CREATIVE PULTRUSIONS

Available in Australia from

CSIS sustainable infrastructure systems

SUPERPILE®
FIBERGLASS REINFORCED POLYMER (FRP) PIPE PILES

PROVIDING LEADERSHIP IN FRP PIPE PILE TECHNOLOGY

CPI PIPE PILES

The SUPERPILE® product line was developed based on what owners, end users, engineers and contractors value in a pipe pile.

FASTEST DRIVEN & LONGEST LASTING

Creative Pultrusions, Inc. (CPI) is the world leader in pultrusion manufacturing. Our commitment to continuous process and product improvement has transformed CPI into a world-renowned pultruder specializing in custom profiles while utilizing high-performance resins and our proprietary high-pressure injection pultrusion technology.

As the world's most innovative leader in the FRP pultrusion industry, over the last two decades, we've developed structural systems that out perform and outlast structures built with traditional materials of construction. CPI has continued to build upon their reputation by introducing a pipe pile product line known as SUPERPILE®. Developed to provide superior performance in harsh marine environments, SUPERPILE® has been developed to drive faster and last longer than traditional piles.

WHAT IS PULTRUSION?

Pultrusion is a continuous manufacturing process utilized to make composite profiles with constant cross-sections whereby reinforcements, in the form of roving and mats, are saturated with resin and guided into a heated die. The resin undergoes a curing process known as polymerization. The once resin saturated reinforcements exit the die in a solid state and in the form of the cross section of the die. The pultrusion process requires little labor and is ideal for mass production of constant cross section profiles.
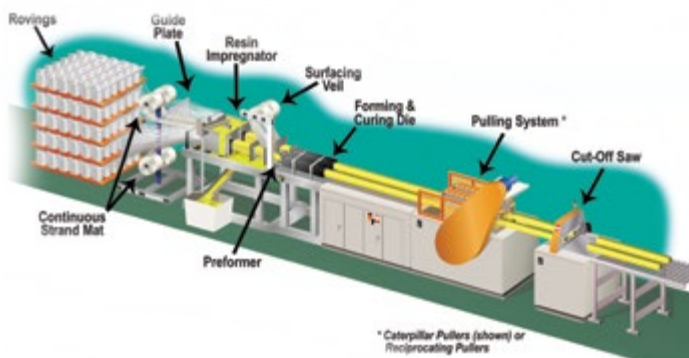
WHAT DO OWNERS VALUE IN SUPERPILE®?

- **Longevity** - Significant Reductions of Future Capital Expenditures
- **Maintenance** - Significant Reductions of Future Maintenance Expenditures
- **Aesthetics** - No Rust Marks, Spalling, Rotting or Section Loss
- **Green** - Low Embodied Energy
- **Environmentally Friendly** - Will Not Leach Dangerous Pesticides, Antifungal or Preservatives into the Environment

WHAT DO END USERS VALUE IN SUPERPILE®?

- **Functionality** - Performs as Designed and Intended
- **Aesthetics** - Professional Look
- **Performance** - Protects Your Boat and Structures

WHAT DO ENGINEERS VALUE IN SUPERPILE®?

- **Engineered Product** - Unlike Wood, FRP is an Engineered Product with a Low Coefficient of Variation (COV)
- **High Strength** - Pound for Pound Stronger than Steel, Concrete and Wood
- **Low Modulus of Elasticity** - Dissipates Vessel Impact Energy
- **Versatile** - Can Be Used as a Foundation Bearing, Dock or Fender Pile
- **Reliable** - Design Values Are Based on a 95% Confidence Value
- **Design** - Can Be Designed Based on Load and Resistance Factor Design (LRFD) or Allowable Stress Design (ASD)
- **Factory Made** - Manufactured in an Environmentally Controlled Complex to Stringent Quality Assurance (QA) Standards

WHAT DO CONTRACTORS VALUE IN SUPERPILE®?

- Significant Shipping Savings
- Drills and Cuts 2x Faster Than Thermoplastic Polymer Piles
- Driven with Standard Pile Driving Equipment
- Lightweight - 1/10th the Weight of a Concrete Pile and 1/4th the Weight of Steel
- Field Drillable
- Ease of Fabrication with Traditional Construction Tools

PDA Analysis, Virginia

PILE CONSTRUCTION

SUPERPILE® Composite Pipe Pile is manufactured with electrical grade fiberglass and high impact, high strength polyurethane resin. The combination of the advanced resin and high strength glass produces a superior strength, highly corrosion resistant pipe pile.
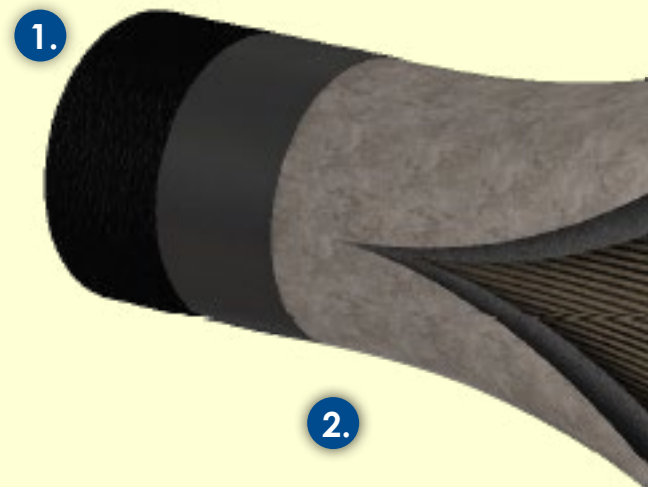
Full Section Pipe Pile Testing, West Virginia University

1. ADVANCED UV PROTECTION

CPI's composite pipe piles are shipped standard with two layers of Ultra Violet (UV) protection. First, CPI adds light stabilizers to each pile. The light stabilizers are mixed into the thermoset resin, prior to production, and function as long term light stability promoters. Second, the composite pipe piles are encompassed with a 10 mil polyester surfacing veil. The 10 mil veil creates a resin rich surface and protects the glass reinforcements from fiber blooming. Additional UV and or abrasion barriers are available.

2. RESIN/MATRIX

The pipe piles are pultruded with high performance thermoset resins. The 12" & 16" round pipe piles are manufactured standard with SUPURTUF™ Polyurethane resin. Polyurethane resins provide optimal strength, toughness and impact resistance. When it comes to high strength, toughness, abrasion and impact properties, nothing outperforms SUPURTUF™ Polyurethane.

PILE TESTING

SUPERPILE® has undergone extensive testing at CPI, West Virginia University's Constructed Facility Center and in the field. Tests that have been conducted: full section to failure, connection, compression, Pile Dynamic Analysis (PDA) and fatigue.

PDA Testing, Virginia

"I have researched, tested and installed composite systems related to civil infrastructure over my entire career. **I was astonished at the high strength and modulus values achieved with the polyurethane pipe piles manufactured by Creative Pultrusions, Inc.** I expect that the US infrastructure will benefit greatly from this tubular pile technology."

~ Hota GangaRao, PhD, P.E., F. ASCE
West Virginia University

3. FIBERGLASS REINFORCEMENTS

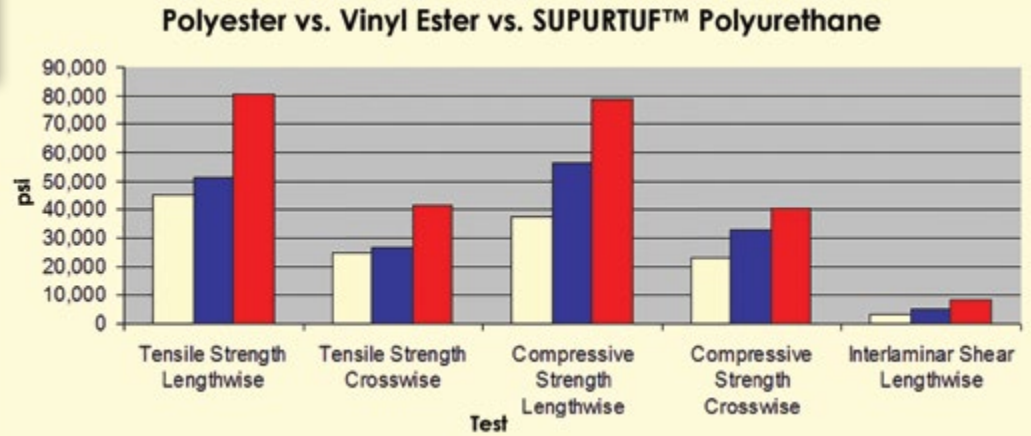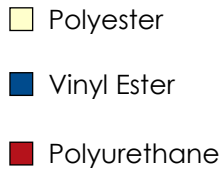All composite pipe piles are manufactured with electrical grade E-glass reinforcements in the form of unidirectional roving, Continuous Filament Mat (CFM) and stitched fabric mats. The combination of fiber reinforcements have been engineered for optimal bending and crush strength, as well as superior stiffness. All E-glass reinforcements meet a minimum tensile strength of 290 ksi per ASTM D2343.
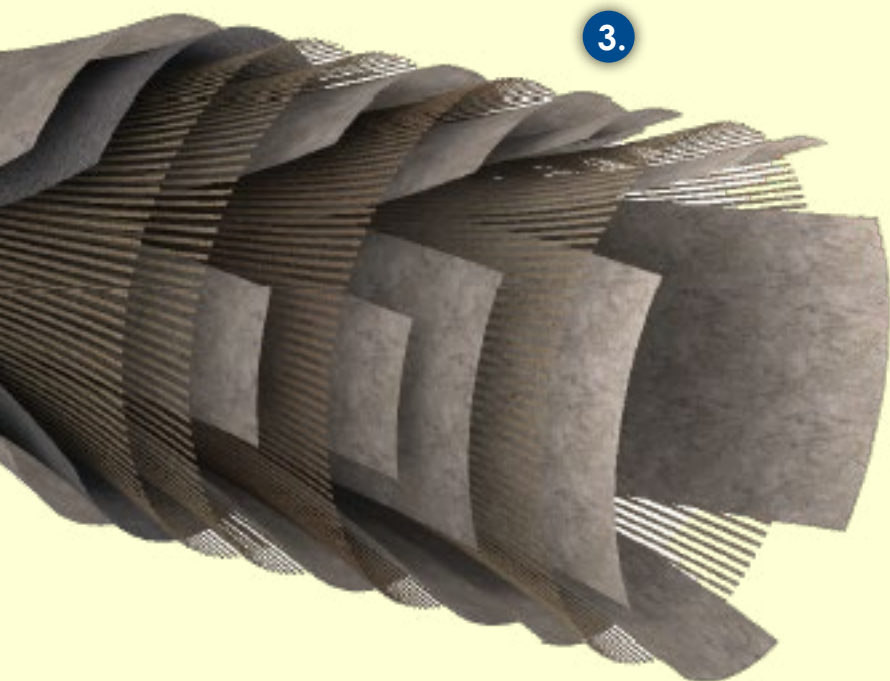
3.

WHY SHOULD YOU BUY & SPECIFY CPI PIPE PILES?

Polyester vs. Vinyl Ester vs. SUPURTUF™ Polyurethane

- ☐ Polyester
- ■ Vinyl Ester
- ■ Polyurethane

FASTEST DRIVEN

Contractors all agree that the hollow SUPERPILE® drives twice as fast as solid wood, concrete and thermoplastic piles.

LONGEST LASTING

Long term durability projections predict a 75+ year service life.

ENERGY ABSORPTION

High strength, low modulus equates to very high energy absorption capacities when compared to wood, steel and concrete.

Polyester vs. Vinyl Ester vs. SUPURTUF™ Polyurethane
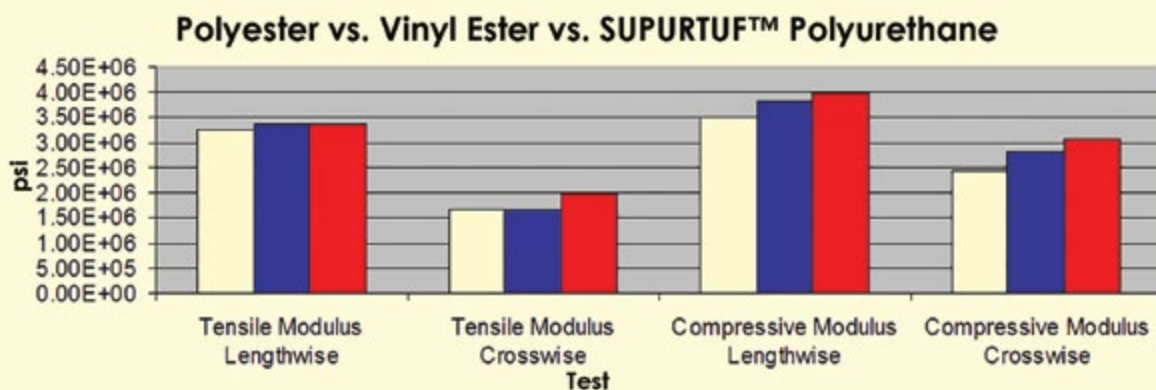
The graphs demonstrate a comparison of polyester, Vinyl Ester and polyurethane resins. The fiber architecture is the same, only the resin type has been modified. The chart demonstrates the strength and modulus difference between resin types.

EASE OF FABRICATION
Can be field drilled and cut in seconds.

NO LEACHING OF PRESERVATIVES, FUNGICIDES OR INSECTICIDES
Environmentally friendly, the SUPERPILE® is inert, unlike wood that leaches dangerous chemicals into the environment.

ENGINEERED SOLUTION
Designed specifically for the piling market and manufactured in a production environment.

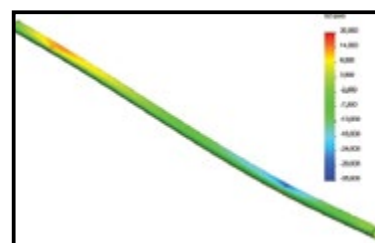- **UNAFFECTED BY MARINE BORERS**
  Will not succumb to aquatic mollusks or crustaceans.

- **WILL NOT ROT**
  Inert to fungi or microbial attack.

- **LIGHTWEIGHT**
  Significantly lighter than steel, concrete and wood piles.

- **SAFETY**
  Very low electrical conductivity, ideal for working around power lines.

- **GREEN**
  Low embodied energy.

- **NON-POLLUTING**
  Accepted by NJDEP as non-polluting material for water and land use.

WHAT ARE OWNERS AND CONTRACTORS SAYING ABOUT SUPERPILE®?

"Creative Pultrusions manufactured 190 SUPERPILES that were supplied by Lee Composites to Dutra Construction. The SUPERPILES replaced deteriorating creosote treated wood guide piles for the San Francisco Marina West Harbor Renovation Project. These piles are used as a fender by boats navigating in and out of their slips. The SUPERPILES are both aesthetically pleasing and have superior functionality to the treated wood piles. In addition, they are more environmentally friendly than their wood counterparts. They were installed very easily with a drop hammer and met all of our expectations. We expect these piles to stand the test of time by offering many years of maintenance free service. We expect to see a lot more of the SUPERPILES on future projects."

~Mike Edde
Dutra Construction

San Francisco West Harbor Renovation Project
December 2011 (Phase 1), San Francisco, California

"Composite piles are filled with concrete are a viable alternative to traditional piles due to the increase in longevity and life"

~Raymond Sciahetano
EIC Associates, Inc.

Statue of Liberty Dock Rehabilitation Project, Liberty Island, NY

"When our Margate Bridge wooden fender system succumbed to the years of wear and tear in a hostile environment, we knew it was time to invest in a new fender system. We chose to specify the latest in fender technology and go with Creative Pultrusion's SUPERPILE. The piles were manufactured to spec. and delivered on time. The robust piles will protect our bridge foundations for many years without leaching any chemicals into our waterways. The piles made sense from a business and environmental standpoint, making the decision to procure the piles easy."

~David Goddard
Ole Hansen and Sons, Inc.

Margate Bridge Installation, Margate New Jersey

"Upon award of the bid, Crofton knew that choosing the right supplier for the FRP piles was critical in order to get value engineering proposal approval by the project start date. Creative was the best choice since they have done extensive testing, are listed on multiple state's Qualified Products Lists and have the engineering support to assist in securing this approval.

Creative addressed all material related questions and concerns brought about by the Engineer of Record and VADOT engineering. In fact, they provided piles so that a PDA could be performed on the 16" dia. FRP SUPERPILE. The PDA eliminated all concerns and questions that Crofton and the Engineering firm had with regards to installation and connection details.

Not only did Creative supply a quality product at a fair price, they stood behind us through the entire project. The engineering team at CPI made my life easier and saved Crofton money in the process."

~Brad Gribble
Crofton Industries

**Fender Rehabilitation
Route 3 Over Piankatank River, Virginia**

MECHANICAL & PHYSICAL PROPERTIES
PIPE PILES

The mechanical and physical data detailed herein is provided for the structural engineer. The mechanical data is published in terms of average and characteristic values. The characteristic values were derived per the requirements as set forth in ASTM D7290 Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications. The characteristic value is defined as 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. The characteristic value is the reference strength.

In terms of Load and Resistance Factor Design (LRFD) design, the reference strength shall be adjusted for end use conditions by applying the applicable adjustment factors to establish the nominal resistance strength. The design strength shall include the nominal resistance, adjusted for end-use conditions, a resistance factor and time effect factor. The reference strength and stiffness shall be multiplied by .85 and .95 respectively to establish the nominal strength and stiffness for installations in sea and fresh water. A time effect factor of 0.4 shall be applied for full design permanent loads that will act during the service life of the structure. Resistant factors shall be established as set forth in the LRFD of Pultruded Fiber Reinforced Polymer (FRP) Structures Pre-Standard. Serviceability shall be checked based on the adjusted average full section modulus of elasticity as established per ASTM D6109.

In terms of Allowable Stress Design (ASD), the pultrusion industry uses a 3.0 safety factor for compression members, 2.5 for flexural members, 3.0 for connections and 3.0 for shear. The characteristic reference strength shall be used for strength and the average E-modulus shall be used for serviceability calculations.

SUPERPILE® Mechanical Properties	Round FRP Pipe Pile TU440 Polyester 10"x3/8" Metric (254mm x 9.52m)		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)	65,722[3]	(453)[3]	52,000	(359)	69,658	(480)	57,270	(395)
Characteristic Flexural Strength per ASTM D6109 psi (Mpa)	*****	*****	*****	*****	56,111	(387)	49,840	(344)
Average Compression Strength per ASTM D6109 psi (Mpa)	65,722[3]	(453)[3]	52,000	(359)	69,658	(480)	57,270	(395)
Characteristic Compression Strength per ASTM D6109 psi (Mpa)	*****	*****	*****	*****	56,111	(387)	49,840	(344)
Average In-Plane Shear Strength psi (Mpa)	10,792	(74)	15,605	(108)	16,039	(111)	17,170	(118)
Characteristic In-Plane Shear Strength psi (Mpa)	9,456	(65)	13,212	(91)	13,713	(95)	14,936	(103)
Average Shear Capacity lbs (Kg)	61,185	(27,753)	106,894	(48,486)	145,153	(65,840)	208,616	(94,626)
Characteristic Shear Capacity lbs (Kg)	53,611	(24,317)	90,502	(41,051)	124,103	(56,292)	181,472	(82,314)
Average Torque Strength lb-ft (kN•m)	49,076	(67)	103,519	(140)	138,829	(188)	269,987	(366)
Characteristic Torque Strength lb-ft (kN•m)	43,001	(58)	87,644	(119)	118,696	(161)	234,859	(318)
Average Axial Compression Strength psi (Mpa)	65,722	(453)	52,000	(359)	69,658	(480)	57,270	(395)
Characteristic Axial Compression Strength psi (Mpa)	*****	*****	*****	*****	56,111	(387)	49,840	(344)
Average Axial Compression Capacity (Short Column) lb (kg)	745,222	(338,027)	712,400	(323,139)	1,260,810	(571,894)	1,391,661	(631,247)
Characteristic Axial Compression Capacity (Short Column) lb (kg)	*****	*****	*****	*****	1,015,609	(460,673)	1,211,112	(549,351)
Average Modulus of Elasticity per ASTM D6109 psi (Gpa)	6.31E+06[4]	(43.5)[4]	5.26E+06	(36.3)	5.91E+06	(40.7)	5.99E+06	(41.3)
Bending Stiffness (EI) per ASTM D6109 lbs•in[2] (kg•mm[2])	8.30E+08[4]	(2.43E+11)[4]	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)	144[3]	(195)[3]	167	(227)	289	(392)	437	(592)

MECHANICAL & PHYSICAL PROPERTIES
PIPE PILES

SUPERPILE® Mechanical Properties	Round FRP Pipe Pile TU440 Polyester 10"x3/8" Metric (254mm x 9.52mm)		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 x1 2.7mm)	
Characteristic Moment Capacity per ASTM D6109 kip-ft (kN•m)	*****	*****	*****	*****	233	(316)	380	(515)
Average Energy Absorption kip-in (kN•m)	*****	*****	341	(39)	643	(73)	829	(94)
Characteristic Energy Absorption kip-in (kN•m)	*****	*****	*****	*****	405	(46)	603	(68)
Average Pin Bearing Strength Crosswise psi (Mpa)	19,155	(132)	19,823	(137)	21,676	(149)	23,666	(163)
Characteristic Pin Bearing Strength Crosswise psi (Mpa)	16,577	(114)	12,447	(86)	12,546	(87)	20,771	(143)
Average Pin Bearing Strength Lengthwise psi (Mpa)	31,824	(219)	30,793	(212)	30,149	(208)	27,788	(192)
Characteristic Pin Bearing Strength Lengthwise psi (Mpa)	27,755	(191)	18,053	(125)	25,132	(173)	19,217	(133)
Average Pile Crush Strength lb (kg) (based on a 9" wide load path)[1]	*****	*****	10,600	(4,808)	17,970	(8,151)	16,600	(7,530)
Characteristic Pile Crush Strength lb (kg) (based on a 9" wide load path)[1]	*****	*****	8,060	(3,656)	13,782	(6,251)	11,667	(5,292)
Average Crush Strength, with FRP Insert, lb (kg) (based on a 9" wide load path)[1]	*****	*****	*****	*****	73,780	(33,466)	44,213	(20,055)
Characteristic Crush Strength, with FRP Insert, lb (kg) (based on a 9" wide load path)[1,2]	*****	*****	*****	*****	51,370	(23,301)	*****	*****
Average Washer Pull Through Strength lb (kg) using a 6"x1/2" square/radius washer	*****	*****	26,084	(11,832)	30,686	(13,919)	27,582	(12,511)
Characteristic Washer Pull Through Strength lb (kg) using a 6"x1/2" square/radius washer	*****	*****	22,107	(10,028)	26,815	(12,163)	25,103	(11,387)
Average Washer Pull Through Strength lb (kg) using a 6"x3/8" square/radius washer	17,377	(7,882)	18,893	(8,570)	25,205	(11,433)	18,878	(8,563)
Characteristic Washer Pull Through Strength lb (kg) using a 6"x3/8" square/radius washer	14,812	(6,719)	13,977	(6,340)	22,420	(10,170)	13,521	(6,133)
Allowable torque permitted on a bolted connection with a 6" radius washer lb-ft (N•m)	50	(68)	50	(68)	50	(68)	50	(68)

Notes:
1. The crush strength value is based on full section testing. The strength value was recorded at the first audible sound and change in the load deflection curve. The ultimate capacity is approximately 60% higher and is defined as the highest recorded load documented during the crush strength test.
2. Characteristic data is unavailable due to the number of tests required. A minimum of 10 tests are required to generate the ASTM D7290 Characteristic values.
3. Full section strength for the TU440 obtained from testing in accordance with ASTM D1036.
4. Modulus of elasticity value obtained from ASTM D638 protocol.
5. Capacity based on testing conducted with 3/4" hardware for the TU440 and 1" hardware for all others.

MECHANICAL & PHYSICAL PROPERTIES
PIPE PILES

SUPERPILE® Physical Properties	Round FRP Pipe Pile TU440 Polyester 10"x3/8" Metric (254mm x 9.52mm)		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)	
Diameter in (cm)	10	(25.4)	12	(30.48)	12	(30.48)	16	(40.64)
Wall thickness in (mm)	0.375	(9.5)	0.375	(9.5)	0.5	(12.7)	0.5	(12.7)
Moment of Inertia in⁴ (cm⁴)	131.51	(5,474)	232	(9,657)	299	(12,445)	732	(30,468)
Section Modulus in³ (cm³)	26.3	(431)	38.6	(633)	49.8	(816)	91.5	(1,499)
Radius of Gyration in (mm)	3.41	(87)	4.11	(104)	4.07	(103)	5.48	(139)
Weight lb/ft (Kg/m)	10.3	(15.3)	12.6	(18.7)	16.9	(25.1)	22.6	(33.6)
Coefficient of Thermal Expansion (CTE) Lengthwise in/in/°F (mm/mm/°C)	5.00E-06	(9.00E-06)	5.00E-06	(9.00E-06)	5.00E-06	(9.00E-06)	5.00E-06	(9.00E-06)
Water Absorption ASTM D570	1.0% (24hrs)	1.0% (24hrs)	0.15% (24hrs)	0.15% (24hrs)	0.15% (24hrs)	0.15% (24hrs)	0.15% (24hrs)	0.15% (24hrs)
Fiber Volume Fraction %	≥50%	≥50%	≥50%	≥50%	≥50%	≥50%	≥50%	≥50%
Cross Sectional Area in² (cm²)	11.3	(72.9)	13.7	(88.4)	18.1	(116.8)	24.3	(156.8)
Surface Area ft²/ft (m²/m)	2.62	(0.80)	3.14	(0.96)	3.14	(0.96)	4.19	(1.28)

MECHANICAL & PHYSICAL PROPERTIES
OCTAGONAL DOCK PILES

The mechanical and physical data detailed herein is provided for the structural engineer. The mechanical data is published in terms of average value and either characteristic or 5% Lower Exclusion Limit (LEL) values. The characteristic values were derived per the requirements as set forth in ASTM D7290 Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications. The characteristic value is defined as a statistically-based material property representing the 80% lower confidence bound on the 5th-percentile value of a specified population. In instances where sufficient data was not available to calculate the characteristic value, a 5% LEL was calculated. The 5% LEL, like the characteristic value, is the 5th-percentile value, however it is somewhat less conservative in that it does not account for the 80% lower confidence bound. The values are listed to account for statistical uncertainty due to a finite sample size. These statistically reduced values should be used as the reference strength.

In terms of Load and Resistance Factor Design (LRFD) design, the reference strength shall be adjusted for end use conditions by applying the applicable adjustment factors to establish the nominal resistance strength. The design strength shall include the nominal resistance, adjusted for end-use conditions, a resistance factor and time effect factor. The reference strength and stiffness shall be multiplied by .85 and .95 respectively to establish the nominal strength and stiffness for installations in sea and fresh water. A time effect factor of 0.4 shall be applied for full design permanent loads that will act during the service life of the structure. Resistant factors shall be established as set forth in the LRFD of Pultruded Fiber Reinforced Polymer (FRP) Structures Pre-Standard. Serviceability shall be checked based on the adjusted average full section modulus of elasticity as established per ASTM D1036.

In terms of Allowable Stress Design (ASD), the pultrusion industry uses a 3.0 safety factor for compression members, 2.5 for flexural members, 3.0 for connections, and 3.0 for shear. The reference strength shall be used for strength and the average modulus shall be used for serviceability calculations.

Octagonal Pile Mechanical Properties	Octagonal Pile 8"x.25" Series II CP076 (203mm x 6.35mm)		Octagonal Pile 10"x.25"Series II CP074 (254mm x 6.35mm)		Octagonal Pile 10"x.275" Series III CP210 (254mm x 6.98mm)	
Average Flexural Strength per ASTM D1036 psi (Mpa)	49,173	(339)	43,832	(302)	43,893	(303)
5% LEL Flexural Strength per ASTM D1036 psi (Mpa)[1]	46,999	(324)	41,374	(285)	42,076	(290)
Average Compression Strength per ASTM D1036 psi (Mpa)	49,173	(339)	43,832	(302)	43,893	(303)
5% LEL Compression Strength per ASTM D1036 psi Mpa)[1]	46,999	(324)	41,374	(285)	42,076	(290)
Average In-Plane Shear Strength psi (Mpa)	12,554	(87)	12,706	(88)	12,866	(89)
Characteristic In-Plane Shear Strength psi (Mpa)	10,940	(75)	10,101	(70)	11,616	(80)
Average Shear Capacity lbs (Kg)	48,458	(21,980)	68,359	(31,007)	86,649	(39,304)
Characteristic Shear Capacity lbs (Kg)	42,230	(19,155)	54,344	(24,650)	78,237	(35,488)
Average Torque Strength lb-ft (kN•m)	24,675	(33)	41,166	(56)	45,621	(62)
Characteristic Torque Strength lb-ft (kN•m)	21,504	(29)	32,726	(44)	41,191	(56)
Average Axial Compression Strength psi (Mpa)	49,173	(339)	43,832	(302)	43,893	(303)
5% LEL Axial Compression Strength psi (Mpa)[1]	46,999	(324)	41,374	(285)	42,076	(290)
Average Axial Compression Capacity (Short Column) lb (kg)	379,617	(172,191)	471,634	(213,930)	591,245	(268,184)
5% LEL Axial Compression Capacity (Short Column) lb (kg)[1]	362,832	(164,578)	445,184	(201,932)	566,764	(257,080)
Average Modulus of Elasticity per ASTM D1036 psi (Gpa)	4.30E+06	(29.6)	4.00E+06	(27.6)	3.70E+06	(25.5)
Bending Stiffness (EI) per ASTM 1036 lbs•in² (kg•mm²)	2.62E+08	(7.67E+10)	5.58E+08	(1.63E+11)	6.35E+08	(1.86E+11)
Average Moment Capacity per ASTM D1036 kip-ft (kN•m)	62	(85)	100	(136)	123	(167)
5% LEL Moment Capacity per ASTM D1036 kip-ft (kN•m)[1]	60	(81)	94	(128)	118	(160)
Average Pin Bearing Strength Crosswise psi (Mpa)	15,357	(106)	11,562	(80)	11,280	(78)
Characteristic Pin Bearing Strength Crosswise psi (Mpa)	8,131	(56)	5,839	(40)	5,453	(38)

MECHANICAL & PHYSICAL PROPERTIES
OCTAGONAL DOCK PILES

Octagonal Pile Mechanical Properties	Octagonal Pile 8"x.25" Series II CP076 (203mm x 6.35mm)		Octagonal Pile 10"x.25"Series II CP074 (254mm x 6.35mm)		Octagonal Pile 10"x.275" Series III CP210 (254mm x 6.98mm)	
Average Pin Bearing Strength Lengthwise psi (Mpa)	27,263	(188)	28,223	(195)	27,132	(187)
Characteristic Pin Bearing Strength Lengthwise psi (Mpa)	16,679	(115)	21,029	(145)	12,867	(89)
Average Washer Pull Through Strength lb kg) using a 4"x3/8" square washer	13,697	(6,213)	14,698	(6,667)	14,571	(6,609)
Characteristic Washer Pull Through Strength lb (kg) using a 4"x3/8" square washer	10,705	(4,856)	11,916	(5,405)	11,798	(5,351)
Allowable torque permitted on a bolted connection with a 4"x3/8" square washer lb-ft (N•m)	50	(68)	50	(68)	50	(68)

Octagonal Pile Physical Properties	Octagonal Pile 8"x.25" Series II CP076 (203mm x 6.35mm)		Octagonal Pile 10"x.25"Series II CP074 (254mm x 6.35mm)		Octagonal Pile 10"x.275" Series III CP210 (254mm x 6.98mm)	
Diameter in (cm)	8	(20.32)	10.2	(25.91)	10.2	(25.91)
Wall thickness in (mm)	0.25	(6.4)	0.25	(6.4)	0.275	(7.0)
Moment of Inertia in^4 (cm^4)	60.87	(2,534)	139.69	(5,814)	171.57	(7,141)
Section Modulus in^3 (cm^3)	15.22	(249)	27.39	(449)	33.64	(551)
Radius of Gyration in (mm)	2.81	(71)	3.60	(91)	11.05	(281)
Weight lb/ft (Kg/m)	6.33	(9)	8.82	(13.1)	11.05	(16.4)
Coefficient of Thermal Expansion (CTE) Lengthwise in/in/°F (mm/mm/°C)	5.00E-06	(9.00E-06)	5.00E-06	(9.00E-06)	5.00E-06	(9.00E-06)
Water Absorption ASTM D570	0.60% (24hrs)	0.60% (24hrs)	0.60% (24hrs)	0.60% (24hrs)	0.60% (24hrs)	0.60% (24hrs)
Fiber Volume Fraction %	≥50%	≥50%	≥50%	≥50%	≥50%	≥50%
Cross Sectional Area in^2 (cm^2)	7.72	(50)	10.76	(69.4)	13.47	(86.9)
Surface Area ft^2/ft (m^2/m)	2.20	(0.67)	2.80	(0.85)	2.80	(0.85)

Octagonal Pile Fire Properties	Octagonal Pile 8"x.25" Series II CP076 (203mm x 6.35mm)	Octagonal Pile 10"x.25"Series II CP074 (254mm x 6.35mm)	Octagonal Pile 10"x.275" Series III CP210 (254mm x 6.98mm)
Flame Rating (UL 94)	V0 Self Extinguishing	V0 Self Extinguishing	V0 Self Extinguishing
Flame Spread ASTM E-84	Class A 25 or less	Class A 25 or less	Class A 25 or less

Octagonal Pile Electrical Properties	Octagonal Pile 8"x.25" Series II CP076 (203mm x 6.35mm)	Octagonal Pile 10"x.25"Series II CP074 (254mm x 6.35mm)	Octagonal Pile 10"x.275" Series III CP210 254mm x 6.98mm)
ASTM F711 (100 kVAC per foot - 5 minutes dry)	Passed	Passed	Passed
IEEE978 (75 kVAC per foot - 1 minute wet)	Passed	Passed	Passed

Notes:
[1]5% Lower Exclusion Limit (LEL) was used as a statistical knockdown in instances where the sufficient number of data points was not available to calculate the characteristic value.
[2]All connection testing was conducted utilizing 3/4" hardware.

The Mechanical and Physical Property Charts for the Octagonal piles have been developed based on extensive third party and in house testing.

SUPERPILE® MECHANICAL LOAD CHARTS

SUPERPILE® is ideal for bridge and dock fendering. The high strength attributes combined with the mid range Modulus of Elasticity (MOE) permits SUPERPILE® to absorb a high amount of energy. The SUPERPILE® Energy Absorption Capacity Chart details the energy absorption capacity in terms of the average and characteristic values. The values were derived from full section testing to failure based on ASTM D6109. The energy calculation is derived by calculating the area under the load deflection curve.

SUPERPILE® ENERGY ABSORPTION CHART

Round FRP Pipe Pile TU455 Polyurethane12"x3/8" Metric (305mmx9.52mm)	Round FRP Pipe Pile TU450 Polyurethane12"x1/2" Metric (305mmx12.7mm)	Round FRP Pipe Pile TU460 Polyurethane16"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)

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

SUPERPILE® BOLTED CONNECTION CAPACITY CHARTS

The following charts depict the round and octagonal piles bolted characteristic connection capacity. Specifically, the piles were tested by positioning a 3/4" dia. rod through the octagonal piles and 1" dia. rod through the round pipe piles. The rods were loaded as depicted in the photos until an ultimate load was achieved. The ultimate load is defined as the maximum recorded load. The failure mode is pin bearing of the FRP material. The tests were conducted in both the lengthwise and transverse directions. The ultimate pin bearing stress was calculated based on the pin diameter, wall thickness and the fact that the rod penetrated two walls. The values used to make the chart were derived from the pin bearing strength obtained during testing. The charts values are based on the diameter of the bolt or bolts used in the connection, the number of bolts and the pile series. The average and characteristic values are included and represent the capacity of a bolt loaded entirely on one side of the pile as depicted in the photograph. The thermoplastic wale, although connected with a bolt that protrudes through both walls of the pipe pile, is supported by the pin bearing strength of one wall, in the lengthwise direction of the FRP 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	
TU440 10" x 3/8" (254mmx9.52mm)	6,505	(2,951)	13,010	(5,901)	7,806	(3,541)	15,612	(7,082)	10,408	(4,721)	20,816	(9,442)
TU455 12" x 3/8" (305mmx9.52mm)	4,231	(1,919)	8,462	(3,838)	5,077	(2,303)	10,155	(4,606)	6,770	(3,071)	13,540	(6,142)
TU450 12" x 1/2" (305mmx12.7mm)	7,854	(3,562)	15,708	(7,125)	9,425	(4,275)	18,849	(8,550)	12,566	(5,700)	25,132	(11,400)
TU460 16" x 1/2"(406mmx12.7mm)	6,005	(2,724)	12,011	(5,448)	7,206	(3,269)	14,413	(6,538)	9,609	(4,358)	19,217	(8,717)
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	(1,182)	5,212	(2,364)	3,127	(1,419)	6,255	(2,837)	4,170	(1,891)	8,340	(3,783)
CP074 10" x. 25" (254mmx6.35mm)	3,286	(1,490)	6,572	(2,981)	3,943	(1,789)	7,886	(3,577)	5,257	(2,385)	10,515	(4,769)
CP210 10" x. 275" (254mmx6.98mm)	2,212	(1,003)	4,423	(2,006)	2,654	(1,204)	5,308	(2,408)	3,539	(1,605)	7,077	(3,210)

Notes:
Table published based on characteristic values per ASTM D7290; proper safety factors are required.

Bolted Connection Test - Parallel

Bolted Connection Test - Perpendicular

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	
TU440 10" x 3/8" (254mmx9.52mm)	3,885	(1,762)	7,770	(3,525)	4,662	(2,115)	9,325	(4,230)	6,216	(2,820)	12,433	(5,639)
TU455 12" x 3/8" (305mmx9.52mm)	2,917	(1,323)	5,835	(2,646)	3,501	(1,588)	7,001	(3,176)	4,668	(2,117)	9,335	(4,234)
TU450 12" x 1/2" (305mmx12.7mm)	3,921	(1,778)	7,841	(3,557)	4,705	(2,134)	9,410	(4,268)	6,273	(2,845)	12,546	(5,691)
TU460 16" x 1/2"(406mmx12.7mm)	6,491	(2,944)	12,982	(5,888)	7,789	(3,533)	15,578	(7,066)	10,386	(4,711)	20,771	(9,422)
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	(576)	2,541	(1,153)	1,525	(692)	3,049	(1,383)	2,033	(922)	4,066	(1,844)
CP074 10" x. 25" (254mmx6.35mm)	912	(414)	1,825	(828)	1,095	(497)	2,190	(993)	1,460	(662)	2,919	(1,324)
CP210 10" x. 275" (254mmx6.98mm)	937	(425)	1,875	(850)	1,125	(510)	2,249	(1,020)	1,500	(680)	2,999	(1,360)

Notes:
Table published based on characteristic values per ASTM D7290; proper safety factors are required.

SUPERPILE® MECHANICAL LOAD CHARTS

SUPERPILE® CRUSH STRENGTH CHARTS

SUPERPILE® sections were tested to evaluate the full section crush strength. Both the 12" and the 16" piles were tested. The 1/2" thick piles were tested with and without an FRP insert. The insert was developed to increase the crush strength in strategic locations within the pile that will have high stress concentrations. The test setup, as depicted in the photograph, involves a section of SUPERPILE® with an induced load applied through a 10" x 10" thermoplastic wale section.

The crush strength was determined based on the recorded load that caused an initial change in the load deflection curve and is the value listed in the charts. The ultimate load, defined as the ultimate load recorded during the test, is approximately 60% higher than the loads depicted in the charts.

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)

SUPERPILE® Crush Strength Test Set Up

SUPERPILE® with Insert, Crush Strength Test Set Up

SUPERPILE®, with FRP Insert, Crush Strength with a 10"x 10" (25.4mm x 25.4mm) Thermoplastic Wale		
Round FRP Pipe Pile TU455 Polyurethane12"x3/8" Metric (305mmx9.52mm)	Round FRP Pipe Pile TU450 Polyurethane12"x1/2" Metric (305mmx12.7mm)	Round FRP Pipe Pile TU460 Polyurethane16"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.

SUPERPILE® MECHANICAL LOAD CHARTS

WASHER PULL THROUGH CHARTS

The round and octagonal pipe piles were tested to determine the washer pull through capacity. The test set up, as depicted in the photo, involves a series of tests in which 6" steel washers, bent to the required radius were loaded to simulate a connection in which the load causes the washer to pull though the pile. The failure load is the load recorded at the first drop in strength on the load/deflection curve. In most cases, the washer deformed prior to the failure load. Note that curved washers are required for use with the round pile and straight washers are required for use with the octagonal piles.

SUPERPILE® Washer Pull Through Strength with a 6"x1/2" (152mm x12.7mm) Steel Washer		
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 Pull Through Strength lb (kg)		
26,084 (11,832)	30,686 (13,919)	27,582 (12,511)
Characteristic Pull Through Strength lb (kg)		
22,107 (10,028)	26,815 (12,163)	25,103 (11,387)

SUPERPILE® Washer Push Pull Through Test Set Up

SUPERPILE® Washer Pull Through Strength with a 6"x3/8" (152mm x9.5)mm Steel Washer			
Round FRP Pipe Pile TU440 Polyurethane10"x3/8" Metric (254mm x 9.52mm)	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 Pull Through Strength lb (kg)			
17,377 (7,822)	18,893 (8,570)	25,205 (11,433)	18,878 (8,563)
Characteristic Pull Through Strength lb (kg)			
14,812 (6,719)	13,977 (6,340)	22,420 (10,170)	13,521 (6,133)

SUPERPILE® Washer Pull Through Strength with a 4"x3/8" (102mm x 9.5mm) Steel Washer		
Octagonal FRP Pile 8"x.25" Series II CP076 Metric (203mm x 6.35mm)	Octagonal FRP Pile 10"x.25" Series II CP074 Metric (254mm x 6.35mm)	Octagonal FRP Pile 10"x.275" Series III CP210 Metric (254mm x 6.98mm)
Average Pull Through Strength lb (kg)		
13,697 (6,213)	14,698 (6,667)	14,571 (6,609)
Characteristic Pull Through Strength lb (kg)		
10,705 (4,856)	11,916 (5,405)	11,798 (5,351)

TYPICAL DOCK TO FENDER PILE CONNECTION

The pile/dock connection cartoon illustrates an attachment scheme that alleviates stress risers. Specifically, hollow composite pipe piles, although extremely strong and robust, have a lower modulus of elasticity than steel. The ability of the FRP material to distribute high load concentrations is not the same as a steel pipe. Therefore, the correct connection details are important in dock fender design. High stress concentration pipe pile connections should include a steel washer or wood block that wraps 1/4 to 1/2 the way around the pile. Tangential loads should be avoided. The chart depicts the loads that can be induced into the pile with a connection that is typical of the test set up and detail cartoon.

SUPERPILE® Typical Dock to Pile Connection

TYPICAL DOCK TO FENDER PILE CONNECTION

SUPERPILE® Typical Dock to Pile Connection Capacity Test Up

SUPERPILE® Dock Connection Capacity for Fender Applications		
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 Connection Capacity lb (kg)		
26,084 (11,832)	30,686 (13,919)	27,582 (12,511)
Characteristic Connection Capacity		
22,107 (10,028)	26,815 (12,163)	25,103 (11,387)

The chart depicting the dock connection capacity is based on crush strength testing conducted with a 9" long by 6" wide by 1/2" thick steel washer.

SLEEVE OPTIONS
THICK AND THIN

The FRP Polyurethane SUPERPILE® exhibits very good abrasion resistance qualities. However, for applications in which continuous rubbing or severe scour can take place, CPI recommends that the pile and/or watercraft be protected with the use of a High Density Polyethylene (HDPE) sleeve. CPI offers several HDPE sleeve profiles.

A thin wall casing sleeve with a thickness of 0.175" (4.4mm), and a thick wall pipe sleeve with a minimum wall thickness of .824" (21mm), are offered for the 12" diameter pipe pile. The resin compound used for the manufacture of polyethylene casing shall be high-density polyethylene with a minimum cell classification of PE334430C, when classified in accordance with ASTM D3350. The thick wall sleeve is classified as a 14" DR 17IPS HDPE Pipe. The 16" diameter pile requires an 18" DR26 IPS Pipe with a minimum wall thickness of .692" (17.6mm).

Thin Wall Sleeve
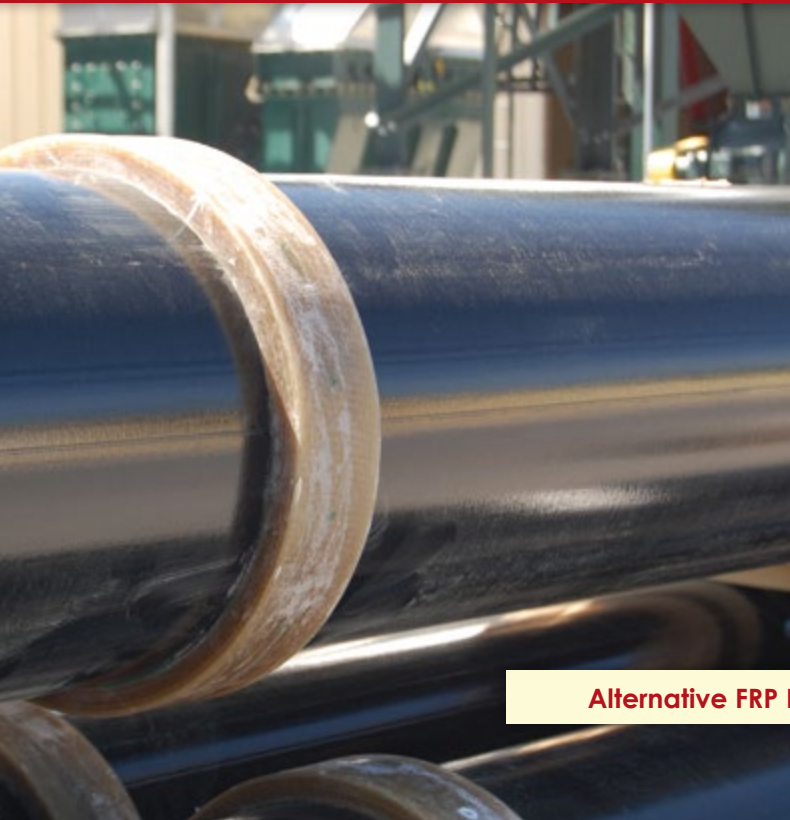
Alternative FRP Ring Close Up

SLEEVE OPTIONS
THICK AND THIN

The thin casing sleeve can be attached to the pipe at the factory and driven as a pile/sleeve assembly. The thick sleeves can be shipped assembled with the pipe pile; however, driving conditions may require that the sleeve be removed from the pile prior to driving and then secured after the pile has been driven. The heavy sleeves are secured with four 3/4" (19mm) bolts and washers placed near the top of the pile.

Thick Wall Sleeve

An alternative option that has had great success involves CPI attaching an FRP ring to the pile prior to being driven. The FRP ring keeps the sleeve held into position onto the pile while allowing the thick sleeve to spin on the pile when a vessel comes into contact with the pile. This detail allows the vessel to freely rub along side of the pile with less friction and for the HDPE sleeve to grow and contract independently of the FRP pile as the coefficient of thermal expansion of the HDPE sleeve is significantly higher than that of the FRP pile.

PILE CAP OPTIONS

The round SUPERPILE® can be capped with non-structural or structural caps. The cosmetic caps are cone or flat shaped and are strictly cosmetic and intended to keep birds and such from entering the piles. CPI recommends that structural caps be used in areas where people can climb on the piles as the possibility exists that a small child could collapse the thermoplastic cap and fall into the piles.

Polyethylene Cone Pile Cap

The non-structural Polyethylene Cone Pile Cap options are UV resistant and available in either black or white color. The estimated life of the Polyethylene Cone Pile Caps is 15 years for black tops and 9 years for white tops. The sleeve is 2" tall and the cone height is 3-1/2" - 4". The polyethylene cone caps should be attached with large head stainless steel self-drilling screws that are normally included if caps are purchased through CPI.
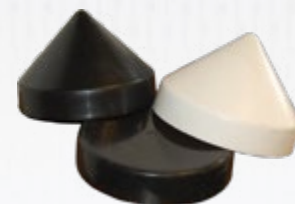
RPL Flat Pile Cap

The non-structural Recycled Plastic Lumber (RPL) Flat Pile Cap are black. Other color options are available for large quantity orders, consult the factory for further information. The RPL pile cap is UV resistant and has an estimated life of 15 years. It is milled from solid recycled plastic lumber flat plate, and is attached with stainless steel self-drilling screws. The cap matches the pile outside diameter and fits flat on the top of the pile with a protruding insert that fits the interior of the pile. The thickness of the flat top plate is 3/8". The protrusion portion of the FRP pile cap is 1-1/8 ".
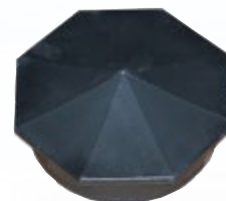
UV Stabilized Polyethylene Top Cap

The **FRP Structural Cap** is a structural cap that will last indefinitely. It is milled from solid FRP plate, painted black and is attached with stainless steel self drilling screws. The cap will support significant loads and can be used to mount lights and other navigational or marine accessories. The FRP cap matches the pile outside diameter and fits flush with the top of the pile with a protruding insert that fits the interior of the pile. The thickness of the flush top plate is 1/2". The protrusion portion of the FRP pile cap ranges from 3/4" to 1".

The octagonal piles are capped with a low density, UV stabilized polyethylene cap. The UV stabilized polyethylene octagonal caps should be fastened with self drilling stainless steel screws.

FRP Structural Cap

COLOR OPTIONS

The standard color of the FRP pile is black. Custom colors are available upon request. CPI recommends that a UV protection layer be incorporated onto the pile surface if the pile is exposed to UV light and the application is architectural or cosmetic.

The UV protection is available in the form of a paint or polyurethane coating or in the form of a high density polyethylene sleeve.

Polyurethane coatings have an advantage as they provide UV and abrasion protection while exhibiting a textured architectural appearance. Polyurethane and paint coatings are offered in various colors. Consult the factory and talk to a representative to determine the best UV protection option for your installation.

BEARING AND DOCK PILES

SUPERPILE® is used extensively for bearing pile applications. The SUPERPILE® can be utilized hollow or concrete filled depending on the strength and stiffness requirements for your application.

Engineers and owners are discovering the benefits of using FRP piles in the splash zone. This exercise will significantly increase the service life of your structure.

As an example, after Hurricane Sandy, the Federal Highway Administration (FHWA) replaced the visitor and service docks on Liberty Island, NY with new docks made of FRP and wood. The FHWA engineers specified polymer piles to be used for the bearing piles in order to increase the service life of the structure. The piles were driven to refusal and filled with concrete. The dock structure was erected and the wood plank decking attached.

Visitor Center Reopens

Liberty Island Installation Site

FRP Bearing Piles

Another example of engineers and owners taking advantage of FRP materials involves the construction of an all composite fire boat dock in Jacksonville, Florida. The dock was designed for a category three hurricane direct hit, as the structure is critical for the fire department rescue team.

SUPERPILE® supports the boat lift. The substructure is made of FRP pultruded channels and beams that support the pultruded grating walkway that extends from the firehouse to the boat lifts.

BEARING AND DOCK PILES

COLUMN LOAD CHARTS

The compression capacity of the pultruded piles can be determined based on both short and long column behavior. The ultimate column load shall be determined by the lesser value of the two equations. Euler buckling governs the capacity of the long column poles.

$$F_{cr} = \sigma_c - 1/7 \frac{KL}{r}$$

Where:

F_{cr} = Critical compression stress
= Axial compression strength
K = Effective length factor
L = Laterally unbraced length of member
r = Radius of gyration about the axis of buckling

$$F_{cr} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$$

Where:

F_{cr} = Critical compression stress
E = Modulus of elasticity
K = Effective length factor
L = Laterally unbraced length of member
r = Radius of gyration about the axis of buckling

The column load charts have been set up based on the short and long column equations presented. Reference Pultex® Pultrusion Design Manual. The column height is considered to be the length of the pile, out of the ground, to the applied compression load. The effective length factor "K" is equal to 1 based on pinned-pinned end conditions.

A pultruded column will fail in either short or long column mode. The long column capacity follows Euler buckling and is influenced by the modulus of elasticity and the radius of gyration and the length of the column.

The loads depicted in the column charts are un-factored ultimate load capacities. A safety factor of three is recommended.

BEARING AND DOCK PILES
COLUMN LOAD CHARTS

SUPERPILE® Round Pile Load Chart

Column Capacity Based on a K=1.0 (Rotation and Translation Fixed)		Ultimate Column Capacity, lb (kg)							
Pole Length, Above Ground, ft	Pole Length, Above Ground, m	Round Pole TU440 10"x3/8"		Round Pole TU455 12"x3/8"		Round Pole TU450 12"x1/2"		Round Pole TU460 16"x1/2"	
40	12.19	35,517	(16,110)	52,145	(23,652)	75,906	(34,430)	187,246	(84,934)
42	12.80	32,215	(14,612)	47,297	(21,453)	68,849	(31,229)	169,838	(77,037)
44	13.41	29,353	(13,314)	43,095	(19,547)	62,732	(28,455)	154,749	(70,193)
46	14.02	26,856	(12,182)	39,429	(17,885)	57,396	(26,034)	141,585	(64,222)
48	14.63	24,665	(11,188)	36,212	(16,425)	52,712	(23,910)	130,032	(58,982)
50	15.24	22,731	(10,311)	33,373	(15,138)	48,580	(22,035)	119,838	(54,357)
52	15.85	21,016	(9,533)	30,855	(13,995)	44,915	(20,373)	110,797	(50,257)
54	16.46	19,488	(8,840)	28,612	(12,978)	41,649	(18,892)	102,742	(46,603)
56	17.07	18,121	(8,220)	26,604	(12,068)	38,727	(17,566)	95,534	(43,333)
58	17.68	16,893	(7,662)	24,801	(11,250)	36,103	(16,376)	89,059	(40,396)
60	18.29	15,785	(7,160)	23,175	(10,512)	33,736	(15,302)	83,221	(37,748)
62	18.90	14,783	(6,706)	21,704	(9,845)	31,594	(14,331)	77,938	(35,352)
64	19.51	13,874	(6,293)	20,369	(9,239)	29,651	(13,449)	73,143	(33,177)
66	20.12	13,046	(5,917)	19,153	(8,688)	27,881	(12,647)	68,777	(31,197)
68	20.73	12,290	(5,574)	18,043	(8,184)	26,265	(11,914)	64,791	(29,389)
70	21.33	11,597	(5,260)	17,027	(7,723)	24,786	(11,243)	61,142	(27,733)
72	21.94	***	***	***	***	23,428	(10,627)	57,792	(26,214)
74	22.55	***	***	***	***	22,178	(10,060)	54,710	(24,816)
76	23.16	***	***	***	***	21,026	(9,537)	51,869	(23,527)
78	23.77	***	***	***	***	19,962	(9,055)	49,243	(22,336)
80	24.38	***	***	***	***	18,976	(8,608)	46,812	(21,233)

Octagonal Pile Load Chart

Column Capacity Based on a K=1.0 (Rotation and Translation Fixed)		Ultimate Column Capacity, lb (kg)					
Pole Length, Above Ground, ft	Pole Length, Above Ground, m	8 in. Series II CP076		10 in. Series II CP074		10 in. Series III CP210	
22	6.71	37,119	(16,837)	78,990	(35,829)	89,950	(40,800)
24	7.31	31,190	(14,148)	66,373	(30,106)	75,583	(34,284)
26	7.92	26,576	(12,055)	56,555	(25,653)	64,402	(29,212)
28	8.53	22,915	(10,394)	48,764	(22,119)	55,530	(25,188)
30	9.14	19,962	(9,054)	42,479	(19,268)	48,373	(21,942)
32	9.75	17,544	(7,958)	37,335	(16,935)	42,515	(19,285)
34	10.36	15,541	(7,049)	33,072	(15,001)	37,661	(17,083)
36	10.97	13,862	(6,288)	29,499	(13,381)	33,592	(15,237)
38	11.58	12,441	(5,643)	26,476	(12,009)	30,149	(13,676)
40	12.19	11,228	(5,093)	23,894	(10,838)	27,210	(12,342)
42	12.80	10,184	(4,620)	21,673	(9,831)	24,680	(11,195)
44	13.41	9,280	(4,209)	19,747	(8,957)	22,487	(10,200)
46	14.02	8,490	(3,851)	18,068	(8,195)	20,575	(9,332)
48	14.63	7,797	(3,537)	16,593	(7,527)	18,896	(8,571)
50	15.24	7,186	(3,260)	15,292	(6,937)	17,414	(7,899)

BEARING AND DOCK PILES

CONCRETE FILLED PILES

SUPERPILE® can be filled with concrete. Most contractors have chosen to drive the pile hollow and then pump the pile full of concrete. Concrete increases the transverse crush strength, bending strength and lengthwise compression strength. Full section testing performed on the 16"diameter pile with 3,800 psi concrete resulted in a 40% increase in bending stiffness and a 50% increase in strength. Note that the pile was not tested to failure. It was tested to a load of 150 kips due to limitations of the test equipment.

The concrete filled 16" SUPERPILE® was tested to determine the crush strength. The pipe pile was loaded by applying a crush load through a 10"square thermoplastic wale section. The load was applied until the predetermined limit of 180 kips was obtained. The pile showed no signs of distress.

Crush Test on Concrete Filled Pile

Full Section Testing of Concrete Filled Pile

DRIVING TIPS

Driving tips are available for the 12" and 16" pipe piles. The cast steel driving tips are conical and are attached to the pile at the production plant. They offer bearing resistance and permit the piles to be concrete filled in situ.

Piles with Driving Tips Ready to Ship

INSTALLATION METHODS

VIBRATORY HAMMER

SUPERPILE® can be efficiently driven with a vibratory hammer. When utilizing a vibratory hammer, an adaptor shall be fabricated to connect the pile to the vibratory hammer. The adaptor shall include an interior steel pipe that fits into the SUPERPILE® to guide the pile. The interior tube should be between 0.5" and 2" of the interior diameter of the FRP pile. The interior pipe shall be welded onto a flat steel plate. The steel plate will apply the compression force into the top of the pile. The steel plate shall be connected to a beam that can be clamped by the vibratory hammer.

The contractor is cautioned that, on some occasions, the pile may require an FRP insert for added compression or pin bearing strength. Therefore, the interior diameter of the pile will change. The contractor should base the vibratory adaptor fabrication on the approved pile drawings.

In the event that a pile needs to be pulled, a vibratory hammer can be utilized to pull the piles. Through bolt the pile and the drive head with three 1" diameter bolts spaced a minimum of 5" apart. Vibrate the pile and pull tension until the pile begins to move. Once the friction has broken, pull the pile without the vibratory hammer engaged. The vibratory hammer oscillation will cause the bolt holes to elongate if engaged for an extended period of time.

Example of Vibratory Hammer Steel Fabrication
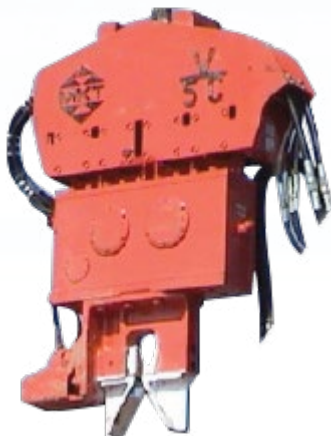
HAMMER	V-5C	
DRIVING FORCE	53 tons	472 kN
FREQUENCY		1,700 CPM
ECCENTRIC MOMENT	1,300 in-lbs.	1,500 kg-cm
AMPLITUDE	1 in.	25.4 mm
CLAMPING FORCE	62 tons	550 kN
MAX. LINE PULL	30 tons	267 kN
HEIGHT	91 in.	2,311 mm
THROAT WIDTH	13 in.	330 mm
SHIPPING WIDTH	79 in.	2,007 mm
WEIGHT W/ CLAMP	7,200 lbs.	3,276 kg
HOSE BUNDLE LENGTH	100 ft.	30 m

Typical Vibratory Drive Hammer Specifications (Courtesy of RPI Construction Equipment)

IMPORTANT NOTICE: In reference to the proper use of this equipment, please be advised that job site conditions may vary due to a change in the geology of a particular area. It is always a good practice to consult with a geotechnical engineer prior to starting a project. Also, a good rule of thumb is to know your soil conditions before selecting pile driving equipment. This can be accomplished by reviewing test soil borings before every project. The above equipment is being used in a granular soil condition which is recommended when using vibratory driver / extractors.
~ RPI Construction Equipment

INSTALLATION METHODS

AIR AND DIESEL IMPACT DRIVING HAMMERS

Diesel and air impact hammers have been successfully utilized to drive install the 12" and 16" diameter SUPERPILE®. A pipe insert driving head or steel pipe cap is required for driving the hollow FRP piles. It is important that the piles are impacted so that the driving force is dissipated over the cross section of the top of the pile. A plywood or composite material pile cushion can also be utilized to reduce driving stresses induced into the pile.

**Vulcan 01 Impact Hammer Driving
16" Diameter SUPERPILE®**

**Example of Pipe Insert Driving Head
for Driving Hollow Piles**

PDA ANALYSIS

Dynamic Pile Testing (PDA) has been successfully performed on SUPERPILE® in the Coastal Plain soils of Virginia. CPI contracted to Crofton Construction Services, Inc. and to Atlantic Coast Engineering for installation of SUPERPILE® by impact driving and to perform PDA analysis in order to have a Pile Dynamic Analysis (PDA) performed on SUPERPILE®.

Crofton Construction Services, Inc. installed two SUPERPILE® in Norfolk, Virginia. The first test pile was installed with a Vulcan 01 Impact Hammer and the second with an APE D30-32 Impact Hammer. Both piles were driven with a closed-end steel toe plate bolted to the bottom of the pile in order to increase the driving resistance of the soils. The pile driven with the Vulcan 01 Air Hammer was driven to refusal (120 blows/ft.) at a depth of 35 feet and then extracted for visual inspection. The pile driven with the APE D30-32 Impact Hammer was driven to a depth of 50 feet, allowed to set overnight, and was re-driven on the following date with dynamic test gauges attached to the pileday and dynamically monitored by Atlantic Coast Engineering.

Testing was performed to aid contractors in the selection of the appropriate impact hammers for installation of the SUPERPILE®. And, to establish, for Geotechnical Engineers, the feasible soil resistances in which the piles may be driven without damage and to identify the allowable driving stress.

The rated capacity of each hammer is utilized in the PDA as follows:

Hammer	Rated Driving Energy	Typical Energy Expected to be Delivered to Pile
Vulcan 01	15 kip-ft	6-9 kip-ft
APE D30-32	74 kip-ft	20-40 kip-ft

PDA ANALYSIS

The test pile driven with the Vulcan 01 Impact Hammer, to refusal, demonstrated a driving resistance of 160 kips, a driving energy of 8 kip-ft., and a compressive driving stress of 8 ksi. The pile was extracted, inspected and revealed no signs of damage.

The test pile driven with the larger APE D30-32 Impact Hammer was driven through the same soils at a blowcount of 9 blows/ft. ending at a blowcount of 12 blows/ft., which was evaluated to represent a resistance of 200 kips with a compressive stress of 11 ksi. No evidence of damage was observed.

After a one day set up period, the pile was re-driven with the APE D30-32 Impact Hammer at a substantially greater resistance. At 235 blows/ft., a driving resistance of 340-370 kips, an average energy transfer of 30 ksi and a recorded compressive driving stress of 13-15 ksi, the pile head split and the pile failed. Prior to the pile head splitting, a CAPWAP® analysis indicated an ultimate axial compressive capacity of 350 kips.

PDA Analysis - Crofton Yard

The PDA testing indicates that impact hammers with a rated energy of 15 to 35 kip-ft are appropriate for the installation of SUPERPILE®.

Hammers with rated energies in the range of 35 to 50 kip-ft should be used with some level of caution, and may require a pile cushion to reduce driving stresses.

Based on observations made during the test pile program, it is recommended that Dynamic Consultants utilize a model PAX PDA unit (with a longer pretrigger buffer than the PAK unit) due to the longer pre-compression time.

For impact and vibratory installed SUPERPILE®, CPI recommends the use of a Wave-Equation Analysis and Driveability Study to assess the soil-pile interaction and estimate pile driving stresses during installation considering the proposed hammer assembly and site soil profile.

CUTTING AND DRILLING INSTRUCTIONS

CUTTING PILES

Concrete Saw

SUPERPILE® can be field cut with a concrete, skill or reciprocating saw. An abrasive blade should always be used. Concrete saws work the best and can be utilized with a standard concrete cutting blade. During drill and sawing operations, dust will be emitted. The dust is considered a nuisance dust, which can irritate your eyes and skin. Therefore, safety glasses, gloves and long sleeve shirts are recommended during the cutting and drilling process.

As documented by OSHA, FRP dust millings have potential to cause eye, skin, and upper respiratory tract irritation.
• Cause - mechanical-irritant properties of the glass fibers.
• FRP particulate is non-hazardous.
• FRP particulate is greater than 6 microns; therefore, it cannot reach the alveoli.
• The International Agency for Research on Cancer (IARC) classified FRP particulate as non-cancer causing in June of 1987.

DRILLING PILES

SUPERPILE® can be drilled with carbide tipped drill bits. CPI recommends B & A Manufacturing Company (http://www.bamanufacturing.com) FGH series drill bits for applications that require multiple holes in a short period of time. Many contractors and utilities have had success when utilizing the FGH series drill bits. The bits will save time and drill thousands of holes before needing to be replaced.

FCH Series Fiberglass Pile Driving Bit

PROPER HANDLING UPON DELIVERY

Proper care should be taken during handling. The piles were packaged and loaded on the flatbed with a tow motor. Contact CPI for the weights of the piles and individual packages.

Proper care should be taken when removing the tie-down straps. Although the piles are cradled in wood chalks, never assume that the wood chalks will keep the piles from shifting.

The pultruded piles are smooth and can be very slippery if they become wet. Never use steel chokers or chains to unload the piles. A nylon strap, preferably with a neoprene skin is recommended. This will reduce the chance of the pile sliding during the picking process. CPI prefers to use light pole handling slings, made by Lift-It® (http://www.lift-it.com). The slings must be double wrapped and the manufacturer's recommendations must be followed.

Lift-It® Sling Double Wrapped Around SUPERPILE®

VISUAL INSPECTION UPON DELIVERY

Upon delivery of the piles, the piles shall be inspected for damage that could affect the long term performance of the piles. Normal wear and tear including abrasions and scuff marks are common and shall not cause concern.

The piles are manufactured to the most current version of ASTM D4385. ASTM D4385 is a pultrusion industry recognized visual specification and can be used for inspection of the piles during delivery or at the plant.

SHIPPING AND RECEIVING

SUPERPILE® is shipped to the job site via flatbed dedicated truck. The continuous manufacturing process permits Creative Pultrusions, Inc. (CPI) to manufacture piles to long lengths eliminating the need for splices.

Prior to shipping, the contractor shall communicate with CPI regarding the packaging and shipping method. Considerations shall include but may not be limited to:

• Length of piles
• Quantity of piles on the truck
• Weight of the pile packages
• Unloading method

Dedicated Truck Hauling 80' Piles to Margate, New Jersey

SUPERPILE® SPECIFICATION

This specification is intended to define pultruded FRP pipe piles for procurement purposes.

1.0 SCOPE

1.1   This specification applies to the material requirements, the manufacture and performance of fiber reinforced polymer piles.

1.2   The mechanical properties shall be published per ASTM D7290.

2.0 MATERIAL DESIGN

2.1   The pultruded pipe pile shall be manufactured by the pultrusion process using a polymer binder containing a minimum 52% "E-CR" or "E" fiberglass by volume. Glass volume shall be 47% in the lengthwise direction and 14% in the crosswise direction.

2.2   E-glass reinforcements shall meet a minimum tensile strength of 290 ksi per ASTM D2343.

2.3   Octagonal pipe piles shall be pultruded with a high performance thermoset resin that is based on a bisphenol-A epoxy matrix.

2.4   The 12" and 16" round fender pipe piles shall be manufactured with a low Volatile Organic Compound (VOC) two component polyol/isocyanate polyurethane matrix with a minimum resin content of 47%.

2.5   The piles shall contain Ultra Violet (UV) protection as a long term light stability promoter. Second, the fiberglass piles shall be encompassed with a 10 mil polyester surfacing veil. The 10 mil veil shall create a resin rich surface and protect the glass reinforcements from fiber blooming.

3.0 STRENGTH & STIFFNESS PROPERTIES

3.1   The octagonal pipe pile strength and stiffness values shall be derived per ASTM D1036.

3.2   The round pipe pile characteristic strength and stiffness values shall be derived per ASTM D6109.

4.0 FINISH

4.1   The surface of the pile shall contain a UV resistant, resin rich, smooth and aesthetically pleasing finish uniform along the entire pile length. The piles shall be manufactured and visually inspected in accordance with ASTM D4385.

SUPERPILE® SPECIFICATION

5.0 MANUFACTURING TOLERANCES

5.1   Pile Length (± 2") or 50 mm

     5.1.1 Squareness of end cut (1/4") or 6.35 mm.
     5.1.2 Pile profile dimensions per ASTM D 3917.
     5.1.3 Straightness: 0.030"/ft. (2.5mm/m) with weight minimizing.
     5.1.4 Weight: +/- 10%.

6.0 SHIPPING

6.1   Crated piles shall be individually protected in cardboard or equivalent protective material in areas in which dunnage makes contact with piles.

6.2   Piles shall be crated in bundles for ease of handling and transfer without damage to the piles by lift equipment.

7.0 QUALITY ASSURANCE

7.1   Quality Assurance shall be performed as described in the organizations quality plan, as approved by the Engineer of Record.

IDENTIFICATION TAGS

Identification Tags, when required by the customer, are supplied by CPI.

The tag is embossed with information, including the manufacturing month and year, the pile part number and a serial number, specific to the application. The information is documented for future reference.

CREATIVE PULTRUSIONS, INC
MADE IN USA MFG MO/YR
ID: TU455-0000

CREATIVE PULTRUSIONS

Available in Australia from

CSIS sustainable infrastructure systems

For additional information about CPI composite piling products, or to learn how to lower your costs while increasing performance, contact a technical representative at 888-CPI-PULL (274-7855), or visit our website at www.creativepultrusions.com.

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