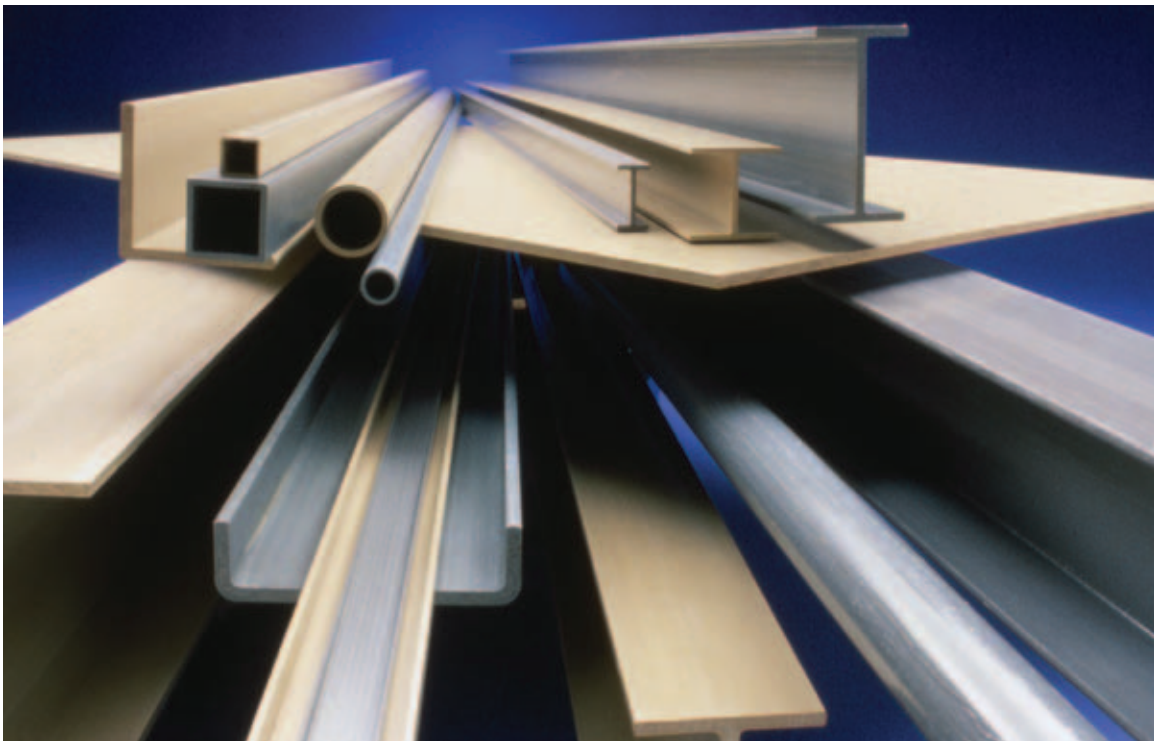
GEF Incorporated

GEF Incorporated
Innovative Solutions in Fiberglass

EXTREN®

FIBERGLASS STRUCTURAL SHAPES AND PLATE



Introduction

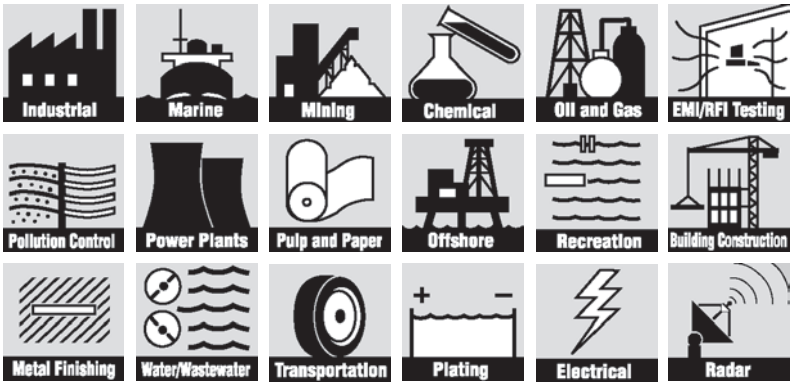
Strongwell's 398,000 sq. ft. Bristol, Virginia facility is the world's largest pultrusion operation.

What you see below is not the erection of a steel structure. Rather, it is a structure being assembled using EXTREN® fiberglass structural members. Today, EXTREN® is replacing steel, aluminum, and wood in a wide variety of structural applications. Why? Because EXTREN® is a problem solving material. This brochure provides basic information about the EXTREN® product line and shows many examples of how EXTREN® provides long-term, cost effective structural solutions for end users in variety of markets and applications.

The features of EXTREN® fiberglass structural shapes are readily translated into user benefits:

- Corrosion Resistant
- Low in Conductivity — Thermally and Electrically
- Nonmagnetic — Electromagnetic Transparency
- Lightweight — Weighs 80% less than Steel
- High Strength
- Dimensional Stability
- Low Maintenance
- Custom Colors

Product Line



EXTREN® is a proprietary combination of fiberglass reinforcements and thermoset polyester or vinyl ester resin systems. It is produced in more than 100 standard shapes. All EXTREN® shapes have a surface veil to protect against glass fibers penetrating the resin surface in service and to increase corrosion and UV resistance.

EXTREN® is offered in three series designed for different environments and applications:

EXTREN® 500

An all-purpose series utilizing an isophthalic polyester resin system with a UV inhibitor. The resin system can be formulated to meet NSF requirements.
Color: olive green

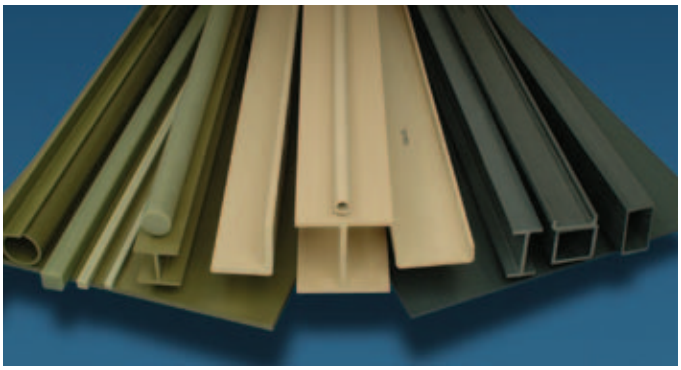
EXTREN® 525

An all-purpose series utilizing a fire retardant isophthalic polyester resin system with a UV inhibitor.
Color: slate gray (plus certain handrail and fixed-ladder components in yellow)

EXTREN® 625

A premium series — both fire retardant and highly corrosion resistant — utilizing a vinyl ester resin system with a UV inhibitor.
Color: beige

A 63' (19.2m) high freestanding fiberglass stair tower at Ft. Story Army Base, Virginia Beach, Virginia.



The three EXTREN® series: (left to right) 500, 625 and 525.

EXTREN® structural shapes were used in a SXEW copper refinery because of the highly corrosive environment.

EXTREN® does not rot or corrode, making it the ideal material for cooling tower construction.

Markets

- Transportation
- Electrical/Electrical Utility
- Chemical Processing
- Cellular Communications
- Consumer/Recreation
- Building Construction
- Food and Beverage
- Pulp and Paper
- Oil and Gas
- Water/Wastewater
- Air Pollution Control
- Aeronautical Defense
- Plating
- Agricultural
- Appliance/Equipment
- Coastal Construction
- Architectural

An odor control cover was constructed using EXTREN® structural shapes for a waste water treatment facility in Puerto Rico.

Lightweight, corrosion resistant 24" (610mm) I-beams span 45' (13.7m) to bridge clarifiers at the Las Rusias, Texas Wastewater Treatment Plant.

EXTREN® structural shapes were used to fabricate pipe supports to hold 1,000 lineal feet (304.8m) of 54" (1371.6mm) diameter pipe.

The Craig Brook National Fish Hatchery in East Orland Maine used corrosive-resistant EXTREN® structural shapes to frame roofing structures over moisture rich crowding pools.

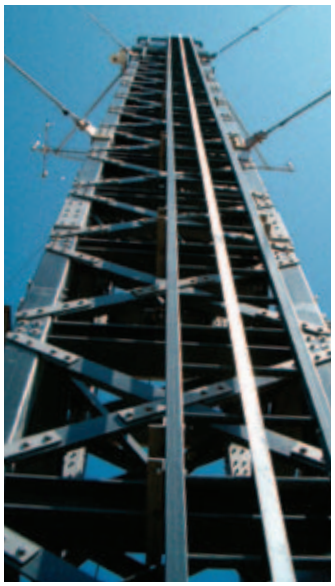
EXTREN® was used as trim on this Oakwood Commons building in Michigan because the beams have the aesthetics of steel, however, EXTREN® does not need to be annually repainted because of its corrosion resistance.

EXTREN® fiberglass plate and structural shapes were used for cellular shielding and were made to match the style and appearance of the Santa Ana Historical building.

The Avila Beach Pier in California was reconstructed using EXTREN® structural shapes for support, DURADEK® pultruded grating, stair treads and handrail.

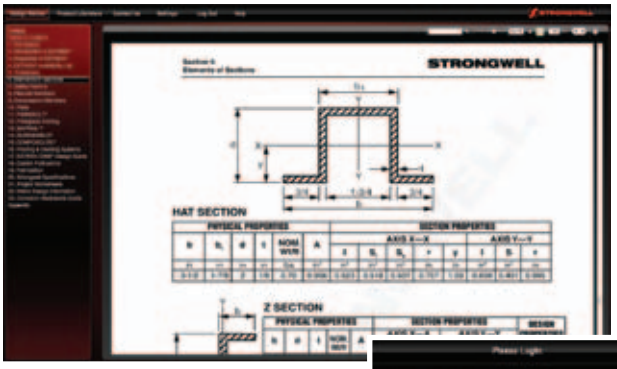
EXTREN® structural shapes were used to fabricate twelve platforms holding the spotlights that illuminate the Forth Bridge in Scotland.

A system of FRP spiral stairs and landings supported by EXTREN® beams circle the Cordova Park Observation Tower at Red Rock Lake near Des Moines, Iowa.

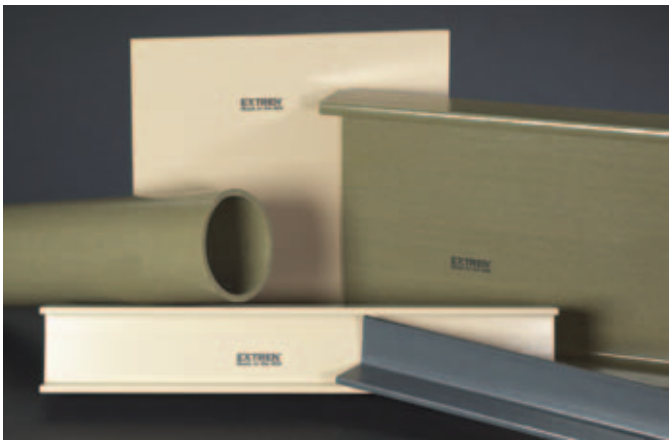


A 62' (19.5m) tall weather tower at Vandenberg Air Force Base near Santa Barbara, California, is composed of EXTREN® structural shapes, ladders and DURADEK® pultruded grating.

Designing with EXTREN®



Strongwell's Design Manual is found online at www.strongwell.com for easy 24-hour access to the most up-to-date design information. Go to the Design Manual log-in page and click the "New Users!" link in yellow. Register your email address and information; you'll receive access immediately via email.



Design By Strongwell

Strongwell has on staff registered professional engineers experienced in the design of fiberglass structures and systems for custom design requirements. Strongwell's extensive experience in fabrication procedures, joint design and stress analysis of composite assemblies, when combined with the use of Strongwell fiberglass products, results in structures of superior, cost-effective design and structural integrity. Clear, straightforward drawings of structures are provided to the customer for approval before fabrication begins unless customer drawings are provided.

Design It Yourself

The Strongwell *Design Manual*, developed by Strongwell, is the most complete reference guide in the industry for designing FRP structures and is used by more engineers and architects than any other FRP engineering guide. With more than 400 pages of engineering data, the *Design Manual* includes properties of materials, beam and column load tables, empirical design equations and sample calculations, connection details, and FRP product and fabrication specifications. Strongwell's *Design Manual* can be found online at www.strongwell.com. It is based upon years of extensive product testing and experience in monitoring applications of EXTREN® fiberglass structural shapes, fiberglass grating, handrail and other proprietary pultruded products.

WARNING!

Fiberglass reinforced thermoset plastic composites are non-homogenous materials (i.e., their strengths and behavior are dependent upon the design of the composite and reinforcement). Other fiberglass structural shapes with a similar exterior appearance to EXTREN® shapes are likely not equal in any other way to EXTREN®, 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 only EXTREN® structurals are used.

EXTREN® Product Logo

A product logo identification program has been implemented by Strongwell after designers and specifiers of EXTREN® learned that problems were occurring because sellers or contractors were substituting look-alike shapes.

Since July 1, 1993, all EXTREN® fiberglass structural shapes and plate have been imprinted with the "EXTREN® Made in the USA" logo every three feet down the length of the part. Square and round tubes have the logo imprinted inside the shape. Small and unobtrusive, the logo assures customers that they are getting EXTREN® properties backed by corrosion, mechanical and structural testing as conducted by Strongwell.

Fabricating with EXTREN®

Bolts and adhesives are used for efficient connections in EXTREN® structures.

Strongwell has trained personnel at two fabrication facilities to take your drawings and/or design to whatever prefabrication stage you choose.

Prefabrication of support beams can include bonding predrilled angles and plate for connections.

Beams are prepped before bonding connections together.

EXTREN® may be painted for better protection against long-term exposure to the sun.

In addition to being the world's largest producer of pultruded parts, Strongwell is also the largest fabricator of structures utilizing pultruded components.

Typical fabrications include beam, column and plate structures, all-fiberglass buildings, platforms and other custom fabrications involving grating and handrail. The features of EXTREN®, such as corrosion resistance and RF transparency, result in very specialized fabricated structures for markets like wastewater treatment, cellular and even architectural applications. Hand lay-up capabilities complement the corporation's structural fabrication capability.

Joining

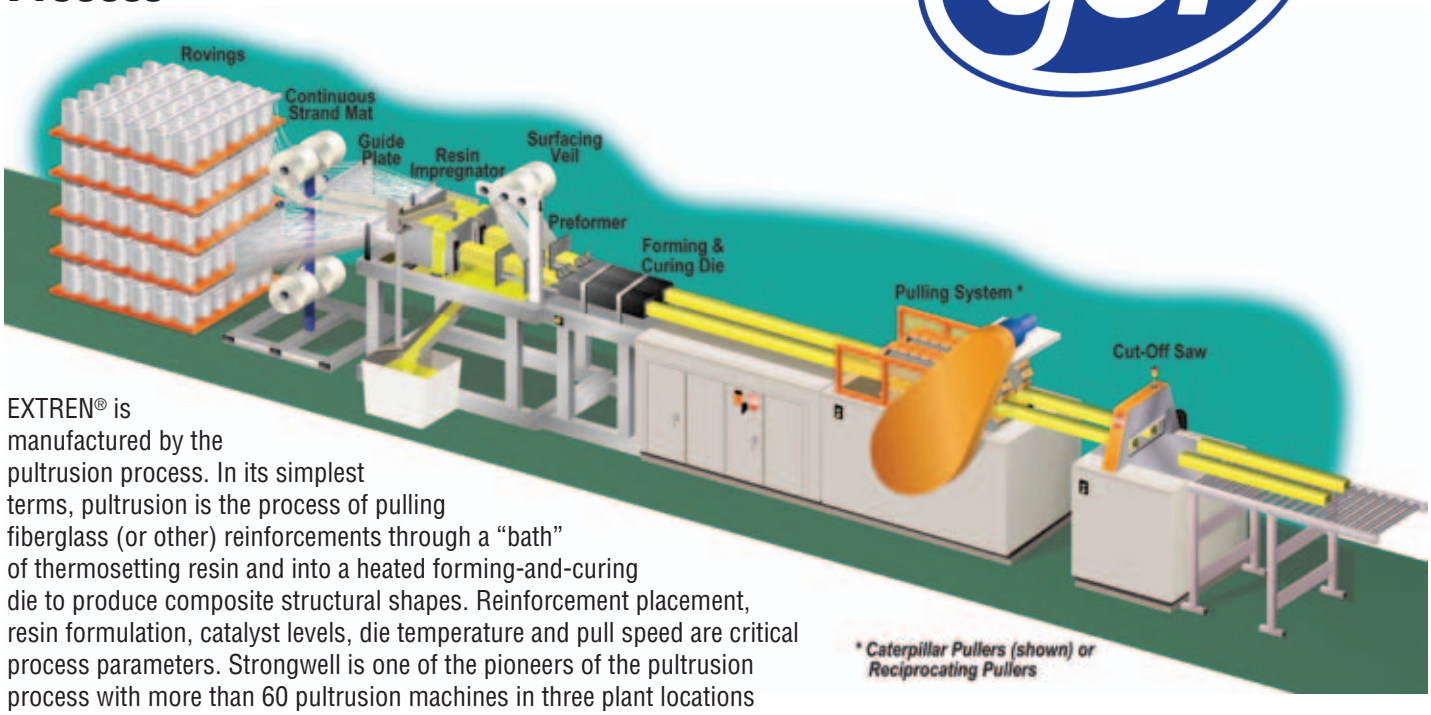
EXTREN® can be fastened mechanically with screws, bolts or rivets. FIBREBOLT® fiberglass studs and hex nuts (available from Strongwell) can also be used. EXTREN® can be joined by adhesives as well. The strongest connections can be made by using a combination of mechanical fasteners with adhesives. Suggested fabrication techniques for EXTREN® are covered in Strongwell's EXTREN® *Fabrication and Repair Manual.*

Material Preparation

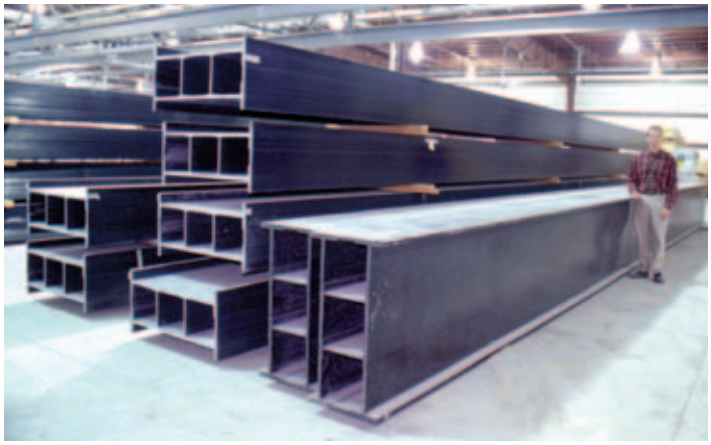
EXTREN® shapes and plate can be sawed, drilled, routed and turned on a lathe or other machine tool. Punching should be limited to thicknesses of 3/16" (4.8mm) and under. Carbide or diamond-tipped saw blades and tool bits are recommended for faster speeds and longer-tool life.

EXTREN® sections can be joined mechanically or with adhesives.

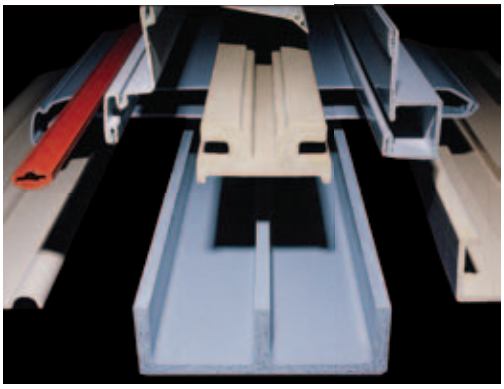
Process

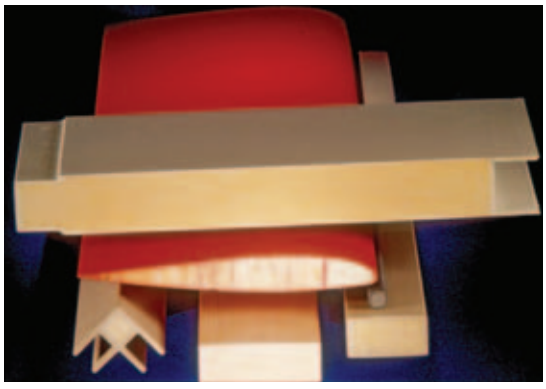


EXTREN® is manufactured by the pultrusion process. In its simplest terms, pultrusion is the process of pulling fiberglass (or other) reinforcements through a "bath" of thermosetting resin and into a heated forming-and-curing die to produce composite structural shapes. Reinforcement placement, resin formulation, catalyst levels, die temperature and pull speed are critical process parameters. Strongwell is one of the pioneers of the pultrusion process with more than 60 pultrusion machines in three plant locations across the United States.



In addition to EXTREN®, Strongwell uses the pultrusion process to produce many other products. For example, the EXTREN DWB® is a combination of carbon and glass fibers. The 36" x 18" (914 x 457mm) double web beams weigh 70 lbs. per linear foot (104 kg/meter). The process is used to produce complex profiles and pultrude over cores. Pultrusion is also utilized for parts integration and to produce easy to assemble systems.





Quality and Availability

Strongwell manufacturing facilities are ISO-9001:2000 certified. This ensures the utmost quality standards for producing EXTREN® structural shapes in a world class facility. A “first article” series of tests on each EXTREN® production run is designed to assure the end user that the structural members meet or exceed published minimum criteria. While distributors stock the most popular shapes of EXTREN® for immediate delivery to their customers, Strongwell also maintains a large inventory to service distributors and prevent long lead times to end users.

Left: Strongwell can perform incoming resin tests to verify the suppliers' conformance to specified requirements.

Right: Strongwell's SATEC Computer Controlled Automatic Testing System is a mechanical testing workhorse.

Bottom: Strongwell's laboratory and research facility is large, well-equipped and professionally staffed.

Properties

	ASTM TEST METHOD	UNITS/ VALUE	SERIES 500/525 SHAPES	SERIES 625 SHAPES	SERIES 500/525 PLATE ④ 1/8" 3.175mm	SERIES 500/525 PLATE ④ 3/16" - 3/8" 4.76-9.5mm	SERIES 500/525 PLATE ④ 1/2" - 1" 9.5-25.4mm	SERIES 625 PLATE ④ 1/8" 3.175mm	SERIES 625 PLATE ④ 3/16" - 1/4" 4.76-6.35mm	SERIES 625 PLATE ④ 3/8" - 1" 9.5-25.4mm
MECHANICAL										
Tensile Stress, LW	D638	psi N/mm²	30,000 207	30,000 207	20,000 138	20,000 138	20,000 138	20,000 138	20,000 138	20,000 138
Tensile Stress, CW	D638	psi N/mm²	7,000 48.3	7,000 48.3	7,500 51.7	10,000 68.9	10,000 68.9	7,500 51.7	10,000 68.9	10,000 68.9
Tensile Modulus, LW	D638	10^6 psi 10^3N/mm²	2.5 17.2	2.6 17.9	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4
Tensile Modulus, CW	D638	10^6 psi 10^3N/mm²	0.8 5.52	0.8 5.52	0.7 4.83	0.9 6.21	1.0 9.65	1.0 6.89	1.0 6.89	1.0 9.65
Compressive Stress, LW	D695	psi N/mm²	30,000 207	30,000 207	24,000 165	24,000 165	24,000 165	24,000 165	24,000 165	24,000 165
Compressive Stress, CW	D695	psi N/mm²	15,000 103	16,000 110	15,500 107	16,500 114	20,000 138	16,500 114	17,500 121	17,500 121
Compressive Modulus, LW	D695	10^6 psi 10^3N/mm²	2.5 17.2	2.6 17.9	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4	1.8 12.4
Compressive Modulus, CW	D695	10^6 psi 10^3N/mm²	0.8 5.52	0.8 5.52	0.7 4.83	0.9 6.21	1.0 9.65	1.0 6.89	1.0 6.89	1.0 9.65
Flexural Stress, LW	D790	psi N/mm²	30,000 207	30,000 207	24,000 165	24,000 165	24,000 165	24,000 165	24,000 165	24,000 165
Flexural Stress, CW	D790	psi N/mm²	10,000 68.9	10,000 68.9	10,000 68.9	13,000 89.6	17,000 117	10,000 68.9	13,000 89.6	17,000 117
Flexural Modulus, LW	D790	10^6 psi 10^3N/mm²	1.6 11.0	1.6 11.0	1.1 7.58	1.1 7.58	1.4 6.65	1.1 7.58	1.1 7.58	1.4 6.65
Flexural Modulus, CW	D790	10^6 psi 10^3N/mm²	0.8 5.52	0.8 5.52	0.8 5.52	0.8 5.52	1.3 8.95	0.8 5.52	0.8 5.52	1.3 8.95
Modulus of Elasticity ①	full section	10^6 psi 10^3N/mm²	2.6 17.9	2.8 19.3						
Modulus of Elasticity: W & I shapes > 4" W & I shapes > 102mm	full section	10^6 psi 10^3N/mm²	2.5 17.2	2.5 17.2						
Shear Modulus, LW ②⑧	—	10^6 psi 10^3N/mm²	0.425 2.93	0.425 2.93						
Short Beam Shear, LW ⑦⑧	D2344	psi N/mm²	4,500 31.0	4,500 31.0						
Bearing Stress, LW	D953	psi N/mm²	30,000 207	30,000 207	32,000 220.6	32,000 221	32,000 221	32,000 221	32,000 221	32,000 221
Poisson's Ratio, LW ⑧	D3039	in/in mm/mm	0.33 .330	0.33 .330	0.31 .310	0.31 .310	0.31 .310	0.32 .320	0.32 .320	0.32 .320
Notched Izod Impact, LW	D256	ft-lbs/in J/mm	25 1.33	25 1.33	15 .801	10 .533	10 .533	15 .801	10 .533	10 .533
Notched Izod Impact, CW	D256	ft-lbs/in J/mm	4 .214	4 .214	5 .267	5 .267	5 .267	5 .267	5 .267	5 .267
PHYSICAL										
Barcol Hardness	D2583	—	45 ③	45 ③	40	40	40	40	40	40
24 hr Water Absorption ⑥	D570	% Max	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Density	D792	lbs/in³ 10^{-3}g/mm³	.062-.070 1.72-1.94	.062-.070 1.72-1.94	.060-.068 1.66-1.88	.060-.068 1.66-1.88	.060-.068 1.66-1.88	.060-.068 1.66-1.88	.060-.068 1.66-1.88	.060-.068 1.66-1.88
Coefficient of Thermal Expansion, LW ⑧	D696	10^{-6} in/in/°F 10^{-6} mm/mm/°C	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0	4.4 8.0
Thermal Conductivity ⑧	C177	BTU-in/ft²Hr/°F w(m*°K)	4 .58	4 .58						

All values are minimum ultimate properties from coupon tests except as noted.

① This value is determined from full section simple beam bending of EXTREN® structural shapes.

② The Shear Modulus value has been determined from tests with full sections of EXTREN® structural shapes. (See Strongwell's Strongwell *Design Manual* for further information.)

③ Value would be 50 if the surfacing veil were not there.

④ Plate compressive stress/modulus measured edgewise and flexural stress/modulus measured flatwise.

⑤ Values apply to Series 525 and 625.

⑥ Measured as a percentage maximum by weight.

⑦ Span to depth ratio of 3:1; EXTREN® angles will have a minimum value of 4000 psi and the I/W shapes are tested in the web.

⑧ Typical values because these are shape and composite dependent tests.

LW — Lengthwise
CW — Crosswise
PF — Perpendicular to laminate face
N.T. — Not Tested

PROPERTIES	ASTM TEST METHOD	UNITS/ VALUE	SERIES 500/525 SHAPES	SERIES 625 SHAPES	SERIES 500/525 PLATE ④ 1/8" 3.175mm	3/16" - 1/4" 4.76-6.35mm	3/8" - 1" 9.5-25.4mm	SERIES 625 PLATE ④ 1/8" 3.175mm	3/16" - 1/4" 4.76-6.35mm	3/8" - 1" 9.5-25.4mm
ELECTRICAL										
Arc Resistance, LW ⑧	D495	seconds	120	120						
Dielectric Strength, LW ⑧	D149	KV/in KV/mm	35 1.38	35 1.38	35 1.38	35 1.38	35 1.38	35 1.38	35 1.38	35 1.38
Dielectric Strength, PF ⑧	D149	volts/mil	200	200	200	N.T	N.T	250	N.T	N.T
FLAMMABILITY ⑤										
Flammability Classification (1/8")	UL 94	VO								
Tunnel Test	E-84	25 Max								
NBS Smoke Chamber	E-662	650-700 (Typical)								
Flammability	D635	Self Extinguishing								
UL Thermal Index	Generic	130ºC								
British Fire Test	BS 476-7	Class 1								

Options

Strongwell offers a broad range of fiberglass industrial products. Two other products often used with EXTREN® are SAFPLATE® and FIBREBOLT®. A brief description of each is given here. Full-color literature is available for each product upon request.

SAFPLATE®

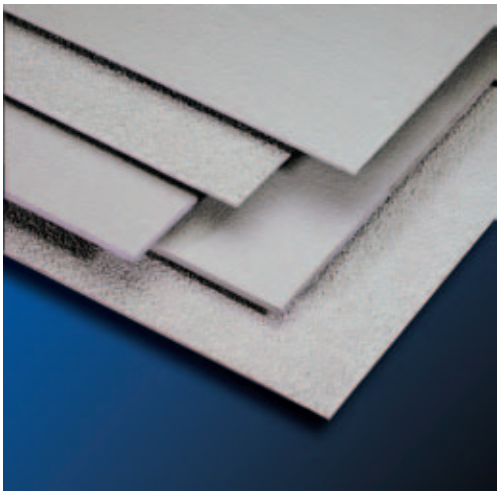
SAFPLATE® fiberglass gritted plate is a tough, corrosion resistant floor plate. The unique combination of pultruded fiberglass plate and an anti-skid grit surface makes SAFPLATE® a textured solid sheet flooring that is ideal for both wet and dry applications. Used in a variety of applications such as trench covers to contain vapors and fumes or pedestrian bridge walkways for sure footing, SAFPLATE® provides a long-lasting, maintenance-free alternative to steel plate for severe and corrosive environments.

SAFPLATE® is available as solid plate or bonded to DURADEK® or DURAGRID® grating. The grit surfaces can be fine, medium or coarse. It is available in 4' x 8' (1.2 x 2.4m) panels in all standard EXTREN® plate thicknesses: 1/8" (3.2mm), 3/16" (4.8mm), 1/4" (6.4mm), 3/8" (9.5mm), 1/2" (12.7mm) and 3/4" (19.1mm). The standard SAFPLATE® is fiberglass reinforced polyester with fire retardant in a gray color. Other resin systems and custom colors are available upon request.

FIBREBOLT®

FIBREBOLT® fiberglass studs and nuts are ideal for applications requiring mechanical fasteners that must be noncorrosive, low in conductivity and/or transparent to electromagnetic waves. FIBREBOLT® studs are machined from pultruded fiberglass vinyl ester rods. The hex shaped nut is thermoplastic. They are easily assembled with a standard six point socket wrench.

FIBREBOLT® studs and hex nuts are available in diameters of 3/8" (9.5mm), 1/2" (12.7mm), 5/8" (15.9mm), 3/4" (19.1mm) and 1" (25.4mm) for immediate delivery. Four foot bolt lengths are standard, with custom lengths and partial length threading available on request. Brown is the standard color. The studs and nuts have UV inhibitors to provide resistance to ultraviolet degradation and corrosion.



SAFPLATE®, a solid anti-skid flooring, helps reduce worker slips and falls in both wet and dry applications.

FIBREBOLT® is widely used as a replacement for metallic fasteners in structures that must be low in conductivity and/or transparent to electromagnetic waves.

Innovative Solutions in Fiberglass

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