACH, CA

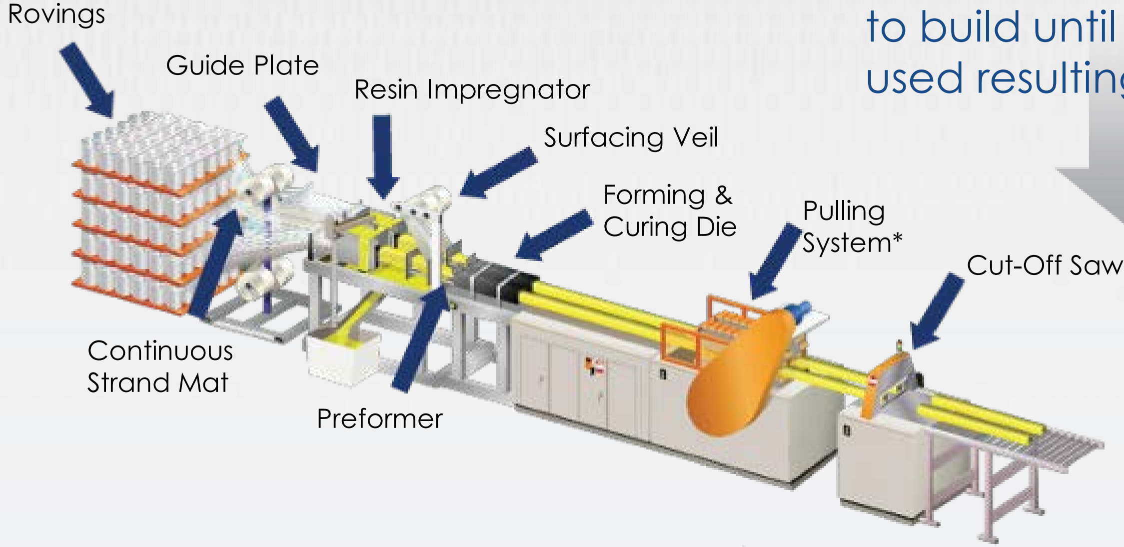
SAN FRANCISCO
WEST HARBOR RENOVATION PROJECT
SAN FRANCISCO, CA

MOORING & FENDER PILES

SUPERPILE® PROFILES ARE MANUFACTURED BY THE PULTRUSION PROCESS

1. Resin and glass fiber reinforcements are combined and formed into the shape of the die on a continuous process.

2. The resin is initiated by the thermal decomposition process. The initiator is heated until a chemical bond dissociation produces two radicals. The chain continues to build until the monomer is used resulting in a cured resin.



**Caterpillar Pullers (shown) or Reciprocating Pullers*

3. The profiles are pulled through a die.

4. Pultruded profiles are cut to length during the continuous manufacturing process.

SUPERPILE® PRODUCTION

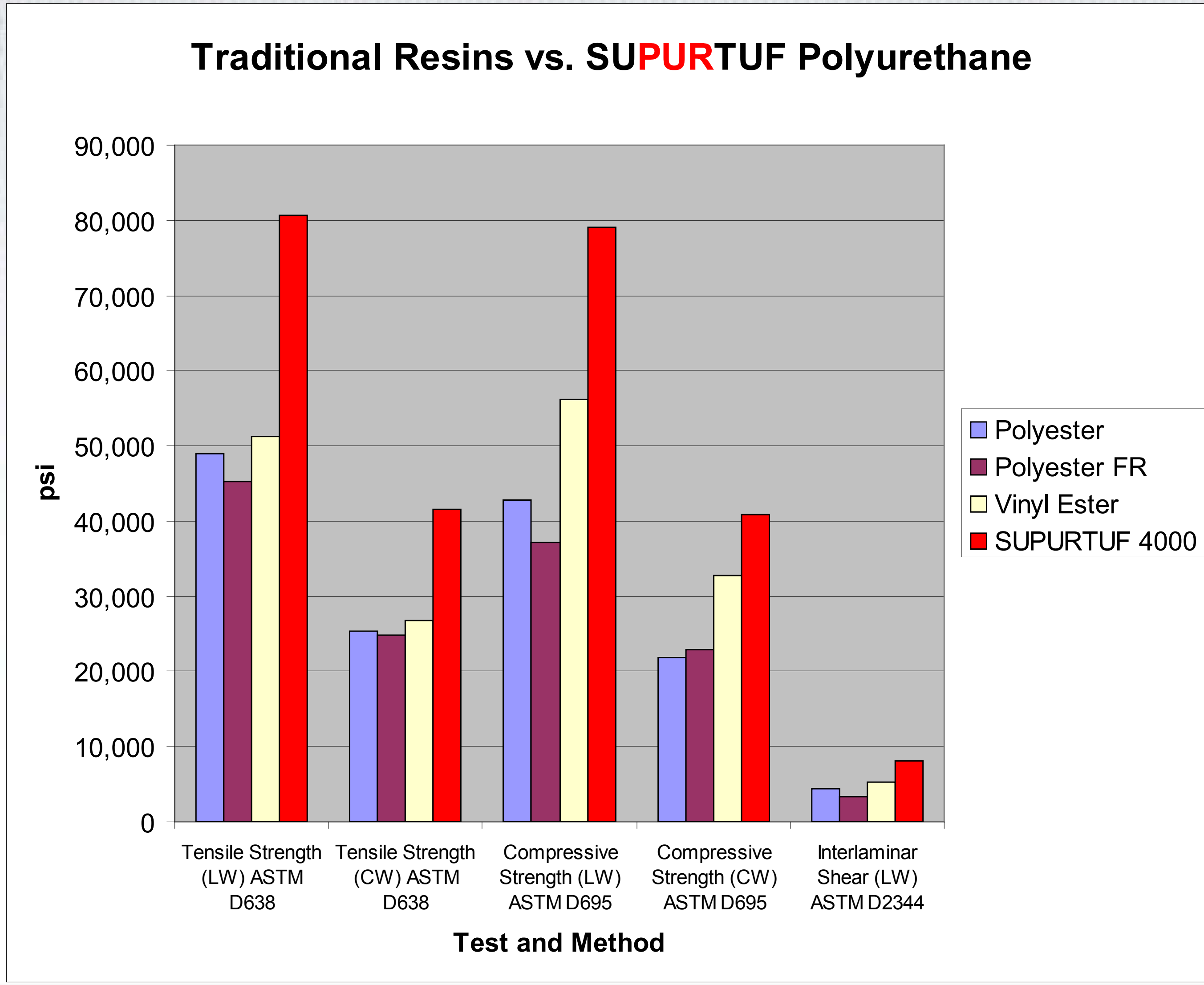
High strength E-glass fiberglass is pulled into the heated die.

The fibers are injected with a high strength polyurethane resin and cure in a continuous process.

Finished product is pulled through the die and into the cut-to-length saw where it is cut and prepared for shipment to the job site.

WHAT MAKES SUPERPILE® PERFORM? SUPURTUF™ POLYURETHANE RESIN!

- Superior Strength
- Superior Chemical Resistance
- Superior Impact Strength
- Superior Toughness
- Superior Energy Absorption



WHY FRP PILES FOR FENDER PROJECTS?
ENERGY ABSORPTION CHARACTERISTICS

Round FRP Pipe Pile TU455 Polyurethane 12"x3/8" Metric (305mmx9.52mm)	Round FRP Pipe Pile TU450 Polyurethane 12"x1/2" Metric (305mmx12.7mm)	Round FRP Pipe Pile TU460 Polyurethane 16"x1/2" Metric (406mmx12.7mm)
Average Energy Absorption kip-in (kN•m) ASTM D6109		
341 (39)	643 (73)	829 (94)
Characteristic Energy Absorption kip-in (kN•m) ASTM D6109		
***** *****	405 (46)	603 (68)

- High Strength And Rather Low Modulus Values, As Compared To Steel, Equate To Very High Energy Absorption Capabilities.
- Ideal For Dock And Bridge Fender Systems Where Energy Absorption Is Critical.
- Derived By Calculating The Area Under The Load/Deflection Curve.

Testing at Ft. Collins, CO

SPECIFYING FRP PILES

- Tested Per ASTM D6109 Test Standards At West Virginia University (WVU).
- Method To Determine The Full Section Bending Modulus Of Elasticity And The Full Section Bending Strength.
- Tested To Determine The Crush Strength, Pin Bearing Strength, Washer Pull Through Strength And Connection Capacities Both At WVU And At Creative Pultrusions, Inc. (CPI) Test Facility.
- Pile Dynamic Analysis (PDA) Performed By Atlantic Coast Engineering.

FULL SECTION BEND TEST

- Full Section Four Point Bend To Failure Per ASTM D6109.
- 20:1 Span To Depth Ratio.
- Established EI.
- Established Bending Strength.
- Established Energy Absorption Characteristics.
- Nineteen 12"x1/2" And Twelve 16"x1/2" Piles Were Tested To Failure.
- Piles From Several Production Runs Were Tested.

Flexural Test, WVU

BOLTED CONNECTIONS FOR FORCES APPLIED PARALLEL TO THE PILE

Characteristic Strengths of Bolted Connections for Forces Applied Parallel to the Pile

Round Polyurethane Piles	Single 5/8" Bolt	Two 5/8" Bolts	Single 3/4" Bolt	Two 3/4" Bolts	Single 1" Bolt	Two 1" Bolts
TU455 12" x 3/8" (305mmx9.52mm)	4,231	8,462	5,077	10,155	6,770	13,540
TU450 12" x 1/2" (305mmx12.7mm)	7,854	15,708	9,425	18,849	12,566	25,132
TU460 16" x 1/2"(406mmx12.7mm)	6,005	12,011	7,206	14,413	9,609	19,217
Octagonal Vinyl Ester Piles	**Single 5/8" Bolt**	**Two 5/8" Bolts**	**Single 3/4" Bolt**	**Two 3/4" Bolts**	**Single 1" Bolt**	**Two 1" Bolts**
CP076 8" x .25" (203mmx6.35mm)	2,606	5,212	3,127	6,255	4,170	8,340
CP074 10" x. 25" (254mmx6.35mm)	3,286	6,572	3,943	7,886	5,257	10,515
CP210 10" x. 275" (254mmx6.98mm)	2,212	4,423	2,654	5,308	3,539	7,077

- Characteristic Design Values Have Been Developed And Published Per ASTM D7290.
- The Capacities Were Developed From Full Section Testing.
- A 1.0" Diameter Bolt Was Used In The Test.
- Failure Load Is Defined As The First Indication Of A Yield In The Load/Displacement Plot.
- Chart Represents The Bolt Being Loaded On One Side Of The Pile.

Bolted Connection Test - Parallel

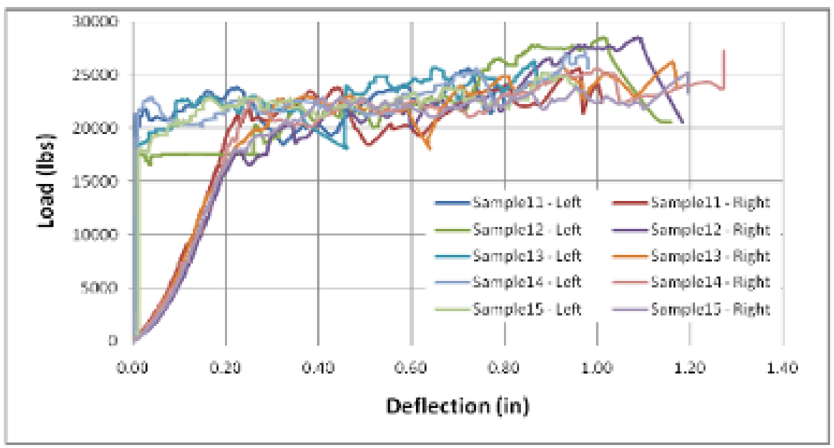
CREATIVE PULTRUSIONS

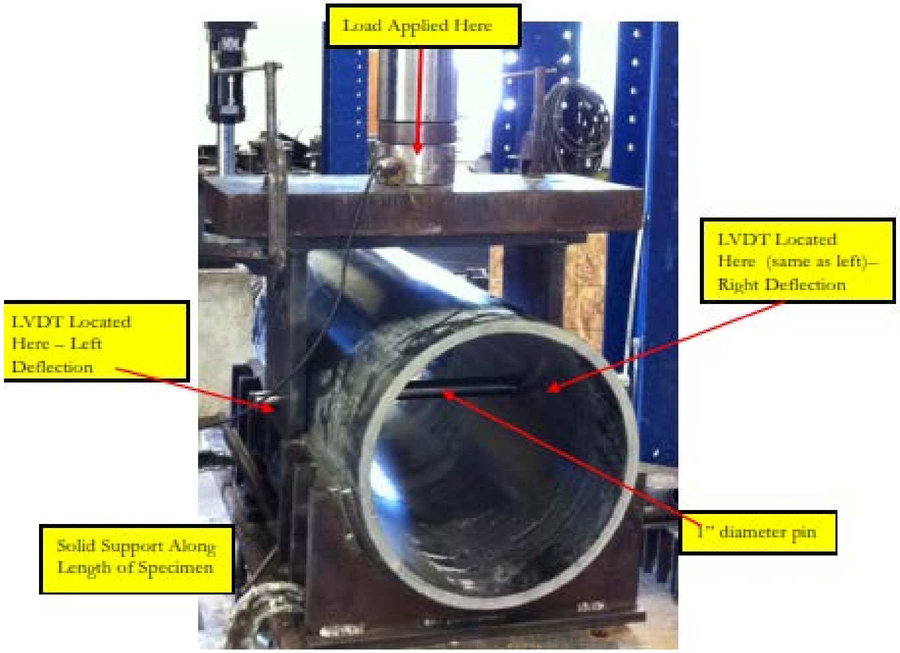
BOLTED CONNECTIONS FOR FORCES APPLIED TRANSVERSE TO THE PROFILE

Characteristic Strengths of Bolted Connections for Forces Applied Perpendicular to the Pile

Round Polyurethane Piles	Single 5/8" Bolt	Two 5/8" Bolts	Single 3/4" Bolt	Two 3/4" Bolts	Single 1" Bolt	Two 1" Bolts
TU455 12" x 3/8" (305mmx9.52mm)	2,917	5,835	3,501	7,001	4,668	9,335
TU450 12" x 1/2" (305mmx12.7mm)	3,921	7,841	4,705	9,410	6,273	12,546
TU460 16" x 1/2"(406mmx12.7mm)	6,491	12,982	7,789	15,578	10,386	20,771
Octagonal Vinyl Ester Piles	**Single 5/8" Bolt**	**Two 5/8" Bolts**	**Single 3/4" Bolt**	**Two 3/4" Bolts**	**Single 1" Bolt**	**Two 1" Bolts**
CP076 8" x .25" (203mmx6.35mm)	1,271	2,541	1,525	3,049	2,033	4,066
CP074 10" x .25" (254mmx6.35mm)	912	1,825	1,095	2,190	1,460	2,919
CP210 10" x .275" (254mmx6.98mm)	937	1,875	1,125	2,249	1,500	2,999

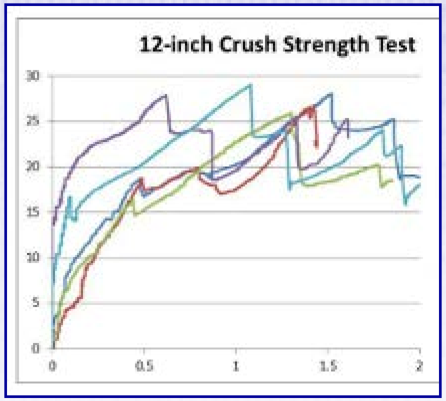
- 1" Diameter Pin.
- Failure Mode, Pin Bearing Of FRP Tube.
- Chart Represents The Bolt Capacity Loaded On One Side Of The Pile.





FULL SECTION CRUSH STRENGTH

SUPERPILE® Crush Strength with a 10" x 10" (24.5mm x 24.5mm) Thermoplastic Wale					
Round FRP Pipe Pile TU455 Polyurethane12"x3/8" Metric (305mm x 9.52mm)		Round FRP Pipe Pile TU450 Polyurethane12"x1/2" Metric (305mm x 12.7mm)		Round FRP Pipe Pile TU460 Polyurethane16"x1/2" Metric (406mm x 12.7mm)	
Average Crush Strength lb (kg)					
10,600	(4,808)	17,970	(8,151)	16,600	(7,530)
Characteristic Crush Strength lb (kg)					
8,060	(3,656)	13,782	(6,251)	11,667	(5,292)



- Crush Strength Derived By Applying A Transverse Load Into The SUPERPILE® Through A 10"x10" Wale Section.
- The Ultimate Load Is Defined As The First Yield Point On The Load Vs. Displacement Plot.

FULL SECTION CRUSH STRENGTH ENHANCEMENT

SUPERPILE®, with FRP Insert, Crush Strength with a 10"x 10" (25.4mm x 25.4mm) Thermoplastic Wale		
Round FRP Pipe Pile TU455 Polyurethane 12"x3/8" Metric (305mmx9.52mm)	Round FRP Pipe Pile TU450 Polyurethane 12"x1/2" Metric (305mmx12.7mm)	Round FRP Pipe Pile TU460 Polyurethane 16"x1/2" Metric (406mmx12.7mm)
Average Crush Strength lb (kg)		
***** *****	73,780 (33,466)	44,213 (20,055)
Characteristic Crush Strength lb (kg)		
***** *****	51,370 (23,301)	***** *****

Notes:
****** Data not available or minimum test quantity not available.

- Crush Strength Can Be Increased With The Addition Of An FRP Insert.
- Crush Strength Can Be Increase To 74 Kips Or Higher When Needed.
- The Addition Of Concrete, In Localized Sections, Can Be Used To Increase The Crush Strength. Testing Has Indicated That The Crush Strength Can Be Increased To 180+ Kips.

CREATIVE PULTRUSIONS

CHARACTERISTIC DESIGN PROPERTIES ARE DETERMINED PER ASTM D7290

WHY ASTM D7290 AND WHY SHOULD I CARE?

It is an internationally recognized standard for evaluating material property characteristic values for polymeric composites for civil engineering structural applications.

The characteristic value is a statistically-based material property representing the 80% lower confidence bound on the 5th percentile value of a specified population.

The characteristic value allows you to use LRFD or Allowable Stress Design techniques and it allows you to fairly compare FRP to other types of piles.

CREATIVE PULTRUSIONS

ASTM D7290-06

- Companies With Good Process Control And Quality Standards Are Rewarded In That The Published Characteristic Design Values Are Higher.
- Places All Suppliers On An Even Playing Ground.
- Enhances The Confidence Level On The Product Performance.
- All Design Data Is Reported Based On An Internationally Recognized Standard.

INTERNATIONAL

Designation: D 7290 – 06

Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications[1]

This standard is issued under the fixed designation D 7290; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard practice covers the procedures for computing characteristic values of material properties of polymeric composite materials intended for use in civil engineering structural applications. The characteristic value is a statistically-based material property representing the 80 % lower confidence bound on the 5th-percentile value of a specified population. Characteristic values determined using this standard practice can be used to calculate structural member resistance values in design codes for composite civil engineering structures and for establishing limits upon which qualification and acceptance criteria can be based.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 883 Terminology Relating to Plastics

D 3878 Terminology for Composite Materials

E 6 Terminology Relating to Methods of Mechanical Testing

E 456 Terminology Relating to Quality and Statistics

E 1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases

E 1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases

E 1471 Guide for Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases

2.2 *Other Document:*

MIL-Handbook-17 Polymer Matrix Composites, Volume 1, Revision F[3]

3. Terminology

3.1 *Definitions*—Terminology D 3878 defines terms relating to high-modulus fibers and their composites. Terminology D 883 defines terms relating to plastics. Terminology E 6 defines terms relating to mechanical testing. Terminology E 456 defines terms relating to statistics. In the event of a conflict between terms, Terminology D 3878 shall have precedence over the other documents.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *characteristic value*—a statistically-based material property representing the 80 % lower confidence bound on the 5th-percentile value of a specified population. The characteristic value accounts for statistical uncertainty due to a finite sample size.

3.2.1.1 *Discussion*—The 80 % confidence bound and 5th-percentile levels were selected so that composite material characteristic values will produce resistance factors for Load and Resistance Factor Design similar to those for other civil engineering materials (see Refs **1** and **2**).[4]

3.2.1.2 *Discussion*—The term "characteristic value" is analogous to the term "basis value" used in the aerospace industry where A- and B-basis values are defined as the 95 % lower confidence bound on the lower 1 % and 10 % values of a population, respectively.

3.2.2 *data confidence factor, Ω*—a factor that is used to adjust the sample nominal value for uncertainty associated with finite sample size.

3.2.3 *nominal value*—the 5th percentile value of the data represented by a probability density function.

[1] This practice is under the jurisdiction of ASTM Committee D30 on Composites and is the direct responsibility of Subcommittee D30.05 on Structural Test Methods.

Current edition approved Sept. 1, 2006. Published September 2006.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

CREATIVE PULTRUSIONS

SUPERPILE® MECHANICAL & PHYSICAL PROPERTIES

Values are Published As Average and per ASTM D7290

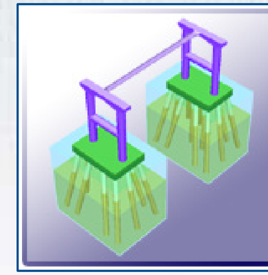
SUPERPILE® Mechanical Properties	Round FRP Pipe Pile TU455 Polyurethane 12"x3/8" Metric (305mm x 9.52mm)		Round FRP Pipe Pile TU450 Polyurethane 12"x1/2" Metric (305mm x 12.7mm)		Round FRP Pipe Pile TU460 Polyurethane 16"x1/2" Metric (406mm x 12.7mm)	
Average Flexural Strength per ASTM D6109 psi (Mpa)	52,000	(359)	69,658	(480)	57,270	(395)
Characteristic Flexural Strength per ASTM D6109 psi (Mpa)[2]	*****	*****	56,111	(387)	49,840	(344)
Average Compression Strength per ASTM D6109 psi (Mpa)	52,000	(359)	69,658	(480)	57,270	(395)
Characteristic Compression Strength per ASTM D6109 psi (Mpa)[2]	*****	*****	56,111	(387)	49,840	(344)
Average In-Plane Shear Strength psi (Mpa)	15,605	(108)	16,039	(111)	17,170	(118)
Characteristic In-Plane Shear Strength psi (Mpa)	13,212	(91)	13,713	(95)	14,936	(103)
Average Shear Capacity lbs (Kg)	106,894	(48,486)	145,153	(65,840)	208,616	(94,626)
Characteristic Shear Capacity lbs (Kg)	90,502	(41,051)	124,103	(56,292)	181,472	(82,314)
Average Torque Strength lb-ft (kN-m)	103,519	(140)	138,829	(188)	269,987	(366)
Characteristic Torque Strength lb-ft (kN-m)	87,644	(119)	118,696	(161)	234,859	(318)
Average Axial Compression Strength psi (Mpa)	52,000	(359)	69,658	(480)	57,270	(395)
Characteristic Axial Compression Strength psi (Mpa)[2]	*****	*****	56,111	(387)	49,840	(344)
Average Axial Compression Capacity (Short Column) lb (kg)	712,400	(323,139)	1,260,810	(571,894)	1,391,661	(631,247)
Characteristic Axial Compression Capacity (Short Column) lb (kg)[2]	*****	*****	1,015,609	(460,673)	1,211,112	(549,351)
Average Modulus of Elasticity per ASTM D6109 psi (Gpa)	5.26E+06	(36.3)	5.91E+06	(40.7)	5.99E+06	(41.3)
Bending Stiffness (EI) per ASTM D6109 lbs-in² (kg-mm²)	1.22E+09	(3.57E+11)	1.77E+09	(5.17E+11)	4.38E+09	(1.28E+12)
Average Moment Capacity per ASTM D6109 kip-ft (kN-m)	167	(227)	289	(392)	437	(592)

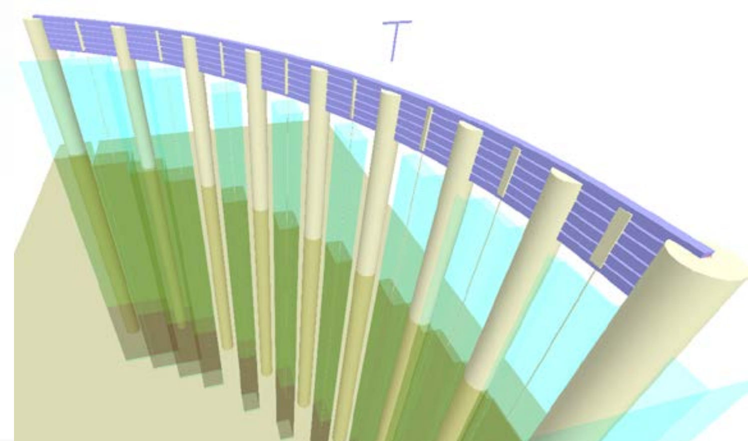
CREATIVE PULTRUSIONS

FENDER SYSTEM DESIGN

- FB-MultiPier is a nonlinear finite element analysis program often used for vessel collision analysis on bridges and fender systems.
- Used extensively by FLDOT and engineering firms throughout the south east for 17+ years.
- Allows for nonlinear soil and structural analysis of the fender system
- Vessel collision data is outlined in the AASHTO LRFD Bridge Design Specification.
- Vessel data collision data past points are established by utilizing the Army Corps of Engineers extensive database of vessel activity.

FB-MultiPier v4.19.3



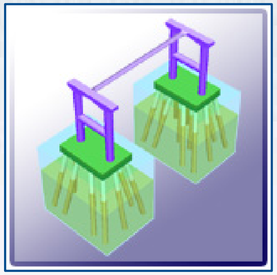


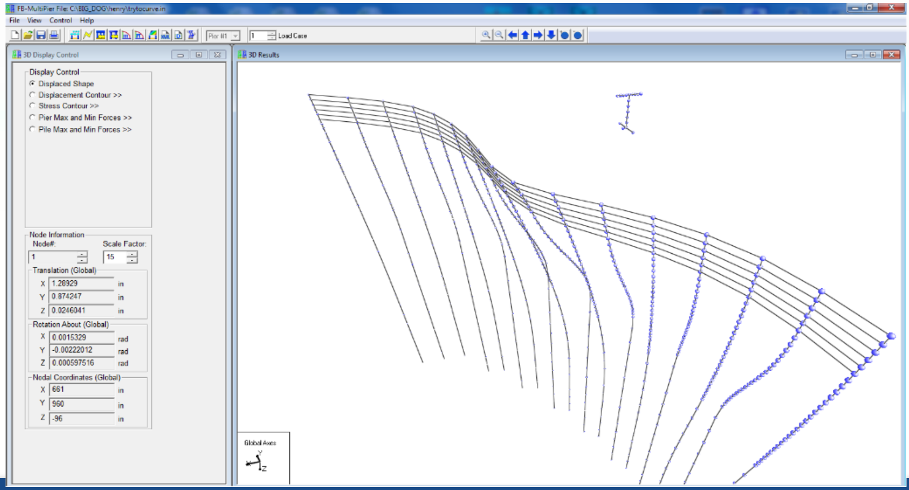
CREATIVE PULTRUSIONS

FENDER SYSTEM DESIGN

- The soil resistance and strain energy of the fender system is analyzed.
- The fender system geometric layout is optimized based on the permissible deflection of the system.
- The energy is derived by the application of a static load applied to the non-linear three dimensional soil pile model.
- Minimum pile tip elevations are determined such that the moment capacity of the pile can be reached before soil failure.

FB-MultiPier v4.19.3





PULTRUDED STRUCTURES DESIGN METHODOLOGY OPTIONS

LRFD or ASD

SUPERPILE® DATA SHEETS AND LOAD & RESISTANCE FACTOR DESIGN (LRFD)

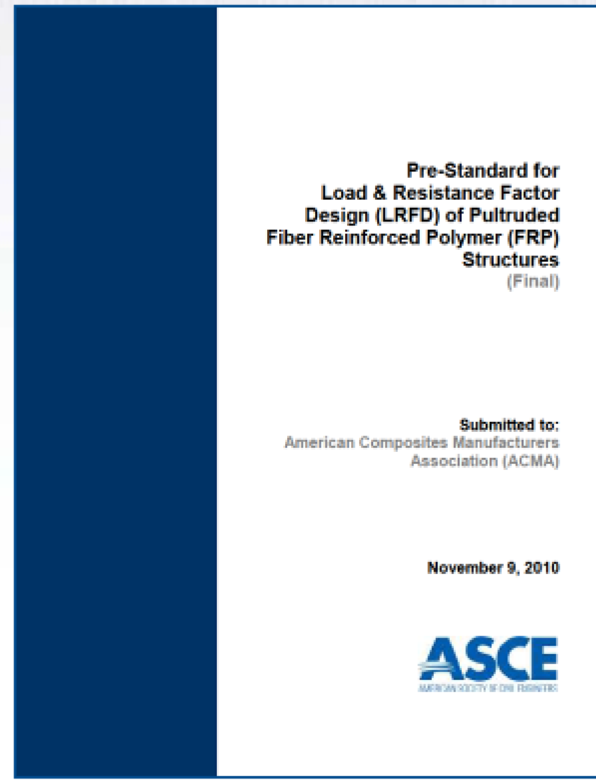
THE CHARACTERISTIC VALUES WERE DEVELOPED FOR AN LRFD DESIGN APPROACH WHERE:

The Characteristic/Reference Strength Values Shall Be Adjusted Per Table 2.4-1 To Account For Moisture.

- 0.85/.80 For Strength For Vinyl Ester & Polyurethane /Polyester.
- .95/.90 For Elastic Modulus For Vinyl Ester & Polyurethane /Polyester.

λ – Time Effect Factor 0.4 For Permanent Load.

φ – Resistance Factor For Local Buckling Controlled Design – .65.


Pre-Standard for
Load & Resistance Factor
Design (LRFD) of Pultruded
Fiber Reinforced Polymer (FRP)
Structures
(Final)

Submitted to:
American Composites Manufacturers
Association (ACMA)

November 9, 2010

ASCE

SUPERPILE® & ALLOWABLE STRESS DESIGN

- Material Properties Are Reduced To Satisfy An Appropriate Safety Factor.
- Typical Safety Factors For Pultruded Structures.

2.5 in Flexure
3.0 in Shear
3.0 for Connections

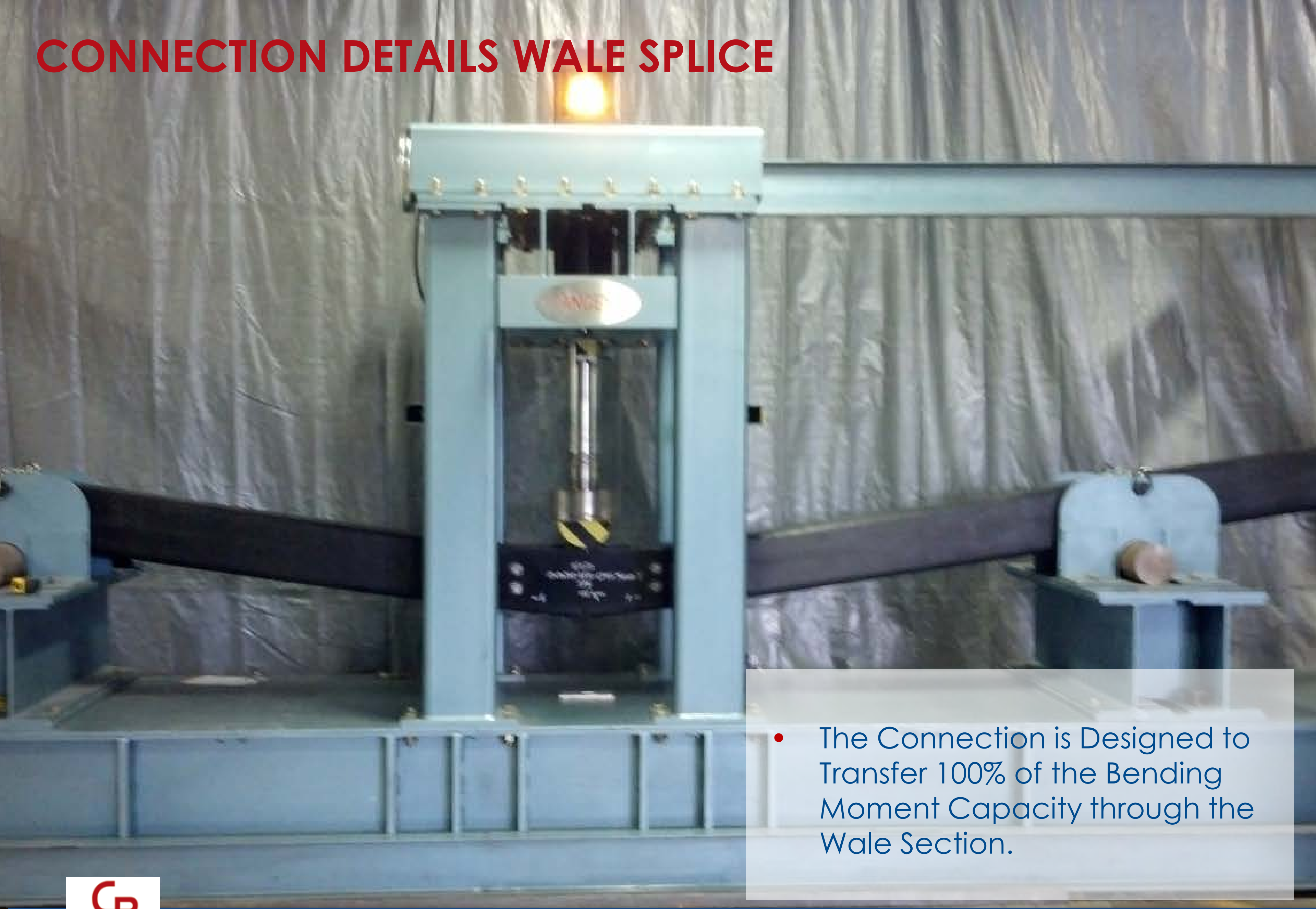
CONNECTION DETAILS

- Stainless Steel Hardware.
- 6" Square Curved Washers.
- 50 Lb-ft Max. Torque.
- Self Drilling Screws For Attaching The Cap.

CONNECTION DETAILS WALE SPLICE

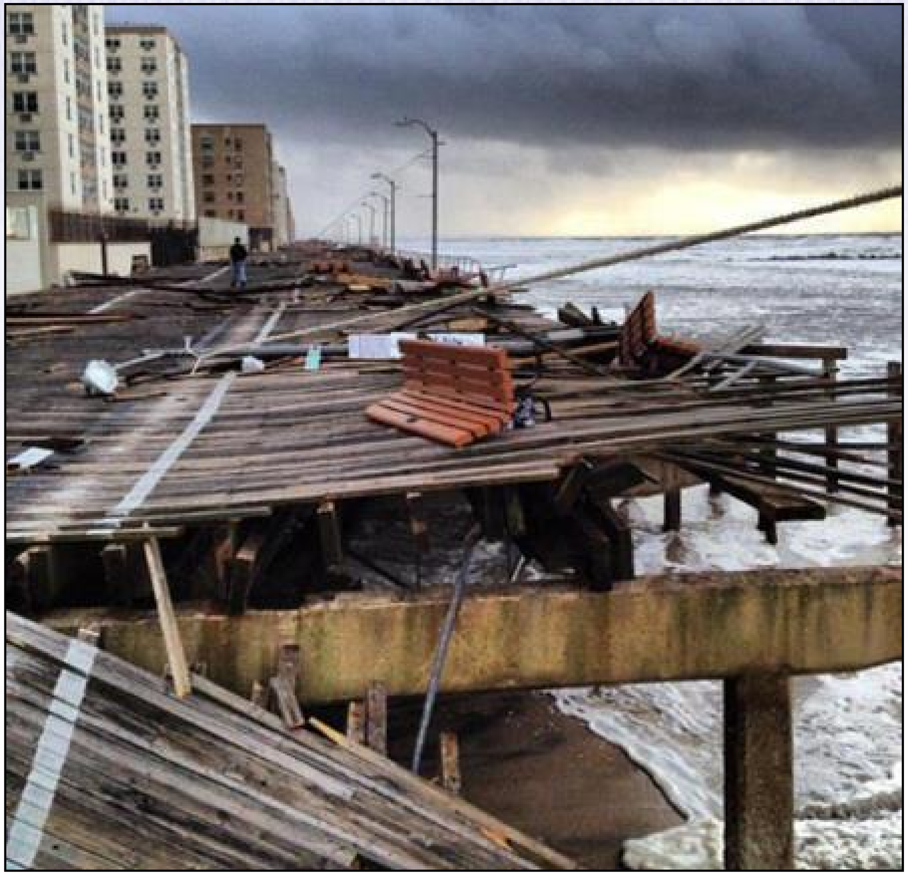
- 3/4" Thick Pultruded Splice Plates.
- Transfer the Moments Through the Wale Sections.
- Through bolted with Stainless Steel Bolts.

CONNECTION DETAILS WALE SPLICE

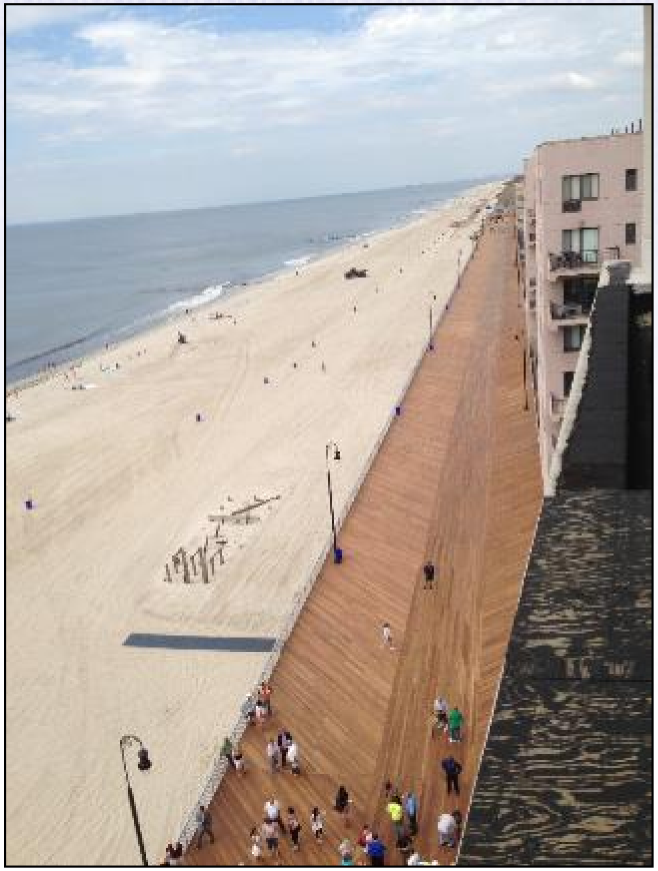


- The Connection is Designed to Transfer 100% of the Bending Moment Capacity through the Wale Section.

HURRICANE SANDY 2012
LONG BEACH NEW YORK BOARDWALK



Just after the storm

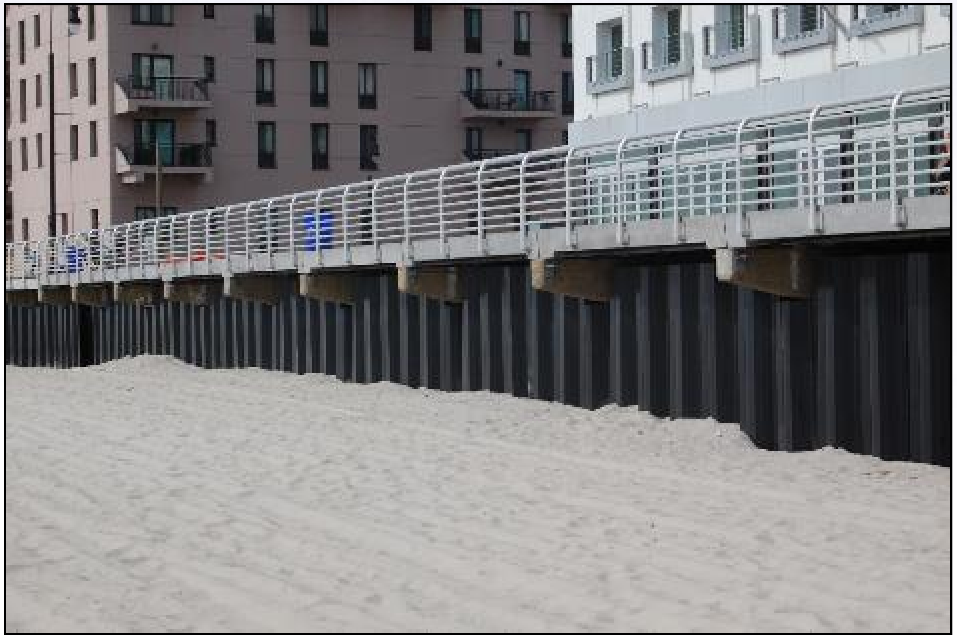


Completed rehab

SUPERLOC® SHEET PILES ARE SUPPLIED TO THE JOB SITE

LONG BEACH, NEW YORK
HURRICANE SANDY REPAIR AND PROTECTION

SUPERLOC® SHEET PILES ARE DRIVEN TO FORM A PROTECTIVE BARRIER AGAINST FUTURE STORM SURGE



2.5 miles of Completed Storm Wall

LONG BEACH, NEW YORK
HURRICANE SANDY REPAIR AND PROTECTION

CREATIVE PULTRUSIONS

KEYPORT, NJ

1,451 lineal ft. (427 m) wall photo taken after hurricane Sandy 2012. Installation 2006.

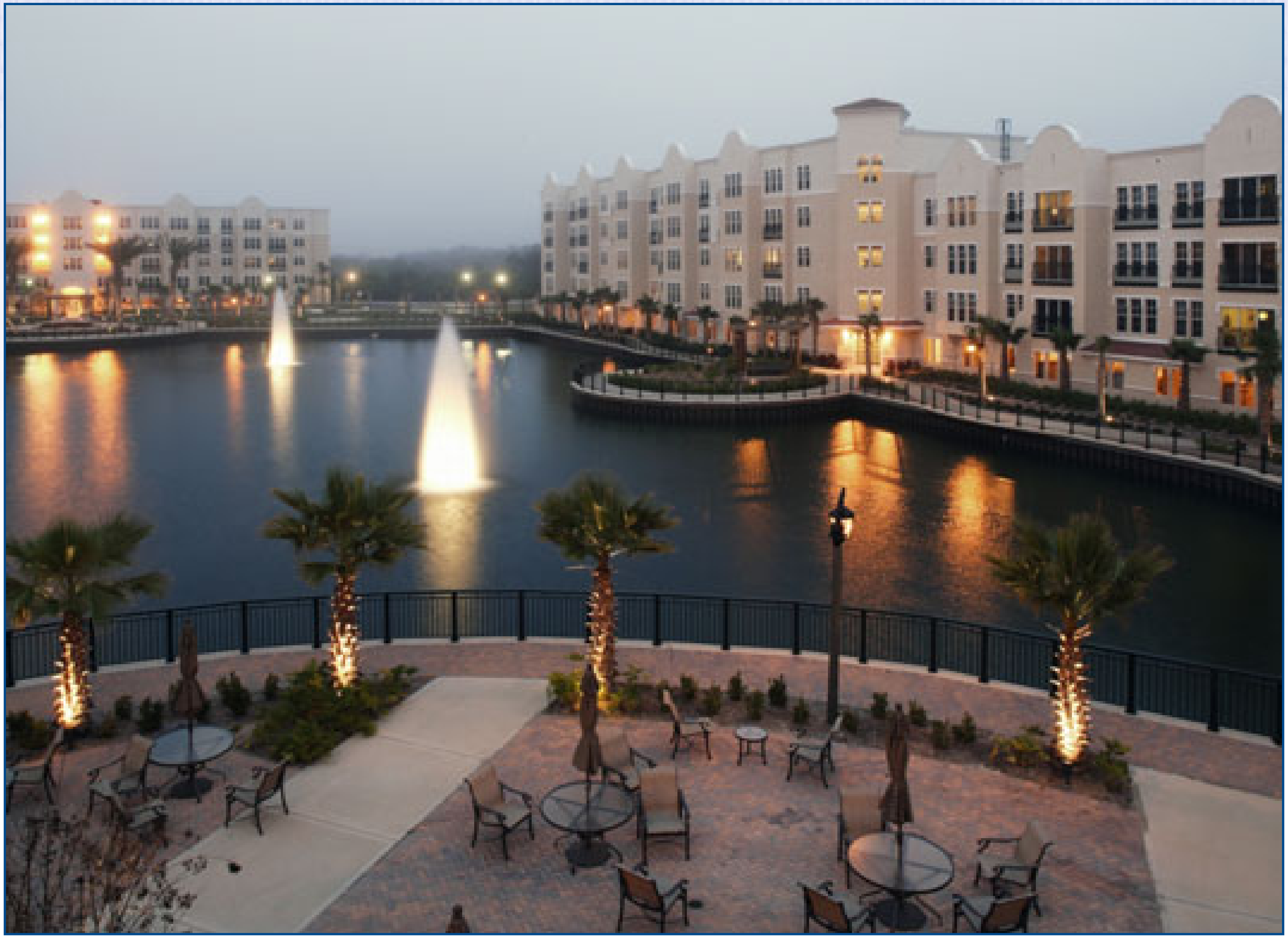
KEYPORT, NJ

Photos of wall taken during Hurricane Sandy

KEYPORT, NJ

Photo taken after Hurricane Sandy 2012

THE GLENRIDGE ON PALMER RANCH
SARASOTA, FL



AZERBAIJAN SERIES 1580

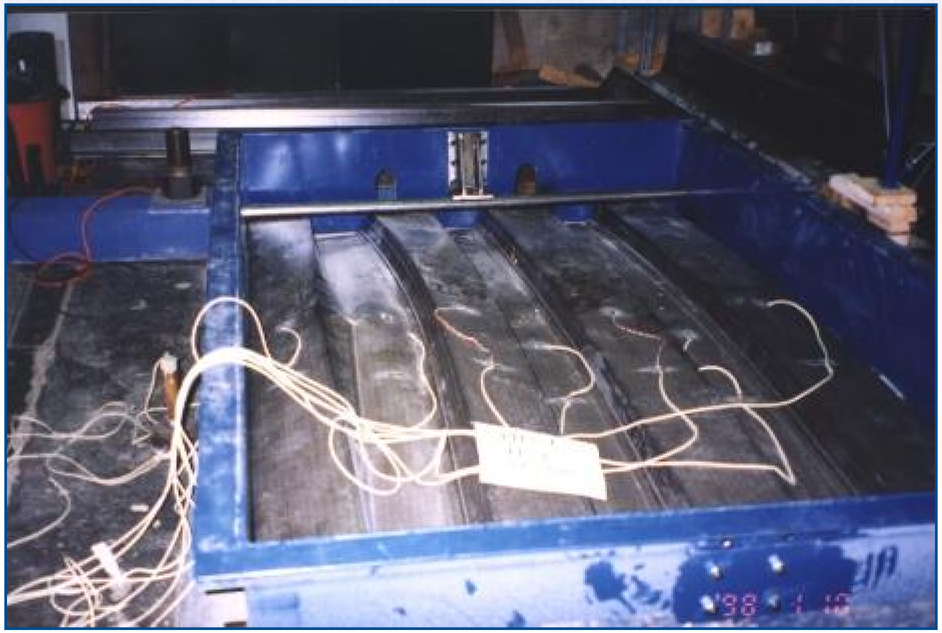
3,280 ft
(1000+ meters)
Causeway

AZERBAIJAN PROJECT

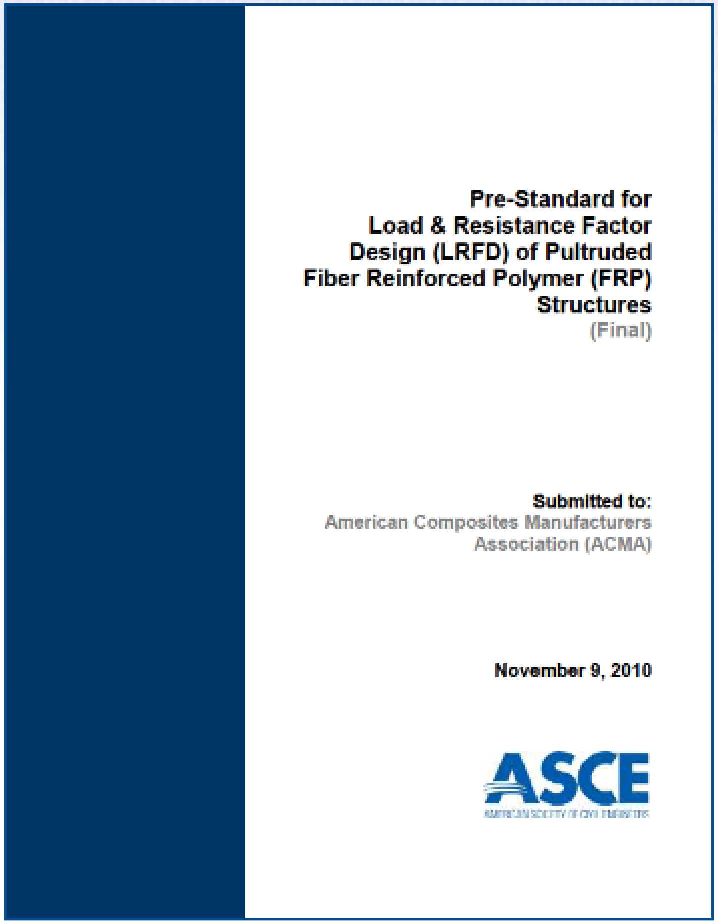
3,280 ft
(1000+ meters) Retaining Wall

CREATIVE
PULTRUSIONS

SUPERLOC® SHEETPILE MOMENT CAPACITY HAS BEEN DEVELOPED BASED ON THE LRFD PRE-STANDARD AND VERIFIED WITH FULL SECTION TESTING AND FEA.



Note: Critical Load capacity is controlled by Local buckling of the compression flange.



Pre-Standard for
Load & Resistance Factor
Design (LRFD) of Pultruded
Fiber Reinforced Polymer (FRP)
Structures
(Final)

Submitted to:
American Composites Manufacturers
Association (ACMA)

November 9, 2010

ASCE

HOW DID CREATIVE DERIVE THE MOMENT CAPACITY OF THEIR SHEET PILE PROFILES?

Two Design approaches were utilized to predict the moment capacity of the 1580 Sheet Pile Section.

Mechanics of Materials and FEA

(a) *Compression flange local buckling*

$$f_{cr} = \frac{4\pi^2 t_f^2}{b_f^2}\left(\frac{\sqrt{(E_{L,f}E_{T,f})}(1+4.1\xi)}{6} + \left(2+0.62\xi^2\right)\left(\frac{E_{T,f}\nu_{LT}}{12}+\frac{G_{LT}}{6}\right)\right) \quad (5.2.3.4\text{-}1)$$

with

$$\xi = \frac{1}{1+\dfrac{4E_{T,f}t_f^3}{5k_r b_f}} \quad (5.2.3.4\text{-}2)$$

$$k_r = \frac{E_{T,w}t_w^3}{3h}\left(1-\left[\left(\frac{2t_f^2h^2E_{L,f}}{11.1b_f^2t_w^2E_{L,f}}\right)\left(\frac{\sqrt{E_{L,f}E_{T,f}}+E_{T,f}\nu_{LT}+2G_{LT}}{1.25\sqrt{E_{L,w}E_{T,w}}+E_{T,w}\nu_{LT}+2G_{LT}}\right)\right]\right) \quad (5.2.3.4\text{-}3)$$

(b) *Web local buckling*

$$f_{cr} = \frac{11.1\pi^2 t_w^2}{6h^2}\left(1.25\sqrt{E_{L,w}E_{T,w}}+E_{T,w}\nu_{LT}+2G_{LT}\right) \quad (5.2.3.4\text{-}4)$$

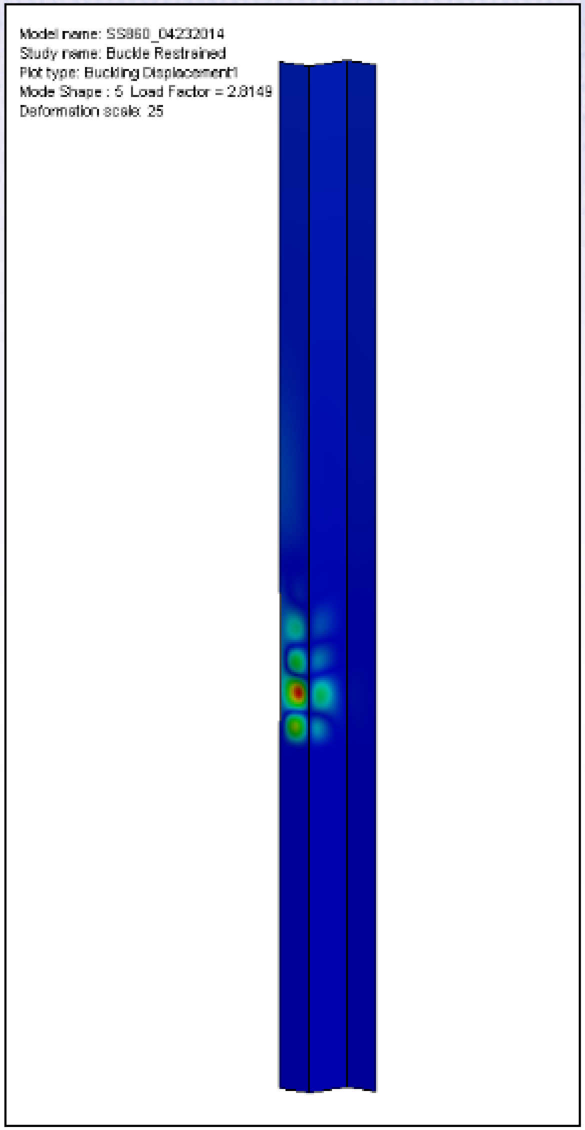
LRFD PRE-STANDARD local buckling equations were used to predict the critical buckling stress in each profile.

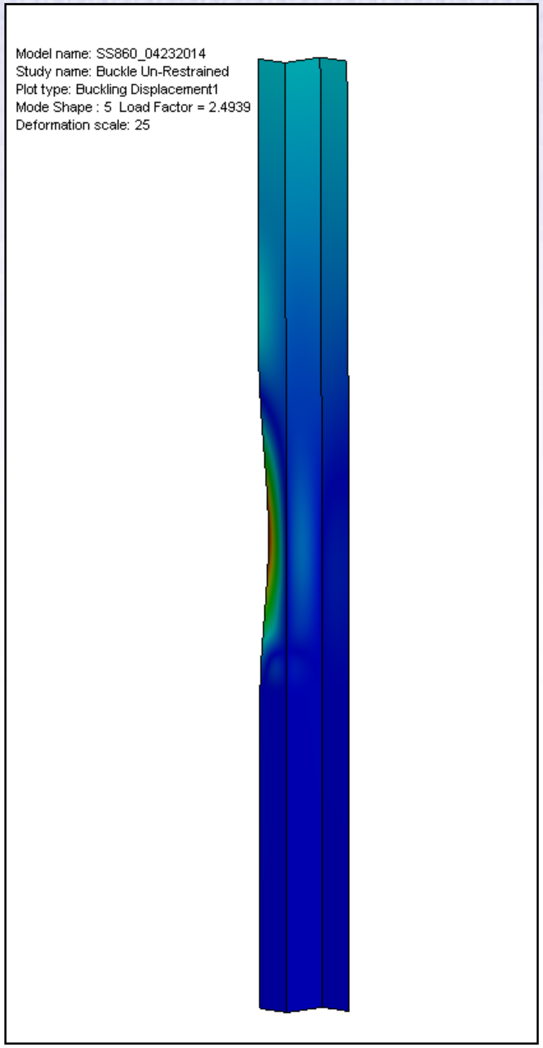
CREATIVE PULTRUSIONS

FINITE ELEMENT ANALYSIS

An FEA model was created using SolidWorks Simulation. The simulation, based on the minimum mechanical properties, predicted a buckling stress of 12,044 psi or a ground line moment of 13,128 ft-lbs/ft of wall.

The mechanics of materials calculations predicted a moment capacity of 14,472 ft-lbs/ft of wall.





1580 FULL SECTION TESTING TO FAILURE

Note: Mock wall constructed, instrumented and tested to failure.

1580 FULL SECTION TESTING TO FAILURE

Note: The Failure moment was16,569 lb-ft/ft of wall which correlated to a compression stress of15,201 psi.

SUMMARY: Mechanics of materials – 14,472 / FEA 13,128 / Full Section 16,569 ft-lbs/ft of wall.

CREATIVE PULTRUSIONS

REFERENCE WHITE PAPER

Development of Design Properties for the Series 1580 Seawall Profile.

Mostoller/Troutman

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Development of Design Properties for the Series 1580 Seawall Profile

Comparison and Validation of Load & Resistance Factor Design (LRFD) and Finite Element Analysis (FEA) of Non-Conforming Profiles

Prepared by:

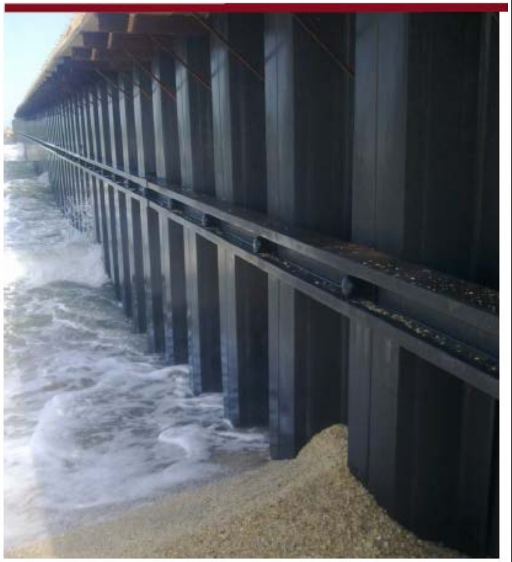
Jeremy Mostoller
Product Design Engineer

Dustin Troutman
Director of Marketing & Product Development

April 28, 2014

Abstract

This paper demonstrates three methods to determine the moment capacity of Fiber Reinforced Polymer (FRP) sheet piling. Composite sheet piling is susceptible to local compression failure prior to reaching the material strength capacity. The low modulus of elasticity in conjunction with the unsupported flange width and thickness greatly affects the true moment capacity of non-metallic sheet piling. This paper describes two modeling methods and the degree of error as compared to a full section cantilever test of the sheet pile wall modeled.



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QUESTIONS?

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