



NCh1198

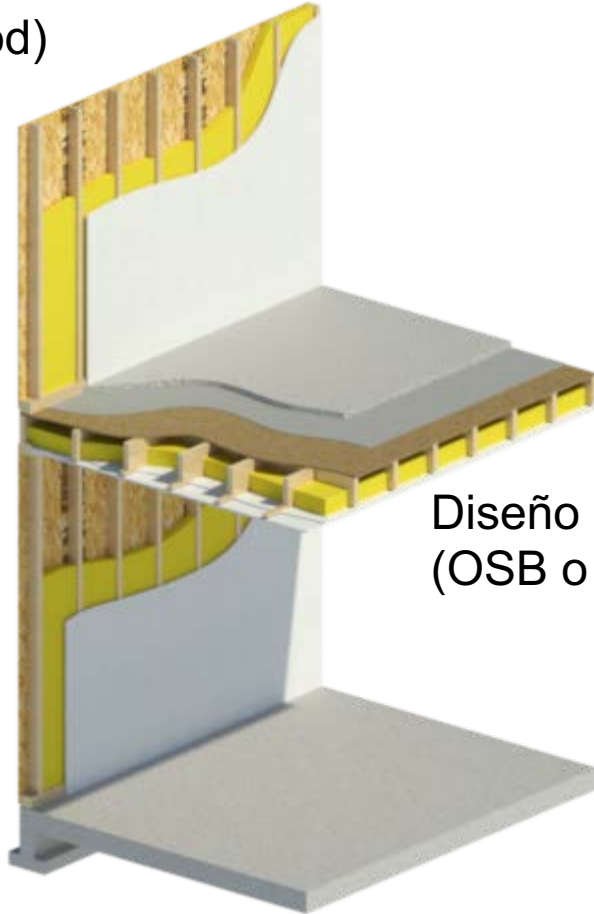
Relevancia de las normativas de tableros para la construcción en madera

Ignacio González Retamal
Departamento de Tecnologías de la Construcción

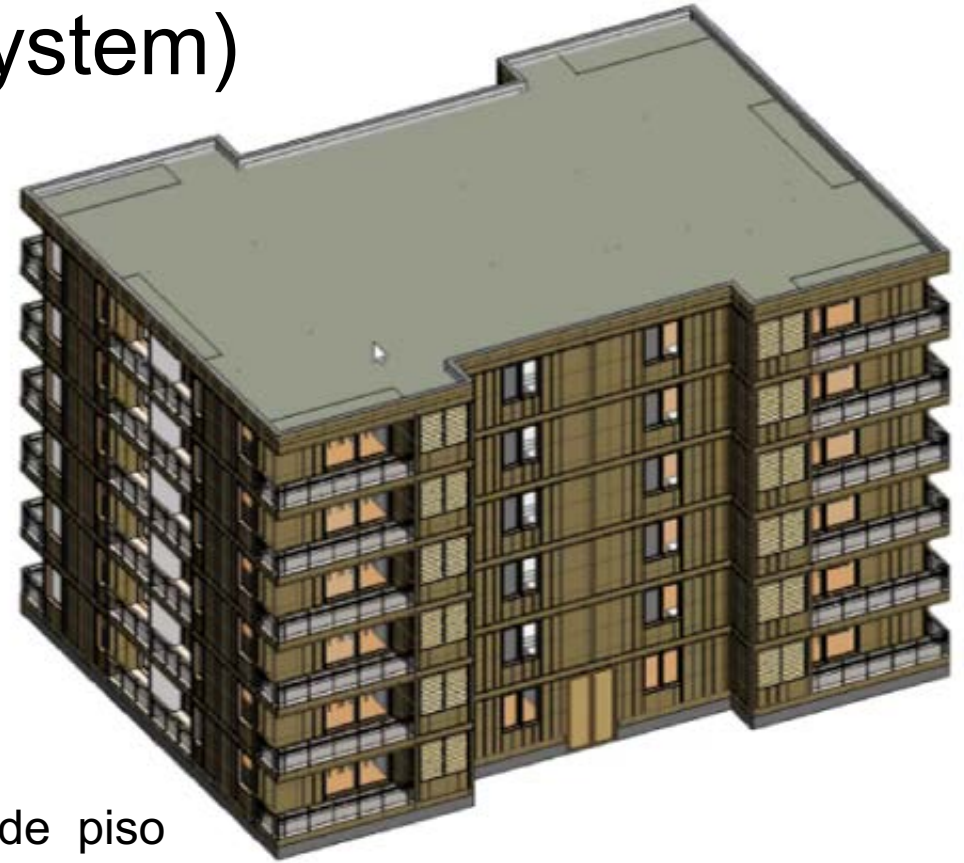
¿Cuál es el uso de los tableros estructurales en el mercado de la construcción maderas?

Sistema Plataforma (light-frame system)

Diseño de muros de corte
(OSB o Plywood)



Diseño de diafragmas de piso
(OSB o Plywood)

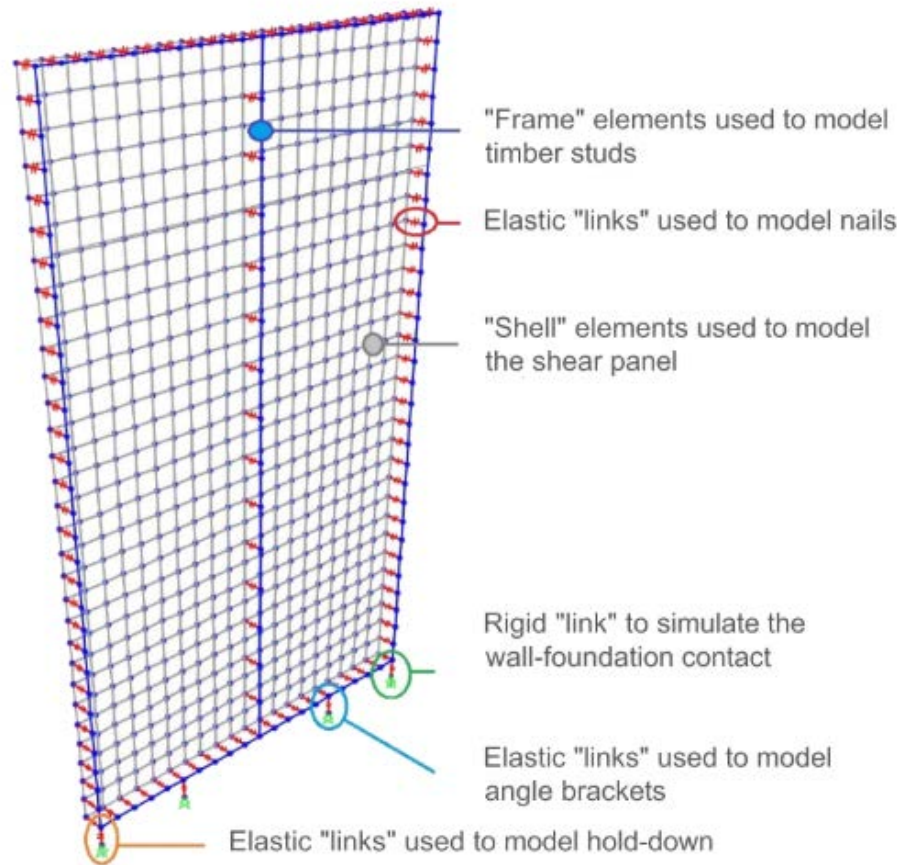


¿Que relevancia tienen los tableros estructurales OSB y Plywood en el diseño de las componentes del sistema plataforma?



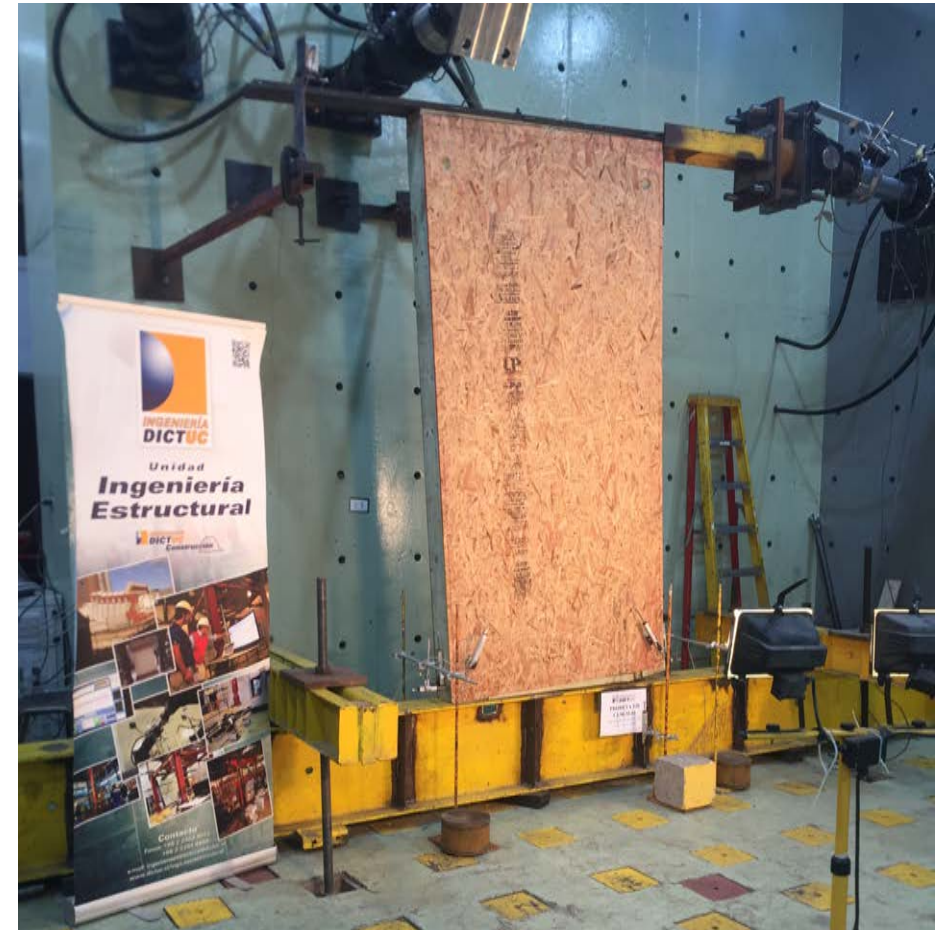
Contribución de rigidez en muros sistema plataforma (light-frame system)

Enfoque numérico



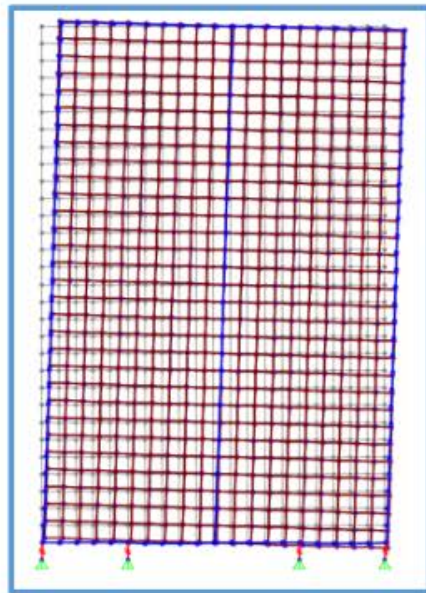
Fuente: <https://en.timbertech.eu/modeling-timber-walls/>

Validación y Enfoque Práctico SDPWS

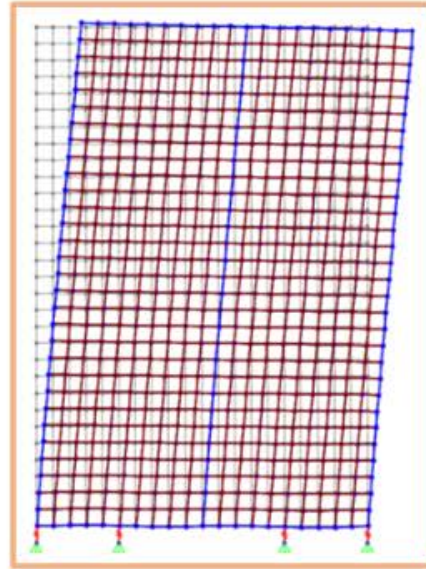


Enfoque numérico

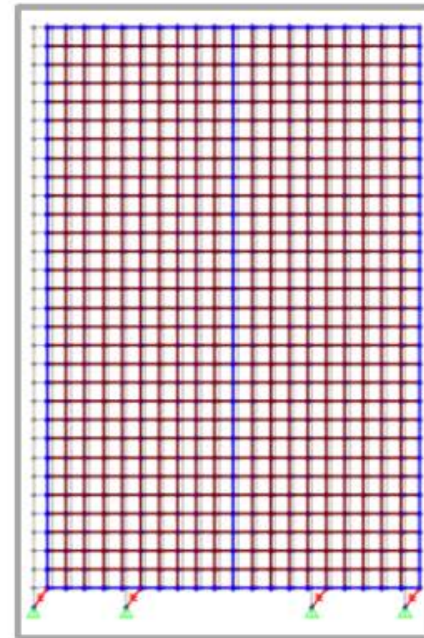
Análisis de la contribución de las placas estructurales OSB o Plywood



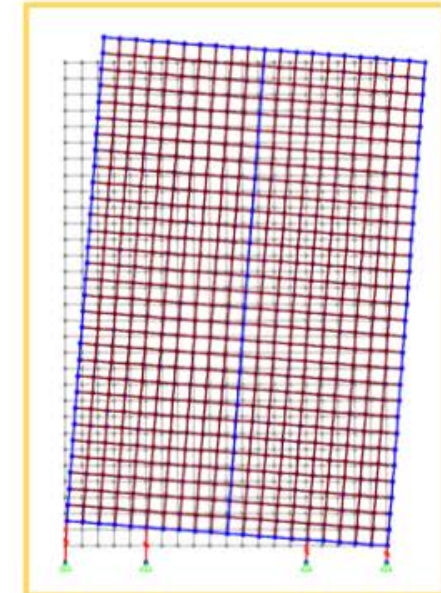
Sheathing to framing
connection deformation



Sheathing panel shear
deformation



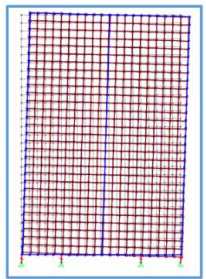
Rigid body translation



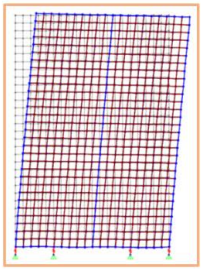
Rigid body rotation

Enfoque numérico

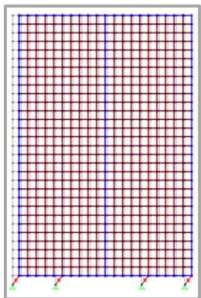
Análisis de la contribución de las placas estructurales OSB o Plywood



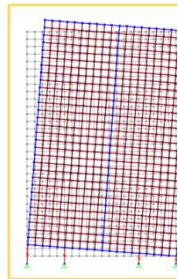
Sheathing to framing connection deformation



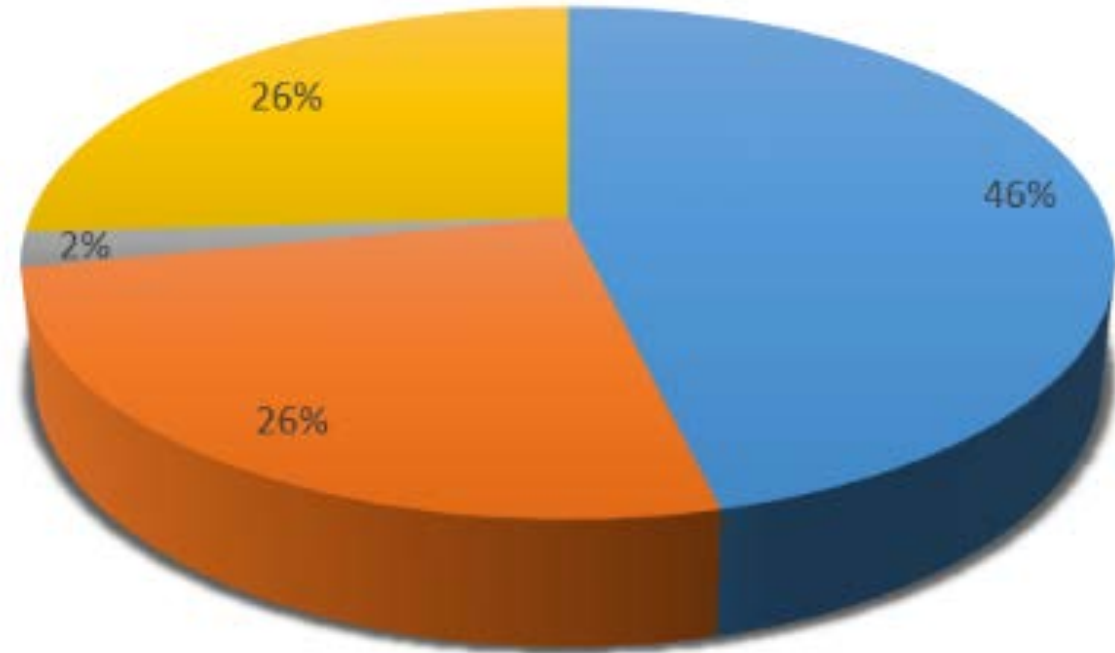
Sheathing panel shear deformation



Rigid body translation



Rigid body rotation



- Sheathing to framing connection deformation
- Sheathing panel shear deformation
- Rigid body translation
- Rigid body rotation

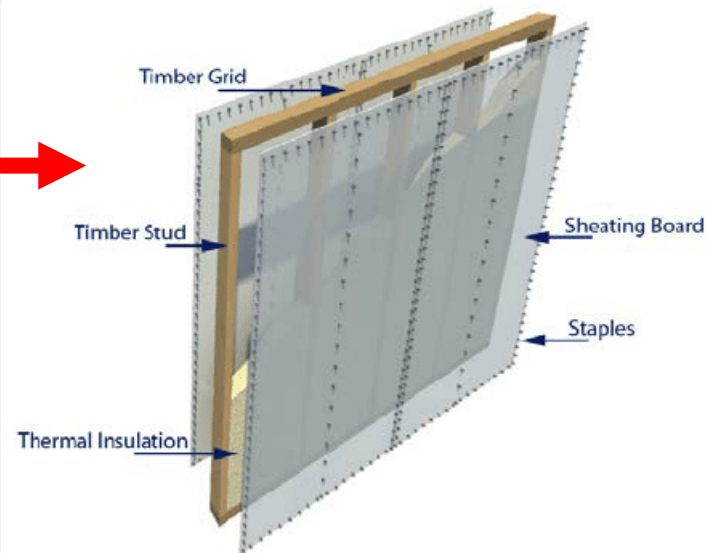
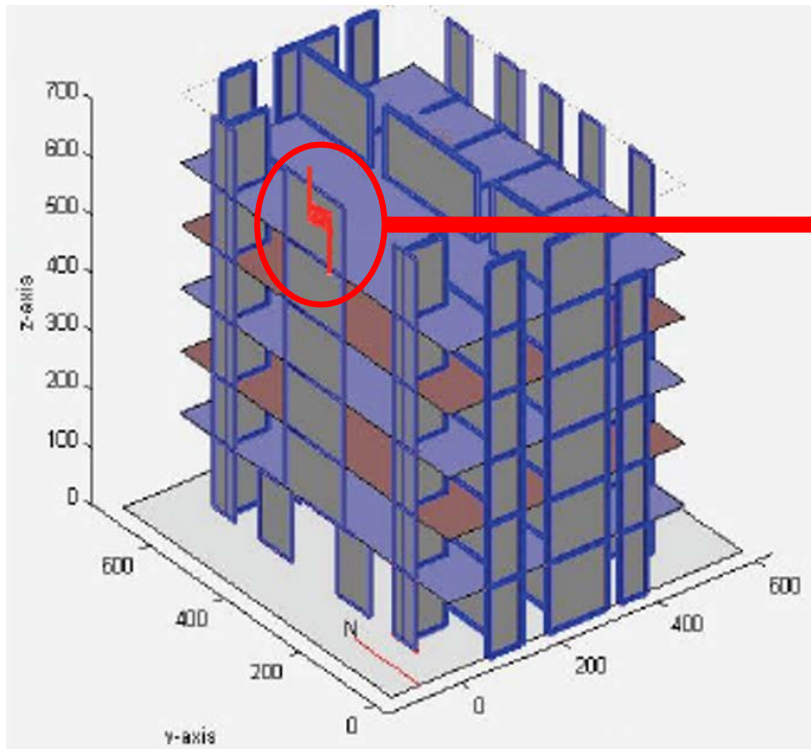


Contribuciones a la deformación

Fuente: <https://en.timbertech.eu/modeling-timber-walls/>

Validación y Enfoque Práctico SDPWS (actualización NCh1198)

Campaña Experimental



→ MURO

→ MADERA

→ OSB

→ OSB-CLAVO-MADERA

→ CLAVO

Fuente: Anil et al, Experimental Analysis of Hysteretic Load Behavior of Timber Framed Shear Walls with Openings (2014).

Validación y Enfoque Práctico SDPWS (actualización NCh1198)

Ensayos de Tableros OSB (Laboratorio de APA-USA):

- Ensayo para determinar el Módulo de Corte



ASTM – D1037



- Ensayo de Flexión para determinar el Módulo de Elasticidad



ASTM – D3043

Validación y Enfoque Práctico SDPWS (actualización NCh1198)

Ensayos de Tableros OSB (Laboratorio de APA-USA):

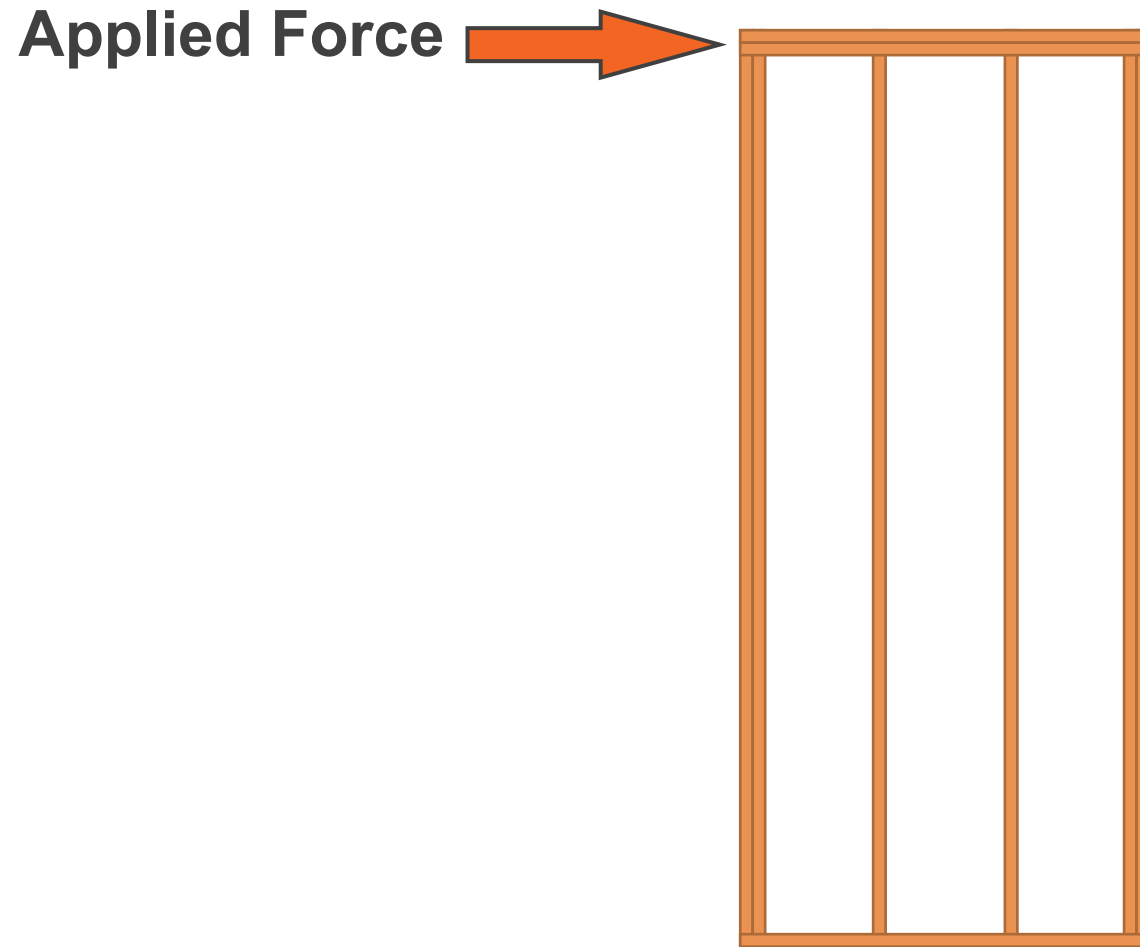
- El objeto era comprobar si los ensayos de los muros están dentro del rango de resistencias de lo establecido en la Norma APA.
- APA ensayó **20 tableros**, $e = 11.1\text{mm}$ tomados de los muros después del ensayo.
 - ↳ Flexión EI (Normal y paralelo al eje resistente del tablero).
 - ↳ Módulo de Corte "G".
- APA ensayó **80 tableros** de dos plantas Chilenas, en espesores de 11.1, 15 y 18mm.
 - ↳ Receta: Pino Radiata + Álamo + Maderas Nativas

LA DIFERENCIA ENCONTRADA ES < 1.0% POR DEBAJO RESPECTO A LOS VALORES PROPUESTOS POR NORMATIVA APA.

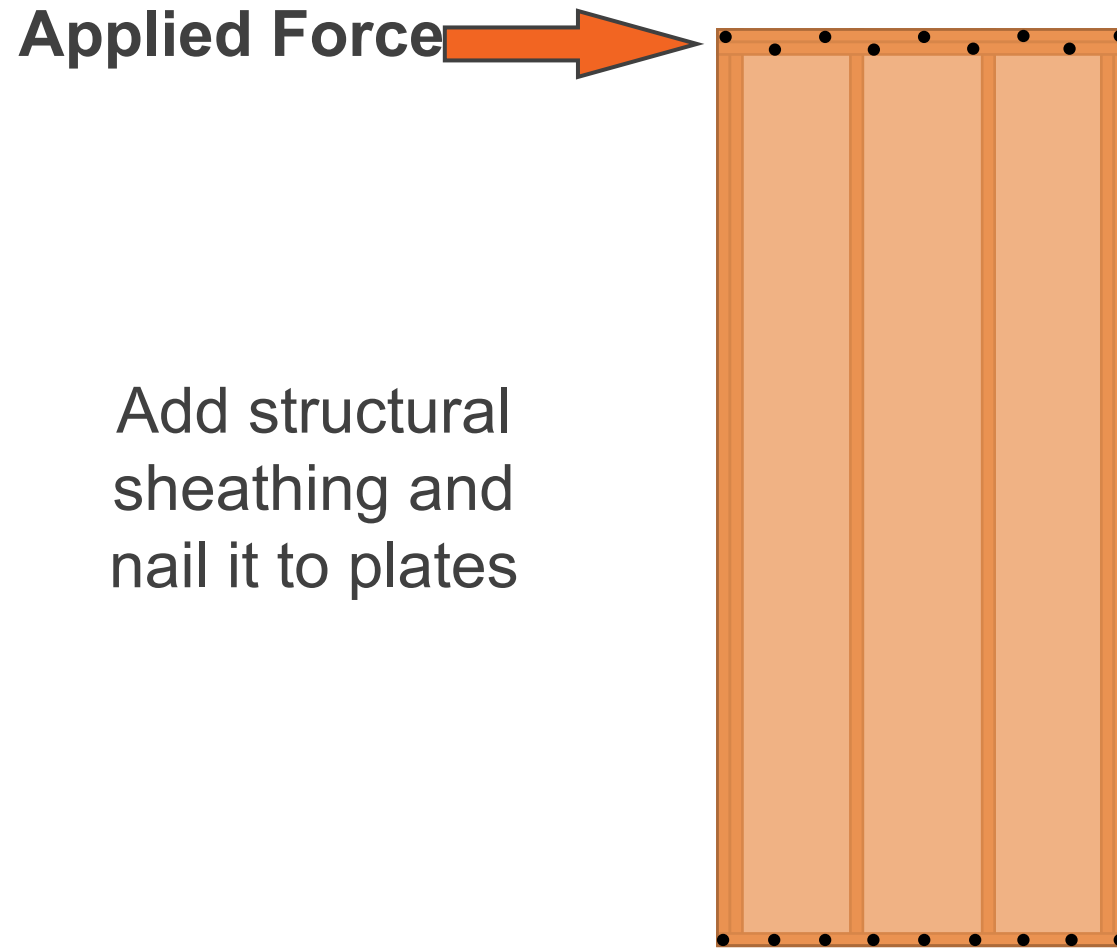
¿Cuál es el aporte práctico al diseño?



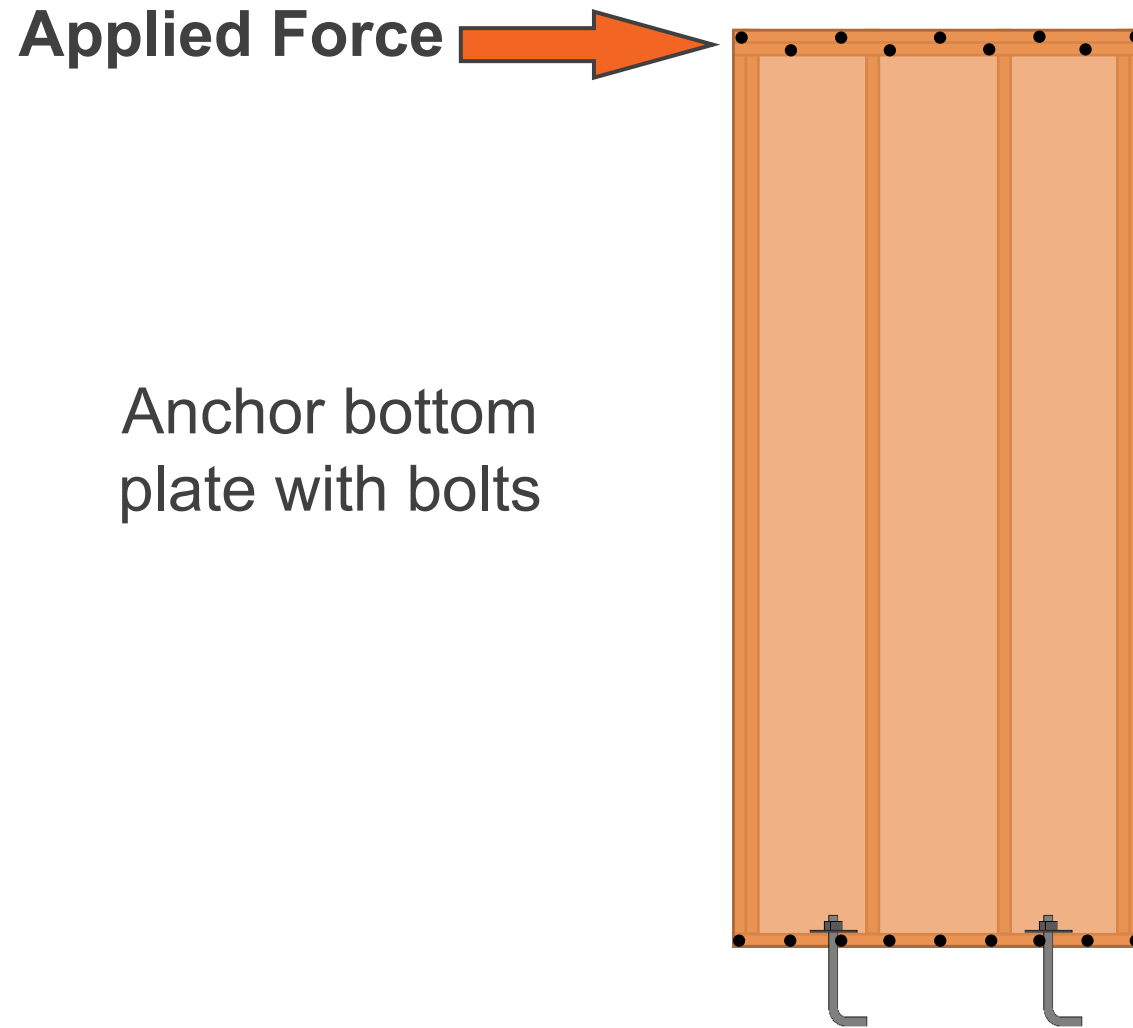
Como se comporta un muro sistema plataforma



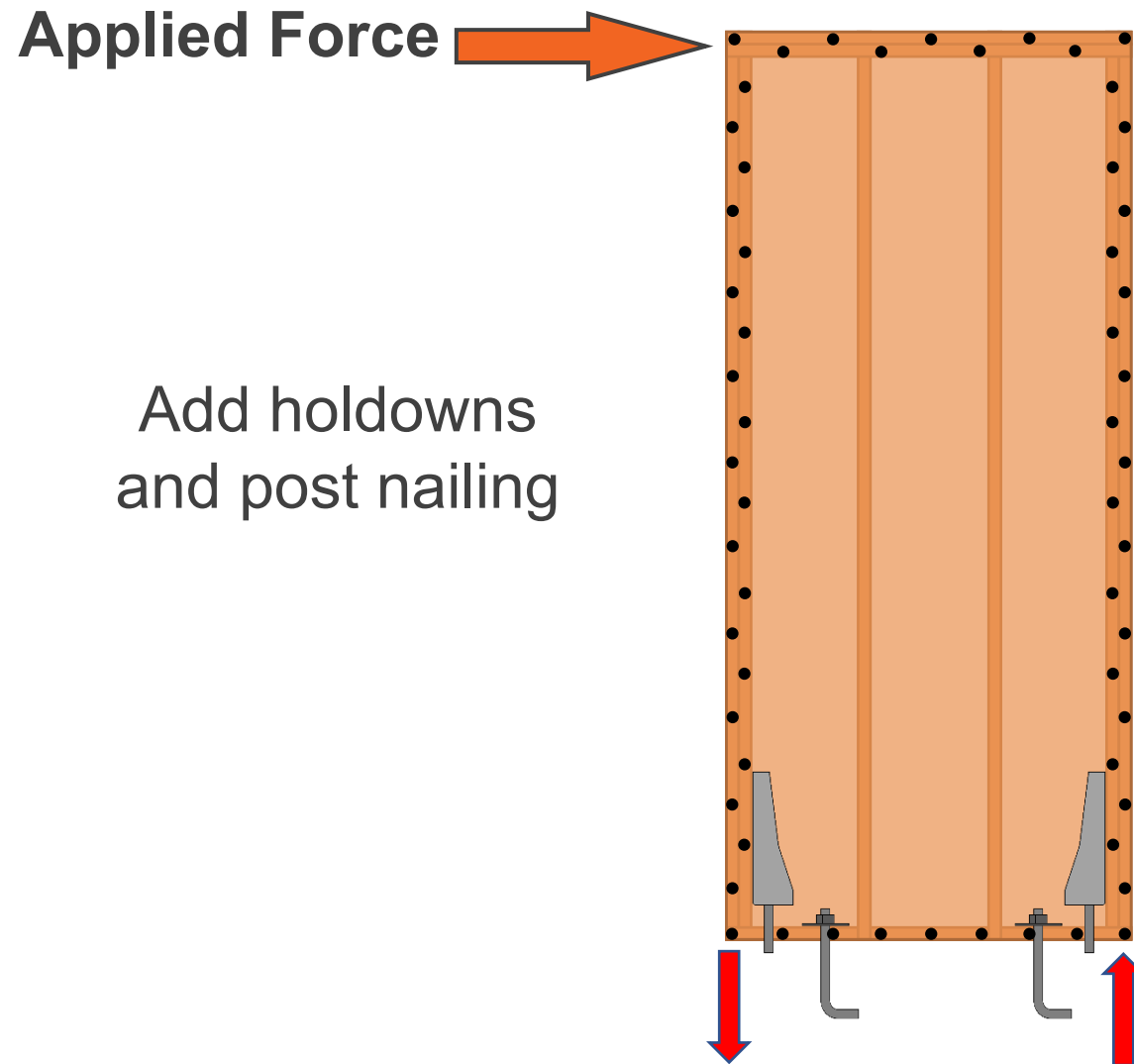
Como se comporta un muro sistema plataforma



Como se comporta un muro sistema plataforma



Como se comporta un muro sistema plataforma



Validación y Enfoque Práctico SDPWS (actualización NCh1198)

Deformación lateral

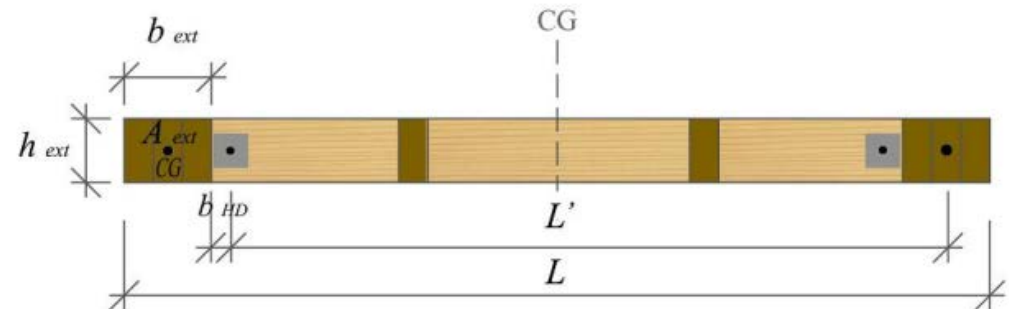
$$\delta_{sw} = \frac{8vh^3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{b} \quad (4.3-1)$$



$$\delta = \left(\frac{2}{3} * \frac{vh^3}{EAb} \right)_{Flexión} + \left(\frac{vh}{G_a} \right)_{Corte} + \left(\frac{h\Delta_a}{b} \right)_{Volcamiento}$$

$$\delta = V \cdot \left(\frac{2}{3} \frac{H^3}{E A_{ext} L^2} \right)_{Flexión} + V \cdot \left(\frac{H}{L \cdot G_a} \right)_{Corte} + T \cdot \left(\frac{H}{L \cdot K_{Anclaje}} \right)_{Volcamiento}$$

- H = altura del muro (cm)
- E = módulo de elasticidad de los pies derecho de borde (kg/cm²)
- A_{ext} = área de la sección transversal de los pies derecho de borde (cm²)
- L = Largo del muro (cm)
- G_a = rigidez de corte (kg/cm)
- K_{anclaje} = Rigidez del anclaje (kg/cm)
- T = Tracción en pies derecho de borde



Validación y Enfoque Práctico SDPWS (actualización NCh1198)

Table 4.3A Nominal Unit Shear Capacities for Wood-Frame Shear Walls^{1,3,6,7}

Wood-based Panels ⁴																			
Sheathing Material	Minimum Nominal Panel Thickness (in.)	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Fastener Type & Size	A SEISMIC										B WIND					
				Panel Edge Fastener Spacing (in.)										Panel Edge Fastener Spacing (in.)					
				6		4		3		2		6	4	3	2				
				v_s (plf)	G_a (kips/in.)	v_s (plf)	G_a (kips/in.)	v_s (plf)	G_a (kips/in.)	v_s (plf)	G_a (kips/in.)	v_w (plf)	v_w (plf)	v_w (plf)	v_w (plf)				
Wood Structural Panels - Structural I ^{4,5}	5/16	1-1/4	Nail (common or galvanized box) 6d	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY								
	3/8 ²			400	13	10	600	18	13	780	23	16	1020	35	22	560	840	1090	1430
	7/16 ²	1-3/8	8d	460	19	14	720	24	17	920	30	20	1220	43	24	645	1010	1290	1710
	15/32			510	16	13	790	21	16	1010	27	19	1340	40	24	715	1105	1415	1875
	15/32	1-1/2	10d	560	14	11	860	18	14	1100	24	17	1460	37	23	785	1205	1540	2045
Wood Structural Panels - Sheathing ^{4,5}	5/16	1-1/4	6d	OSB	PLY	OSB	PLY	OSB	PLY	OSB	PLY								
	3/8			360	13	9.5	540	18	12	700	24	14	900	37	18	505	755	980	1260
	3/8 ²		400	11	8.5	600	15	11	780	20	13	1020	32	17	560	840	1090	1430	
	7/16 ²	1-3/8	8d	440	17	12	640	25	15	820	31	17	1060	45	20	615	895	1150	1485
	15/32			480	15	11	700	22	14	900	28	17	1170	42	21	670	980	1260	1640
15/32	1-1/2	10d	520	13	10	760	19	13	980	25	15	1280	39	20	730	1065	1370	1790	
Plywood Siding	5/16	1-1/4	Nail (galvanized casing) 6d	620	22	14	920	30	17	1200	37	19	1540	52	23	870	1290	1680	2155
	3/8	1-3/8		8d	680	19	13	1020	26	16	1330	33	18	1740	48	22	950	1430	1860
Particleboard Sheathing - (M-S "Exterior Glue" and M-2 "Exterior Glue")	3/8		Nail (common or galvanized box) 6d	280	13		420	16		550	17		720	21		390	590	770	1010
	3/8			8d	320	16		480	18		620	20		820	22		450	670	870
	1/2		10d	240	15		360	17		460	19		600	22		335	505	645	840
	1/2			260	18		380	20		480	21		630	23		365	530	670	880
	5/8			280	18		420	20		540	22		700	24		390	590	755	980
Structural Fiberboard Sheathing	1/2		Nail (galvanized roofing) 11 ga. galv. roofing nail (0.120" x 1-1/2" long x 7/16" head)	370	21		550	23		720	24		920	25		520	770	1010	1300
	25/32			400	21		610	23		790	24		1040	26		560	840	1090	1430
			Nail (galvanized roofing) 11 ga. galv. roofing nail (0.120" x 1-3/4" long x 3/8" head)				340	4.0		460	5.0		520	5.5		470	700	900	1170
							340	4.0		460	5.0		520	5.5		470	700	900	1170



Validación y Enfoque Práctico SDPWS (actualización NCh1198)

Table 4.3 A Nominal Unit Shear Capacities for Wood-Frame Shear Wall							
Wood-based Panels							
Sheathing Material		Minimum nominal panel thickness [cm]	Fastener Type & Size	A SEISMIC			
				Panel Edge Fastener Spacing			
				15 [cm]	10 [cm]	7.5 [cm]	5 [cm]
				vs [tonf/m]	vs [tonf/m]	vs [tonf/m]	vs [tonf/m]
Wood Structural Panels Sheathing	Sh	0.95	8d	0.655	0.952	1.220	1.577
	Sh	1.11	8d	0.714	1.042	1.339	1.741
	Sh	1.19	8d	0.774	1.131	1.458	1.905
	Sh	1.19	10d	0.923	1.369	1.786	2.292
	Sh	1.51	10d	1.012	1.518	1.979	2.589

OSB

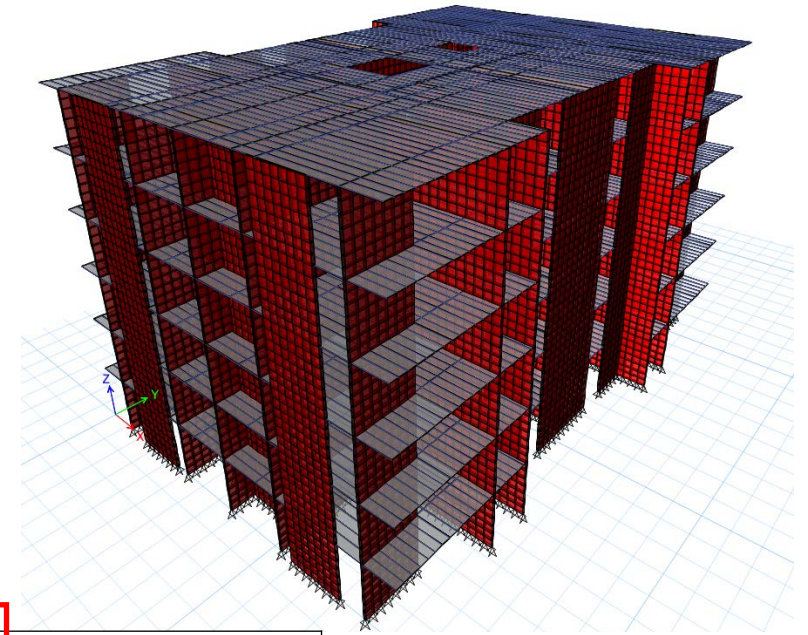
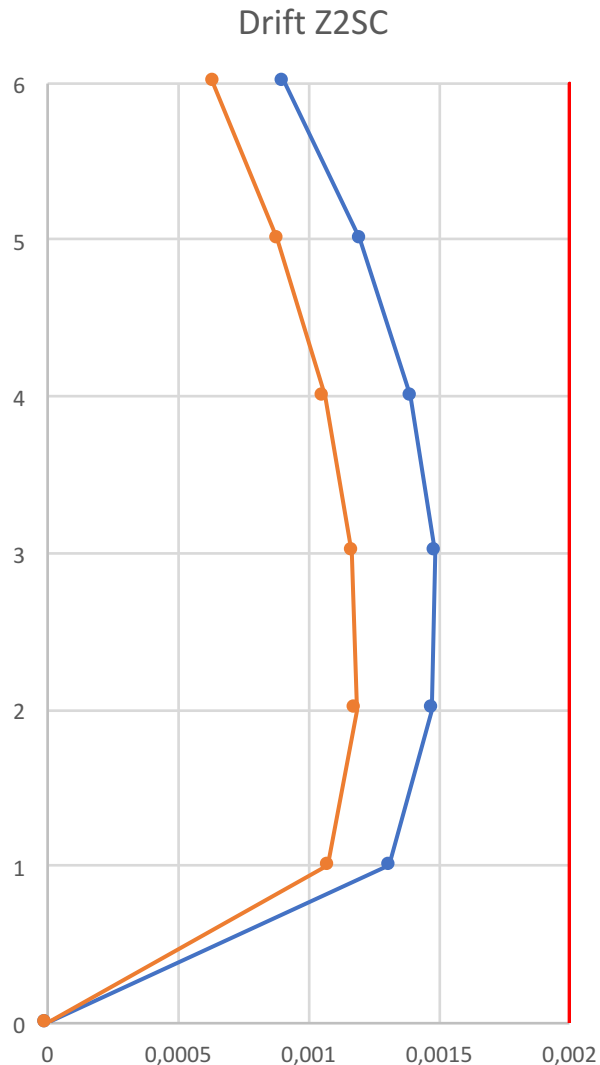
v = Corte unitario admisible
 G_a = Rigidez de corte



Table 4.3 A Nominal Unit Shear Capacities for Wood-Frame Shear Wall							
Wood-based Panels							
Sheathing Material		Minimum nominal panel thickness [cm]	Fastener Type & Size	A SEISMIC			
				Panel Edge Fastener Spacing			
				15 [cm]	10 [cm]	7.5 [cm]	5 [cm]
				G_a [tonf/m]	G_a [tonf/m]	G_a [tonf/m]	G_a [tonf/m]
Wood Structural Panels Sheathing	Sh	0.95	8d	303.585	446.449	553.597	803.608
	Sh	1.11	8d	267.869	392.875	500.023	750.034
	Sh	1.19	8d	232.153	339.301	446.449	696.460
	Sh	1.19	10d	392.875	535.739	660.744	928.614
	Sh	1.51	10d	339.301	464.307	589.312	857.182

Validación y Enfoque Práctico SDPWS (actualización NCh1198)

Ejemplo edificio 6 pisos Z2SC



Método segmentado SDPWS

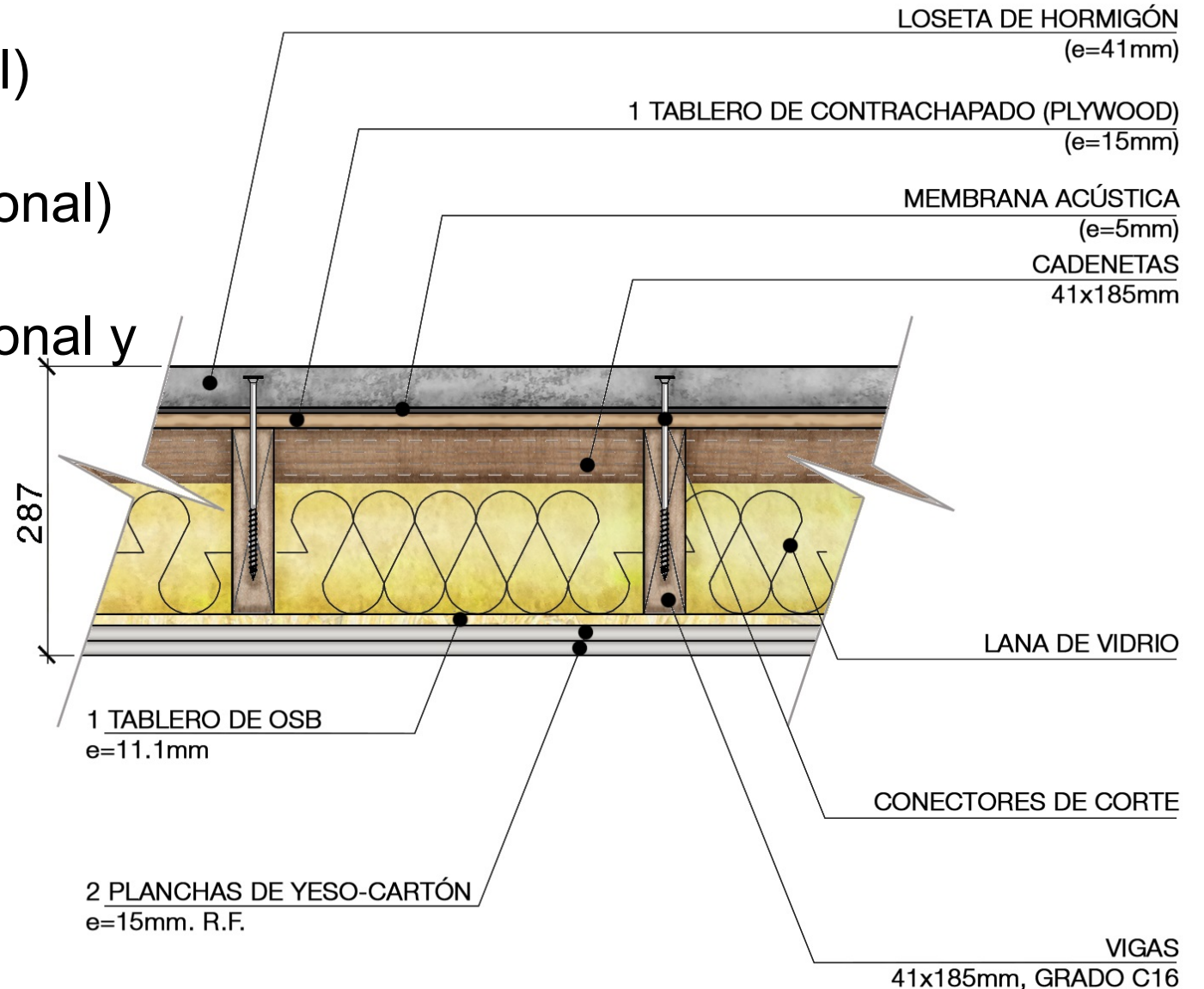
Piso	Acum $\delta_{flexión}$ [cm]	Acum δ_{corte} [cm]	Acum δ_{vol} [cm]
6	1.7%	69.9%	28.4%
5	1.8%	67.2%	30.9%
4	1.8%	64.6%	33.6%
3	1.7%	65.4%	32.9%
2	1.5%	64.0%	34.5%
1	1.5%	60.2%	38.3%

Caso diafragmas de piso enfoque SDPWS

Diseño de vigas (carga gravitacional)

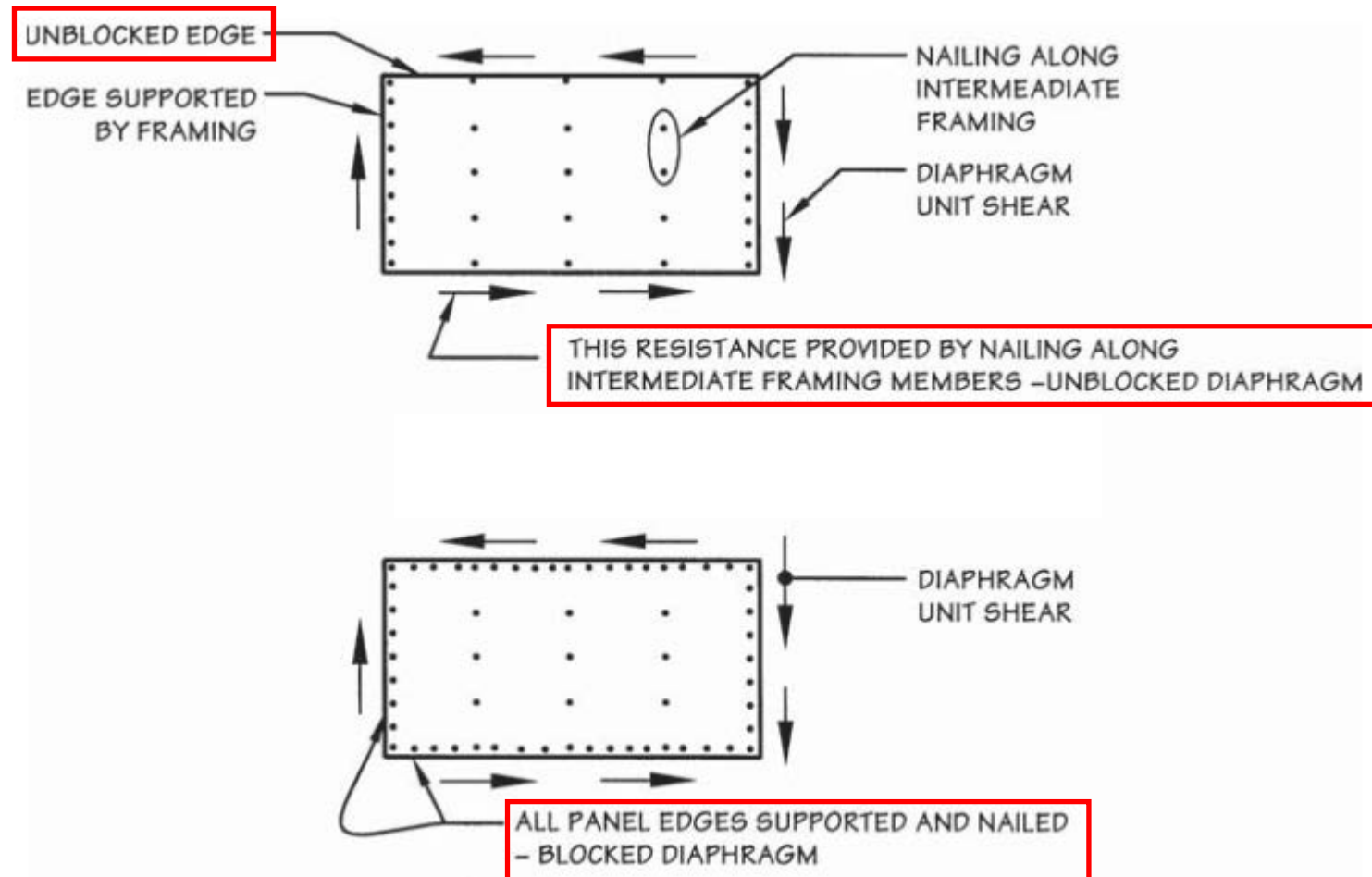
Espesor del tablero (carga gravitacional)

Clavado del tablero (carga gravitacional y carga lateral)



Caso diafragmas de piso enfoque SDPWS

Clavado del tablero (carga gravitacional y carga lateral)

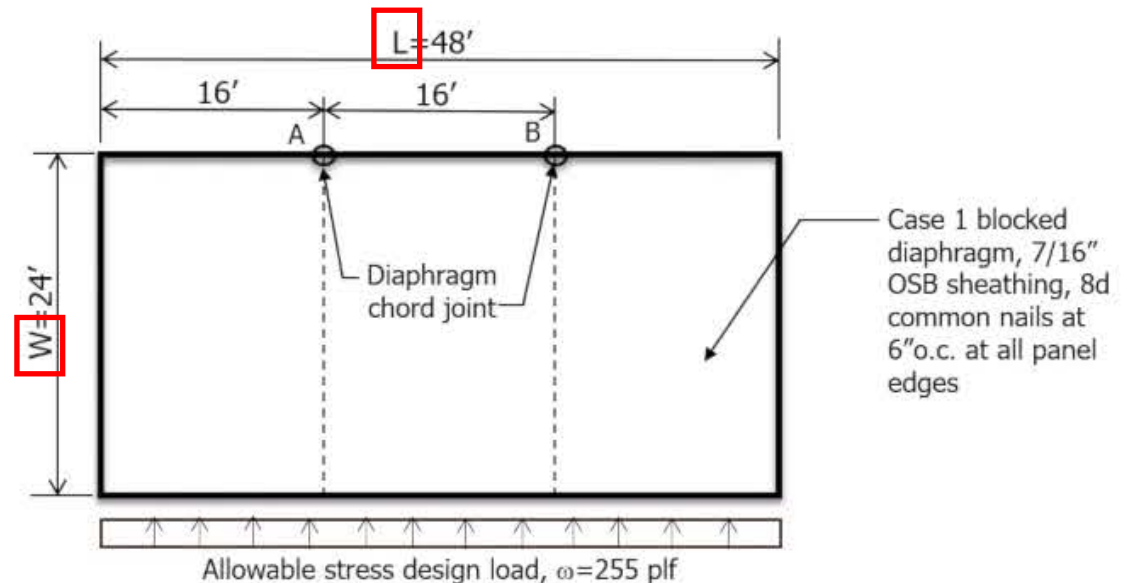


Caso diafragmas de piso enfoque SDPWS

Clavado del tablero (carga lateral)

Table 4.2.4 Maximum Diaphragm Aspect Ratios
(Horizontal or Sloped Diaphragms)

Diaphragm Sheathing Type	Maximum L/W Ratio
Wood structural panel, unblocked	3:1
Wood structural panel, blocked	4:1
Single-layer straight lumber sheathing	2:1
Single-layer diagonal lumber sheathing	3:1
Double-layer diagonal lumber sheathing	4:1



Caso diafragmas de piso enfoque SDPWS

Table 4.2A Nominal Unit Shear Capacities for Wood-Frame Diaphragms

Blocked Wood Structural Panel Diaphragms^{1,2,3,4,5}

OSB y Plywood

v = Corte unitario admisible
Ga = Rigidez de corte

Sheathing Grade	Common Nail Size	Minimum Fastener Penetration in Framing Member or Blocking (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Nailed Face at Adjoining Panel Edges and Boundaries (in.)	A SEISMIC													
					Nail Spacing (in.) at diaphragm boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4), and at all panel edges (Cases 5 & 6)													
					6		4		2-1/2		2							
					Nail Spacing (in.) at other panel edges (Cases 1, 2, 3, & 4)													
6		6		4		3		v _c (plf)		G _a (kips/in.)								
OSB		PLY		OSB		PLY		OSB		PLY								
Structural I	6d	1-1/4	5/16	2	370	15	12	500	8.5	7.5	750	12	10	840	20	15		
				3	420	12	9.5	560	7.0	6.0	840	9.5	8.5	950	17	13		
				2	540	14	11	720	9.0	7.5	1060	13	10	1200	21	15		
	8d	1-3/8	3/8	2	600	12	10	800	7.5	6.5	1200	10	9.0	1350	18	13		
				3	640	24	17	850	15	12	1280	20	15	1460	31	21		
				3	720	20	15	960	12	9.5	1440	16	13	1640	26	18		
Sheathing and Single-Floor	6d	1-1/4	5/16	2	340	15	10	450	9.0	7.0	670	13	9.5	760	21	13		
				3	380	12	9.0	500	7.0	6.0	760	10	8.0	860	17	12		
			3/8	2	3	2	370	13	9.5	500	7.0	6.0	750	10	8.0	840	18	12
						3	420	10	8.0	560	5.5	5.0	840	8.5	7.0	950	14	10
						2	480	15	11	640	9.5	7.5	960	13	9.5	1090	21	13
						3	540	12	9.5	720	7.5	6.0	1080	11	8.5	1220	18	12
	8d	1-3/8	3/8	2	510	14	10	680	8.5	7.0	1010	12	9.5	1150	20	13		
				3	570	11	9.0	760	7.0	6.0	1140	10	8.0	1290	17	12		
			7/16	2	3	2	540	13	9.5	720	7.5	6.5	1060	11	8.5	1200	19	13
						3	600	10	8.5	800	6.0	5.5	1200	9.0	7.5	1350	15	11
						2	580	25	15	770	15	11	1150	21	14	1310	33	18
						3	650	21	14	860	12	9.5	1300	17	12	1470	28	16
15/32	2	3	2	640	21	14	850	13	9.5	1280	18	12	1460	28	17			
			3	720	17	12	960	10	8.0	1440	14	11	1640	24	15			

Caso diafragmas de piso enfoque SDPWS

Table 4.2C Nominal Unit Shear Capacities for Wood-Frame Diaphragms

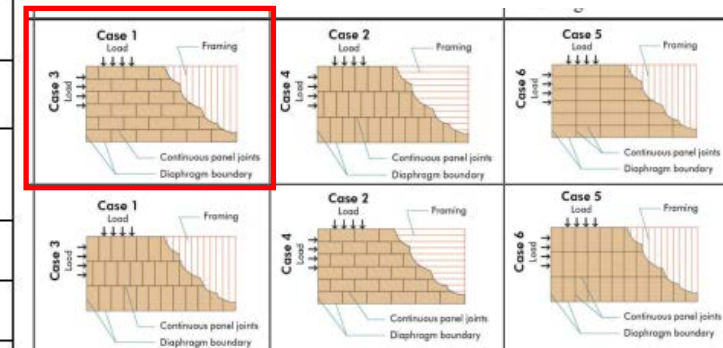
Unblocked Wood Structural Panel Diaphragms^{1,2,3,4,5}

OSB y Plywood

v_s = Corte unitario admisible
 G_a = Rigidez de corte

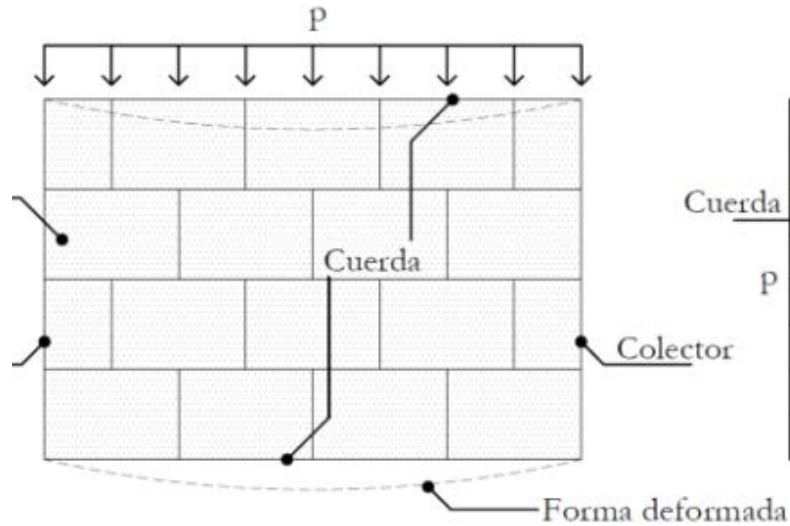
Sheathing Grade	Common Nail Size	Minimum Fastener Penetration in Framing (in.)	Minimum Nominal Panel Thickness (in.)	Minimum Nominal Width of Nailed Face at Supported Edges and Boundaries (in.)
Structural I	6d	1-1/4	5/16	2 3
	8d	1-3/8	3/8	2 3
	10d	1-1/2	15/32	2 3
Sheathing and Single-Floor	6d	1-1/4	5/16	2 3
			3/8	2 3
	8d	1-3/8	3/8	2 3
			7/16	2 3
			15/32	2 3
			15/32	2 3
			19/32	2 3
			10d	1-1/2

A SEISMIC					
6 in. Nail Spacing at diaphragm boundaries and supported panel edges					
Case 1			Cases 2,3,4,5,6		
v_s (plf)	G_a (kips/in.)		v_s (plf)	G_a (kips/in.)	
	OSB	PLY		OSB	PLY
330	9.0	7.0	250	6.0	4.5
370	7.0	6.0	280	4.5	4.0
480	8.5	7.0	360	6.0	4.5
530	7.5	6.0	400	5.0	4.0
570	14	10	430	9.5	7.0
640	12	9.0	480	8.0	6.0
300	9.0	6.5	220	6.0	4.0
340	7.0	5.5	250	5.0	3.5
330	7.5	5.5	250	5.0	4.0
370	6.0	4.5	280	4.0	3.0
430	9.0	6.5	320	6.0	4.5
480	7.5	5.5	360	5.0	3.5
460	8.5	6.0	340	5.5	4.0
510	7.0	5.5	380	4.5	3.5
480	7.5	5.5	360	5.0	4.0
530	6.5	5.0	400	4.0	3.5
510	15	9.0	380	10	6.0
580	12	8.0	430	8.0	5.5
570	13	8.5	430	8.5	5.5
640	10	7.5	480	7.0	5.0

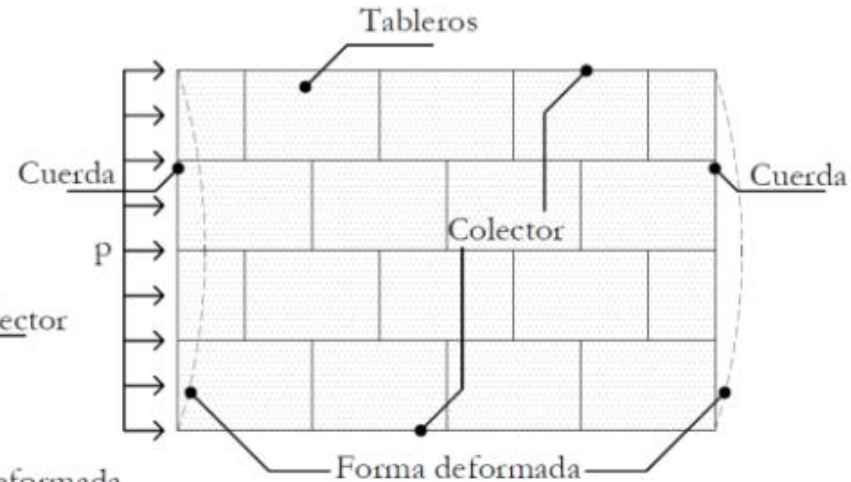


Caso diafragmas de piso enfoque SDPWS

Fuerza transversal



Fuerza longitudinal



En Chile los diafragmas deben ser rígidos para cumplir con las exigencias normativas de deformación lateral (NCh433)

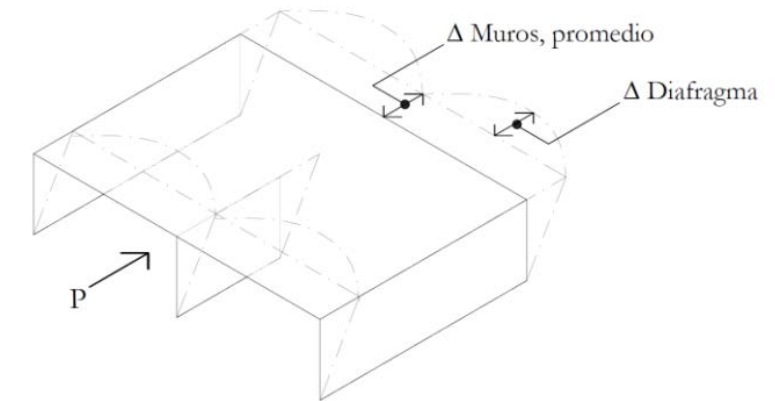
Deformación Flexión cuerdas

Deformación Rigidez de corte placa y clavos

Deformación deslizamiento empalmes cuerdas

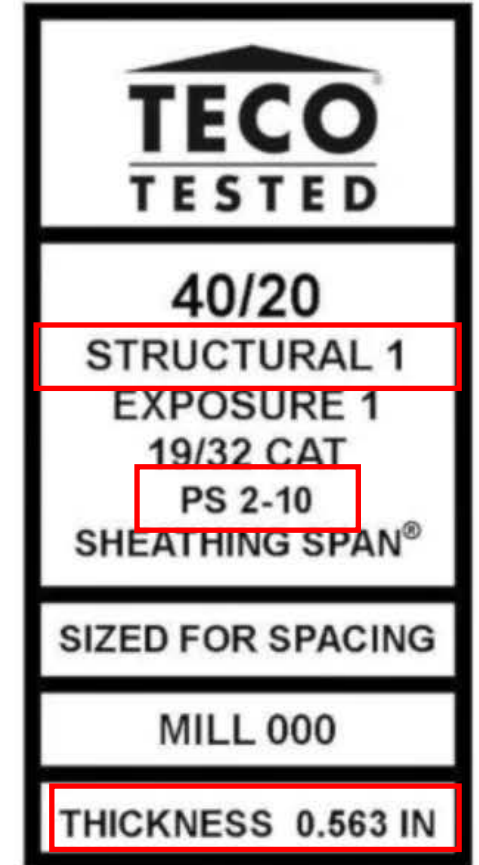
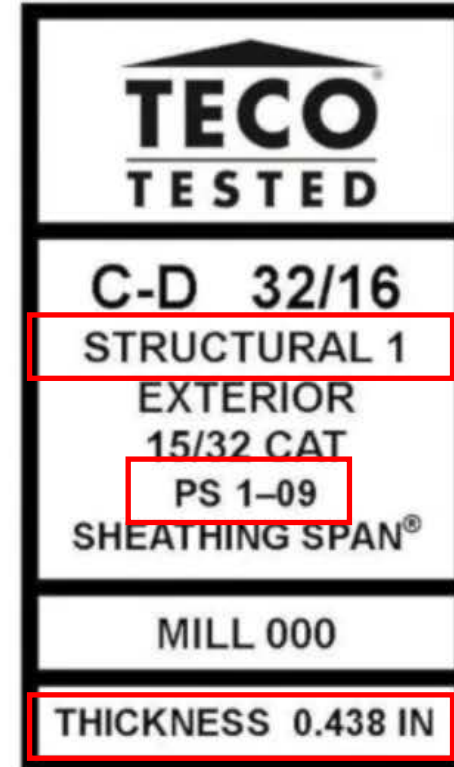
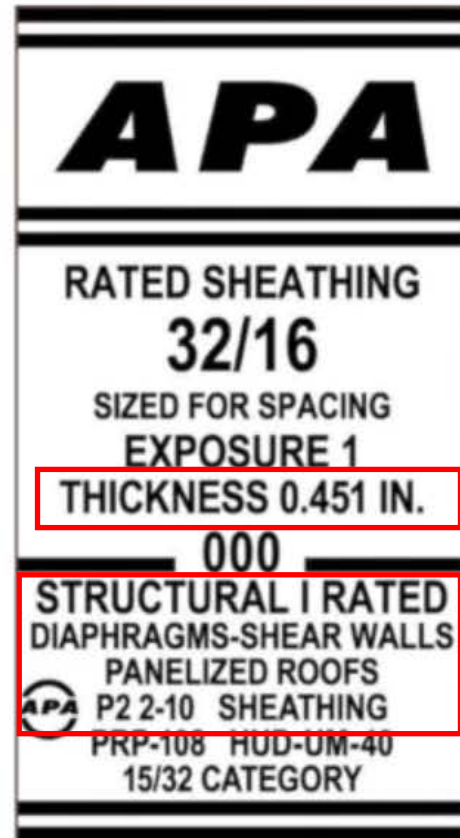
$$\delta_{dia} = \frac{5vL^3}{8EAW} + \frac{0.25vL}{1000G_a} + \frac{\sum(x\Delta_c)}{2W} \quad (4.2-1)$$

$$\delta_{dia} \geq 2 \cdot \delta_{mur}$$



Tableros estructurales OSB y Plywood

Ejemplos de marcado de tableros con grados estructurales y espesores



Source: APA – The Engineered Wood Association

Source: PFS TECO

Normativa tableros estructurales

Plywood PS 1-09 Structural Plywood

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Effective Date May 1, 2010

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NCh3617

Oriented strand board OSB

PS 2-10 Performance Standard for Wood-Based Structural-Use Panels

Effective Date June 1, 2011

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NCh3618

Resumen de la nueva normativa Chilena de tableros estructurales

Campo de aplicación:

- Capítulo de diseño de muros de corte con enfoque práctico. SDPWS y modificación norma NCh1198.
- Capítulo de diseño de diafragmas de piso con carga gravitacional y carga lateral. Enfoque práctico con SDPWS y anexo normativo modificación NCh1198.
- Proporciona información al consumidor y al diseñador