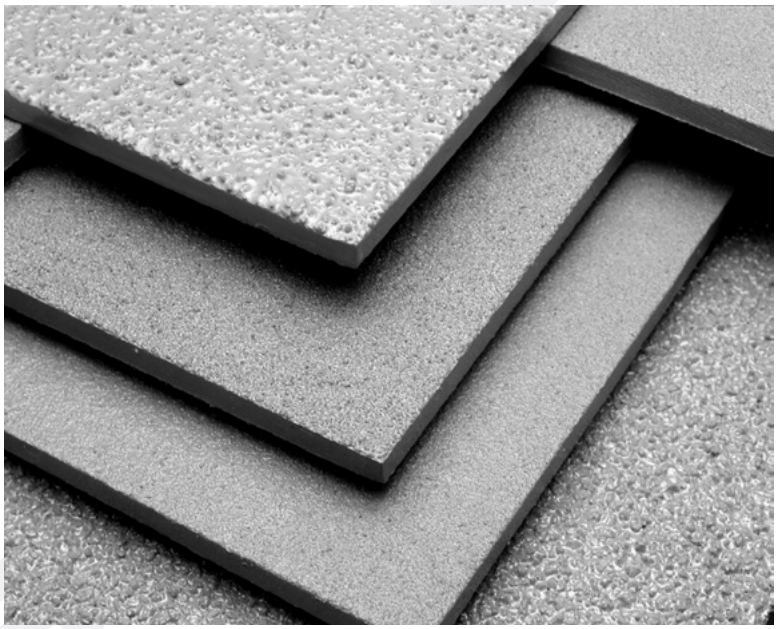
SECTION 10

PLATE



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.

SYMBOLS FOR PLATE

CW Crosswise (transverse) to the direction of pultrusion

E Modulus of elasticity (psi)

$\mathbf{F_b}$ Allowable flexural stress (psi)

$\mathbf{F_u}$ Ultimate flexural stress (psi)

I Moment of inertia (in^4)

LW Lengthwise (parallel) to the direction of pultrusion

M Bending moment from applied loads (lbs-in)

S Section modulus (in^3)

S.F. Factor of safety

a Long dimension of rectangular plate (in)

b Short dimension of rectangular plate (in)

c Concentrated load (lbs/ft of width)

$\mathbf{f_b}$ Flexural stress from applied loads (psi)

l Length of flat sheet (center to center of supports) (in)

t Thickness of section (in)

u Uniform load (lbs/ft^2)

w Uniform beam load (lbs/in)

Δ Deflection (in)

Δ**c** Deflection due to concentrated load (in)

Δ**u** Deflection due to uniform load (in)

PLATE

INTRODUCTION

EXTREN® plate can be used as structural members to carry loads applied normal to the surface. Stresses and deflections in the members can be computed by using theories applicable to beams or to orthotropic plate behavior. Directional mechanical properties are inherent in **EXTREN®** plate due to the pultrusion manufacturing process.

Specific properties necessary for design are provided in Section 3 — **PROPERTIES OF EXTREN®**. Values of various material properties are the test results of the minimum ultimate coupon properties. The values are listed as lengthwise or crosswise relative to the direction of motion of the plate through the forming die. The user of pultruded plate must be careful to orient the product in a structure in the same direction as that corresponding to the direction indicated by the property design value.

Theories and equations based on exact and approximate analysis are discussed in detail in the *"Structural Plastics Design Manual"* — Reference 2, and other reference books. For purposes of design with **EXTREN®** plate, the following procedures are recommended.

ONE-WAY ACTION

Supports for the plate are parallel to each other and limited to two edges of the plate. Selection of the plate thickness for a given load and span or the determination of a load for a given plate thickness and span can be found in the following load/deflection tables. The directional properties of the plate used in the calculations must correspond to the alignment of the plate in the direction of the span between the supports. For uniformly distributed loads over the surface of the plate, it is convenient to work with a "rectangular beam" strip one foot wide to determine stresses and deflections. The load tables are based on a simple span condition. Stresses and deflections for other loading conditions, such as continuous span should be considered in accordance with standard analytical procedures for beams.

The load/deflection tables were generated limiting the deflection to 1% of the span (*l*/100) and to 1/2 the thickness of the plate. Using this deflection criteria, flexural stress was never a controlling factor. Other deflection criteria may be used at the engineer's discretion.

The tables are typical values based on the strength and stiffness in the lengthwise (LW) direction. For load values in the crosswise (CW) direction, multiply the listed load values by the ratio of the flexural modulus in the CW direction divided by the flexural modulus in the LW direction. The tables for 1/4" thick plate through 1" thick plate can be used for all **EXTREN®** series as the flexural moduli for the different series are the same.

A safety factor (S.F.) of 2.5 is used for the allowable load computations in the tables.

SAMPLE PROBLEM

A flat roof with rafters located at 2 feet on center is to be covered with **EXTREN®** 525 plate to support a live load of 10 pounds per square foot. Maximum allowable deflection cannot exceed *l*/100 or t/2. As a trial, check 1/4" thick plate.

$$\Delta = \frac{5wl^4}{384EI} = \frac{(5)(10/12)(24)^4}{384(2.0 \times 10^6)(0.0156)} = 0.116"$$

$$M = \frac{wl^2}{8} = \frac{(10/12)(24)^2}{8} = 60 \text{ lb-in}$$

$$f_b = \frac{M}{S} = \frac{60 \text{ lb-in}}{0.125 \text{ in}^3} = 480 \text{ psi}$$

$$F_b = \frac{F_u}{S.F.} = \frac{24{,}000 \text{ psi}}{2.5} = 9{,}600 \text{ psi}$$

Using the load/deflection tables, 1/4" thick plate will deflect 0.116" at the center of the span which meets the deflection criteria of 0.125" on a simple span of 24" provided the plates are installed so the lengthwise direction is perpendicular to the rafter direction. If the plates span in the crosswise direction, deflection would be calculated as follows:

$$\Delta \text{ CW} = \frac{E_{LW}}{E_{CW}} \text{ x } \Delta \text{ LW}$$

$$\Delta \text{ CW} = \frac{2.0}{0.8} \text{ x } 0.116 = 0.290"$$

It is noted that the calculated deflection value in the above example is greater than the t/2 deflection limit given in the load tables. The t/2 value is a reference value for the Design Engineer allowing for discretionary judgement.

The standard plate length is 8 feet long so it could extend continuously over 4 spans. The maximum deflection occurring at the end span for the uniform load over 4 spans with the sheets spanning in the lengthwise direction would be as follows:

$$\Delta = 0.0065 \text{ x } \frac{(10/12)(24)^4}{(2.0\text{x}10^6)(0.0156)} = 0.058"$$

The above formula can be found in Section 8 — **FLEXURAL MEMBERS (BEAMS)**; Beam Diagram and Formulas Sub-Section, Load Case 39.

TWO-WAY ACTION

When supports are located around four sides of a plate, the member deforms into a dished configuration and the orthotropic characteristics of the material may be used to an advantage. A limited number of solutions for specific cases are available in various technical literature for orthotropic plates. The *Structural Plastics Design Manual*— Reference 2 includes procedures for determining deflections and stresses of a plate when simply supported at the four edges. The solutions described are based on small-deflection flexural theory and provide approximate values for maximum deflections and stresses.

The two-way load tables of this manual were computed from the recommended procedures of Reference 2 using the values from Section 3 — **PROPERTIES OF EXTREN®**. Computed allowable loads were based on a maximum deflection of the plate equal to one-half the thickness (t/2) of the sheet in accordance with the theoretical limitations or //100 of the shortest span whichever is smaller. Since the load deflection relationship is linear, reduced deflections are proportional to reduced values of allowable load. If plates are continuous over the support, the maximum deflections will be smaller than t/2 for the load shown in the table. In general, the bending stresses will be well below the flexural strength of the material.

Selected dimensions in the two-way load tables for rectangular plates should include the majority of the combinations of sizes used for most applications. The designer may interpolate between the sizes given in the tables to obtain the allowable loads for plate sizes not given in the table. If unusually large spans are required, the designer is referred to Reference 2 for governing equations and parametric charts.

PLATE

Allowable Loads

EXTREN® 500, 525, 600, and 625

Plate spanning in Lengthwise Direction

For allowable loads when plate is spanning in crosswise direction, multiply table values by 0.4

LOAD/DEFLECTION TABLE

SPAN	1/4" THICKNESS I = 0.0156 in⁴/ft. of width, S= 0.125 in³/ft. of width, wt = 2.34 lb/ft²												MAX LOAD AT Δ = l /100 OR t/2
12"	u	20	30	40	50	60	70	80	90	100	120	140	160	167
	Δu	0.014	0.022	0.029	0.036	0.043	0.050	0.058	0.065	0.072	0.086	0.101	0.115	0.120
	c	10	15	20	25	30	35	40	45	50	60	70	80	104
	Δc	0.012	0.017	0.023	0.029	0.035	0.040	0.046	0.052	0.058	0.069	0.081	0.092	0.120
18"	u	13	20	27	33									34
	Δu	0.047	0.073	0.099	0.121									0.125
	c	10	15	20	25									32
	Δc	0.038	0.058	0.079	0.096									0.125
24"	u	5	10											11
	Δu	0.058	0.116											0.125
	c	5	10											14
	Δc	0.046	0.092											0.125

u IS UNIFORM LOAD LBS/FT²
Δ u IS DEFLECTION UNDER UNIFORM LOAD
c IS CONCENTRATED LOAD LBS/FT WIDTH
Δ c IS DEFLECTION UNDER CONCENTRATED LOAD

PLATE

Allowable Loads

EXTREN® 500, 525, 600, and 625

Plate spanning in Lengthwise Direction

For allowable loads when plate is spanning in crosswise direction, multiply table values by 0.4

LOAD/DEFLECTION TABLE

SPAN		3/8" THICKNESS I = 0.0527 in⁴/ft. of width, S= 0.28 in³/ft. of width, wt = 3.54 lb/ft²											MAX LOAD AT Δ = l /100 OR t/2
12"	u	20	30	40	50	60	80	100	200	300	400	500	562
	Δu	0.004	0.006	0.009	0.011	0.013	0.017	0.021	0.043	0.064	0.085	0.107	0.120
	c	10	15	20	25	30	40	50	100	150	200	250	351
	Δc	0.003	0.005	0.007	0.009	0.010	0.014	0.017	0.034	0.051	0.068	0.085	0.120
18"	u	20	30	40	50	60	80	100	150				167
	Δu	0.022	0.032	0.043	0.054	0.065	0.086	0.108	0.162				0.180
	c	15	23	30	38	45	60	75	113				156
	Δc	0.017	0.026	0.035	0.043	0.052	0.069	0.086	0.130				0.180
24"	u	10	20	30	40	50							55
	Δu	0.034	0.068	0.102	0.137	0.171							0.188
	c	10	20	30	40	50							69
	Δc	0.027	0.055	0.082	0.109	0.137							0.188
30"	u	10	20										23
	Δu	0.083	0.167										0.188
	c	13	25										35
	Δc	0.067	0.133										0.188
36"	u	10											11
	Δu	0.173											0.188
	c	15											20
	Δc	0.138											0.188

u IS UNIFORM LOAD LBS/FT²
Δ u IS DEFLECTION UNDER UNIFORM LOAD
c IS CONCENTRATED LOAD LBS/FT WIDTH
Δ c IS DEFLECTION UNDER CONCENTRATED LOAD

PLATE

Allowable Loads

EXTREN® 500, 525, 600, and 625

Plate spanning in Lengthwise Direction

For allowable loads when plate is spanning in crosswise direction, multiply table values by 0.65

LOAD/DEFLECTION TABLE

SPAN	1/2" THICKNESS I = 0.125 in⁴/ft. of width, S= 0.500 in³/ft. of width, wt = 4.68 lb/ft²													MAX LOAD AT Δ = l /100 OR t/2
12"	u	20	30	40	50	60	80	100	250	500	750	1000	1250	1333
	Δu	0.002	0.003	0.004	0.005	0.006	0.007	0.009	0.023	0.045	0.068	0.090	0.113	0.120
	c	10	15	20	25	30	40	50	125	250	370	500	625	833
	Δc	0.001	0.002	0.003	0.004	0.004	0.006	0.007	0.018	0.036	0.054	0.072	0.090	0.120
18"	u	20	30	40	50	60	80	100	250					370
	Δu	0.009	0.014	0.018	0.023	0.027	0.036	0.046	0.114					0.180
	c	15	23	30	38	45	60	75	188					370
	Δc	0.007	0.011	0.015	0.018	0.022	0.029	0.036	0.091					0.180
24"	u	20	30	40	50	60	80	100	150					167
	Δu	0.029	0.043	0.058	0.072	0.086	0.115	0.144	0.216					0.240
	c	20	30	40	50	60	80	100	150					209
	Δc	0.023	0.035	0.046	0.058	0.069	0.092	0.115	0.173					0.240
30"	u	20	30	40	50	60								71
	Δu	0.070	0.105	0.141	0.176	0.211								0.250
	c	25	38	50	63	75								111
	Δc	0.056	0.084	0.113	0.141	0.169								0.250
36"	u	10	20	30										34
	Δu	0.073	0.146	0.219										0.250
	c	15	30	45										65
	Δc	0.058	0.117	0.175										0.250
42"	u	10												18
	Δu	0.135												0.250
	c	18												40
	Δc	0.108												0.250
48"	u	10												11
	Δu	0.230												0.250
	c	20												27
	Δc	0.184												0.250

u IS UNIFORM LOAD LBS/FT²
Δ u IS DEFLECTION UNDER UNIFORM LOAD
c IS CONCENTRATED LOAD LBS/FT WIDTH
Δ c IS DEFLECTION UNDER CONCENTRATED LOAD

PLATE

Allowable Loads

EXTREN® 500, 525, 600, and 625

Plate spanning in Lengthwise Direction

For allowable loads when plate is spanning in crosswise direction, multiply table values by 0.65

LOAD/DEFLECTION TABLE

SPAN	*5/8" THICKNESS I = 0.244 in⁴/ft. of width, S= 0.781 in³/ft. of width, wt = 5.79 lb/ft²										MAX LOAD AT Δ = l /100 OR t/2
12"	u	100	200	300	400	500	1000	1500	2000	2500	2600
	Δu	0.005	0.009	0.014	0.018	0.023	0.046	0.069	0.092	0.115	0.120
	c	50	100	150	200	250	500	750	1000	1250	1622
	Δc	0.004	0.007	0.011	0.015	0.018	0.037	0.055	0.074	0.092	0.120
18"	u	100	200	300	400	500	600	700			768
	Δu	0.023	0.047	0.070	0.093	0.117	0.140	0.163			0.180
	c	75	150	225	300	375	450	525			723
	Δc	0.019	0.037	0.056	0.075	0.093	0.112	0.131			0.180
24"	u	20	40	100	200	300					326
	Δu	0.015	0.030	0.074	0.148	0.221					0.240
	c	20	40	100	200	300					407
	Δc	0.012	0.024	0.059	0.118	0.177					0.240
30"	u	20	40	60	100	150					167
	Δu	0.036	0.072	0.108	0.180	0.270					0.300
	c	25	50	75	125	188					260
	Δc	0.029	0.058	0.086	0.144	0.216					0.300
36"	u	20	40	60	80						84
	Δu	0.075	0.149	0.224	0.299						0.312
	c	30	60	90	120						157
	Δc	0.060	0.120	0.179	0.239						0.312
42"	u	10	20	30	40						45
	Δu	0.069	0.138	0.208	0.277						0.312
	c	18	35	53	70						99
	Δc	0.055	0.111	0.166	0.221						0.312
48"	u	10	20								27
	Δu	0.118	0.236								0.312
	c	20	40								66
	Δc	0.094	0.189								0.312
54"	u	10									17
	Δu	0.189									0.312
	c	23									47
	Δc	0.151									0.312
60"	u	10									11
	Δu	0.288									0.312
	c	25									34
	Δc	0.231									0.312

u IS UNIFORM LOAD LBS/FT²
Δ u IS DEFLECTION UNDER UNIFORM LOAD
c IS CONCENTRATED LOAD LBS/FT WIDTH
Δ c IS DEFLECTION UNDER CONCENTRATED LOAD

* Non-stock size subject to mill run requirement.

PLATE

Allowable Loads

EXTREN® 500, 525, 600, and 625

Plate spanning in Lengthwise Direction

For allowable loads when plate is spanning in crosswise direction, multiply table values by 0.65

LOAD/DEFLECTION TABLE

SPAN		3/4" THICKNESS I = 0.422 in⁴/ft. of width, S= 1.125 in³/ft. of width, wt = 6.94 lb/ft²										MAX LOAD AT Δ = l /100 OR t/2
12"	u	100	200	400	600	800	1000	1500	2000	3000	4000	4499
	Δu	0.003	0.005	0.011	0.016	0.021	0.027	0.040	0.053	0.080	0.107	0.120
	c	50	100	200	300	400	500	750	1000	1500	2000	2804
	Δc	0.002	0.004	0.009	0.013	0.017	0.021	0.032	0.043	0.064	0.085	0.120
18"	u	100	200	400	600	800	1000	1200				1333
	Δu	0.013	0.027	0.054	0.081	0.108	0.135	0.162				0.180
	c	75	150	300	450	600	750	900				1250
	Δc	0.011	0.022	0.043	0.065	0.086	0.108	0.130				0.180
24"	u	50	100	200	300	400	500					563
	Δu	0.021	0.043	0.085	0.128	0.171	0.213					0.240
	c	50	100	200	300	400	500					702
	Δc	0.017	0.034	0.068	0.102	0.136	0.171					0.240
30"	u	50	100	150	200	250						288
	Δu	0.052	0.104	0.156	0.208	0.260						0.300
	c	63	125	188	250	313						450
	Δc	0.042	0.083	0.125	0.167	0.208						0.300
36"	u	50	75	100	125	150						167
	Δu	0.108	0.162	0.216	0.270	0.324						0.360
	c	75	113	150	188	225						313
	Δc	0.086	0.130	0.173	0.216	0.259						0.360
42"	u	20	40	60	80							94
	Δu	0.080	0.160	0.240	0.320							0.375
	c	35	70	105	140							205
	Δc	0.064	0.128	0.192	0.256							0.375
48"	u	20	30	40								55
	Δu	0.136	0.205	0.273								0.375
	c	40	60	80								138
	Δc	0.109	0.164	0.218								0.375
54"	u	10	20	30								34
	Δu	0.109	0.219	0.328								0.375
	c	23	45	68								97
	Δc	0.087	0.175	0.262								0.375
60"	u	10	20									22
	Δu	0.167	0.333									0.375
	c	25	50									71
	Δc	0.133	0.267									0.375

u IS UNIFORM LOAD LBS/FT²
Δ u IS DEFLECTION UNDER UNIFORM LOAD
c IS CONCENTRATED LOAD LBS/FT WIDTH
Δ c IS DEFLECTION UNDER CONCENTRATED LOAD

PLATE

Allowable Loads

EXTREN® 500, 525, 600, and 625

Plate spanning in Lengthwise Direction

For allowable loads when plate is spanning in crosswise direction, multiply table values by 0.65

LOAD/DEFLECTION TABLE

SPAN	*1" THICKNESS I = 1.00 in⁴/ft. of width, S= 2.00 in³/ft. of width, wt = 9.27 lb/ft²												MAX LOAD AT Δ = l /100 OR t/2
12"	u	100	200	400	600	800	1000	2000	4000	6000	8000	10000	10677
	Δu	0.001	0.002	0.005	0.007	0.009	0.011	0.023	0.045	0.068	0.090	0.113	0.120
	c	50	100	200	300	400	500	1000	2000	3000	4000	5000	6667
	Δc	0.001	0.002	0.004	0.005	0.007	0.009	0.018	0.036	0.054	0.072	0.090	0.120
18"	u	100	200	400	600	800	1000	2000	3000				3158
	Δu	0.006	0.011	0.023	0.034	0.046	0.057	0.114	0.171				0.180
	c	75	150	300	450	600	750	1500	2250				2956
	Δc	0.005	0.009	0.018	0.027	0.036	0.046	0.091	0.137				0.180
24"	u	100	200	400	600	800	1000	1200					1333
	Δu	0.018	0.036	0.072	0.108	0.144	0.180	0.216					0.240
	c	100	200	400	600	800	1000	1200					1667
	Δc	0.014	0.029	0.058	0.086	0.115	0.144	0.173					0.240
30"	u	100	200	300	400	500	600						682
	Δu	0.044	0.088	0.132	0.176	0.220	0.264						0.30
	c	125	250	375	500	625	750						1068
	Δc	0.035	0.070	0.105	0.141	0.176	0.211						0.30
36"	u	50	100	150	200	250	300						396
	Δu	0.046	0.091	0.137	0.182	0.228	0.273						0.360
	c	75	150	225	300	375	450						740
	Δc	0.036	0.073	0.109	0.146	0.182	0.219						0.360
42"	u	50	75	100	125	150	200						248
	Δu	0.084	0.127	0.169	0.211	0.253	0.338						0.420
	c	88	132	175	219	263	350						544
	Δc	0.068	0.101	0.135	0.169	0.203	0.270						0.420
48"	u	20	40	60	80	100	150						167
	Δu	0.058	0.115	0.173	0.230	0.288	0.432						0.480
	c	40	80	120	160	200	300						416
	Δc	0.046	0.092	0.138	0.184	0.230	0.346						0.480
54"	u	20	40	60	80	100							108
	Δu	0.092	0.185	0.277	0.369	0.461							0.500
	c	45	90	135	180	225							305
	Δc	0.074	0.148	0.221	0.295	0.369							0.500
60"	u	20	40	60									71
	Δu	0.141	0.281	0.422									0.500
	c	50	100	150									222
	Δc	0.113	0.225	0.338									0.500

u IS UNIFORM LOAD LBS/FT²
Δ u IS DEFLECTION UNDER UNIFORM LOAD
c IS CONCENTRATED LOAD LBS/FT WIDTH
Δ c IS DEFLECTION UNDER CONCENTRATED LOAD

* Non-stock size subject to mill run requirement.

SAFPLATE® FIBERGLASS GRITTED PLATE

SAFPLATE® is the trade name for a proprietary line of pultruded fiberglass gritted plate produced by Strongwell. **SAFPLATE®** is composed of **EXTREN®** pultruded fiberglass plate with an epoxy coated anti-skid grit surface. The standard product line is produced in 4-ft. x 8-ft. panels of **EXTREN®** Series 525 (slate gray) plate, fiberglass reinforced polyester with fire retardant. The standard grit surface is a silica gradation of 35 to 50 mesh.

SAFPLATE® is available in all standard **EXTREN®** plate thicknesses: 1/8", 3/16", 1/4", 3/8", 1/2", 3/4". The allowable loads are the same as those listed in this section for **EXTREN®** plate. Typical properties of **EXTREN®** plate apply to standard **SAFPLATE®** (see Section 3 — **PROPERTIES OF EXTREN®**).

SAFPLATE® is available as solid plate or bonded to **DURADEK®**/**DURAGRID®** grating. See Section 12 — **FIBERGLASS GRATING**.

SAFPLATE® can be customized to meet the requirements of a variety of applications.

Options include:

- Choice of grit surface – In addition to the standard grit surface, an extra coarse grit (angular, sharp edged quartz 14-25 mesh gradation) or a fine grit (round grain sand 70-100 mesh gradation) may be requested.
- Choices of resin system – Standard **SAFPLATE®** is **EXTREN®** Series 525, but all other **EXTREN®** Series are available upon request.
- Custom colors available for large quantities.

The skid resistance of **SAFPLATE®** tested for static coefficient of friction per ASTM D-2047, resulted in average test results of 0.99 for **SAFPLATE®** with extra-coarse grit and 0.95 for **SAFPLATE®** with standard grit. This exceeds the typical requirements of 0.50 recommended by OSHA for walking surfaces and The American Disabilities Act (ADA) requirement of 0.60 for accessible routes and 0.80 for ramps.