

Design Capacities for Structural Plywood

Allowable Stress Design (ASD)

The design values in this document correspond with those published in the 2005 edition of the AF&PA American Wood Council's *Allowable Stress Design (ASD)/LRFD Manual for Engineered Wood Construction*. TECO has chosen to do so to provide harmony among users--architects, engineers, specifiers and the regulatory community. These are "Industry Recommended" values, but are not rigorously evaluated for on-going verification.

Load capacities, which are presented here for allowable stress design (ASD) (Table A), are applicable to plywood panels qualified in accordance with TECO test protocol. Nominal panel thickness (Table B) assists in calculation of geometric cross-sectional properties. The applicable section properties (Table C) can be divided into load capacity to determine design strength and stiffness. Load capacities in Table A are based on normal duration of load for untreated panels under dry conditions. Because these values are plywood-specific, the appropriate panel grade and construction adjustment factors, C_G , have already been applied. Designers must be careful to avoid making the C_G adjustments again.

Adjustment factors for other conditions are permitted in accordance with applicable code provisions. The *National Design Specification for Wood Construction (NDS)* provides guidance on the use of adjustment factors.

General Design Information

Methods presented in this section may be used to calculate uniform load capacity of structural-use panels in floor, roof and wall applications. The design capacities presented in Table A include the grade and construction factor, C_G . Other applicable adjustment factors as specified in Section 9.3 of the 2005 edition of the ANSI/AF&PA NDS-2005, National Design Specifications (NDS) for Wood Construction ASD/LRFD and Section C9.3 of the 2005 Edition of the AF&PA American Wood Councils' *Commentary National Design Specification (NDS) for Wood Construction ASD/LRFD*, should be applied to the design capacities.

There are three possible span conditions to consider when computing the uniform load capacities of structural-use panels depending on the size and orientation of the panel and the spacing of the framing support members. These include single-span, two-span and three-span (see below). For normal framing practice and standard panel size (i.e., 4x8 foot), when the panel strength axis is perpendicular to framing supports, the three-span condition is used for support spacing up to and including 32 inches on center. Use the two-span condition for support spacing greater than 32 inches on center but no greater than 48 inches on center. When the panel strength axis is placed parallel to framing supports, the three-span condition is used for support spacing up to and including 16 inches on center. Use the two-span condition for support spacing greater than 16 inches but no greater than 24 inches on center. Use the single-span condition for support spacing greater than 24 inches on center.

The formulas presented are for computing uniform loads on structural-use panels applied over conventional framing. These equations are based on standard beam formulas altered to accept the mixed units. For support spacing less than 48 inches, nominal two-inch framing members are assumed. For support spacing 48 inches and greater, nominal four-inch framing members are assumed. Since the formulas assume that no blocking is used, the formulas are for one-way "beam" action rather than two-way "plate" action. The resulting loads are for the structural panels only and do not account for the design of the framing support members. The resulting loads calculated from the equations are assumed to apply to full size panels in standard sheathing applications. Considerations for concentrated loads should be made in compliance with local building codes and maximum span recommendations.

Table A
Wood Structural Panel Design Capacities Based on Span Ratings^(a)

Span Rating	Strength							Planar Shear		Stiffness and Rigidity					
	Bending $F_b S$ (lb-in/ft of width)		Axial Tension $F_t A$ (lb/ft of width)		Axial Compression $F_c A$ (lb/ft of width)		Shear through the thickness ^(b,c) $F_v t_v$ (lb/in of shear-resisting panel length)	Planar Shear F_s (lb/Q) (lb/ft of width)		Bending EI (lb-in ² /ft of width)		Axial EA (lb/ft of width x 10 ⁶)		Rigidity through the thickness $G_v t_v$ (lb/in of panel depth)	
	Capacities relative to strength axis ^(d)														
	0°	90°	0°	90°	0°	90°	0° / 90°	0°	90°	0°	90°	0°	90°	0°	90°
Sheathing Span[®]															
24/0	3-ply	250	54	2,300	600	2,850	2,500	53	156	273	66,000	3,600	3.35	2.90	25,000
32/16	3-ply	370	92	2,800	1,250	3,550	3,100	62	198	347	126,500	8,100	4.15	3.60	27,000
	4-ply	407	110	2,800	1,250	5,325	4,650	81	198	479	126,500	17,820	4.15	3.60	35,100
	5-ply	444	166	3,640	1,625	5,325	4,650	93	215	165	126,500	25,110	4.15	3.60	40,500
40/20	3-ply	625	150	2,900	1,600	4,200	4,000	68	246	431	247,500	18,000	5.00	4.50	28,500
	4-ply	688	180	2,900	1,600	6,300	6,000	88	246	595	247,500	39,600	5.00	4.50	37,050
	5-ply	750	270	3,770	2,080	6,300	6,000	102	267	205	247,500	55,800	5.00	4.50	42,750
48/24	4-ply	930	270	4,000	1,950	7,500	7,200	98	300	725	440,000	64,900	5.85	5.00	40,300
	5-ply	1,014	405	5,200	2,535	7,500	7,200	113	325	250	440,000	91,450	5.85	5.00	46,500
Floor Span[®]															
20 oc	4-ply	528	168	2,900	1,600	6,300	6,000	87	246	595	231,000	28,600	5.00	4.50	36,400
	5-ply	576	252	3,770	2,080	6,300	6,000	101	267	205	231,000	40,300	5.00	4.50	42,000
24 oc	4-ply	704	258	3,350	1,950	7,500	7,200	96	300	725	330,000	57,200	5.85	5.00	39,000
	5-ply	768	387	4,355	2,535	7,500	7,200	111	325	250	330,000	80,600	5.85	5.00	45,000
32 oc	5-ply	1,044	684	5,200	3,250	9,450	9,300	120	390	300	715,000	232,500	7.50	7.30	54,000
48 oc	5-ply	1,920	1,224	7,280	4,745	12,150	10,800	158	501	385	1,265,000	496,000	8.20	7.30	75,750

- (a) The design values in this table correspond with those published in the 2005 edition of the AF&PA American Wood Council's *Allowable Stress Design (ASD)/LRFD Manual for Engineered Wood Construction* Tables M9.2.1- M9.2.4, which are available from the AF&PA American Wood Council. The appropriate panel grade and construction adjustment factor, C_G , has already been incorporated into these design values—do not apply the C_G factor a second time. These values do not apply to Structural I panels. See Tables M9.2.1 – M9.2.4 for the appropriate multipliers for Structural I panels.
- (b) Shear through the thickness design capacities are limited to sections two feet or less in width; wider sections may require further reductions.
- (c) 5-ply applies to plywood with 5 or more layers; for 5-ply/3-layer plywood, use values for 4-ply plywood.
- (d) Strength axis is defined as the axis parallel to the face and back orientation of the grain (veneer), which is generally the long panel direction, unless otherwise marked.

Table B
Relationship Between Span Rating and Nominal Thickness for Plywood^(a)

Span Rating	Nominal Thickness ^(b) (in.)										
	3/8	7/16	15/32	1/2	19/32	5/8	23/32	3/4	7/8	1	1-1/8
Sheathing Span[®]											
24/0	0.375	0.437	0.469	0.500							
24/16		0.437	0.469	0.500							
32/16			0.469	0.500	0.594	0.625					
40/20					0.594	0.625	0.719	0.750			
48/24							0.719	0.750	0.875		
Floor Span[®]											
16 oc					0.594	0.625					
20 oc					0.594	0.625					
24 oc							0.719	0.750			
32 oc									0.875	1.000	
48 oc											1.125

- (a) The values in this table correspond with those published in the 2005 edition of the AF&PA American Wood Council's *Commentary National Design Specification (NDS) for Wood Construction ASD/LRFD* Table C9.2.3, which is available from the AF&PA American Wood Council.
 (b) The predominant thickness for each span rating is highlighted in bold.

Table C
Panel Section Properties^(a,b) for Plywood

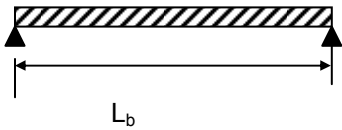
Nominal Thickness, t (in.)		Weight ^(c) (psf)	Cross Sectional Area, A (in. ² /ft)	Moment of Inertia, I (in. ⁴ /ft)	Section Modulus, S (in. ³ /ft)	Statical Moment, Q (in. ³ /ft)	Shear Constant, lb/Q (in. ² /ft)
Fraction	Decimal						
3/8	0.375	1.1	4.500	0.053	0.281	0.211	3.00
7/16	0.437	1.3	5.250	0.084	0.383	0.287	3.50
15/32	0.469	1.4	5.625	0.103	0.440	0.330	3.75
1/2	0.500	1.5	6.000	0.125	0.500	0.375	4.00
19/32	0.594	1.8	7.125	0.209	0.705	0.529	4.75
5/8	0.625	1.9	7.500	0.244	0.781	0.586	5.00
23/32	0.719	2.2	8.625	0.371	1.033	0.775	5.75
3/4	0.750	2.3	9.000	0.422	1.125	0.844	6.00
7/8	0.875	2.6	10.500	0.670	1.531	1.148	7.00
1	1.000	3.0	12.000	1.000	2.000	1.500	8.00
1-1/8	1.125	3.4	13.500	1.424	2.531	1.898	9.00

- (a) The values in this table correspond with those published in the 2005 edition of the AF&PA American Wood Council's *Commentary National Design Specification (NDS) for Wood Construction ASD/LRFD* Table C9.2.4, which is available from the AF&PA American Wood Council.
 (b) Based on a rectangular cross sectional width of one foot.
 (c) Weight is based on an assumed panel density of 36 pcf.

Uniform Load Formulas for Structural-Use Panels ¹

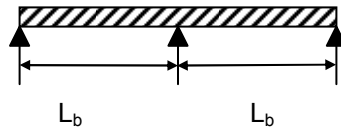
Uniform Loads Based on Bending

The following formulas may be used to calculate loads based on design bending (M):



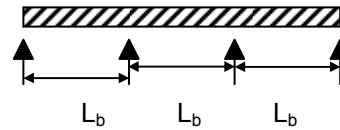
Single span:

$$w_b = \frac{96 M}{L_b^2}$$



Two-span condition:

$$w_b = \frac{96 M}{L_b^2}$$



Three-span condition:

$$w_b = \frac{120 M}{L_b^2}$$

where:

- w_b = uniform load based on bending strength (psf)
- M = Bending Strength Capacity, $F_b S$ in (lb.-in./ft.)
- L_b = span (center-to-center of supports, in.)

Uniform Loads Based on Shear

The following formulas may be used to calculate uniform loads based on planar shear (V_s):

Single span:

$$w_s = \frac{24 V_s}{L_s}$$

Two-span condition:

$$w_s = \frac{(19.2) V_s}{L_s}$$

Three-span condition:

$$w_s = \frac{20 V_s}{L_s}$$

where:

- w_s = uniform load based on shear strength (psf)
- V_s = Planar Shear Capacity, $F_s (I_b/Q)$ in (lb./ft.)
- L_s = clear span (in., center-to-center of supports minus support width, in.)

Uniform Loads Based on Deflection Requirements

The following formulas may be used to calculate deflection under uniform load, or allowable loads based on deflection requirements.

Single span:

$$\Delta = \frac{w L_{\Delta}^4}{(921.6)EI}$$

Two-span condition:

$$\Delta = \frac{w L_{\Delta}^4}{(2220)EI}$$

Three-span condition:

$$\Delta = \frac{w L_{\Delta}^4}{(1743)EI}$$

where:

Δ = deflection (in.)

$w = w_{LL}$ = uniform live load (psf)
— Or —

$w = w_{TL}$ = uniform total load (psf)

EI = Bending Stiffness Capacity (lb.-in.²/ft.)

L_{Δ} = clear span + SW (in.)

SW = support width factor, 0.25 inch for two-inch nominal lumber framing and 0.625 inch for four- inch nominal lumber framing.

¹The formulas are standard beam formulas adjusted to accept mixed units. It is assumed the resulting loads are applied on all spans to full-sized panels in standard sheathing applications. Refer to the 2005 edition of the ANSI/AF&PA NDS-2005, National Design Specifications (NDS) for Wood Construction ASD/LRFD, for further requirements regarding the use of these formulas and appropriate adjustment factors available from the AF&PA American Wood Council.

Plywood Roof Design Example Calculations Using ASD

4x8 foot, 32/16, 4-ply, TECO SHEATHING SPAN[®] plywood panels are installed as roof sheathing over roof trusses (nominal 2 inch wide) spaced at 32 inches on-center. The panels are installed with the long panel direction (strength axis) perpendicular to the roof truss members. The job specifications indicate that the roof is to be designed to support a 20 psf snow load @ 1.15 load duration with an allowable live load deflection (w_{LL}) of span/240 and an allowable total load deflection (w_{TL}) of span/180. Determine if the specified panel will adequately meet these requirements.

Bending Strength

From Table A, the $F_b S$ (bending capacity) of a 32/16, 4-ply SHEATHING SPAN panel installed with the stress applied parallel to the strength axis is equal to 407 lb-in/ft of width. The C_G factor (panel grade and construction factor) has already been applied to this capacity, but the load duration factor, C_D , of 1.15 can also be applied for snow load. Since the trusses are spaced at 32 in. on center and the panels are oriented with their 8 ft dimension perpendicular to the framing, use the equation for the three-span condition.

$$w_b = \frac{120 F_b S}{L_b^2}$$

$$w_b = \frac{120 (407 \text{ lb-in/ft})(1.15)}{(32 \text{ in})^2}$$

$$w_b = \underline{55 \text{ psf}}$$

Shear in the Plane Strength

From Table A, the F_s (lb/Q), planar shear capacity, of a 32/16, 4-ply SHEATHING SPAN panel installed with the stress applied parallel to the strength axis is equal to 198 lb/ft of width. The C_G factor (panel grade and construction factor) has already been applied to this capacity, but the load duration factor, C_D , of 1.15 can also be applied for snow load.

$$w_s = \frac{20 F_s (\text{lb/Q})}{L_s}$$

$$w_s = \frac{20 (198 \text{ lb/ft})(1.15)}{(32 \text{ in} - 1.5 \text{ in})}$$

$$w_s = \underline{149 \text{ psf}}$$

Bending Stiffness

From Table A, the EI (bending stiffness capacity) of a 32/16, 4-ply SHEATHING SPAN panel installed with the stress applied parallel to the strength axis is equal to 126,500 lb-in²/ft of width. The C_G factor (panel grade and construction factor) has already been applied to this capacity. Notice that the load duration factor, C_D does not apply to bending stiffness.

$$\Delta_{LL} = \frac{w_{LL} L_{\Delta}^4}{(1743) EI}$$

$$w_{LL} = \frac{(1743)EI \Delta_{LL}}{L_{\Delta}^4} \quad \text{where } \Delta_{LL} = L/240$$

$$w_{LL} = \frac{(1743)(126,500 \text{ lb-in}^2/\text{ft})(32/240)}{(32 \text{ in} - 1.5 \text{ in} + .25 \text{ in})^4}$$

$$w_{LL} \approx 33 \text{ psf}$$

$$\Delta_{TL} = \frac{w_{TL} L_{\Delta}^4}{(1743) EI}$$

$$w_{TL} = \frac{(1743)EI \Delta_{TL}}{L_{\Delta}^4} \quad \text{where } \Delta_{TL} = \text{span}/180$$

$$w_{TL} = \frac{(1743)(126,500 \text{ lb-in}^2/\text{ft})(32/180)}{(32 \text{ in} - 1.5 \text{ in} + .25 \text{ in})^4}$$

$$w_{TL} \approx 44 \text{ psf}$$

Based on the specifications for this design example, the design capacity of the 32/16, 4-ply SHEATHING SPAN plywood panels is controlled by bending stiffness. The 44 psf represents the maximum uniform load that can be applied to the panels before the deflection criterion of span/180 is exceeded. As long as the dead load of the roof system (i.e., weight of panels, shingles, etc.) does not exceed 24 psf (i.e. 44 psf total load – 20 psf snow load), the 32/16, 4-ply SHEATHING SPAN plywood will meet the design specifications for this project.