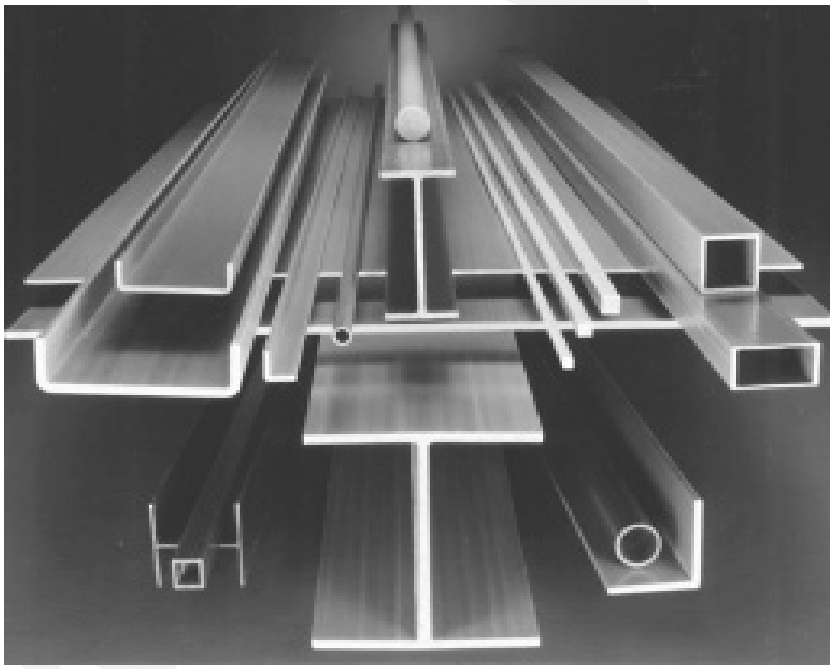
SECTION 2

INTRODUCTION TO EXTREN®



Look for this blue line in the left margin of the Design Manual documents. This line shows you where the latest update has been made.

INTRODUCTION TO EXTREN®

WHAT IS EXTREN®?

EXTREN® is the registered trade name for a proprietary line of **standard pultruded fiberglass structural shapes and plate** produced by Strongwell. The **EXTREN®** line consists of more than 100 different fiberglass shapes, each with a very specific, proprietary composite design.

Types of glass reinforcements used in EXTREN®

Continuous filament mat:	Long glass fibers intertwined and bound with a small amount of resin called a binder. The mat provides multi-directional strength properties.
Continuous strand roving:	Each strand contains 800-4,000 fiber filaments. Many strands are used in each pultruded profile. The rovings provide strength in the longitudinal (pultruded) direction.
Multiaxial reinforcements:	High-performance, engineered fabrics consisting of unidirectional fibers oriented in one or more directions.
Other:	Other reinforcements may be used based on performance requirements.

Resins used in EXTREN®

Polyester:	A general duty resin which provides excellent corrosion resistance in many applications.
Vinyl Ester:	A premium grade resin which has higher strength properties, retains strength better at elevated temperatures, and provides a wider range of corrosion resistance than polyester.
Custom:	EXTREN® Series 900 may use custom resin systems or blends.

Surfacing Veil

All **EXTREN®** has a surfacing veil of polyester non-woven fabric which encases the glass reinforcement and adds a resin-rich surface. This combination of fabric and resin provides greater protection against corrosives and also eliminates “fiber blooming” (the occurrence of glass fibers on the surface) which was prevalent in early pultruded shapes in outdoor applications.

THE FEATURES OF EXTREN®

EXTREN® structural shapes have numerous features that engineers might use individually or in combination to solve structural problems.

- **HIGH STRENGTH** — Stronger than structural steel on a pound-for-pound basis (in the 0° direction), **EXTREN®** has been used to form the superstructures of multi-story buildings, walkways, sub-floors, and platforms.
- **LIGHTWEIGHT** — Weighing as much as 80% less than steel, and 30% less than aluminum, **EXTREN®** structural shapes are easily transported, handled, and lifted into place. Total structures can often be preassembled and shipped to the jobsite ready for installation.
- **CORROSION RESISTANT** — **EXTREN®** will not rot and is impervious to a broad range of corrosive environments. This feature makes it a natural selection for indoor or outdoor structures in pulp and paper mills, chemical plants, water and sewage treatment plants, or other corrosive environments.
- **LOW CONDUCTIVITY** — An excellent insulator, **EXTREN®** has low electrical and thermal conductivity.
- **ELECTRO-MAGNETIC TRANSPARENCY** — **EXTREN®** is transparent to radio waves, microwaves, and other electromagnetic frequencies.
- **DIMENSIONAL STABILITY** — The coefficient of thermal expansion of **EXTREN®** shapes is slightly less than steel in the 0° direction and significantly less than aluminum.

THE THREE EXTREN® SERIES

EXTREN® is pultruded structural composite profiles and plate produced exclusively by Strongwell with the **EXTREN®** logo embedded in the surfacing veil. It meets or exceeds the minimum published mechanical, physical, electrical, flammability, and corrosive properties of the respective Series published in the Strongwell Design Manual.

EXTREN® Series 500:

Premium Polyester Resin, UV inhibitor added, standard color is olive green.
A general purpose resin with excellent corrosion properties

EXTREN® Series 525:

Premium Polyester Resin, Flame retardant additives, UV inhibitor added, standard color is slate gray.
A general purpose resin with excellent corrosion properties and improved fire performance

EXTREN® Series 600:

Premium Vinyl Ester Resin, UV inhibitor added, standard color is light gray.
For harsher corrosive environments and higher temperature applications

EXTREN® Series 625:

Premium Vinyl Ester Resin, Flame retardant additives, UV inhibitor added, standard color is beige.
For harsher corrosive environments, higher temperature applications, with improved fire performance

EXTREN® Series 900:

In addition to **EXTREN®** products, Strongwell manufactures custom pultrusions. These pultrusions vary from **EXTREN®** in either shape, resin type, or reinforcement (type, amount, location and/or orientation). Designers may choose to vary one or all of these parameters to improve strength, temperature resistance, corrosion resistance, machinability or some other characteristic. See Section 18 — **CUSTOM PULTRUSIONS**. Consult Strongwell with specific needs or questions.

EXTREN DWB® is pultruded structural composite double web beam with surfacing veil produced exclusively by Strongwell. It meets or exceeds the minimum published mechanical and physical properties of EXTREN DWB® published in the Strongwell Design Manual. See Section 17 — **EXTREN DWB® DESIGN GUIDE**.

EXTREN TC® is pultruded structural composite thermal cure rod and bar produced exclusively by Strongwell. It does not contain a surfacing veil or logo unless requested. EXTREN TC® meets or exceeds the minimum published mechanical, physical, electrical, flammability, and corrosive properties of EXTREN TC® published in the Strongwell Design Manual.

E23:

All standard EXTREN® products meet and/or exceed the structural requirements of E17 European standards. EXTREN® can be manufactured upon request to meet the mechanical and physical properties of BS EN 13706 (E23) European standards.

NSF:

Most Strongwell products can be manufactured to meet NSF 61 certification upon request. Contact Strongwell for details.

Flame retardant properties of EXTREN® can be found in Section 3 — **PROPERTIES OF EXTREN®**.

If the service environment is corrosive, refer to Section 22 — **CORROSION RESISTANCE GUIDE**. If the applicable corrosives are not listed, consult with Strongwell.

EXTREN® VS. CONVENTIONAL MATERIALS

Designing with **EXTREN®** using this manual is not much different than designing with other materials. The designer should, however, keep the following primary differences in mind:

Relatively Low Modulus of Elasticity

The modulus of elasticity of **EXTREN®** is approximately one-tenth that of steel. As a result, deflection is often a controlling design factor.

Anisotropic

Pultruded composites are not homogeneous or isotropic; therefore, the mechanical properties of **EXTREN®** are directional. When designing with **EXTREN®**, it is important to consider stresses in both the transverse and longitudinal directions.

Relatively Low In-Plane Shear Modulus

The shear modulus of pultruded fiberglass shapes is low compared to metals. Accordingly, the designer should be aware that shear stresses add deflection to loaded beams above the classical flexural deflection. Refer to Section 8 — **FLEXURAL MEMBERS** for more detailed information and design examples.

The Effect of Temperature

EXTREN® structural shapes are more susceptible to property degradation at high temperatures than are metals. The designer should keep this in mind where the design temperature is above 150°F for polyester and 200°F for vinyl ester. Contrary to intuitive thinking, **EXTREN®** shapes become stiffer in cold temperatures. See “Temperature Effects” in Section 3 — **PROPERTIES OF EXTREN®** for expanded discussion of the effects of temperature.

Corrosion Resistance

EXTREN® shapes are often placed in corrosive environments. Generally, **EXTREN®** shapes offer superior corrosion resistance when compared to conventional building materials. See Section 22 — **CORROSION RESISTANCE GUIDE** for guidance.

EXTREN® Structural Tube is Not Pipe

EXTREN® tubes have been designed for structural applications such as columns and handrails and not as fluid carrying pipe. **EXTREN®** may be used to carry fluids if there is no internal pressure. The end-user should consult Section 22 — **CORROSION RESISTANCE GUIDE** to confirm the suitability of the resin to handle the fluid being considered and should also test the **EXTREN®** tube to confirm its ability to carry the fluid without leaking.

EXTREN® VS. OTHER PULTRUDED PRODUCTS

Referring to the previous discussion of “What is Fiberglass Reinforced Polymer”, the designer should be aware that two pultruded shapes with identical external dimensions can vary dramatically in physical properties depending on the resin formulation and the amount and type of reinforcement. **This manual should not be used for fiberglass shapes other than those manufactured by Strongwell.**

EXTREN® VS. TRADITIONAL MATERIALS (PROPERTY COMPARISON)

		EXTREN® 500/525 SHAPES①	EXTREN® 600/625 SHAPES①	EXTREN TC® ROD & BAR①	CARBON STEEL (M1020)	316 STAINLESS STEEL	HASTELLOY C-276 (ANNLD.)	ALUMINUM 6061-T61 T651	PONDEROSA PINE	RIGID PVC	RIGID PVC 10% GLASS	FIBERGLASS COMPRESSION MOLDING (SMC)	SPRAY-UP (30-50% GLASS)
MECHANICAL													
Tensile Strength (N/mm^2)	LW	207	207	689	414	552	689	310	2.90	42.7	53.8	55.2 - 138	62.1 - 124
	CW	48.3	48.3	-	414	552	689	310	-	42.7	53.8	55.2 - 138	62.1 - 124
Tensile Modulus ($x\ 10^3\ N/mm^2$)	LW	17.2	17.9	41.4	207	193	179	68.9	-	2.69	3.10	11.0 - 17.2	5.52 - 12.4
	CW	5.52	6.89	-	207	193	179	68.9	-	2.69	3.10	11.0 - 17.2	5.52 - 12.4
Flexural Strength (N/mm^2)	LW	207	207	689	414	552	689	310	106	75.8	80.7	124 - 207	110 - 193
	CW	68.9	68.9	-	414	552	-	310	64.8	75.8	80.7	124 - 207	110 - 193
Flexural Modulus ($x\ 10^3\ N/mm^2$)	LW	13.8	15.2	41.4	207	193	179	68.9	6.89	2.41	3.10	9.02 - 12.4	6.89 - 8.30
	CW	5.52	5.52	-	207	193	179	68.9	-	2.41	3.10	9.02 - 12.4	6.89 - 8.30
Izod Impact (J/mm)	LW	1.33	1.33	2.14	N/A	0.454 - 0.587	-	-	-	0.085	0.085	0.534 - 1.07	0.214 - 0.641
	CW	0.214	0.214	-	N/A	-	-	-	-	0.085	0.085	0.534 - 1.07	0.214 - 0.641
Specific Gravity		1.7	1.7	2.0	7.8	7.92	8.96	2.50	0.520	1.38	1.39	1.5 - 1.7	1.4 - 1.6
PHYSICAL													
Density ($x\ 10^{-3}\ g/mm^3$)		1.72 - 1.94	1.72 - 1.94	1.99 - 2.10	7.86	8.03	8.97	2.55	0.526	1.44	1.44	1.49 - 1.69	1.39 - 1.63
Thermal Conductivity ($W\text{-}m/m^{-2}/°C$)		83.1	83.1	104	5400 - 9554	1994 - 3842	1475	24923	1.66	27.0	-	1.12 - 1.27	1.04 - 1.23
Coefficient of Thermal Expansion ($x\ 10^{-6}\ mm/mm/°C$)		12.0	12.0	9.0	10.9 - 14.5	16.4 - 18.2	-	24.5	3.09	67.3	41.8	18.2 - 32.7	21.8 - 36.4

① Values Are Minimum Ultimate Properties From Coupons.

FIBERGLASS PULTRUSION THICKNESS RELATIVE TO STEEL, ALUMINUM, OR WOOD②

FIBERGLASS PULTRUSION CONSTRUCTION	STEEL*			ALUMINUM*			WOOD*		
	Tensile Strength	Rigidity	Flexural Strength	Tensile Strength	Rigidity	Flexural Strength	Tensile Strength	Rigidity	Flexural Strength
50% Mat & Roving (EXTREN®)	2.5	2.15	1.82	1.0	1.49	1.16	0.25	0.79	0.45
70% Roving only (Thermal Cure Rod & Bar)	1.0	1.71	1.12	0.4	1.19	0.71	0.10	0.63	0.27

* Copied from *Engineered Materials Handbook*, Vol. 1, “Composites”, pg. 541

② As an example, a 50% mat & roving fiberglass pultrusion would need to be 1.16 times as thick as an aluminum part to achieve the same ‘flexural strength’.