

# DESIGN MANUAL

## ***EXTREN® and Other Proprietary Pultruded Products***

- **EXTREN®** *Standard Structural Shapes and Plate*
- **FIBREBOLT®** *Studs and Nuts*
- **DURADEK®, DURAGRID®** and **DURAGRID® Phenolic** *Fiberglass Grating*
- **DURASHIELD®** *Building Panels*
- **SAFRAIL™** *Handrail and Ladders*
- **COMPOSOLITE®** *Fiberglass Building Panel System*
- **SAFPLANK®** *Fiberglass Plank System*
- **EXTREN DWB®**
- **Rod and Bar**
- **Special Sections**

The design information in this manual is to be used exclusively with  
Strongwell's proprietary products which are described herein.

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**EXTREN®**, **DURADEK®**, **DURAGRID®**, **DURASHIELD®**, **FIBREBOLT®**,  
**SAFPLATE®**, **SAFRAIL™**, **SAFPLANK®**, and **EXTREN DWB®**

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**STRONGWELL**

400 Commonwealth Ave., P.O. Box 580, Bristol, VA 24203-0580  
(276) 645-8000, FAX (276) 645-8132

[www.strongwell.com](http://www.strongwell.com)

# ATTENTION DESIGNERS!

*If you are designing with the Strongwell Design Manual, assure that only Strongwell fiberglass products are used on the structure or structures you have designed.*

It's all too common! Strongwell gets a call about a problem with **EXTREN**<sup>®</sup> structurals. By a site visit or by samples sent in for testing we make an interesting discovery - the shapes are not **EXTREN**<sup>®</sup>. Yes, the Strongwell *Design Manual* was used, and yes, **EXTREN**<sup>®</sup> was specified — but the seller or contractor substituted an “equal”— sometimes without the knowledge of the designer or the owner.

Please consider the following questions:

1. All fiberglass structural shapes have the same properties?  
True or False
2. All structural shape manufacturers have rigorous quality assurance systems and procedures in place to assure quality?  
True or False
3. All structural shape manufacturers test each lot of material and will certify compliance with published properties?  
True or False
4. In comparing **EXTREN**<sup>®</sup> with a fiberglass structural shape produced by another pultrusion company, in what ways are the **EXTREN**<sup>®</sup> shape and the competitive shape likely to be equal?
  - a) glass reinforcement percentage
  - b) glass reinforcement location
  - c) glass reinforcement type
  - d) degree of reinforcement wet out
  - e) resin formula
  - f) pull speed
  - g) none of the above

As you might suspect by now, the answers are:

1. False
2. False
3. False
4. g - none of the above

Designing with the Strongwell *Design Manual* and allowing other products to be used is analogous to designing in one grade of steel and allowing another grade with different properties to be substituted.

Insist that **EXTREN**<sup>®</sup> and other Strongwell products be used, especially if your PE stamp is on the design drawings.

To assist engineers, architects and others using the Strongwell *Design Manual*, Strongwell has implemented a logo identification program to eliminate confusion with other products appearing similar to **EXTREN**<sup>®</sup>. Since July 1, 1993, all fiberglass structural shapes and plate have been imprinted with the **EXTREN**<sup>®</sup> logo every three feet down the length of the part. Square and round tube have the logo imprinted inside the shape. Small and unobtrusive, the logo assures customers that they are getting **EXTREN**<sup>®</sup> when **EXTREN**<sup>®</sup> is specified and that the product has all advertised **EXTREN**<sup>®</sup> properties backed up by corrosion, mechanical and structural testing as conducted by Strongwell.

Thank you for using the Strongwell *Design Manual* for FRP structural designs. If you have comments or questions, please call the Customer Service Department at Strongwell (276) 645-8000.

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## LIST OF REFERENCES

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**PREFACE**

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The Strongwell *Design Manual* has had various titles since its introduction as the EXTREN® Engineering Manual in 1979. At that time, the EXTREN® Engineering Manual contained information pertaining only to EXTREN® structural shapes and plate.

The manual's name changed to the EXTREN® *Design Manual* in 1989 and was restructured to emulate the format of the American Institute of Steel Construction (AISC) manual used for structural steel designs. The new format made it easy for design engineers to understand the information and helped create greater acceptance of fiber reinforced polymer (FRP) structural shapes and plate. Information relating to pultruded grating, DURASHIELD® foam core panels and SAFRAIL™ handrail and ladder systems were added to the manual as well.

Strongwell's current manual is entitled the Strongwell *Design Manual*. EXTREN® structural shapes and plate remain the core of the manual, but the *Design Manual* now contains information regarding most of Strongwell's pultruded products and can be used as a comprehensive reference guide for the structural engineer.

The new Strongwell *Design Manual* reflects much more than a title change. Strongwell has accumulated a tremendous amount of knowledge through decades of manufacturing experience, application monitoring, and most importantly, through extensive product testing. Strongwell's testing efforts have resulted in more definitive information on product performance and have helped the company develop additional empirical formulas to accurately reflect the performance of its pultruded FRP materials under applied loads. Improved product performance, which is a result of both advancements in the pultrusion process and the quality of raw materials available, is also reflected throughout the new *Design Manual*.

Strongwell continually strives to further improve its products, and as such, will update the information in this manual from time to time. To ensure that you receive the most current information available, please keep Strongwell advised of your current email and mailing addresses. The most current edition is April 2004.

**WARNING!**

Fiberglass reinforced plastic structural shapes are nonhomogeneous, with strength and behavior dependent upon composite design, processing techniques, and quality standards. Other fiberglass structural shapes with a similar exterior appearance to EXTREN® shapes are likely not equal in any other way, including glass content, glass placement, glass type, wet-out, resin mixture, or pull speed. Do not use the Strongwell *Design Manual* to design a structure unless you assure that EXTREN® structurals are used.

**CAUTION**

Strongwell has assembled this manual as an aid to our customers and has employed available engineering information in connection with the load tables, formulas and other technical data concerning the products covered in the manual. The usefulness of the information contained in the manual may vary depending on the particular application of the product and the environment to which the product is subjected. Accordingly, Strongwell does not warrant the usefulness or the applicability of the information contained herein to any specific application. Moreover, Strongwell cannot assume liability for the accuracy of any data contained in this manual and makes no warranties of any type in connection therewith. The information contained in the manual may be changed without notice. The products manufactured or sold by Strongwell are subject to specific written warranties and exclusions, to which reference should be made.

**GENERAL NOMENCLATURE**

<b>A</b>	Cross-sectional area (in <sup>2</sup> )
<b>A<sub>w</sub></b>	Cross-sectional area of web or webs (in <sup>2</sup> )
<b>B</b>	Derived constant for use in Eq. B-5
<b>C<sub>1</sub></b>	Lateral buckling coefficient
<b>CW</b>	Crosswise (transverse) to the direction of pultrusion
<b>D</b>	Outside diameter of round tube (in) Diameter of round rod (in) Diameter of round hole in square tube (in)
<b>E</b>	Modulus of Elasticity (psi)
<b>F<sub>a</sub></b>	Allowable compressive stress in short column mode (psi)
<b>F<sub>a</sub>'</b>	Allowable compressive stress in long column mode (psi)
<b>F<sub>b</sub></b>	Allowable flexural stress (psi)
<b>F<sub>b</sub>'</b>	Allowable flexural stress – laterally unsupported beams (psi)
<b>F<sub>u</sub></b>	Ultimate compressive stress (psi)
<b>F<sub>u</sub>'</b>	Ultimate flexural stress – laterally supported beams (psi)
<b>F<sub>u</sub>'</b>	Ultimate compressive stress – long column mode (psi)
<b>F<sub>u</sub>'</b>	Ultimate flexural stress – laterally unsupported beams (psi)
<b>F<sub>v</sub></b>	Allowable shear stress (psi)
<b>F.S.</b>	Factor of Safety
<b>G</b>	Shear modulus (psi)
<b>I</b>	Moment of Inertia (in <sup>4</sup> )
<b>I<sub>x</sub>, I<sub>y</sub></b>	Moment of inertia about X-X or Y-Y axis (in <sup>4</sup> )
<b>J</b>	Torsional constant (in <sup>4</sup> )
<b>K</b>	Effective length factor for buckling
<b>K<sub>b</sub></b>	Coefficient for flexural deflection
<b>K<sub>v</sub></b>	Coefficient for shear deflection
<b>K<sub>x</sub>, K<sub>y</sub></b>	Effective length factor for buckling about X-X or Y-Y axis
<b>L</b>	Length of beam or column (center to center of supports) (ft)
<b>L<sub>u</sub></b>	Unbraced length of beam or column (center to center of lateral braces) (ft)
<b>LW</b>	Lengthwise (parallel) to the direction of pultrusion
<b>M</b>	Bending moment from applied loads (lb-in)
<b>N</b>	Derived constant for use in Eq. B-5
<b>P</b>	Concentrated load on beam (lbs) Axial load on column (lbs)
<b>P<sub>a</sub></b>	Allowable axial load on column (lbs)
<b>PF</b>	Perpendicular to laminate face
<b>R</b>	Radius (in) Reaction from applied loads (lbs)
<b>R<sub>f</sub></b>	Flange toe radius (in)
<b>R<sub>i</sub></b>	Radius of inside corner (in)
<b>R<sub>o</sub></b>	Radius of outside corner (in)
<b>S</b>	Section modulus (in)
<b>S<sub>b</sub></b>	Section modulus from the bottom of an unsymmetrical section (in <sup>3</sup> )

**GENERAL NOMENCLATURE**

<b>S<sub>1</sub></b>	Section modulus from the top of an unsymmetrical section (in <sup>3</sup> )
<b>S<sub>x</sub>, S<sub>y</sub></b>	Section modulus about X-X or Y-Y axis (in <sup>3</sup> )
<b>V</b>	Shear from applied loads (lbs)
<b>W</b>	Uniform beam load (lbs/ft)
<b>Wt</b>	Weight of section (lbs)
<b>a</b>	Long dimension of rectangular plate (in)
<b>b</b>	Width of section (in) Short dimension of rectangular plate (in) Outside dimension of square tube or bar (in)
<b>b<sub>f</sub></b>	Width of flange (in)
<b>b<sub>i</sub></b>	Width between the flanges in the strut (in) Top width of Hat Section (in)
<b>c</b>	Concentrated load (lbs/ft of width)
<b>d</b>	Full depth of section (in)
<b>d<sub>i</sub></b>	Outside dimension of flanges in F-section (in)
<b>f<sub>a</sub></b>	Axial stress from applied loads (psi)
<b>f<sub>b</sub></b>	Flexural stress from applied loads (psi)
<b>f<sub>v</sub></b>	Shear stress from applied loads (psi)
<b>l</b>	Length of beam, column or flat sheet (center to center of supports) (in)
<b>l<sub>u</sub></b>	Unbraced length of beam or column (center to center of lateral braces) (in)
<b>r</b>	Radius of gyration (in)
<b>r<sub>x</sub>, r<sub>y</sub>, r<sub>z</sub></b>	Radius of gyration about X-X, Y-Y or Z-Z axis (in)
<b>s</b>	Spacing between back to back channels or angles (in)
<b>t</b>	Thickness of section (in) Wall thickness of tubes (in)
<b>t<sub>b</sub></b>	Thickness of depth dimension (in)
<b>t<sub>d</sub></b>	Thickness of depth dimension (in)
<b>t<sub>f</sub></b>	Thickness of flange (in)
<b>t<sub>w</sub></b>	Thickness of web (in)
<b>u</b>	Uniform load (lbs/ft <sup>2</sup> )
<b>v</b>	Poisson's ratio
<b>w</b>	Uniform beam load (lbs/in)
<b>x</b>	Distance from the outside of the web to the minor axis (Y-Y) of a channel section or other similar unsymmetrical sections (in) Subscript relating symbol to strong axis (X-X)
<b>y</b>	Distance from the neutral X-X axis to the outermost fibers of the cross section (in) Distance from the back of flange to the major axis (X-X) of a tee section or other similar unsymmetrical sections (in) Subscript relating symbol to weak axis (Y-Y)
<b>⊠</b>	Deflection (in)
<b>⊠<sub>c</sub></b>	Deflection due to concentrated load (in)
<b>⊠<sub>u</sub></b>	Deflection due to uniform load (in)
<b>v</b>	Poisson's ratio