Mastering Wood Structural Panel Design and Specification

Noah Humberston, PE – Engineered Wood Specialist



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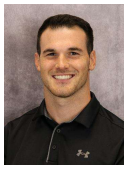

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https://www.apawood.org/presentation-survey

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Course Description

This webinar provides an in-depth overview of wood structural panel (WSP) specification and design principles, focusing on APA's Panel Design Specification (Form D510) and Load-Span Tables for APA WSP (Form Q225). Attendees will gain a comprehensive understanding of plywood and OSB panel properties, APA trademarks, code compliance, and how to apply design values when specifying WSPs in structural applications. The course includes two practical design examples for the structural design of heavily loaded roof and wall sheathing. Ideal for engineers and other design professionals involved in wood construction.

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Learning Objectives

1. Identify the composition and manufacturing standards of wood structural panels (WSPs).
2. Describe the mechanical properties and adjustment factors used in WSP design.
3. Apply APA's Panel Design Specification and load-span tables to determine allowable loads for WSPs in various structural applications.
4. Evaluate design factors such as nail withdrawal and head pull-through that contribute to the structural integrity of WSP sheathed assemblies.

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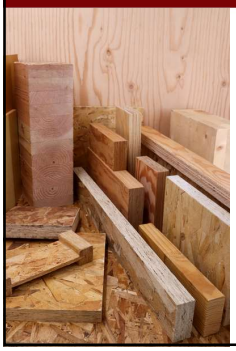
WSP Design and Specification



What are Engineered Wood Products?

Framing Products:

- **I-Joists**
- **Glulam – Glued Laminated Timber**
- **SCL – Structural Composite Lumber**
  - PSL – Parallel Strand Lumber
  - LVL – Laminated Veneer Lumber
  - LSL – Laminated Strand Lumber
  - OSL – Oriented Strand Lumber
- **Rim Board**
- **Cross-Laminated Timber (CLT)**

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WSP Design and Specification

What are Engineered Wood Products?

Panel Products:

- **Wood Structural Panels (WSP)**
  - Plywood
  - OSB – Oriented Strand Board
- **Siding**
- **Specialty Panels**
  - Radiant Barrier
  - Formwork
  - Industrial Panels
  - Overlaid Panels

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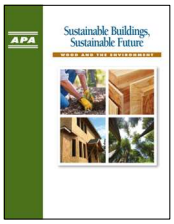
WSP Design and Specification

Sustainable Benefits of Engineered Wood

- Produced from small-dimension lumber harvested from managed and sustainable forests
- Growing trees sequester carbon and emit oxygen
- Timber resource utilization optimized using a wide range of lumber grades
- Higher strength with less wood material
- Manufacturing involves low energy use process



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WSP Design and Specification

Manufacturing Standards

PS 1: Voluntary Product Standard *PRESCRIPTIVE* Standard *(revised 2020)*

PS 2: Voluntary Product Standard *PERFORMANCE* Standard *(revised 2019)*

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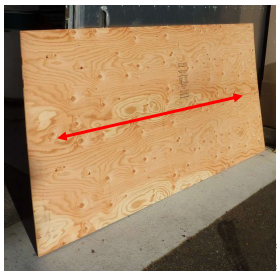
Panel Strength and Stiffness

A little wood science...

- Wood is strongest in the direction of the grain.
- Some species of wood are stronger than others.
- The construction and layup of panels impacts the strength.
- The more wood, the greater the strength.



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What Exactly is Plywood?

- The “original” wood structural panel
- Composed of thin sheets of veneers or plies arranged in layers
- May have even number of plies but always has odd number of layers
- Each layer consists of one or more veneers with same grain direction
- By alternating grain direction, strength and stiffness are maximized and shrinking and swelling minimized

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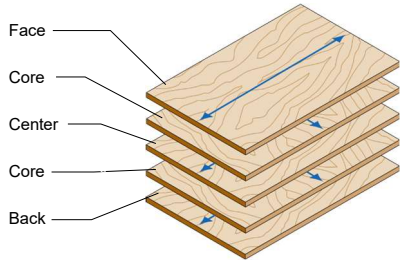
Plywood Layup



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What Exactly is Oriented Strand Board (OSB)?

- Panels manufactured of compressed wood strands
- Strands are arranged in layers (usually three to five)
- The orientation of layers achieves the same advantages of cross laminated veneers in plywood

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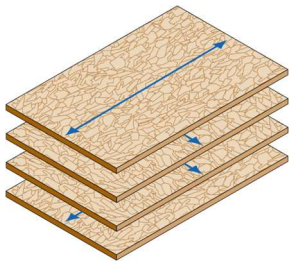
WSP Design and Specification

Oriented Strand Board (OSB) Layup



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Oriented Strand Board (OSB)

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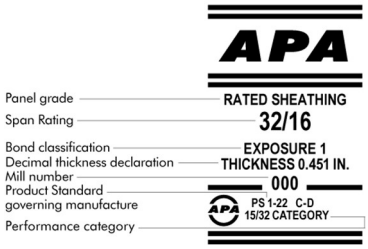
The APA Trademark Stamp



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APA Trademark

Rated for four end uses:

- Sheathing
- Underlayment
- Single-floor (Sturd-I-Floor®)
- Exterior siding

Two bond classifications:

- Exterior
- Exposure I

Additional sheathing category: Structural I:

- Denotes additional strength in cross-panel direction and racking

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WSP Design and Specification

APA Trademark: Product Standard

PS 1

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RATED SHEATHING
32/16
EXPOSURE 1
THICKNESS 0.451 IN.
000
PS 1-22 C-D
15/32 CATEGORY

Prescriptive
Plywood

OR

PS 2

APA
RATED SHEATHING
32/16
SIZED FOR SPACING
EXPOSURE 1
THICKNESS 0.451 IN.
000
PS 2-18 SHEATHING
HUD-UM-40
15/32 CATEGORY

Performance
Plywood & OSB

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APA Trademark: Performance Category

- Related to the panel thickness range
- Linked to the nominal panel thickness designations used IBC and IRC and other design manuals
- Span rating can vary for same performance category

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RATED STURD-I-FLOOR
24oc
SIZED FOR SPACING
EXPOSURE 1
THICKNESS 0.703 IN.
000
PS 2-18 SINGLE FLOOR
HUD-UM-40
23/32 CATEGORY

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WSP Design and Specification

APA Trademark: Performance Category

TABLE 12

PERFORMANCE CATEGORY AND NOMINAL THICKNESS (in.) BY SPAN RATING
(The predominant Performance Category for each span rating is highlighted in **bold** type.)

Span Rating	Performance Category									
	3/8	7/16	15/32	1/2	19/32	5/8	23/32	3/4	7/8	1	1-1/8
Sheathing											
W24	**0.375**	0.437	0.469								
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		
Single Floor											
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**

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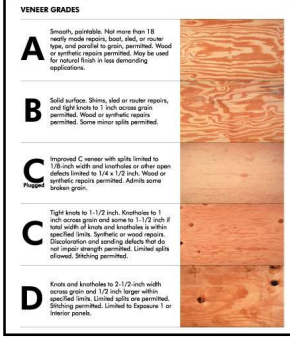

APA Trademark: Plywood Surface Texture

A - Smooth, paintable. Not more than 18 neatly made repairs.

B - Solid surface. Repairs, and tight knots to 1".

C-Plugged - Improved C veneer. Knotholes or other open defects limited to 1/4" x 1/2".

C - Tight knots to 1-1/2". Knotholes to 1" across grain. Occasional 1-1/2" knothole.

D - Knots and knotholes to 2-1/2". Occasional 3" knothole.

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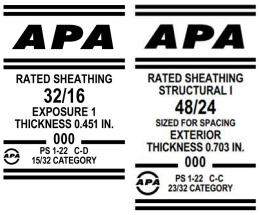
APA Trademark: Bond Classification

Exposure 1:

- Moisture-resistant adhesive
- Permit D-grade veneer (plywood)

Exterior:

- Moisture-resistant adhesive
- Minimum C-grade veneer (plywood)



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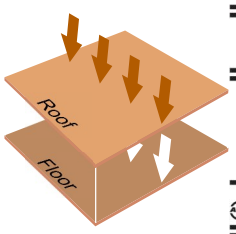
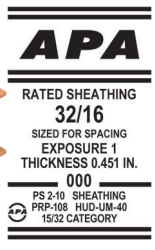
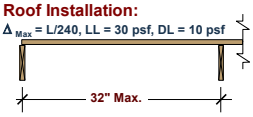
APA Trademark: Span Rating





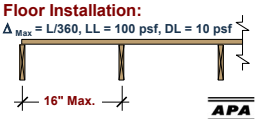
Roof Installation:

Δ_{Max} = L/240, LL = 30 psf, DL = 10 psf



Floor Installation:

Δ_{Max} = L/360, LL = 100 psf, DL = 10 psf



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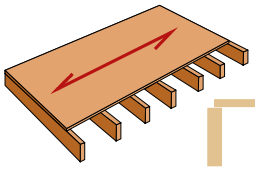
WSP Design and Specification

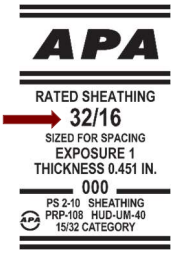
Span Rating Design Criteria



1. Strength axis perpendicular to supports

2. Continuous across three or more supporting members

3. Minimum 24" panel width



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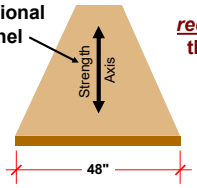
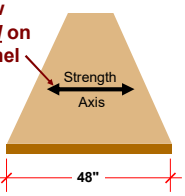
Strength Axis

Arrow optional on the panel



Common

Arrow *required* on the panel



Not Common

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Strength Axis

APA Engineered Wood Construction Guide, Form E30, Table 33

TABLE 33

RECOMMENDED UNIFORM ROOF LIVE LOADS FOR APA RATED SHEATHING[a] AND APA RATED STURD-I-FLOOR WITH STRENGTH AXIS PERPENDICULAR TO SUPPORTS[b]

Panel Span Rating	Minimum Panel Performance Category	Maximum Span (in.) With Edge Support[c]	Maximum Span (in.) Without Edge Support	Allowable Live Loads (psf)[d] Spacing of Supports Center-to-Center (in.) 12	16	20	24	32	40	48	60
APA RATED SHEATHING[a]											
24/0	3/8	24	19.2"	190	100	60	30				
24/16	7/16	24	24	190	100	65	40				
32/16	15/32	32	28	300	165	110	65	30			
40/20	19/32	40	32	—	275	195	120	60	30		
48/24	23/32	48	36	—	—	270	175	95	45	30	

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Strength Axis

APA Engineered Wood Construction Guide, Form E30

TABLE 36

RECOMMENDED ROOF LOADS (PSF) FOR APA RATED SHEATHING WITH STRENGTH AXIS PARALLEL TO SUPPORTS[a,b] (OSB and 5-ply/5-layer plywood panels unless otherwise noted)

Panel Grade	Panel Performance Category	Span Rating	Maximum Span (in.)	Load at Maximum Span	
				Live	Total
APA STRUCTURAL I RATED SHEATHING	7/16	24/16	24[c]	15	25
	15/32, 1/2	32/16	24	30[d]	40[d]
	19/32, 5/8	40/20	24	70[e]	80[e]
	23/32, 3/4	48/24	24	105[f]	115[f]
APA RATED SHEATHING	7/16	24/16	16	35	45
	15/32, 1/2	32/16	24[c]	15[g]	25[g]
	19/32, 5/8	40/20	24	40[h]	50[h]
	23/32, 3/4	48/24	24	70[e]	80[e]

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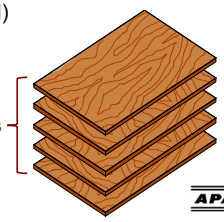
Structural I Sheathing

- Increased shear capacity
- Increased stiffness, especially across the panel
- Available in OSB (performance tested)

Group 1 Species



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Wood Structural Panel Design Values

NDS 9.2.1 Panel Stiffness and Strength

- Reference panel stiffness and strength design values (the product of material and section properties) shall be obtained from an approved source.

NDS C9.1.1 Scope

- "The provisions of NDS Chapter 9 contain only the basic requirements applicable to engineering design of wood structural panels. Specific requirements . . . are available from the wood structural panel manufacturer or the qualified agency."

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Mechanical Properties

- Provided in APA Form D510
- Used for engineering design
- Usually not required for typical applications
- Listed design capacities are conservative

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Mechanical Properties

APA Form D510

Section 4.4: Capacities

- This section provides background information on each capacity type

Based on test of panels bearing APA trademark

- Specifier must ensure the correct panel is used in construction

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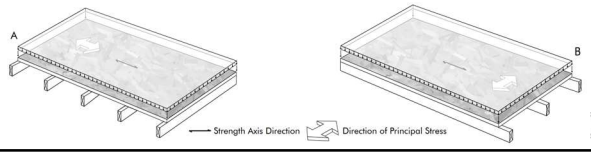
Panel Flexure (Flatwise Panel Bending)

Bending Stiffness (EI) in Modulus of Elasticity (E)

- Capacity to resist deflection
- Units of EI are in lb-in^2 per foot of panel width
- Significantly lower values for stress perpendicular to strength



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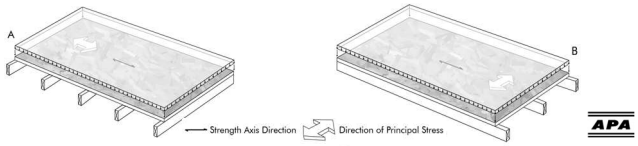
Panel Flexure (Flatwise Panel Bending)

Bending Strength (F_bS) and Allowable Bending Stress (F_b)

- Allowable bending strength capacity is the design maximum moment
- Units of F_bS are lbf-in per foot of panel width
- Significantly lower values for stress perpendicular to strength axis



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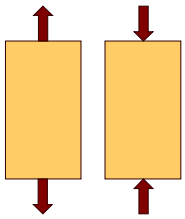
Panel Axial Strength & Stiffness

- Tensile Capacity (F_tA) and Allowable Tensile Stress (F_t)
- Compressive Capacity (F_cA) and Compressive Tensile Stress (F_c)
- Panel Axial Stiffness (EA) and Axial Modulus of Elasticity (E)
- Units of lbf per foot of panel width



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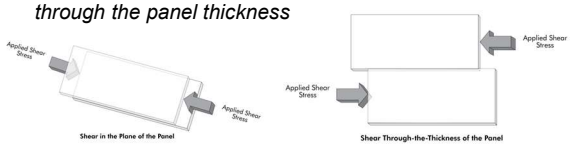
Shear Strength

- Shear Capacity (F_s[lb/Q]) and Allowable Shear Stress (F_s) *in the plane of the panel*
- Shear Capacity (F_v[lb/Q]) and Allowable Shear Stress (F_v) *through the panel thickness*
- Panel Shear Rigidity (G_vt_v) and Modulus of Rigidity (G_v) *through the panel thickness*



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Panel Bearing Capacity ($F_{c\perp}A$) and Allowable Bearing Stress ($F_{c\perp}$)

- Tabulated design values based on 0.04" deformation limit
- Design bearing stress of 360 psi for WSP under dry-use conditions (equilibrium MC <16%)
- For 0.02" deformation limit, can be chosen as 210 psi
- TT-001: *Allowable Bearing Stress for APA Wood Structural Panels*

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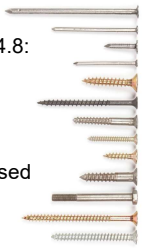
Fastener Design Values



- APA Form D510 provides guidance in section 4.4.8:
  - 4.4.8.1: Nail Withdrawal
  - 4.4.8.2: Wood Screw Withdrawal
  - 4.4.8.3: Fastener Head Pull-Through
  - 4.4.8.4: Fastener Lateral Design Values
- For WSP, Equivalent Specific Gravity (ESG) is used in place of "G" in the NDS equations for fastener withdrawal and head pull-through

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Equivalent Specific Gravity (ESG)

TABLE 4

EQUIVALENT SPECIFIC GRAVITY (ESG) FOR WOOD STRUCTURAL PANELS IN DRY SERVICE CONDITIONS FOR FASTENER WITHDRAWAL AND FASTENER HEAD PULL-THROUGH[a]

Loading Mode	Fasteners	Applicable Equation	Plywood		OSB
			Group 1	Others	
			Equivalent Specific Gravity (ESG)		
Fastener Withdrawal	Smooth- or Screw-Shank Carbon Steel Nails	1	0.40	0.40	0.40
	Ring-Shank Carbon Steel Nails	2	0.56	0.56	0.56
	Wood Screws	3	0.45	0.45	0.45
Fastener Head Pull-Through	Fasteners (Round Heads)[b]	4 or 5	0.50	0.42[c]	0.50

a. For use with the equations shown in Sections 4.4.8.1 through 4.4.8.3 of this specification or the equations specified in the NDS.
b. For fasteners with a round-head diameter of 0.234 through 0.500 in.
c. Use 0.42 when species of the plies is not known. When species of the plies is known, specific gravity listed for the actual species may be used or the weighted average may be used for mixed species.

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Nail Withdrawal Design Values

$$W_{sn} = 1380\ G^{5/2}\ D \quad [1]$$

$$W_{rn} = 1800\ G^{2}\ D \quad [2]$$

where:

W_{sn} = reference nail withdrawal design value for smooth- or screw-shank carbon steel nails, lbf/in. penetration,

W_{rn} = reference nail withdrawal design value for ring-shank carbon steel nails, lbf/in. penetration,

G = equivalent specific gravity (ESG) listed in Table 4, and

D = nail diameter, in.

- Reference nail withdrawal design values are tabulated in Form D510 Appendix A, Tables A1 and A2

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Wood Screw Withdrawal Design Values

$$W_{ws} = 2850\ G^{2}\ D \quad [3]$$

where:

W_{ws} = reference wood screw withdrawal design value, lbf/in. thread penetration,

G = equivalent specific gravity (ESG) listed in Table 4, and

D = wood screw diameter, in.

- Reference nail withdrawal design values are tabulated in Form D510 Appendix A, Table A3

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Fastener Head Pull-Through Design Values

- A nailed or screwed sheathing to wood joint may be limited by fastener head pull-through strength of the WSP
- Calculated values are tabulated in Form D510 Appendix B, Table B1

When $t \le 2.5\ D_H$ $\quad W_H = 690\ \pi\ D_H\ G^2\ t \quad [4]$

When $t > 2.5\ D_H$ $\quad W_H = 1725\ \pi\ D_H^2\ G^2 \quad [5]$

where:

t = wood structural panel thickness, in.,

W_H = reference fastener head pull-through design value, lbf,

D_H = fastener round head diameter, in. (0.234 in. $\le D_H \le$ 0.500 in.), and

G = equivalent specific gravity (ESG) listed in Table 4

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Fastener Lateral Design Values

- Calculated using the dowel bearing strength of WSP provided in Form D510 Table 5 and the yield limit equations provided in Table 12.3.1A of the NDS.
- Chapter 12 of the NDS provides the calculated reference fastener lateral load design values for various fastener types, configurations, and framing and sheathing materials

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TABLE 5

DOWEL BEARING STRENGTH (F_e) AND ESG FOR WOOD STRUCTURAL PANELS IN DRY SERVICE CONDITIONS

Dowel-type fastener (nails, screws and bolts) diameter (D)	Plywood								OSB			
	Group 1				Others[a]							
	∥[b]		⊥[c]		∥[b]		⊥[c]		∥[b]		⊥[c]	
	$F_{e\parallel}$ (psi)	ESG	$F_{e\perp}$ (psi)	ESG	$F_{e\parallel}$ (psi)	ESG	$F_{e\perp}$ (psi)	ESG	$F_{e\parallel}$ (psi)	ESG	$F_{e\perp}$ (psi)	ESG
D ≤ 1/4 in.	4,650	0.50	4,650	0.50	3,350	0.42	3,350	0.42	4,650	0.50	4,650	0.50
1/4 in. < D ≤ 1/2 in.[d]	5,600	0.50	3,150	0.50	4,700	0.42	2,450	0.42	3,700	0.33	3,700	0.56

a. Use when species of the plies is not known. When species of the plies is known, specific gravity of the actual species and the corresponding dowel bearing strength may be used, or the weighted average may be used for mixed species.
b. Dowel bearing strength when the dowel is loaded parallel to the strength axis of the panel.
c. Dowel bearing strength when the dowel is loaded perpendicular to the strength axis of the panel.
d. Refer to *APA Technical Note: Fastener Loads for Plywood – Bolts*, Form E825, for 1/2 in. < D ≤ 3/4 in. used with plywood.

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Table 12.3.1A Yield Limit Equations

Yield Mode	Single Shear		Double Shear	
I_m	$Z = \frac{D\ell_m F_{em}}{R_d}$	(12.3-1)	$Z = \frac{D\ell_m F_{em}}{R_d}$	(12.3-7)
I_s	$Z = \frac{D\ell_s F_{es}}{R_d}$	(12.3-2)	$Z = \frac{2D\ell_s F_{es}}{R_d}$	(12.3-8)
II	$Z = \frac{k_1 D\ell_s F_{es}}{R_d}$	(12.3-3)		
III_m	$Z = \frac{k_2 D\ell_m F_{em}}{(1+2R_t)R_d}$	(12.3-4)		
III_s	$Z = \frac{k_3 D\ell_s F_{es}}{(2+R_t)R_d}$	(12.3-5)	$Z = \frac{2k_3 D\ell_s F_{es}}{(2+R_t)R_d}$	(12.3-9)
IV	$Z = \frac{D^2}{R_d}\sqrt{\frac{2F_{em}F_{yb}}{3(1+R_t)}}$	(12.3-6)	$Z = \frac{2D^2}{R_d}\sqrt{\frac{2F_{em}F_{yb}}{3(1+R_t)}}$	(12.3-10)

Notes:

$$k_1 = \frac{\sqrt{R_e + 2R_e^2(1+R_t+R_t^2) + R_t^2R_e^3} - R_e(1+R_t)}{(1+R_e)}$$

$$k_2 = -1 + \sqrt{2(1+R_t) + \frac{2F_{yb}(1+2R_t)D^2}{3F_{em}\ell_m^2}}$$

$$k_3 = -1 + \sqrt{\frac{2(1+R_t)}{R_t} + \frac{2F_{yb}(2+R_t)D^2}{3F_{em}\ell_s^2}}$$

D = diameter, in. (see 12.3.7)
F_{yb} = dowel bending yield strength, psi
R_d = reduction term (see Table 12.3.1B)
R_e = F_{em}/F_{es}
R_t = ℓ_m/ℓ_s
ℓ_m = main member dowel bearing length, in.
ℓ_s = side member dowel bearing length, in.
F_{em} = main member dowel bearing strength, psi (see Table 12.3.3)
F_{es} = side member dowel bearing strength, psi (see Table 12.3.3)

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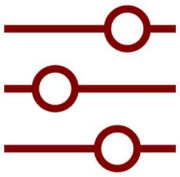
WSP Design and Specification

Adjustments – Section 4.5 of Form D510

- Duration of load (DOL)
- Creep
- Service moisture conditions
- Elevated temperature
- Pressure treatment
- Panel size
- Panel edge support



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WSP Design and Specification

Duration of Load (DOL)

TABLE 6

LOAD DURATION FACTORS FOR WOOD STRUCTURAL PANELS

Time Under Load	DOL Adjustment Factor* (C_D)
Permanent	0.90
Normal	1.00
Two Months	1.15
Seven Days	1.25
Wind or Earthquake	1.60

*Adjustment for impact load does not apply to wood structural panels.

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WSP Design and Specification

Creep

- For WSP under constant load that will stress panels ≥ ½ of their design strength capacity
- Not a concern for typical construction applications
- Adjustment factors in APA Form D510 Table 7

TABLE 7

CREEP ADJUSTMENT FACTORS FOR WOOD STRUCTURAL PANELS

Moisture Content	Creep Adjustment Factor (C_c) for Permanent Loads: Plywood	OSB
Dry (< 16% MC)	1/2	1/2
16% MC or greater	1/2	1/6

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Service Moisture Conditions

- Tabulated WSP design capacities apply to panels with EMC less than 16% in-service
- Adjustment factors for higher EMC are shown in Table 8 of APA form D510

TABLE 8

MOISTURE CONTENT ADJUSTMENT FACTORS FOR WOOD STRUCTURAL PANELS

Allowable Design Capacity	Moisture Content Adjustment Factor (C_M)
Strength (F_v, S, $F_t A$, $F_c A$, $F_b(Ib/Q)$, F_{rt})	0.75
Stiffness (EI, EA, G_{rt})	0.85
Bearing ($F_{c\perp} A$) Plywood OSB	0.50 0.20
Nail withdrawal strength	0.75
Wood screw withdrawal strength and lateral strength for dowel-type fasteners (nails, screws and bolts) of 1/2 inch or less in diameter	NDS Table 11.3.3

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Elevated Temperature

- D510 capacities apply to panels at temperatures of 70° Fahrenheit and lower
- WSP parts of buildings should generally not be exposed to temperatures over 200°F
- Between 70°F and 200°F, capacities generally do not need to be adjusted
- Designer should exercise judgement if high temperature and moisture conditions will occur simultaneously

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Pressure Treatment

- D510 WSP capacities apply, without adjustment, to plywood pressure impregnated with preservative chemicals and redried per AWPA standard U1
- Unadjusted D510 WSP capacities do NOT apply to fire-retardant treated WSP
  - Capacities and end-use conditions should be per the company providing the treating and redrying service
  - See APA Technical Note: Fire-Retardant-Treated (FRT) Plywood, Form K320

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Panel Size and Panel Edge Support

- Bending and tension strength capacities noted in D510 are for panels 24" or greater in width
- For panels with width b < 24", a panel size adjustment factor, C_s, shall be applied to bending and tensile strength

[6] $b \geq 24$ inches, $C_s = 1.00$

[7] $24 > b \geq 8$ in., $C_s = 0.25 + 0.0313\,b$

[8] $b < 8$ in., $C_s = 0.50$

- Form R275: Narrow-Width Roof Sheathing Applications

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Design Example 1

- ASCE 7-16, Table 7.2-5 Ground Snow Load for Selected Locations in Washington
- White Pass:
  - Ground Snow Load: 244 psf
  - Elevation: 4,720 feet

Table 7.2-5 Ground Snow Loads for Selected Locations in Washington

City/Town	County	Ground Snow Load (lb/ft²)	Elevation (ft)
Arlington	Snohomish	17	120
Auburn	King	20	85
Bainbridge Island	Kitsap	15	100
Bellevue	King	20	100
Bellingham	Watcom	15	100
Bonney Lake	Pierce	18	40
Bothell	King	20	90
Univ. Place	Pierce	20	400
Vancouver	Clark	20	150
Walla Walla	Walla Walla	18	1,000
Wenatchee	Chelan	22	780
White Pass	Yakima	244	4,720
Yakima	Yakima	19	1,066

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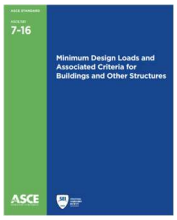
Design Example 1

ASCE 7-16

- Exposure factor
- Thermal factor
- Importance factor
- Slope of roof
- Unbalanced loading and drifts



Assume:

- Roof snow load = ground snow load = 244 psf
- Allowable stress design (i.e., load combo is D+S)
- Dead = 10 psf, D+S = 244+10 = 254psf

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Design Example 1

APA Panel Design Specification (Form D510)

Assume:

- Roof framing @ 24" oc
- Framing members 3x or greater
- C_D = 1.15 (2 months, snow), applies to bending and shear, not deflection
- Deflection Criteria L/240 (IBC)
- 1 1/8 Performance Category OSB Sturd-I-Floor with a Span Rating of 48 oc
  - EI = 1,150,000 lbf-in.^{2}/ft of panel width
  - F_bS = 1,900 lbf-in./ft of panel width
  - F_s(Ib/Q) = 385 lbf/ft of panel width

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Design Properties from PDS (Form D510)

TABLE 9

PANEL DESIGN CAPACITIES

Span Rating	Stress Parallel to Strength Axis: Plywood 3-ply	4-ply	5-ply	OSB	Stress Perpendicular to Strength Axis: Plywood 3-ply	4-ply	5-ply	OSB
PANEL BENDING STIFFNESS, EI (lbf-in.²/ft of panel width)								
24/0	86,000	86,000	86,000	60,000	3,600	7,900	11,000	11,000
24/16	125,000	125,000	125,000	115,000	8,100	18,000	25,000	25,000
32/16	125,000	125,000	125,000	115,000	8,100	18,000	25,000	25,000
40/20	250,000	250,000	250,000	200,000	18,000	39,500	56,000	56,000
48/24	NA	440,000	440,000	350,000	NA	65,000	91,500	91,500
16 oc	165,000	165,000	165,000	150,000	11,000	24,000	34,000	34,000
20 oc	230,000	230,000	230,000	195,000	13,000	28,500	40,500	40,500
24 oc	NA	330,000	330,000	300,000	NA	57,000	80,500	80,500
32 oc	NA	NA	715,000	650,000	NA	NA	235,000	235,000
48 oc	NA	NA	1,265,000	1,150,000	NA	NA	495,000	495,000
Structural I Multiplier	1.0	1.0	1.0	1.0	1.5	1.5	1.6	1.6
PANEL BENDING STRENGTH, F_bS (lbf-in./ft of panel width)								
24/0	250	275	300	300	54	65	97	97
24/16	320	350	385	385	64	77	115	115
32/16	370	405	445	445	92	110	165	165
40/20	625	690	750	750	150	180	270	270
48/24	NA	930	1,000	1,000	NA	270	405	405
16 oc	415	435	500	500	100	120	180	180
20 oc	480	530	575	575	140	170	250	250
24 oc	NA	705	770	770	NA	260	385	385
32 oc	NA	NA	1,050	1,050	NA	NA	685	685
48 oc	NA	NA	1,900	1,900	NA	NA	1,200	1,200
Structural I Multiplier	1.0	1.0	1.0	1.0	1.3	1.4	1.5	1.5

PANEL SHEAR IN THE PLANE, F_s(lb/Q) (lbf/ft of panel width)

24/0	185	185	170	130	275	275	130	130
24/16	200	200	215	165	345	480	165	165
32/16	200	200	215	165	345	480	165	165
40/20	245	245	265	205	430	595	205	205
48/24	NA	300	325	250	NA	725	250	250
16 oc	245	245	265	205	430	595	205	205
20 oc	245	245	265	205	430	595	205	205
24 oc	NA	300	325	250	NA	725	250	250
32 oc	NA	NA	385	300	NA	NA	300	300
48 oc	NA	NA	500	385	NA	NA	385	385
Structural I Multiplier	1.4	1.4	1.4	1.0	1.4	1.4	1.0	1.0

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Pressure – Bending Strength

- **2 span:**
  $w_b = 96 \times (1900 \times 1.15) / 24^2$
  w_b = 364 psf > 254 psf ☑
- **3 span:**
  $w_b = 120 \times (1900 \times 1.15) / 24^2$
  w_b = 455 psf > 254 psf ☑
- **1 span:**
  Don't do it… requires extra blocking

4.7.4 Loads Based on Bending Strength

The following formulas shall be used for computing loads based on design bending strength capacity (F_bS).

For a single span:

$$w_b = \frac{96\,F_bS}{\ell_1^2} \quad [9]$$

For a two-span condition:

$$w_b = \frac{96\,F_bS}{\ell_1^2} \quad [10]$$

For a three-span condition:

$$w_b = \frac{120\,F_bS}{\ell_1^2} \quad [11]$$

where:

w_b = uniform load based on bending strength, psf,

F_bS = design bending strength capacity, lbf-in./ft, and

ℓ_1 = span (center to center of supports), in.

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Pressure – Shear Strength

- **2 span:**
  w_s = 19.2 × 385 × 1.15/(24-2.5)
  w_s = 395 psf > 254 psf ☑
- **3 span:**
  w_s = 395 × 20/19.2
  w_s = 412 psf > 254 psf ☑
- **1 span:**
  Don't do it… requires extra blocking

4.7.5 Uniform Loads Based on Shear Strength

The following formulas shall be used for computing loads based on design shear strength capacity (F_v[lbf/Q]).

For a single span:

$$w_s = \frac{24\ F_v(lbf/Q)}{\ell_s} \quad [12]$$

For a two-span condition:

$$w_s = \frac{19.2\ F_v(lbf/Q)}{\ell_s} \quad [13]$$

For a three-span condition:

$$w_s = \frac{20\ F_v(lbf/Q)}{\ell_s} \quad [14]$$

where:

w_s = uniform load based on shear strength, psf,

F_v(lbf/Q) = design shear strength capacity, lbf/ft, and

ℓ_s = clear span (center to center of supports minus support width), in.

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Check Live Load Bending Deflection

Allowable = 24/240 = 0.100"

- **2 span:**
  Δ = 244 × (24-2.5+0.625) 4/(2220*1.15e6)
  Δ = 0.023" < 0.100" ☑
- **3 span:**
  Δ = 0.023 × 2220/1743
  Δ = 0.029" < 0.100" ☑
- **1 span:**
  Don't do it… requires extra blocking

4.7.6 Uniform Loads Based on Deflection Requirements

The following formulas shall be used for computing deflection under uniform load, or allowable loads based on deflection requirements.

For a single span:

$$\Delta = \frac{w\ell_s^4}{921.6\ EI} \quad [15]$$

For a two-span condition:

$$\Delta = \frac{w\ell_s^4}{2220\ EI} \quad [16]$$

For a three-span condition:

$$\Delta = \frac{w\ell_s^4}{1743\ EI} \quad [17]$$

where:

Δ = deflection, in.,

w = uniform load, psf,

EI = design apparent bending stiffness (see Section 4.4.1), lbf-in.²/ft,

ℓ_s = clear span + SW, in., and

SW = support-width factor, equal to 0.25 inch for two-inch-nominal lumber framing and 0.625 inch for four-inch-nominal lumber framing (see Section 4.7.2 for support widths).

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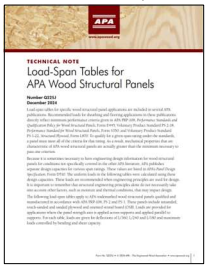
APA Form Q225



TECHNICAL NOTE

Load-Span Tables for APA Wood Structural Panels

Number Q225J
December 2024

TABLE 2c

UNIFORM LOADS (PSF) ON APA RATED OSB STURD-I-FLOOR, MULTI-SPAN, NORMAL DURATION OF LOAD, DRY CONDITIONS, PANELS 24 INCHES OR WIDER

Span Rating[a]	Load Governed By[c]	Strength Axis[a] Perpendicular to Supports Span Center-to-Center of Supports (inches) 12	16	19.2	24	30	32	36	40	48	60	Parallel to Supports Span Center-to-Center of Supports (inches) 12	16	24
20 o.c.	L/360	848	319	175	85	41	34	30	21	14		176	66	22
	L/240	1,273	479	262	127	62	51	45	32	21		264	99	34
	L/180	1,697	638	349	169	83	68	59	43	28		352	133	45
	Bending	479	270	187	120	77	67	43	35	24		208	117	42
	Shear	390	283	232	182	144	134	114	102	88		390	283	175
24 o.c.	L/360	1,305	491	269	130	64	52	46	33	21	10	350	132	44
	L/240	1,958	736	403	195	96	78	69	49	32	16	525	198	67
	L/180	2,610	982	537	260	128	104	91	66	43	21	700	263	89
	Bending	642	361	251	160	103	90	57	46	32	21	321	180	64
	Shear	476	345	282	222	175	164	139	125	108	85	476	345	213
32 o.c.	L/360	2,828	1,064	582	282	138	113	99	71	46	23	1,022	385	130
	L/240	4,242	1,596	873	423	207	169	148	107	70	34	1,534	577	195
	L/180	5,656	2,128	1,164	564	276	225	198	142	93	45	2,045	769	260
	Bending	875	492	342	219	140	123	78	63	44	28	571	321	114
	Shear	571	414	339	267	211	197	167	150	129	102	571	414	256
48 o.c.	L/360	5,003	1,882	1,030	499	244	199	175	126	82	40	2,154	810	273
	L/240	7,505	2,823	1,545	748	367	299	263	189	123	60	3,230	1,215	410
	L/180	10,006	3,764	2,060	998	489	399	350	252	164	80	4,307	1,620	547
	Bending	1,583	891	618	396	253	223	141	114	79	51	1,000	563	200
	Shear	733	531	435	342	270	252	214	192	166	131	733	531	329

a. The strength axis is the long panel dimension unless otherwise identified.
b. Nominal thickness may vary within span rating. For range of thicknesses, see Table 5 of APA's *Panel Design Specification*, Form D510.
c. Some capacities may be increased by application of formulas in *Panel Design Specification*, Form D510.

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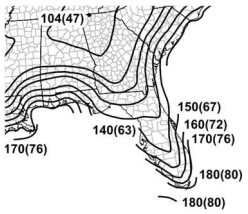
WSP Design and Specification

Design Example 2

- Wall sheathing for typical home in Miami-Dade County, Florida
  - Local building department indicates ultimate wind speed is 170 mph
  - Assume component and cladding wind pressure of 41.8 psf



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WSP Design and Specification

Calculate Allowable Pressures Based on PDS

Panel Design Specification (Form D510)

Assume:

- Wall Sheathing is 7/16 Cat OSB, 24/16 STR I
- Wall framing @ 16" oc
- SPF framing members, 2x or greater
- Exterior stucco finish
- C_D = 1.6 (10 min), applies to bending and shear, not deflection

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WSP Design and Specification

APA Span Table Form Q225

- Bending: 81 psf × 1.6 = 129.6 psf > 41.8 ☑
- Shear: 207 psf × 1.6 = 331.2 psf > 41.8 ☑
- Deflection (L/360 limit): 42 psf > 41.8 ☑

TABLE 2b

UNIFORM LOADS (PSF) ON APA RATED OSB STRUCTURAL I SHEATHING. MULTI-SPAN, NORMAL DURATION OF LOAD, DRY CONDITIONS, PANELS 24 INCHES OR WIDER

Span Rating[a]	Load Governed By[c]	Strength Axis[a] Perpendicular to Supports Span Center-to-Center of Supports (inches) 12	16	19.2	24	30	32	36	40	48	60	Parallel to Supports Span Center-to-Center of Supports (inches) 12	16	24
24/0	L/360	261	98	54	26	13	10					77	29	10
	L/240	392	147	81	39	19	16					115	43	15
	L/180	522	196	107	52	26	21					153	58	19
	Bending	250	141	98	63	40	35					121	68	24
	Shear	248	179	147	116	91	85					248	179	111
24/16	L/360	339	128	70	34	17	14	12				111	42	14
	L/240	509	191	105	51	25	20	18				167	63	21
	L/180	679	255	140	68	33	27	24				223	84	28
	Bending	321	180	125	80	51	45	29				144	81	29
	Shear	286	207	169	133	105	98	83				286	207	128

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WSP Design and Specification

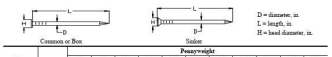
What About Nail Head Pull-Through?

Pull-though equation from PDS, nail dimensions from the NDS

Assume:

- Nail is 8d sinker (D_H = 0.266")
- Initial intermediate nailing 12" oc
- G = 0.50 (from PDS Table 4 for STR I OSB)

Table L4 Standard Common, Box, and Sinker Steel Wire Nails[1,2]



Type		Penny-weight											
		6d	7d	8d	10d	12d	16d	20d	30d	40d	50d	60d
Common	L	2	2-1/4	2-1/2	3	3-1/4	3-1/2	4	4-1/2	5	5-1/2	6
	D	0.113	0.113	0.131	0.148	0.148	0.162	0.192	0.207	0.225	0.244	0.263
	H	0.266	0.266	0.281	0.312	0.312	0.344	0.406	0.438	0.469	0.5	0.531
Box	L	2	2-1/4	2-1/2	3	3-1/4	3-1/2	4	4-1/2	5		
	D	0.099	0.099	0.113	0.128	0.128	0.135	0.148	0.148	0.162		
	H	0.266	0.266	0.297	0.312	0.312	0.344	0.375	0.375	0.406		
Sinker	L	1-7/8	2-1/8	2-3/8	2-7/8	3-1/8	3-1/4	3-3/4	4-1/4	4-3/4		5-3/4
	D	0.092	0.099	0.113	0.12	0.135	0.148	0.177	0.192	0.207		0.244
	H	0.254	0.270	0.266	0.281	0.312	0.344	0.375	0.406	0.438		0.5

1. Tolerances are specified in ASTM F1667. Typical shape of common, box, and sinker steel wire nails shown. See ASTM F 1667 for other nail types.
2. It is permitted to remove the height of the tapered tip in 2D.

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WSP Design and Specification

What About Nail Head Pull-Through?

Pull-though equation from PDS, nail dimensions from the NDS:

- 2.5 D_H = 0.665 > t = 0.435 (use eq. 4)
  $W_H = 690 \times \pi \times 0.266 \times 0.5^2 \times 0.435 \times 1.6$
  W_H = 100 lbf

Trib. Area = 16" × 12" / 144 = 1.33 SF

When $t \le 2.5\ D_H$ $\quad W_H = 690\ \pi\ D_H\ G^2\ t$ [4]

When $t > 2.5\ D_H$ $\quad W_H = 1725\ \pi\ D_H^2\ G^2$ [5]

where:

t = wood structural panel thickness, in.,

W_H = reference fastener head pull-through design value, lbf,

D_H = fastener round head diameter, in. (0.234 in. ≤ D_H ≤ 0.500 in.), and

G = equivalent specific gravity (ESG) listed in Table 4

Nail head pull-through pressure cap.:

- 100lbf / 1.33 SF = 75 psf > 41.8 psf ☑

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WSP Design and Specification

What About Nail Withdrawal from Framing?

Withdrawal equation (and table) and nail dimensions from the NDS

Assume:

- Nail is 8d sinker (d = 0.113", L = 2.375")
- Initial intermediate nailing 12" oc
- G = 0.43 (from NDS for SPF lumber)

$W = 1380\ G^{5/2}\ D$ (12.2-3)

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WSP Design and Specification

What About Nail Withdrawal from Framing?

Nail Withdrawal:

- W = 28 lbf/in × (2.375 in. – 0.435 in.) × 1.6 = 86 lbf
- Pressure limited by nail withdrawal 86lbf /1.33 SF = 64 psf > 41.8 psf ☑

- **May consider intermediate spacing @ 6" oc, use longer nail, larger diameter nail, or ring shank nail**

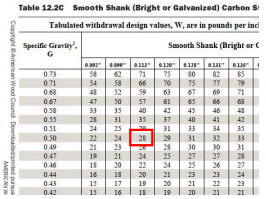

Table 12.2C Smooth Shank (Bright or Galvanized) Carbon S

Tabulated withdrawal design values, W, are in pounds per inc

Specific Gravity[2], G	Smooth Shank (Bright or C						
	0.092"	0.099"	0.113"	0.120"	0.128"	0.131"	0.135"
0.73	58	62	71	75	80	82	85
0.71	54	58	66	70	75	77	79
0.68	48	52	59	63	67	69	71
0.67	47	50	57	61	65	66	68
0.58	33	35	40	42	45	46	48
0.55	28	31	35	37	40	41	42
0.51	24	25	30	31	33	34	35
0.50	22	24	28	29	31	32	33
0.49	21	23	27	28	30	30	31
0.47	19	21	24	25	27	27	28
0.46	18	20	22	24	25	26	27
0.44	16	18	20	21	23	23	24
0.43	15	17	19	20	21	22	23
0.42	15	16	18	19	20	21	21

Source: [illegible] Wood Council, Design Value Publication ANSI/AWC NDS-2018

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Limits to Design per D510 and Q225

Some Applications Not Controlled by Uniform Load

Floors:

- Framing systems commonly designed for 40 psf live load
- Allowable uniform load on panels at max floor span rating (per the APA trademark) is much greater than typical design loads
- Does NOT mean floor spans can be increased – span rating based on other factors

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Questions?

https://www.apawood.org/presentation-survey

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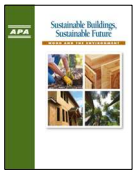
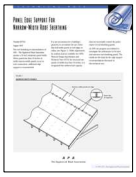
Referenced APA Publications

Form D510



Form F305

Form Q225



Form R275

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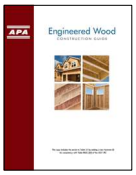
Referenced APA Publications

Form E825



Form E30

Form K320

Form TT-001

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APA Field Staff

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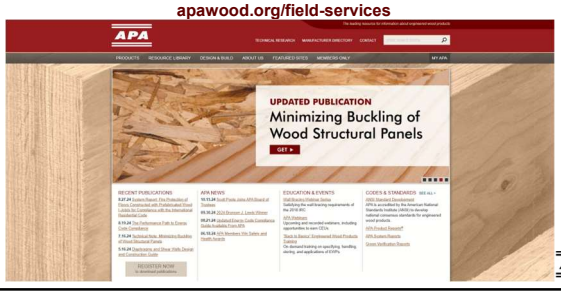

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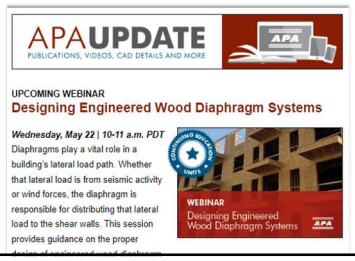
APA Update Newsletter
(www.apawood.org)



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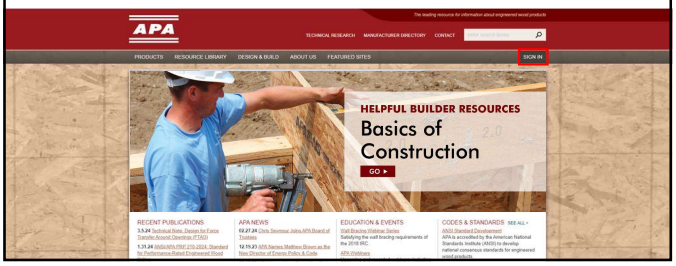
APA Update Newsletter
(www.apawood.org)



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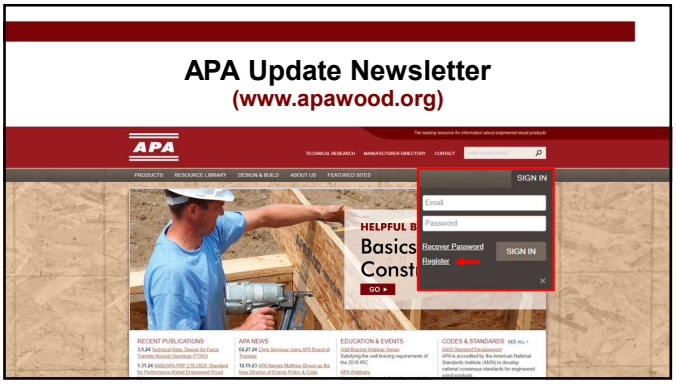
APA Update Newsletter
(www.apawood.org)



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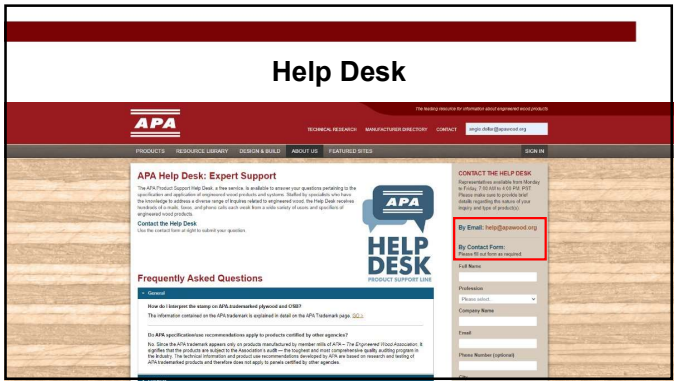
Help Desk



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Thank you for attending!

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