

# SuperLoc™ Sheet Pile System

## Technical Information for Engineers

*Wale & Retaining Wall System (US Patent #6,893,191 B2/May 17, 2005)*

### Introduction

In the late 1990's Creative Pultrusions, Inc., (CPI) developed the patented SuperLoc™ composite sheet pile system. Since the product's inception CPI has focused on continuous product and process improvements. These improvements, including UV optimization, geometry enhancements, accessories and manufacturing controls have lead to CPI manufacturing the most advanced structurally superior sheet piles available in the market.

CPI's staff of civil, mechanical, stress and manufacturing engineers work diligently to produce the best design information and products for engineers around the world to utilize. It is our job to disseminate SuperLoc™'s mechanical and physical attributes so you can design our system into your project, with overwhelming confidence.



Finished Installation/SuperLoc™ Series 1560, Wales and Top Cap

The SuperLoc™ Data Sheets have been developed based on the latest Pultrusion Industry codes and standards. CPI's engineering staff actively participates, along side industry and academia professionals, to assist in writing the codes and standards associated with pultruded profiles.

### Resins

CPI manufactures the SuperLoc™ sheet piles and accessories in both vinyl ester and polyester resin formulations. Proper resin selection should be based on the environmental aspects of the site conditions including the soil and water pH and chemical exposure.

Vinyl Ester (VE) Resins are based on bisphenol-A epoxy resin. VE resins provide resistance to a wide range of acids, alkalis, bleaches and solvents for use in many chemical environments. They also offer excellent toughness and fatigue resistance. The mechanical properties are typically 10% to 15% higher than polyester properties. A long service life can be expected for waterfront environments in salt and fresh water.

Isophthalic Polyester (I) pultrusions are manufactured for corrosion related applications. I resins display

excellent structural properties and are resistant to acids, salts, and many dilute chemicals at moderate temperatures. They perform well in acidic environments; however, I pultrusions are not recommended for caustic or alkaline environments. The pH should be kept below 10.5. Oxidizing environments usually present limitations. A long service life can be expected for waterfront environments in salt and fresh water.



## UV Exposure and Weathering

Ultraviolet rays and heat from solar radiation degrade the molecular structure of most materials. The extent of degradation ranges from mere fading to reduction in strength. Additives in the form of ultraviolet light absorbers and inhibitors greatly increase the performance in long term sunlight exposure.

Polyester synthetic veils are applied to the SuperLoc™ in order to encapsulate the e-glass fibers and provide a resin rich surface. Test results of advanced accelerated UV testing, as well as full section testing in the Florida sun, have demonstrated that less than a 5% decrease in strength will occur over time. Results have shown that UV degradation does not affect the modulus of elasticity. Fading of the polymerized resin will occur at various rates over time. Typically, within three years the gloss is eliminated and a visual whitening or yellowing can be observed on the surface. In general, the amount of sunlight and intensity will depend on the geographical location. Therefore, the rate at which composite materials will lighten is variable. The SuperLoc™ system utilizes the most advanced resin technology and pigmentation to ensure the best possible aesthetics over time.

## Codes and Standards

In September of 2006 ASTM D 7290-06 “Standard Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications” was published. Until the development of the ASTM D 7290-06 Standard, manufacturers and marketers, of pultruded members, could present their data in the format of their choice. The standard protects both manufacturers and engineers, as it provides statistical based data that rewards tight process control. It also gives engineers the comfort that the data was derived per a world recognized standard.



Example of Tensile Test Set Up

The adoption of the ASTM D 7290-06 Standard dictates that every manufacturer must present their data based on a characteristic value representing the 80% lower confidence bound on the 5th-percentile value of a specified population. In general terms, 80% of the test labs would report that 95 out of 100 of the test results would be at or above the minimum value published in the Data Sheet. The characteristic values determined using the ASTM D 7290-06 Standard 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. The data presented in the SuperLoc™ Data Sheets was developed per the ASTM D 7290-06 Standard.

## LRFD/ASD Analysis, Definition and Results

Currently, no standards exist that dictate how to test and publish design information, related to moment capacity of Fiberglass Reinforced Polymer (FRP) sheet pile walls. The moment capacities documented in the SuperLoc™ Data Sheets were developed by following the design standards outlined in the “American Society of Civil Engineers (ASCE) Pre-Standard for Load & Resistance Factor Design (LRFD) of Pultruded Fiber Reinforced Polymer (FRP) Structures”.

The data sheets contain design values based on both LRFD and Allowable Stress Design (ASD) principles. The LRFD published moments have been factored for manufacturing process control, environment, load type and failure mode conditions. The ASD design values are factored per the ASTM D 7290 Standard only.



## LRFD/ASD Analysis, Definition and Results (cont'd)

The primary failure mode of most pultruded FRP products is local compression buckling. The geometry of the sheet pile section plays a very important role in the overall moment capacity of a pultruded sheet. The shear and flexural modulus of elasticity values in addition to the unsupported width and thickness of the compression flange dictate the local buckling capacity of the sheet pile in bending.

Referencing the LRFD, Chapter Five Section 2.3.4, compression flange local buckling governs the moment capacity of the sheet. The shear capacity is governed by Chapter Five Sections 3.2 and 3.3. The failure mode is either material rupture or web shear buckling.



Example of Local Compression Buckling

The LRFD published moment capacities have been factored in accordance with the following factors:

The material properties were tested and reported in accordance to ASTM D7290-06 representing the 80% lower confidence bound on the 5th-percentile value of a specified population.

Nominal strength of the material in accordance with Chapter Two Sections 2.4.1 and 2.4.4 adjustment factors for long term performance in water.

### Polyester Resin

CM Strength - .80

CM Stiffness - .85

### Vinyl Ester Resin

CM Strength - .85

CM Stiffness - .95

Time effect factor for a permanent load  $\lambda = 0.4$

Resistance factor ( $\phi$ ) for shear and flexural members  $\phi = .80$  or  $.65$  and varies depending on the governing mode of failure.

Industry standards for ASD include a 2.5 safety factor for flexural members, and a 3.0 in shear. The Modulus of Elasticity (MOE) for the allowable stress design is taken as the lesser of the tensile or compression modulus of the flange or web and is based on the average modulus.

The MOE, in accordance with the LRFD, requires that the lesser of the characteristic compression or tensile modulus of the flange or web section be utilized for deflection calculations.

## Testing/Calculations Correlation

The SuperLoc™ sheet pile sections have been tested in full section bending, either in a lab environment or in full section in the field. The full section testing correlated well with the LRFD predictions. In fact, the percent difference, in all cases, was below 20%. The full section failure modes correlated well with the LRFD predictions.



Example of Full Section Testing

## Specifying

The Engineer of Record (EOR) should specify FRP sheet piling based on the latest standards and codes within the Pultrusion Industry. The proper specifications will protect the owner, EOR and the manufacturer. The proper specifications will effectively communicate the manufacturing and material property expectations to all involved.

CPI strongly recommends that the specification reference that all material properties be characterized per ASTM D 7290-06. Second, a reference that the FRP sheet pile and accessories be manufactured and fabricated per the Code of Standard Practice for the Fabrication and Installation of Pultruded FRP Structures. The code can be viewed and downloaded from the American Composites Manufacturers Association web site ([www.acmanet.org](http://www.acmanet.org)). The code is currently in the ANSI balloting phase and will become an ANSI standard in early 2012.

The minimum moment, shear and MOE should be specified based on the requirements of your project. FRP materials have a low strength MOE when compared to steel; therefore, the EOR should be sure to scrutinize the deflection of the wall for fitness and aesthetics.

CPI strongly encourages the EOR to request the safety factors and methods for determining the moment capacities from the FRP sheet pile manufacturers. The FRP industry codes and standards are just now finding their way into the Civil/Geotechnical arena, making it important that you understand the safety factors and how they were derived.

## Installation

SuperLoc™ Sheet piles can be installed with common pile driving equipment in soils with blow counts less than 20. Blow counts between 20 and 40 may require a steel mandrel.

CPI recommends vibratory hammers that weigh 2,500 lbs. or less.

(Photo courtesy of Gulf Synthetics, LLC)



Example of Driving SuperLoc™ Sheet Piles

FOR MORE DETAILS ON THE SUPERLOC™ SHEET PILE SYSTEM AND SUPERWALE™ CONTACT:

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