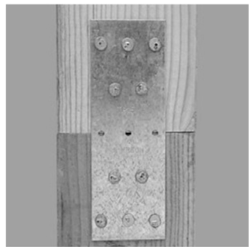
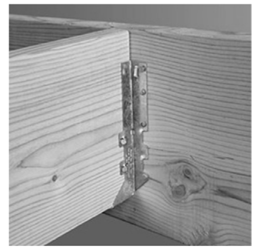
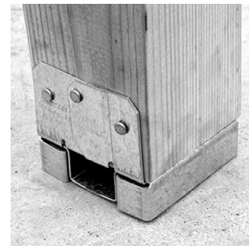
Mechanical Connections





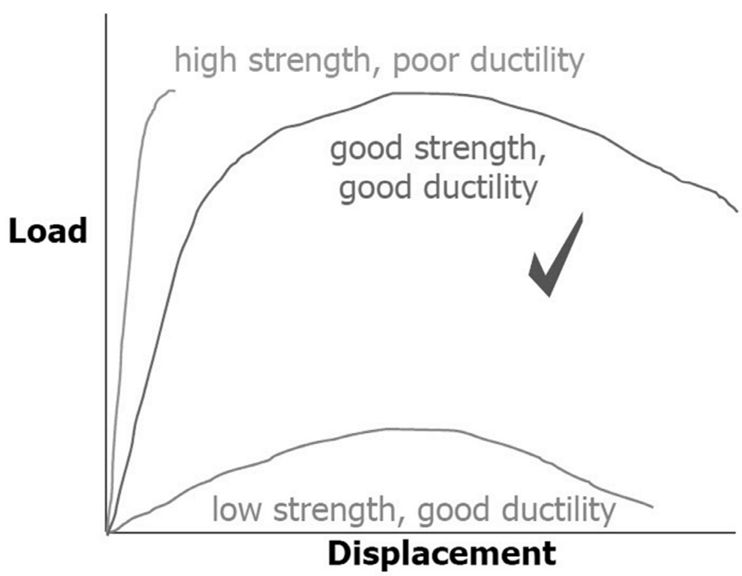


Connection Behavior

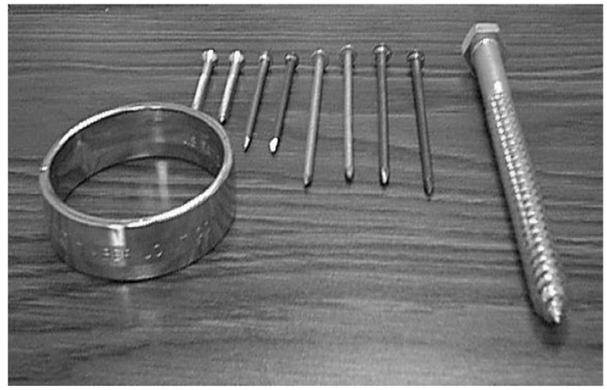
Strength
- transmits load

Ductility
- gives warning
- absorbs energy

Design
- size
- number
- slenderness of fastener
- spacing
- end distance



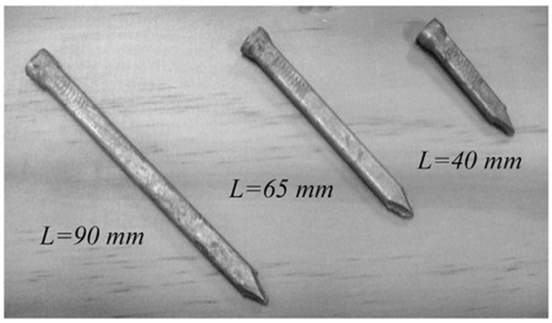
Connection Behavior



Nails
- low strength
- high ductility

Bolts
- high strength
- low ductility

Performance = strength + ductility



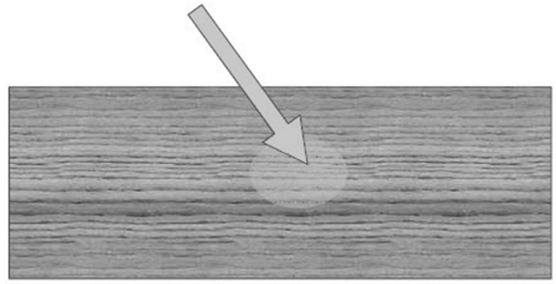
Connection Behavior

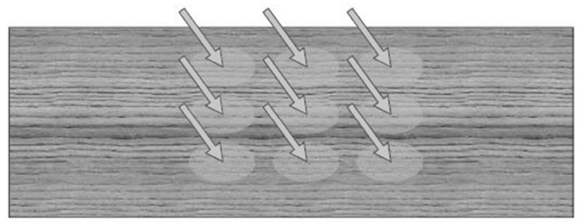
Wood Strength
- high parallel to grain
- low across the grain

End support is good

Connection Behavior

Spread the load on wood
- one large fastener – bad
- several small fasteners - good

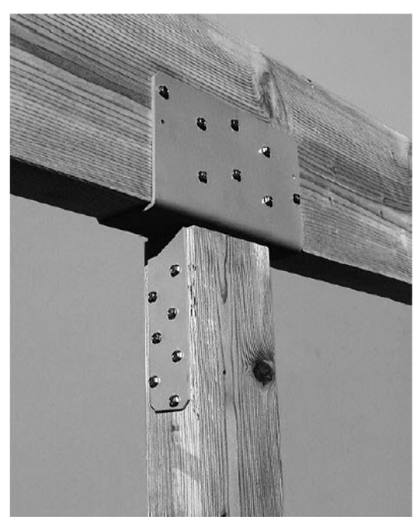




Connection Behavior

Single connector
- concentrates load
- splits wood or crush
- no redundancy

Multi-connectors
- spreads load
- less splitting
- more redundancy



Connection Behavior

Connectors that spread load

Hanger hardware

Connection Behavior

Truss gusset plate connectors

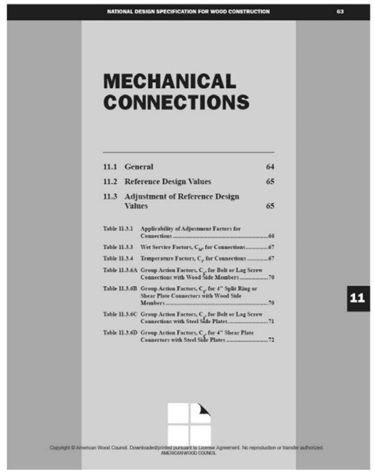
NDS 2018

Chapter 11
(general overview)

Chapter 12
(nails, screws, bolts, and pins)

Chapter 13
(split ring & shear plate)

Chapter 14
(timber rivets)



MECHANICAL CONNECTIONS

11

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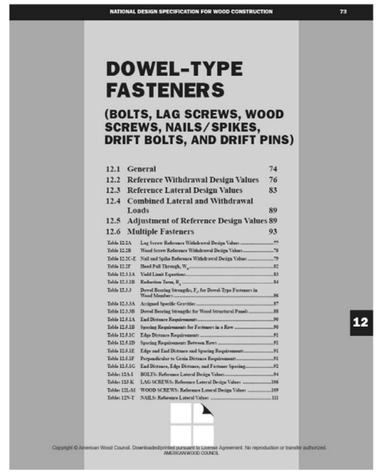

DOWEL-TYPE FASTENERS

(BOLTS, LAG SCREWS, WOOD SCREWS, NAILS/SPIKES, DRIFT BOLTS, AND DRIFT PINS)

12

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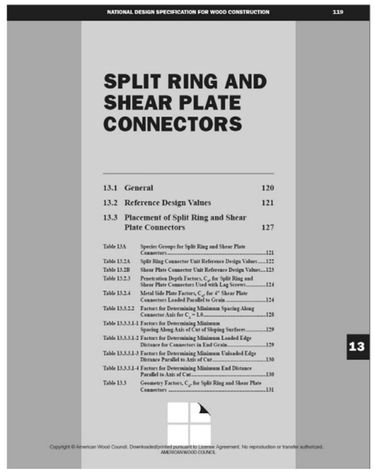

SPLIT RING AND SHEAR PLATE CONNECTORS

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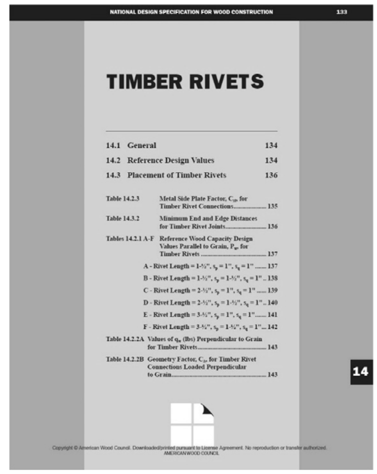

TIMBER RIVETS

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service factors

Table 11.3.1 Applicability of Adjustment Factors for Connections

		ASD Only	ASD and LRFD									LRFD Only		
		Load Duration Factor[1]	Wet Service Factor	Temperature Factor	Group Action Factor	Geometry Factor[3]	Penetration Depth Factor[3]	End Grain Factor[3]	Metal Side Plate Factor[3]	Diaphragm Factor[3]	Toe-Nail Factor[3]	Format Conversion Factor K_F	Resistance Factor ϕ	Time Effect Factor
Lateral Loads														
Dowel-type Fasteners (e.g. bolts, lag screws, wood screws, nails, spikes, drift bolts, & drift pins)	$Z' = Z$ x	C_D	C_M	C_t	C_g	C_Δ	-	C_{eg}	-	C_{di}	C_{tn}	3.32	0.65	λ
Split Ring and Shear Plate Connectors	$P' = P$ x	C_D	C_M	C_t	C_g	C_Δ	C_d	-	C_{st}	-	-	3.32	0.65	λ
	$Q' = Q$ x	C_D	C_M	C_t	C_g	C_Δ	C_d	-	-	-	-	3.32	0.65	λ
Timber Rivets	$P' = P$ x	C_D	C_M	C_t	-	-	-	-	C_{st}[4]	-	-	3.32	0.65	λ
	$Q' = Q$ x	C_D	C_M	C_t	-	C_Δ[5]	-	-	C_{st}[4]	-	-	3.32	0.65	λ
Spike Grids	$Z' = Z$ x	C_D	C_M	C_t	-	C_Δ	-	-	-	-	-	3.32	0.65	λ
Withdrawal Loads														
Nails, spikes, lag screws, wood screws, & drift pins	$W' = W$ x	C_D	C_M[2]	C_t	-	-	-	C_{eg}	-	-	C_{tn}	3.32	0.65	λ
Pull-Through														
Fasteners with Round Heads	$W_H' = W_H$ x	C_D	C_M	C_t	-	-	-	-	-	-	-	3.32	0.65	λ

1. The load duration factor, C_D, shall not exceed 1.6 for connections (see 11.3.2).
2. The wet service factor, C_M, shall not apply to toe-nails loaded in withdrawal (see 12.5.4.1).
3. Specific information concerning geometry factors C_Δ, penetration depth factors C_d, end grain factors, C_{eg}, metal side plate factors, C_{st}, diaphragm factors, C_{di}, and toe-nail factors, C_{tn}, is provided in Chapters 12, 13, and 14.
4. The metal side plate factor, C_{st}, is only applied when rivet capacity (P_r, Q_r) controls (see Chapter 14).
5. The geometry factor, C_Δ, is only applied when wood capacity, Q_w, controls (see Chapter 14).

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service factors

- C_D
- C_t

11.3.4 Temperature Factor, C_t

Reference design values shall be multiplied by the temperature factors, C_t, in Table 11.3.4 for connections that will experience sustained exposure to elevated temperatures up to 150°F (see Appendix C).

11.3.2 Load Duration Factor, C_D (ASD Only)

Reference design values shall be multiplied by the load duration factors, $C_D \leq 1.6$, specified in 2.3.2 and Appendix B, except when the capacity of the connection is controlled by metal strength or strength of concrete/masonry (see 11.2.3, 11.2.4, and Appendix B.3). The impact load duration factor shall not apply to connections.

Table 11.3.4 Temperature Factors, C_t, for Connections

In-Service Moisture Conditions[1]	C_t		
	T≤100°F	100°F<T≤125°F	125°F<T≤150°F
Dry	1.0	0.8	0.7
Wet	1.0	0.7	0.5

1. Wet and dry service conditions for connections are specified in 11.3.3.

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service factors

- C_M

Table 11.3.3 Wet Service Factors, C_M, for Connections

Fastener Type	Moisture Content: At Time of Fabrication	Moisture Content: In-Service	C_M
Lateral Loads			
Split Ring and Shear Plate Connectors[1]	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.8
	any	> 19%	0.7
Dowel-type Fasteners (e.g. bolts, lag screws, wood screws, nails, spikes, drift bolts, & drift pins)	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.4[2]
	any	> 19%	0.7
Timber Rivets	≤ 19%	≤ 19%	1.0
	≤ 19%	> 19%	0.8
Withdrawal Loads			
Lag Screws & Wood Screws	any	≤ 19%	1.0
	any	> 19%	0.7
Nails & Spikes[3]	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.25[3]
	≤ 19%	> 19%	0.25[3]
	> 19%	> 19%	1.0
Pull-Through Loads			
Fasteners with Round Heads	any	≤ 19%	1.0
	any	> 19%	0.7

1. For split ring or shear plate connectors, moisture content limitations apply to a depth of 3/4" below the surface of the wood.
2. C_M = 0.7 for dowel-type fasteners with diameter, D, less than 1/4".
   C_M = 1.0 for dowel-type fastener connections with:
   1) one fastener only, or
   2) two or more fasteners placed in a single row parallel to grain, or
   3) fasteners placed in two or more rows parallel to grain with separate splice plates for each row.
3. For Roof Sheathing Ring Shank (RSRS) and Post-Frame Ring Shank (PF) nails, C_M=1.0.

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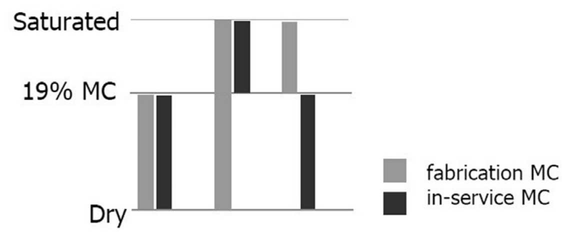
WET SERVICE FACTOR, C_M

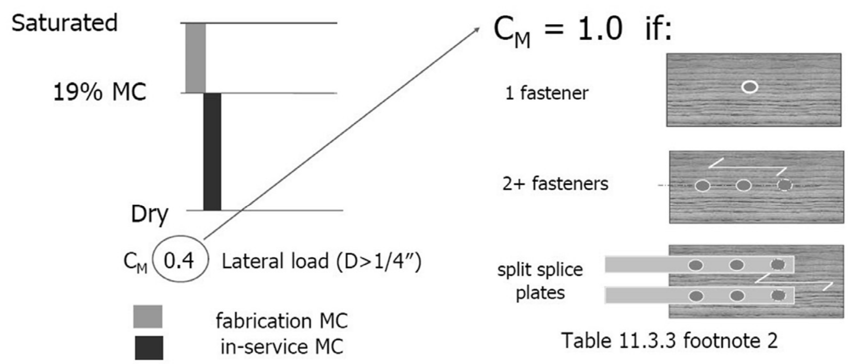
service factors

- C_M
- Dowel type connectors



- Dowel-type connectors
  - bolts
  - drift pins
  - drift bolts
  - lag screws
  - wood screws
  - nails

C_M				
	1.0	0.7	0.4*	Lateral load (*C_M=0.7 for D<1/4")
	1.0	0.7	1.0	Withdrawal load - lag & wood screws only
	1.0	0.25	0.25	Withdrawal load - nails & spikes



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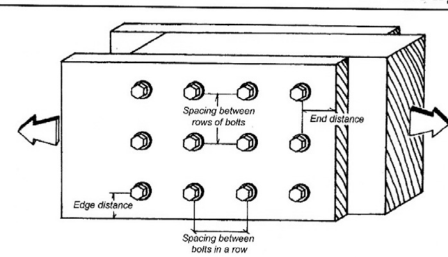
For dowel type fasteners:
service factors

- C_g (chap 11) Group Action Factor
- C∆ (chap 12) Geometry Factor
- Ceg (chap 12) End Grain Factor
- Cdi (chap 12) Diaphragm Factor
- Ctn (chap 12) Toe-Nail Factor

Figure 12G Bolted Connection Geometry



Parallel to grain loading in all wood members ($Z_{\parallel}$)

11.3.6 Group Action Factors, C_g

11.3.6.1 Reference lateral design values for split ring connectors, shear plate connectors, or dowel-type fasteners with D ≤ 1" in a row shall be multiplied by the following group action factor, C_g:

$$C_g = \left[\frac{m(1-m^{2n})}{n\left[\left(1+R_{EA}m^n\right)(1+m)-1+m^{2n}\right]} \right] \left[\frac{1+R_{EA}}{1-m} \right] \qquad (11.3\text{-}1)$$

Cg = 1 for dowel type fasteners with D < ¼"

Table 12.5.1A End Distance Requirements

Direction of Loading	End Distances: Minimum end distance for $C_\Delta = 0.5$	Minimum end distance for $C_\Delta = 1.0$
Perpendicular to Grain	2D	4D
Parallel to Grain, Compression: (fastener bearing away from member end)	2D	4D
Parallel to Grain, Tension: (fastener bearing toward member end)		
for softwoods	3.5D	7D
for hardwoods	2.5D	5D

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Withdrawal Strength:

- Table 12.2A Lag Screws
- Table 12.2B Threaded Wood Screws
- Table 12.2C Smooth Nails
- Table 12.2D Smooth Stainless Nails
- Table 12.2E Ring Shank Nails
- Table 12.2F Head Pull-Through

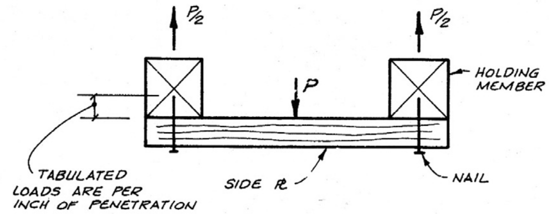

Figure 12.19a Basic withdrawal connection.

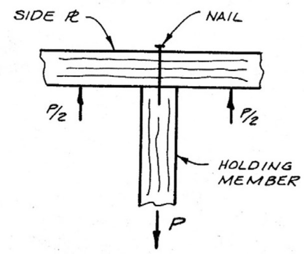

Figure 12.19b Withdrawal from end grain—not allowed.

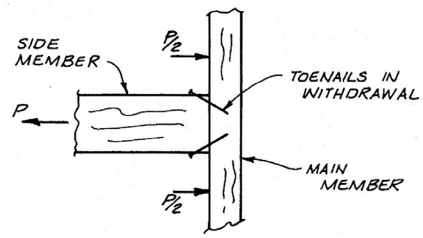

Figure 12.19c Toenail connection withdrawal from side grain.

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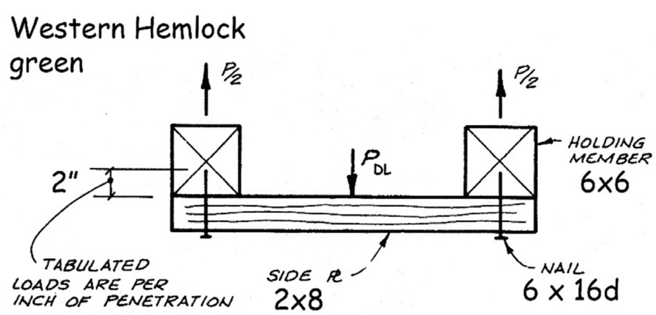
Withdrawal Strength Example



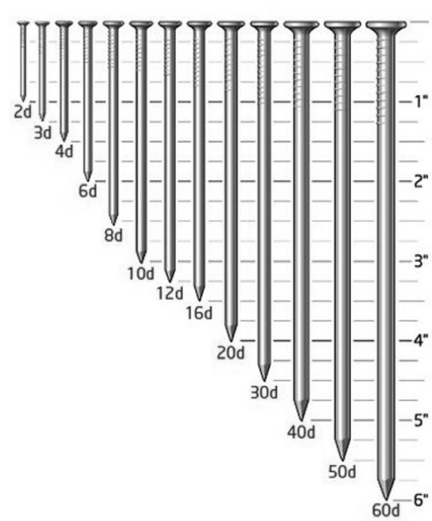
Find the allowable DL capacity
(fabricated green – used dry)

For 16d box nails (NDS Appendix L4)
D = 0.135”
L = 3.5”
penetration = 3.5 – 1.5 = 2”

G = 0.47 (NDS Table 12.3.3A)

Withdrawal, w = 28 LB/IN (Table 12.2C)
penetration, p = 2”
W = p x w = 2 x 28 = 56 LBS/nail
W’ = W (C_D C_M C_t C_{tn})
= 56(0.9 0.25 1.0 1.0) = 12.6 LBS/nail

Pmax = n W’ = 12 x 12.6 = 151 LBS



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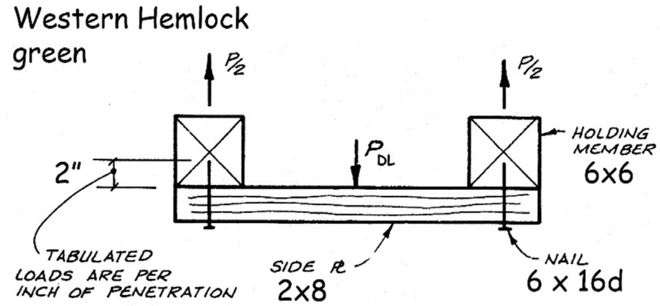
Withdrawal Strength Example

For 16d box nails (NDS Appendix L4)

D = 0.135”

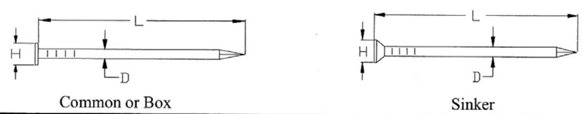
L = 3.5”

penetration = 3.5 – 1.5 = 2”



G = 0.47 (NDS Table 12.3.3A)

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



D = diameter, in.
L = length, in.
H = head diameter, in.

Type		Pennyweight										
		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	0.234	0.250	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 assume the length of the tapered tip is 2D.

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Withdrawal Strength Example

For 16d box nails (NDS Appendix L4)

D = 0.135”

L = 3.5”

G = 0.47 (NDS Table 12.3.3A)

Withdrawal, w = 28 LB/IN (Table 12.2C)

Table 12.2C Smooth Shank (Bright or Galvanized) Carbon Steel Nail and Spike Reference Withdrawal Design Values, W[1,3]

Tabulated withdrawal design values, W, are in pounds per inch of fastener penetration into side grain of wood member (see 12.2.3.1)

Specific Gravity[2], G	Smooth Shank (Bright or Galvanized) Carbon Steel Nail and Spike Diameter, D																	
	0.092"	0.099"	0.113"	0.120"	0.128"	0.131"	0.135"	0.148"	0.162"	0.177"	0.192"	0.207"	0.225"	0.244"	0.263"	0.283"	0.312"	0.375"
0.73	58	62	71	75	80	82	85	93	102	111	121	130	141	153	165	178	196	236
0.71	54	58	66	70	75	77	79	87	95	104	113	121	132	143	154	166	183	220
0.68	48	52	59	63	67	69	71	78	85	93	101	109	118	128	138	149	164	197
0.67	47	50	57	61	65	66	68	75	82	90	97	105	114	124	133	144	158	190
0.58	33	35	40	42	45	46	48	52	57	63	68	73	80	86	93	100	110	133
0.55	28	31	35	37	40	41	42	46	50	55	59	64	70	76	81	88	97	116
0.51	24	25	29	31	33	34	35	38	42	45	49	53	58	63	67	73	80	96
0.50	22	24	28	29	31	32	33	36	40	43	47	50	55	60	64	69	76	91
0.49	21	23	26	28	30	30	31	34	38	41	45	48	52	57	61	66	72	87
0.47	19	21	24	25	27	27	28	31	34	37	40	43	47	51	55	59	65	78
0.46	18	20	22	24	25	26	27	29	32	35	38	41	45	48	52	56	62	74
0.44	16	18	20	21	23	23	24	26	29	31	34	37	40	43	47	50	55	66
0.43	15	17	19	20	21	22	23	25	27	30	32	35	38	41	44	47	52	63
0.42	15	16	18	19	20	21	21	23	26	28	30	33	35	38	41	45	49	59
0.41	14	15	17	18	19	19	20	22	24	26	29	31	33	36	39	42	46	56
0.40	13	14	16	17	18	18	19	21	23	25	27	29	31	34	37	40	44	52
0.39	12	13	15	16	17	17	18	19	21	23	25	27	29	32	34	37	41	49
0.38	11	12	14	15	16	16	17	18	20	22	24	25	28	30	32	35	38	46
0.37	11	11	13	14	15	15	16	17	19	20	22	24	26	28	30	33	36	43
0.36	10	11	12	13	14	14	14	16	17	19	21	22	24	26	28	30	33	40
0.35	9	10	11	12	13	13	14	15	16	18	19	21	23	24	26	28	31	38
0.31	7	7	8	9	9	10	10	11	12	13	14	15	17	18	19	21	23	28

1. Tabulated withdrawal design values, W, for nail or spike connections shall be multiplied by all applicable adjustment factors (see Table 11.3.1).
2. Specific gravity shall be determined in accordance with Table 12.3.3A.
3. Tabulated withdrawal design values for smooth shank nails are permitted to be used for deformed shank nails of equivalent diameter, D.

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Withdrawal Strength Example

Withdrawal, w = 28 LB/IN (Table 12.2C)
penetration, p = 2”
W = p x w = 2 x 28 = 56 LBS/nail
W’ = W (C_D C_M C_t C_{tn})
    = 56(0.9 0.25 1.0 1.0) = 12.6 LBS/nail

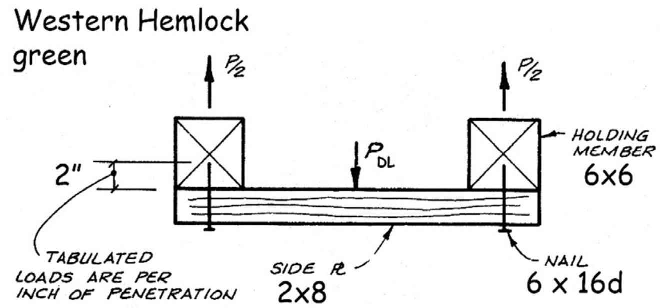

Table 11.3.1 Applicability of Adjustment Factors for Connections

		ASD Only	ASD and LRFD									LRFD Only		
		Load Duration Factor[1]	Wet Service Factor	Temperature Factor	Group Action Factor	Geometry Factor[3]	Penetration Depth Factor[3]	End Grain Factor[3]	Metal Side Plate Factor[3]	Diaphragm Factor[3]	Toe-Nail Factor[3]	Format Conversion Factor K_F	Resistance Factor ϕ	Time Effect Factor
Lateral Loads														
Dowel-type Fasteners (e.g. bolts, lag screws, wood screws, nails, spikes, drift bolts, & drift pins)	$Z' = Z$ x	C_D	C_M	C_t	C_g	C_Δ	-	C_{eg}	-	C_{di}	C_{tn}	3.32	0.65	λ
Split Ring and Shear Plate Connectors	$P' = P$ x	C_D	C_M	C_t	C_g	C_Δ	C_d	-	C_{st}	-	-	3.32	0.65	λ
	$Q' = Q$ x	C_D	C_M	C_t	C_g	C_Δ	C_d	-	-	-	-	3.32	0.65	λ
Timber Rivets	$P' = P$ x	C_D	C_M	C_t	-	-	-	-	C_{st}[4]	-	-	3.32	0.65	λ
	$Q' = Q$ x	C_D	C_M	C_t	-	C_Δ[5]	-	-	C_{st}[4]	-	-	3.32	0.65	λ
Spike Grids	$Z' = Z$ x	C_D	C_M	C_t	-	C_Δ	-	-	-	-	-	3.32	0.65	λ
Withdrawal Loads														
Nails, spikes, lag screws, wood screws, & drift pins	$W' = W$ x	C_D	C_M[2]	C_t	-	-	-	C_{eg}	-	-	C_{tn}	3.32	0.65	λ
Pull-Through														
Fasteners with Round Heads	$W'_H = W_H$ x	C_D	C_M	C_t	-	-	-	-	-	-	-	3.32	0.65	λ

1. The load duration factor, C_D, shall not exceed 1.6 for connections (see 11.3.2).
2. The wet service factor, C_M, shall not apply to toe-nails loaded in withdrawal (see 12.5.4.1).
3. Specific information concerning geometry factors C_Δ, penetration depth factors C_d, end grain factors, C_{eg}, metal side plate factors, C_{st}, diaphragm factors, C_{di}, and toe-nail factors, C_{tn}, is provided in Chapters 12, 13, and 14.
4. The metal side plate factor, C_{st}, is only applied when rivet capacity (P_r, Q_r) controls (see Chapter 14).
5. The geometry factor, C_Δ, is only applied when wood capacity, Q_w, controls (see Chapter 14).

NDS 2018 - Chapter 12

Withdrawal Strength Example

Find the allowable DL capacity
(fabricated green – used dry)

For 16d box nails (NDS Appendix L4)
D = 0.135”
L = 3.5”
penetration = 3.5 – 1.5 = 2”

G = 0.47 (NDS Table 12.3.3A)

Withdrawal, w = 28 LB/IN (Table 12.2C)
penetration, p = 2”
W = p x w = 2 x 28 = 56 LBS/nail
W’ = W (C_D C_M C_t C_{tn})
    = 56(0.9 0.25 1.0 1.0) = 12.6 LBS/nail

Pmax = n W’ = 12 x 12.6 = 151 LBS

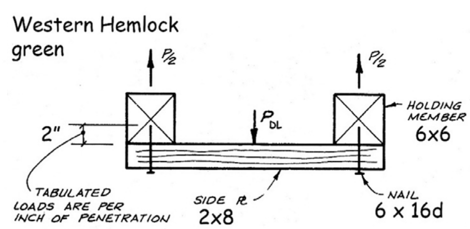

Table 11.3.3 Wet Service Factors, C_M, for Connections

Fastener Type	Moisture Content: At Time of Fabrication	Moisture Content: In-Service	C_M
Lateral Loads			
Split Ring and Shear Plate Connectors[1]	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.8
	any	> 19%	0.7
Dowel-type Fasteners (e.g. bolts, lag screws, wood screws, nails, spikes, drift bolts, & drift pins)	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.4[2]
	any	> 19%	0.7
Timber Rivets	≤ 19%	≤ 19%	1.0
	≤ 19%	> 19%	0.8
Withdrawal Loads			
Lag Screws & Wood Screws	any	≤ 19%	1.0
	any	> 19%	0.7
Nails & Spikes[3]	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.25[3]
	≤ 19%	> 19%	0.25[3]
	> 19%	> 19%	1.0
Pull-Through Loads			
Fasteners with Round Heads	any	≤ 19%	1.0
	any	> 19%	0.7

1. For split ring or shear plate connectors, moisture content limitations apply to a depth of 3/4" below the surface of the wood.
2. C_M = 0.7 for dowel-type fasteners with diameter, D, less than 1/4".
   C_M = 1.0 for dowel-type fastener connections with:
   1) one fastener only, or
   2) two or more fasteners placed in a single row parallel to grain, or
   3) fasteners placed in two or more rows parallel to grain with separate splice plates for each row.
3. For Roof Sheathing Ring Shank (RSRS) and Post-Frame Ring Shank (PF) nails, C_M=1.0.

NDS 2018 Appendix E

Axial Load Connection

three limit states

- E.2 net tension
- E.3 row tear-out
- E.4 group tear-out

closely spaced fasteners in group tear-out

Appendix E (Non-mandatory) Local Stresses in Fastener Groups

E.1 General

Where a fastener group is composed of closely spaced fasteners loaded parallel to grain, the capacity of the fastener group may be limited by wood failure at the net section or tear-out around the fasteners caused by local stresses. One method to evaluate member strength for local stresses around fastener groups is outlined in the following procedures.

E.1.1 Reference design values for timber rivet connections in Chapter 14 account for local stress effects and do not require further modification by procedures outlined in this Appendix.

E.1.2 The capacity of connections with closely spaced, large diameter bolts has been shown to be limited by the capacity of the wood surrounding the connection. Connections with groups of smaller diameter fasteners, such as typical nailed connections in wood-frame construction, may not be limited by wood capacity.

E.2 Net Section Tension Capacity

The adjusted tension capacity is calculated in accordance with provisions of 3.1.2 and 3.8.1 as follows:

$$Z_{NT}' = F_t' A_{net} \qquad \text{(E.2-1)}$$

where:

Z_{NT}' = adjusted tension capacity of net section area

F_t' = adjusted tension design value parallel to grain

A_{net} = net section area per 3.1.2

E.3 Row Tear-Out Capacity

The adjusted tear-out capacity of a row of fasteners can be estimated as follows:

$$Z_{RTi}' = n_i \frac{F_v' A_{critical}}{2} \qquad \text{(E.3-1)}$$

where:

Z_{RTi}' = adjusted row tear out capacity of row i

F_v' = adjusted shear design value parallel to grain

$A_{critical}$ = minimum shear area of any fastener in row i

n_i = number of fasteners in row i

E3.1 Assuming one shear line on each side of bolts in a row (observed in tests of bolted connections), Equation E.3-1 becomes:

$$Z_{RTi}' = \frac{F_v' t}{2}\left[n_i s_{critical}\right](2\ \text{shear lines}) \qquad \text{(E.3-2)}$$

$$= n_i F_v' t s_{critical}$$

where:

$s_{critical}$ = minimum spacing in row i taken as the lesser of the end distance or the spacing between fasteners in row i

t = thickness of member

The total adjusted row tear-out capacity of multiple rows of fasteners can be estimated as:

$$Z_{RT}' = \sum_{i=1}^{n_{row}} Z_{RTi}' \qquad \text{(E.3-3)}$$

where:

Z_{RT}' = adjusted row tear out capacity of multiple rows

n_{row} = number of rows

E.3.2 In Equation E.3-1, it is assumed that the induced shear stress varies from a maximum value of $f_v = F_v'$ to a minimum value of $f_v = 0$ along each shear line between fasteners in a row and that the change in shear stress/strain is linear along each shear line. The resulting triangular stress distribution on each shear line between fasteners in a row establishes an apparent shear stress equal to half of the adjusted design shear stress, $F_v'/2$, as shown in Equation E.3-1. This assumption is combined with the critical area concept for evaluating stresses in fastener groups and provides good agreement with results from tests of bolted connections.

E3.3 Use of the minimum shear area of any fastener in a row for calculation of row tear-out capacity is based on the assumption that the smallest shear area between fasteners in a row will limit the capacity of the row of fasteners. Limited verification of this approach is provided from tests of bolted connections.

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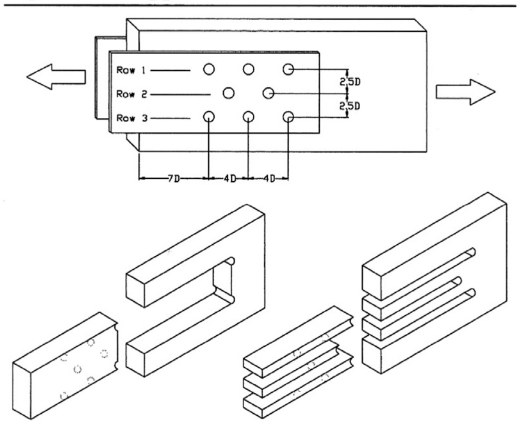
NDS 2018 Appendix E

Axial Load Connection

three limit states

- E.2 net tension
- E.3 row tear-out
- E.4 group tear-out

Figure E1 Staggered Rows of Bolts



E.4 Group Tear-Out Capacity

The adjusted tear-out capacity of a group of "n" rows of fasteners can be estimated as:

$$Z_{GT}' = \frac{Z_{RT-1}'}{2} + \frac{Z_{RT-n}'}{2} + F_t' A_{group-net} \qquad \text{(E.4-1)}$$

where:

Z_{GT}' = adjusted group tear-out capacity

Z_{RT-1}' = adjusted row tear-out capacity of row 1 of fasteners bounding the critical group area

Z_{RT-n}' = adjusted row tear-out capacity of row n of fasteners bounding the critical group area

$A_{group-net}$ = critical group net section area between row 1 and row n

E.4.1 For groups of fasteners with non-uniform spacing between rows of fasteners various definitions of critical group area should be checked for group tear-out in combination with row tear-out to determine the adjusted capacity of the critical section.

Appendix E

3 failure modes

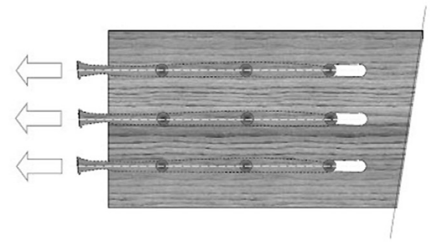
- Appendix E NDS Expressions
  - Net tension:

$$Z'_{NT} = F'_t A_{net}$$

  - Row tear-out:

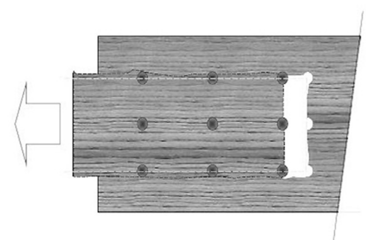
$$Z'_{RT_i} = n_i F'_v t s_{\min}$$

$$Z'_{RT} = \sum_{i=1}^{n_{row}} Z'_{RT_i}$$



  - Group tear-out

$$Z'_{GT} = \frac{Z'_{RT-top}}{2} + \frac{Z'_{RT-bottom}}{2} + F'_t A_{group-net}$$

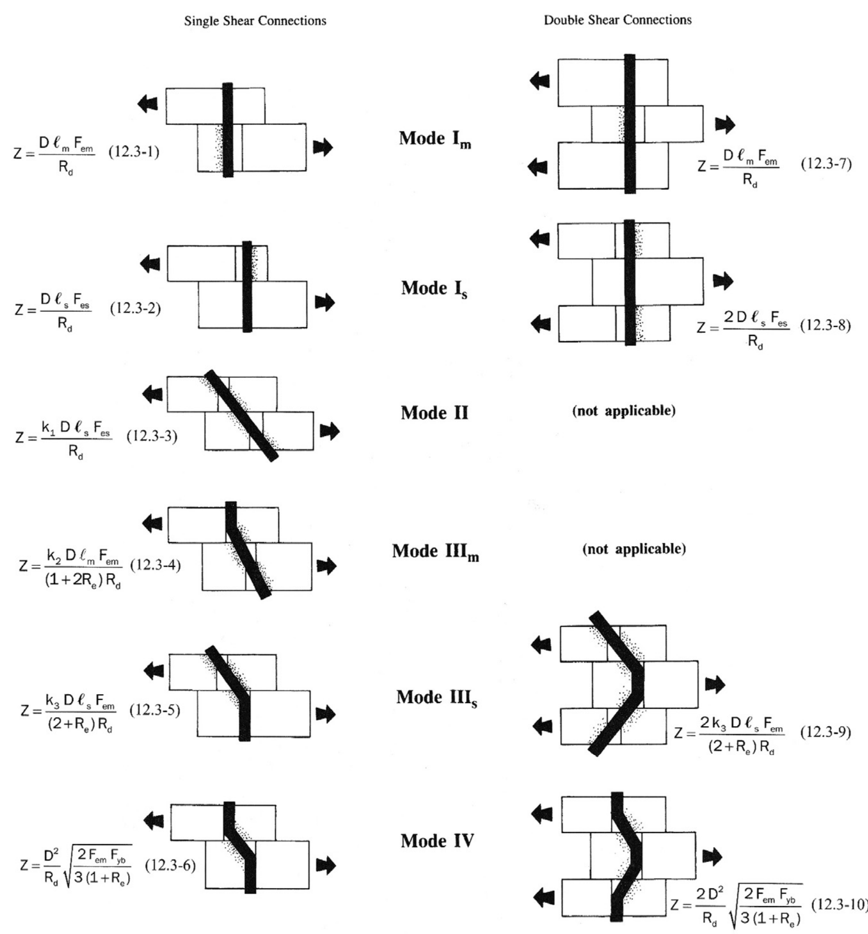


- Note: spacing between outer rows of fasteners paralleling the member on a single splice plate $\leq$ 5″

Chapter 12

Connection Yield Modes

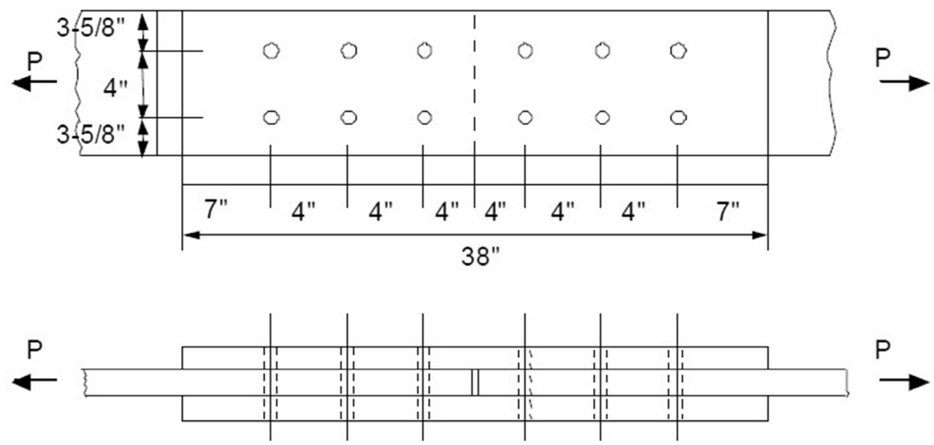
Yield Limit Equations
for Dowel Fasteners
Table 12.3.1A



NDS Appendix E tension connection – 2x12's So.Pine No.2 C_D = 1.25

lap splice connection example – 1" bolts w/ 1-1/16" holes

BOLTED SPLICE – LOCAL STRESSES



NDS Appendix E

tension connection – 2x12's So.Pine No.2 C_D = 1.25

net tension check

EXAMPLE: BOLTED SPLICE – LOCAL STRESSES

- Assume 1″ diameter x 5″ long bolts
- 2x12 No. 2 Southern Pine main and side members

Net Section Tension Check

$Z_{NT}' = F_t' A_{net}$

$F_t' = 450(1.25) = 562.5$ psi

$A_{net} = 13.7$ in^2

$Z_{NT}' = 7{,}706$ lbs

Note: hole size for net area includes 1/16″ oversizing per NDS 12.1.3.2

E.2 Net Section Tension Capacity

The adjusted tension capacity is calculated in accordance with provisions of 3.1.2 and 3.8.1 as follows:

$$Z_{NT}' = F_t' A_{net} \qquad \text{(E.2-1)}$$

where:

Z_{NT}' = adjusted tension capacity of net section area

F_t' = adjusted tension design value parallel to grain

A_{net} = net section area per 3.1.2

NDS Appendix E

tension connection – 2x12's So.Pine No.2 C_D = 1.25

row tear-out check

EXAMPLE: BOLTED SPLICE – LOCAL STRESSES

Row Tear-Out Check

$Z_{RTi}' = n_i F_v' t s_{critical}$

$n_i = 3$

$F_v' = 175(1.25) = 219$ psi

$t = 1.5''$

$s_{critical} = 4''$

Z_{RTi}' = 3,938 lbs for one row

Z_{RT}' = 7,875 lbs for two rows

Note: $s_{critical}$ is the minimum of the end distance and the in-row bolt spacing = 4″

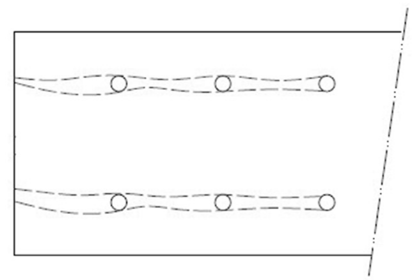
E.3 Row Tear-Out Capacity

The adjusted tear-out capacity of a row of fasteners can be estimated as follows:

$$Z_{RTi}' = n_i \frac{F_v' A_{critical}}{2} \quad \text{(E.3-1)}$$

$$Z_{RTi}' = \frac{F_v' t}{2}\left[n_i s_{critical}\right](2\text{ shear lines}) \quad \text{(E.3-2)}$$

$$= n_i F_v' t s_{critical}$$



NDS Appendix E

tension connection – 2x12's So.Pine No.2 C_D = 1.25

group tear-out check $A_{group\text{-}net}$ = (4 – 1 1/16) 1.5 = 4.406 in^2

EXAMPLE: BOLTED SPLICE – LOCAL STRESSES

Group Tear-Out Check

$Z_{GT}' = Z_{RT1}'/2 + Z_{RT2}'/2 + F_t' A_{group\text{-}net}$

$Z_{RT1}' = Z_{RT2}'$ = 3,938 lbs

$F_t' = 450(1.25) = 562.5$ psi

$A_{group\text{-}net} = 4.41$ in^2

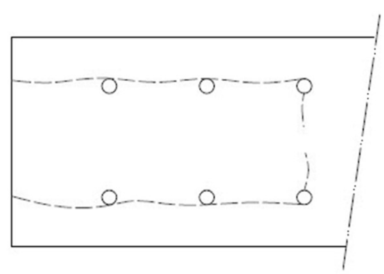
Z_{GT}' = 6,418 lbs

Note: hole size for net area includes 1/16″ oversizing per NDS 12.1.3.2

E.4 Group Tear-Out Capacity

The adjusted tear-out capacity of a group of "n" rows of fasteners can be estimated as:

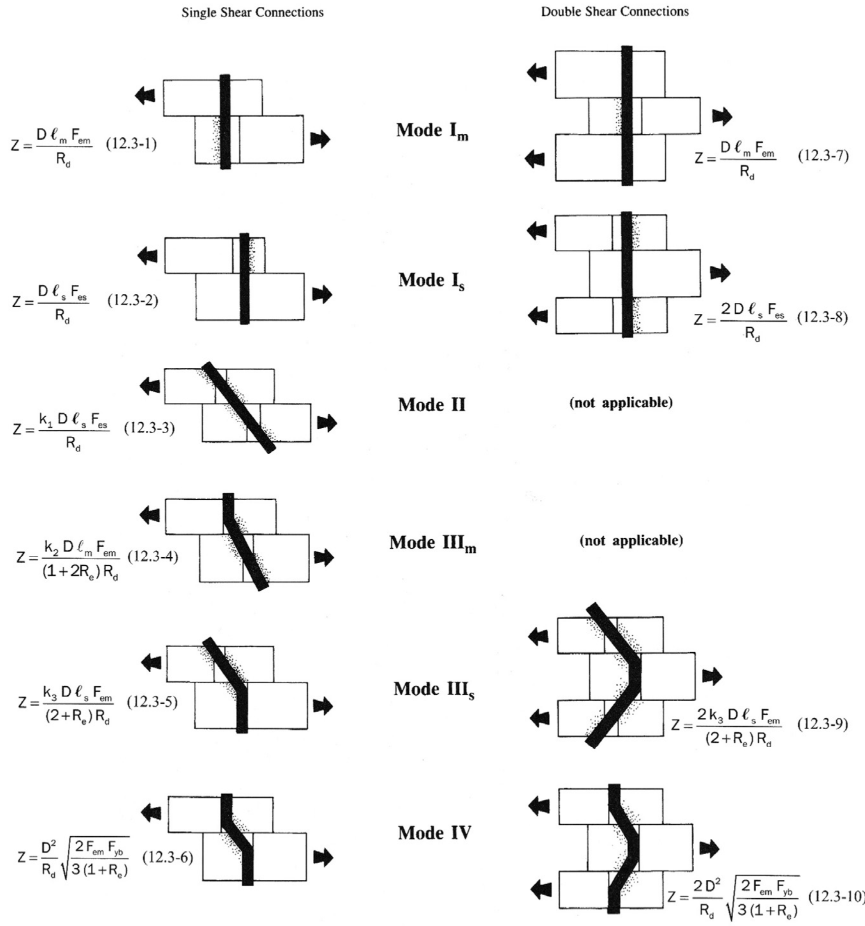
$$Z_{GT}' = \frac{Z_{RT-1}'}{2} + \frac{Z_{RT-n}'}{2} + F_t' A_{group-net} \quad \text{(E.4-1)}$$



Chapter 12

Connection Yield Modes

Yield Limit Equations
for Dowel Fasteners
Table 12.3.1A



NDS Appendix E

tension connection – 2x12's So.Pine No.2 C_D = 1.25
fastener yield limit equations

D = 1 IN
Fyb = 45000 PSI
Rd (Table 12.3.1B) 4
Re = 1
Rt = 1
Lm = 1.5 IN
Ls = 1.5 IN
Fem = 6150 PSI
Fes = 6150 PSI
k3 = 2.241

Z = 2306 LB/bolt (least)
adjustment factors:
C_D = 1.25
C_g = 0.97
C_Δ = 0.571
C_M = Ct = 1.0
Z (adj. factors) = Z'
Z' = 1598 LB / bolt = **9589 LBS total**

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)	→ least value	$Z = \frac{D \ell_m F_{em}}{R_d}$ = 2306 LBS	(12.3-7)
I_s	$Z = \frac{D \ell_s F_{es}}{R_d}$	(12.3-2)		$Z = \frac{2 D \ell_s F_{es}}{R_d}$ = 4613 LBS	(12.3-8)
II	$Z = \frac{k_1 D \ell_s F_{es}}{R_d}$	(12.3-3)			
III_m	$Z = \frac{k_2 D \ell_m F_{em}}{(1+2R_e) R_d}$	(12.3-4)			
III_s	$Z = \frac{k_3 D \ell_s F_{em}}{(2+R_e) R_d}$	(12.3-5)		$Z = \frac{2 k_3 D \ell_s F_{em}}{(2+R_e) R_d}$ = 4307 LBS	(12.3-9)
IV	$Z = \frac{D^2}{R_d}\sqrt{\frac{2 F_{em} F_{yb}}{3(1+R_e)}}$	(12.3-6)		$Z = \frac{2D^2}{R_d}\sqrt{\frac{2 F_{em} F_{yb}}{3(1+R_e)}}$ = 6003 LBS	(12.3-10)

Notes:

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

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

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

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)

NDS Appendix E

tension connection – 2x12's So.Pine No.2 C_D = 1.25
fastener yield limit equations

D = 1 IN
Fyb = 45000 PSI
Rd (Table 12.3.1B) 4
Re = 1
Rt = 1
Lm = 1.5 IN
Ls = 1.5 IN
Fem = 6150 PSI
Fes = 6150 PSI
k3 = 2.241

Z = 2306 LB / bolt (least)
adjustment factors:
C_D = 1.25
C_g = 0.97 (calculated)   0.99 (table)
C_Δ = 0.571
C_M = Ct = 1.0
Z (adj. factors) = Z'
Z' = 1598 LB / bolt = **9589 LBS total**

11.3.6 Group Action Factors, C_g

11.3.6.1 Reference lateral design values for split ring connectors, shear plate connectors, or dowel-type fasteners with D ≤ 1" in a row shall be multiplied by the following group action factor, C_g:

$$C_g = \left[\frac{m(1-m^{2n})}{n\left[\left(1+R_{EA}m^n\right)(1+m)-1+m^{2n}\right]}\right]\left[\frac{1+R_{EA}}{1-m}\right] \qquad (11.3\text{-}1)$$

Table 11.3.6A Group Action Factors, C_g, for Bolt or Lag Screw Connections with Wood Side Members[2]

For D = 1", s = 4", E = 1,400,000 psi

A_s/A_m[1]	A_s[1] in.^{2}	2	3	4	5	6	7	8	9	10	11	12
		Number of fasteners in a row										
0.5	5	0.98	0.92	0.84	0.75	0.68	0.61	0.55	0.50	0.45	0.41	0.38
	12	0.99	0.96	0.92	0.87	0.81	0.76	0.70	0.65	0.61	0.57	0.53
	20	0.99	0.98	0.95	0.91	0.87	0.83	0.78	0.74	0.70	0.66	0.62
	28	1.00	0.98	0.96	0.93	0.90	0.87	0.83	0.79	0.76	0.72	0.69
	40	1.00	0.99	0.97	0.95	0.93	0.90	0.87	0.84	0.81	0.78	0.75
	64	1.00	0.99	0.98	0.97	0.95	0.93	0.91	0.89	0.87	0.84	0.82
1	5	1.00	0.97	0.91	0.85	0.78	0.71	0.64	0.59	0.54	0.49	0.45
	12	1.00	0.99	0.96	0.93	0.88	0.84	0.79	0.74	0.70	0.65	0.61
	20	1.00	0.99	0.98	0.95	0.92	0.89	0.86	0.82	0.78	0.75	0.71
	28	1.00	0.99	0.98	0.97	0.94	0.92	0.89	0.86	0.83	0.80	0.77
	40	1.00	1.00	0.99	0.98	0.96	0.94	0.92	0.90	0.87	0.85	0.82
	64	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.93	0.91	0.90	0.88

1. Where A_s/A_m > 1.0, use A_m/A_s and use A_m instead of A_s.
2. Tabulated group action factors (C_g) are conservative for D < 1", s < 4", or E > 1,400,000 psi.

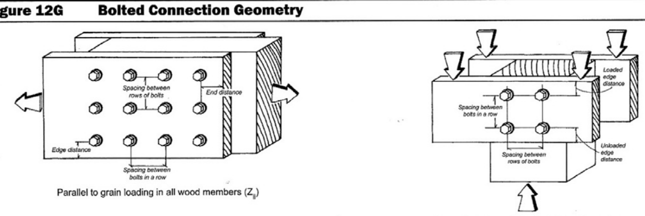
NDS Appendix E

tension connection – 2x12's So. Pine
No.2 C_D = 1.25

D = 1 IN
Fyb = 45000 PSI
Rd (Table 12.3.1B) 4
Re = 1
Rt = 1
Lm = 1.5 IN
Ls = 1.5 IN
Fem = 6150 PSI
Fes = 6150 PSI
k3 = 2.241

Z = 2306 LB / bolt (least)
adjustment factors:
C_D = 1.25
C_g = 0.97 (calculated)   0.99 (table)
C_Δ = 0.571
C_M = Ct = 1.0
Z (adj. factors) = Z'
Z' = 1598 LB / bolt = **9589 LBS total**

Figure 12G Bolted Connection Geometry



Parallel to grain loading in all wood members ($Z_\parallel$)

Perpendicular to grain loading in the side member and parallel to grain loading in the main member ($Z_{s\perp}$)

Table 12.5.1A End Distance Requirements

Direction of Loading	End Distances: Minimum end distance for C_Δ = 0.5	Minimum end distance for C_Δ = 1.0
Perpendicular to Grain	2D	4D
Parallel to Grain, Compression: (fastener bearing away from member end)	2D	4D
Parallel to Grain, Tension: (fastener bearing toward member end)		
for softwoods	3.5D	7D
for hardwoods	2.5D	5D

(b) For loading at an angle to the fastener, where dowel-type fasteners are used, the minimum shear area for C_Δ = 1.0 shall be equivalent to the shear area for a parallel member connection with minimum end distance for C_Δ = 1.0 (see Table 12.5.1A and Figure 12E). The minimum shear area for C_Δ = 0.5 shall be equivalent to ½ the minimum shear area for C_Δ = 1.0. Where the actual shear area is greater than or equal to the minimum shear area for C_Δ = 0.5, but less than the minimum shear area for C_Δ = 1.0, the geometry factor, C_Δ, shall be determined as follows:

$$C_\Delta = \frac{\text{actual shear area}}{\text{minimum shear area for } C_\Delta = 1.0}$$

(c) Where the actual spacing between dowel-type fasteners in a row for parallel or perpendicular to grain loading is greater than or equal to the minimum spacing (see Table 12.5.1B), but less than the minimum spacing for C_Δ = 1.0, the geometry factor, C_Δ, shall be determined as follows:

$$C_\Delta = \frac{\text{actual spacing}}{\text{minimum spacing for } C_\Delta = 1.0}$$

12.5.1.3 Where D ≥ 1/4", edge distance and spacing between rows of fasteners shall be in accordance with Table 12.5.1C and Table 12.5.1D and applicable requirements of 12.1. The perpendicular to grain distance between the outermost fasteners shall not exceed 5" (see Figure 12H) unless special detailing is provided to accommodate cross-grain shrinkage of the wood member. For structural glued laminated timber members, the perpendicular to grain distance between the outermost fasteners shall not exceed the limits in Table 12.5.1F, unless special detailing is provided to accommodate cross-grain shrinkage of the member.

12.5.1.4 Where fasteners are installed in the narrow edge of cross-laminated timber panels and D ≥ 1/4", end distances, edge distances, and fastener spacing in a row shall not be less than the minimum values in Table 12.5.1G.

Table 12.5.1B Spacing Requirements for Fasteners in a Row

Direction of Loading	Spacing: Minimum spacing	Minimum spacing for C_Δ = 1.0
Parallel to Grain	3D	4D
Perpendicular to Grain	3D	Required spacing for attached members

NDS Chapter 12

Table 12F for :

tm = 1.5”

ts = 1.5”

D = 1”

G = 0.55

from eq. 12.3-7 :

Z_{ll} = 2306 LBS / bolt

from table 12F

Z_{ll} = 2310 LBS / bolt

then

adjustment factors:

C_D = 1.25

C_g = 0.97

C_Δ = 0.571

C_M = Ct = 1.0

Z (adj. factors) = Z’

Z’ = 1599 lb/ bolt = **9596 LBS total**

BOLTS

Table 12F BOLTS: Reference Lateral Design Values, Z, for Double Shear (three member) Connections[1,2]

for sawn lumber or SCL with all members of identical specific gravity

Thickness: Main Member	Thickness: Side Member	Bolt Diameter	G=0.67 Red Oak			G=0.55 Mixed Maple Southern Pine			G=0.50 Douglas Fir-Larch			G=0.49 Douglas Fir-Larch(N)			G=0.46 Douglas Fir(S) Hem-Fir(N)		
t_m in.	t_s in.	D in.	$Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.
1-1/2	1-1/2	1/2	1410	960	730	1150	800	550	1050	730	470	1030	720	460	970	680	420
		5/8	1760	1310	810	1440	1130	610	1310	1040	530	1290	1030	520	1210	940	470
		3/4	2110	1690	890	1730	1330	660	1580	1170	590	1550	1130	560	1450	1040	520
		7/8	2460	1920	960	2020	1440	720	1840	1260	630	1800	1210	600	1690	1100	550
		1	2810	2040	1020	2310	1530	770	2100	1350	680	2060	1290	650	1930	1200	600
1-3/4	1-3/4	1/2	1640	1030	850	1350	850	640	1230	770	550	1200	750	530	1130	710	490
		5/8	2050	1370	940	1680	1160	710	1530	1070	610	1500	1060	600	1410	1000	550
		3/4	2460	1810	1040	2020	1550	770	1840	1370	680	1800	1310	660	1690	1210	600
		7/8	2870	2240	1120	2350	1680	840	2140	1470	740	2110	1410	700	1970	1290	640
		1	3280	2380	1190	2690	1790	890	2450	1580	790	2410	1510	750	2250	1400	700
2-1/2	1-1/2	1/2	1530	960	1120	1320	800	910	1230	730	790	1210	720	760	1160	680	700
		5/8	2150	1310	1340	1870	1130	1020	1760	1040	880	1740	1030	860	1660	940	780
		3/4	2890	1770	1480	2550	1330	1110	2400	1170	980	2380	1130	940	2280	1040	860
		7/8	3780	1920	1600	3360	1440	1200	3060	1260	1050	3010	1210	1010	2820	1100	920
		1	4690	2040	1700	3840	1530	1280	3500	1350	1130	3440	1290	1080	3220	1200	1000
3-1/2	1-1/2	1/2	1530	960	1120	1320	800	940	1230	730	860	1210	720	850	1160	680	810
		5/8	2150	1310	1510	1870	1130	1290	1760	1040	1190	1740	1030	1170	1660	940	1090
		3/4	2890	1770	1980	2550	1330	1550	2400	1170	1370	2380	1130	1310	2280	1040	1210
		7/8	3780	1920	2240	3360	1440	1680	3180	1260	1470	3150	1210	1410	3030	1100	1290
		1	4820	2040	2380	4310	1530	1790	4090	1350	1580	4050	1290	1510	3860	1200	1400
	1-3/4	1/2	1660	1030	1180	1430	850	1030	1330	770	940	1310	750	920	1250	710	870
		5/8	2310	1370	1630	1990	1160	1380	1860	1070	1230	1840	1060	1200	1760	1000	1090
		3/4	3060	1810	2070	2670	1550	1550	2510	1370	1370	2480	1310	1310	2370	1210	1210
		7/8	3940	2240	2240	3470	1680	1680	3270	1470	1470	3240	1410	1410	3110	1290	1290
		1	4960	2380	2380	4400	1790	1790	4170	1580	1580	4120	1510	1510	3970	1400	1400
	3-1/2	1/2	1660	1180	1180	1500	1040	1040	1430	970	970	1420	960	960	1370	920	920
		5/8	2590	1770	1770	2340	1560	1420	2240	1410	1230	2220	1390	1200	2150	1290	1090
		3/4	3730	2380	2070	3380	1910	1550	3220	1750	1370	3190	1700	1310	3090	1610	1210
		7/8	5080	2820	2240	4600	2330	1680	4290	2130	1470	4210	2070	1410	3940	1960	1290
		1	6560	3340	2380	5380	2780	1790	4900	2580	1580	4810	2520	1510	4510	2410	1400
5-1/4	1-1/2	5/8	2150	1310	1510	1870	1130	1290	1760	1040	1190	1740	1030	1170	1660	940	1110
		3/4	2890	1770	1980	2550	1330	1690	2400	1170	1580	2380	1130	1550	2280	1040	1480
		7/8	3780	1920	2520	3360	1440	2170	3180	1260	2030	3150	1210	1990	3030	1100	1900
		1	4820	2040	3120	4310	1530	2680	4090	1350	2360	4050	1290	2260	3860	1200	2100
	1-3/4	5/8	2310	1370	1630	1990	1160	1380	1860	1070	1270	1840	1060	1250	1760	1000	1180
		3/4	3060	1810	2110	2670	1550	1790	2510	1370	1660	2480	1310	1630	2370	1210	1550
		7/8	3940	2240	2640	3470	1680	2260	3270	1470	2100	3240	1410	2060	3110	1290	1930
		1	4960	2380	3240	4400	1790	2680	4170	1580	2360	4120	1510	2260	3970	1400	2100
	3-1/2	5/8	2590	1770	1770	2340	1560	1560	2240	1410	1460	2220	1390	1450	2150	1290	1390
		3/4	3730	2380	2480	3380	1910	2180	3220	1750	2050	3190	1700	1970	3090	1610	1810
		7/8	5080	2820	3290	4600	2330	2530	4390	2130	2210	4350	2070	2110	4130	1960	1930
		1	6630	3340	3570	5740	2780	2680	5330	2580	2360	5250	2520	2260	4990	2410	2100
5-1/2	1-1/2	5/8	2150	1310	1510	1870	1130	1290	1760	1040	1190	1740	1030	1170	1660	940	1110
		3/4	2890	1770	1980	2550	1330	1690	2400	1170	1580	2380	1130	1550	2280	1040	1480
		7/8	3780	1920	2520	3360	1440	2170	3180	1260	2030	3150	1210	1990	3030	1100	1900
		1	4820	2040	3120	4310	1530	2700	4090	1350	2480	4050	1290	2370	3860	1200	2200
	3-1/2	5/8	2590	1770	1770	2340	1560	1560	2240	1410	1460	2220	1390	1450	2150	1290	1390
		3/4	3730	2380	2480	3380	1910	2180	3220	1750	2050	3190	1700	2020	3090	1610	1900
		7/8	5080	2820	3290	4600	2330	2650	4390	2130	2310	4350	2070	2210	4130	1960	2020
		1	6630	3340	3740	5740	2780	2810	5330	2580	2480	5250	2520	2370	4990	2410	2200
7-1/2	1-1/2	5/8	2150	1310	1510	1870	1130	1290	1760	1040	1190	1740	1030	1170	1660	940	1110
		3/4	2890	1770	1980	2550	1330	1690	2400	1170	1580	2380	1130	1550	2280	1040	1480
		7/8	3780	1920	2520	3360	1440	2170	3180	1260	2030	3150	1210	1990	3030	1100	1900
		1	4820	2040	3120	4310	1530	2700	4090	1350	2530	4050	1290	2480	3860	1200	2390
	3-1/2	5/8	2590	1770	1770	2340	1560	1560	2240	1410	1460	2220	1390	1450	2150	1290	1390
		3/4	3730	2380	2480	3380	1910	2180	3220	1750	2050	3190	1700	2020	3090	1610	1940
		7/8	5080	2820	3290	4600	2330	2890	4390	2130	2720	4350	2070	2670	4130	1960	2560
		1	6630	3340	4190	5740	2780	3680	5330	2580	3380	5250	2520	3230	4990	2410	3000

1. Tabulated lateral design values, Z, for bolted connections shall be multiplied by all applicable adjustment factors (see Table 11.3.1).
2. Tabulated lateral design values, Z, are for “full-body diameter” bolts (see Appendix Table L1) with bolt bending yield strength, F_{yb}, of 45,000 psi.

NDS Appendix E 3-member connection – 2x12’s So.Pine No.2 C_D = 1.25

results

EXAMPLE: BOLTED SPLICE – LOCAL STRESSES

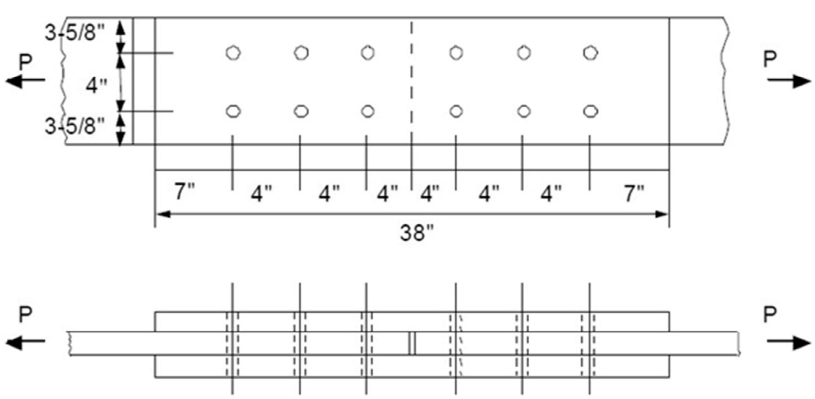
Final Bolt Capacity

Z’ = 9,602 lbs

Z_{NT}’ = 7,706 lbs

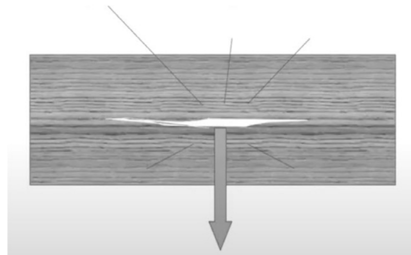
Z_{RT}’ = 7,875 lbs

$\boxed{Z_{GT}\text{'} = 6{,}418 \text{ lbs}}$



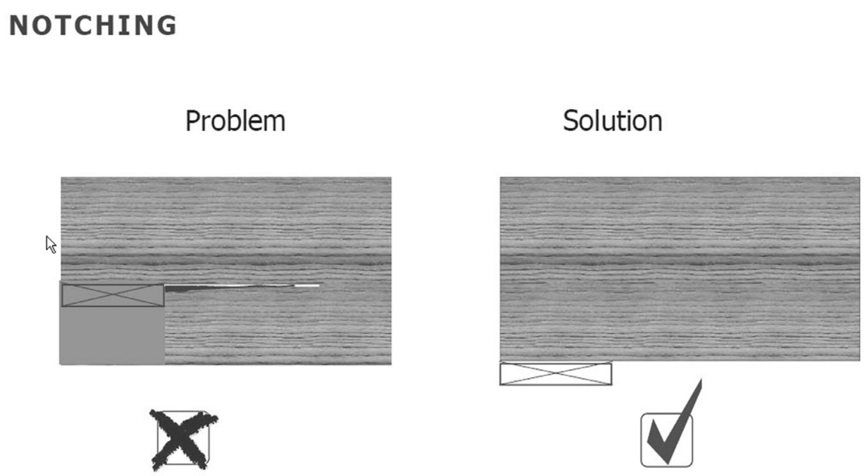
Connection Details

Avoid tension perpendicular to grain



Situations

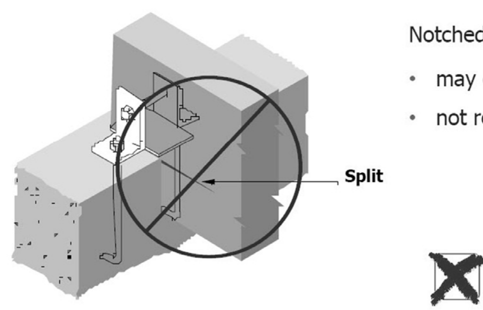
- notches
- large diameter fasteners
- hanging loads



Connection Details

Notches

BEAM TO CONCRETE

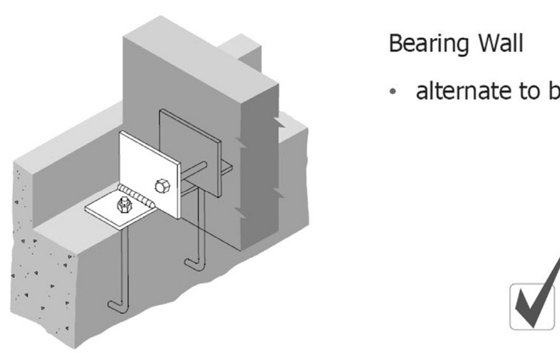


Notched Beam Bearing

- may cause splitting
- not recommended

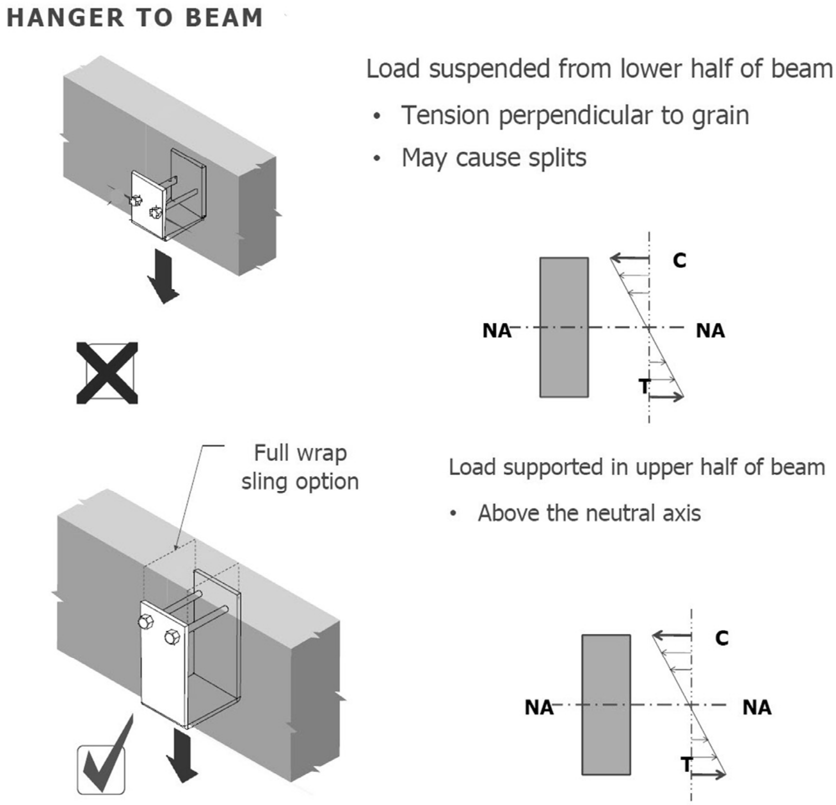
Bearing Wall

- alternate to beam notch



Connection Details

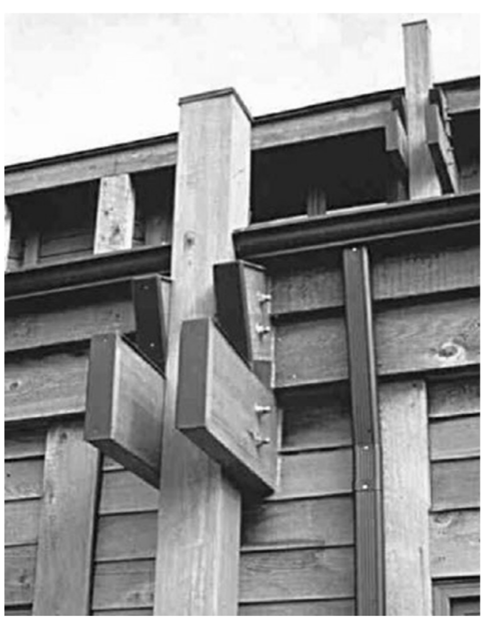
Hangers

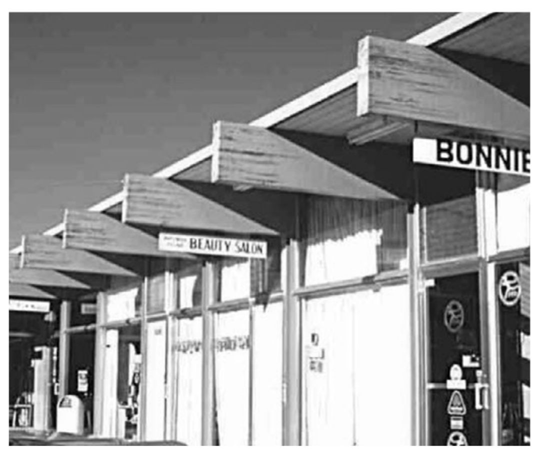


Connection Details

exposure to moisture

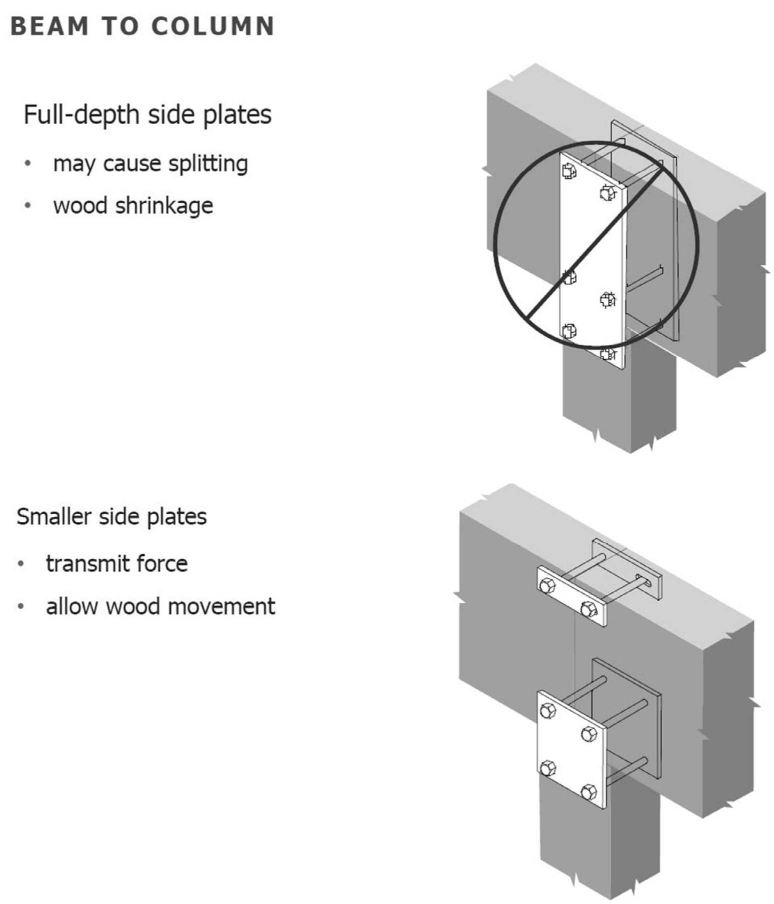
- end grain wicks water
- natural decay resistant species – e.g. cedar
- treated lumber





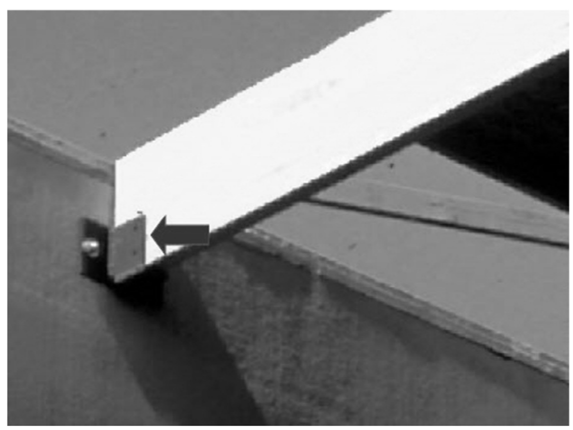
Connection Details

splitting due to shrinkage



Connection Details

water damage
shrinkage splitting

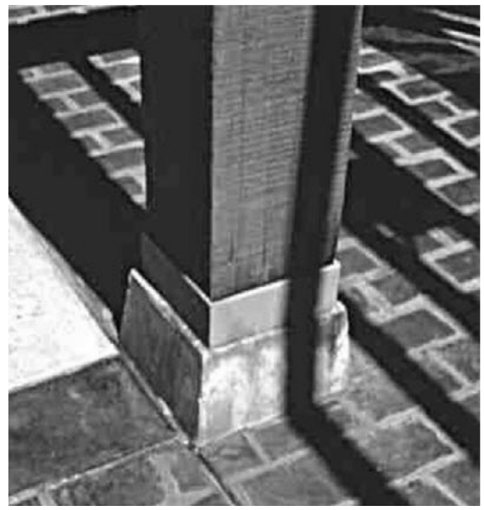


Solutions

- connectors at base
- slotted connectors

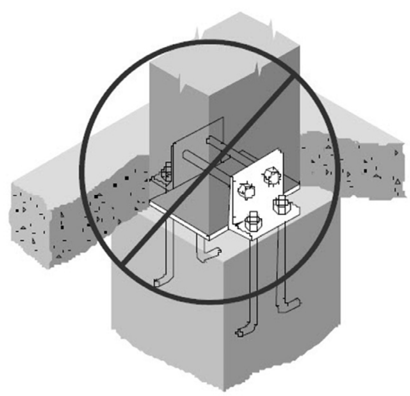
Connection Details

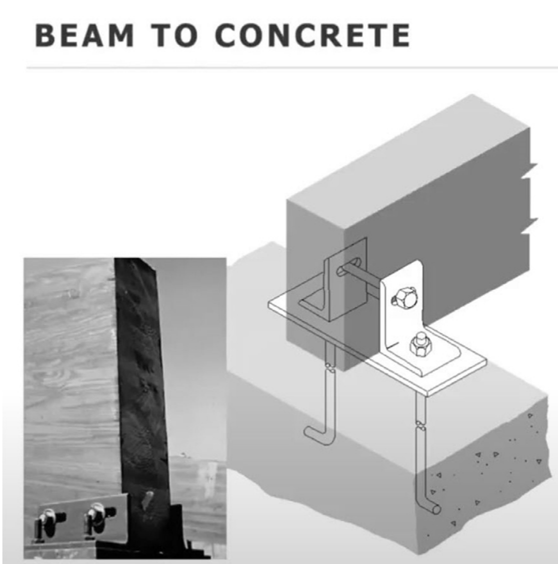
Water damage
- avoid contact with concrete or masonry
- provide ½" air gap
- provide weep holes

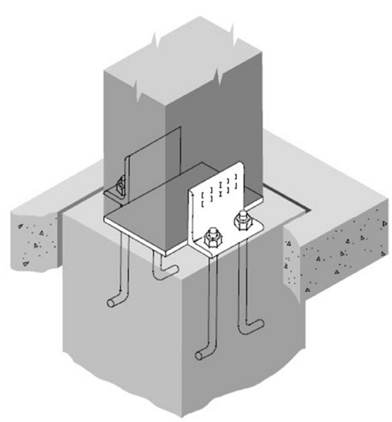


Connection Details

Water damage
- avoid contact with concrete or masonry
- provide ½" air gap
- provide weep holes



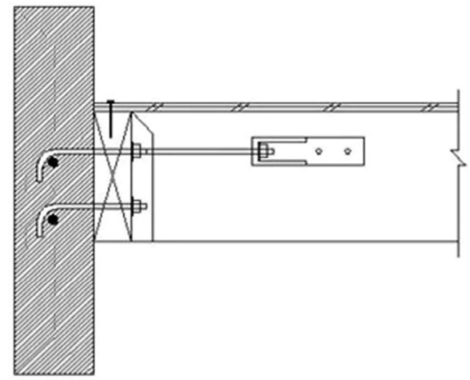




Connection Details

Seismic forces
- diaphragm connections to walls

- Wood Diaphragms

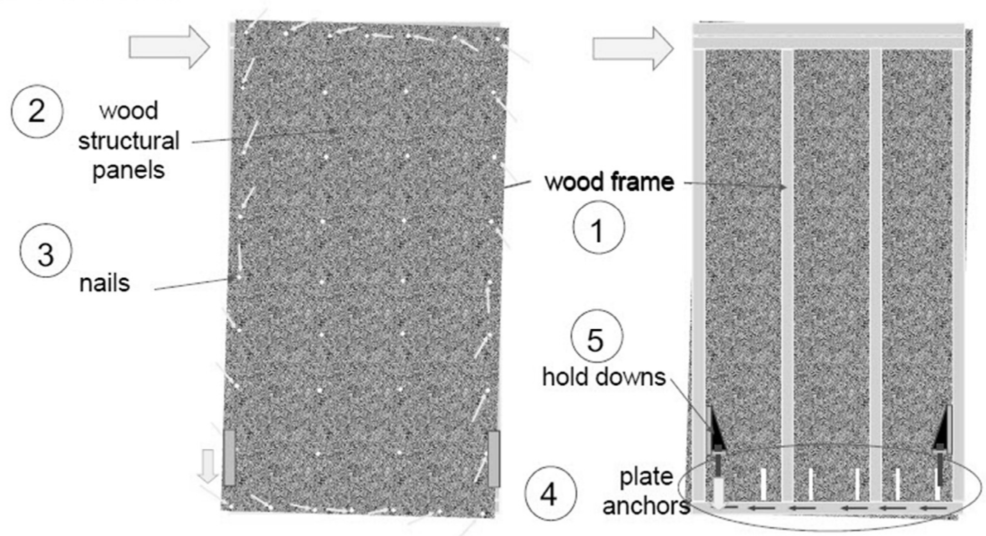


Connection Details

Seismic forces
- shear walls

SHEAR WALL - PARTS

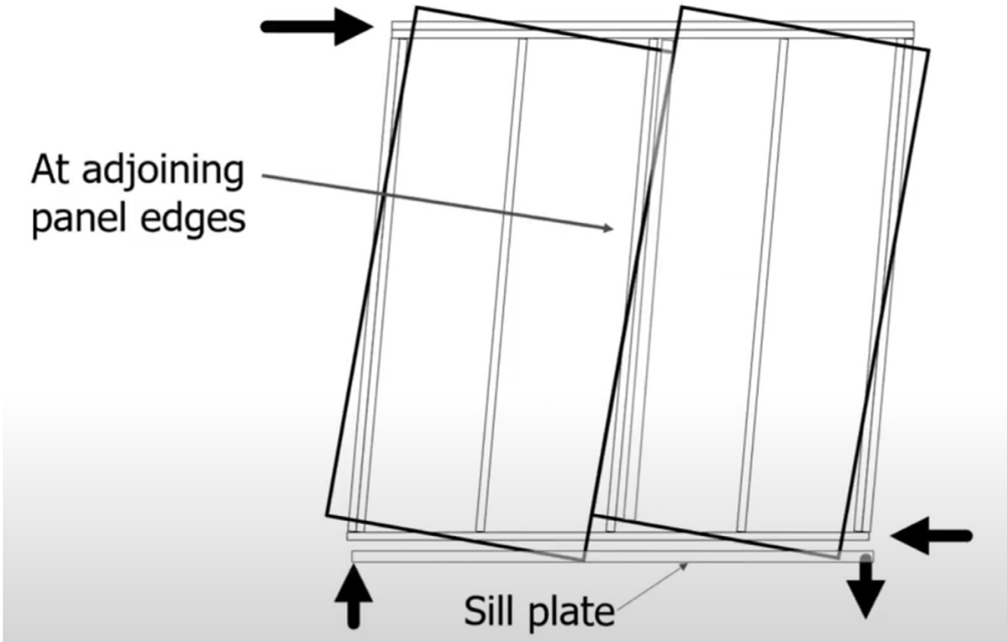
Five parts of a shear wall



Connection Details

Seismic forces

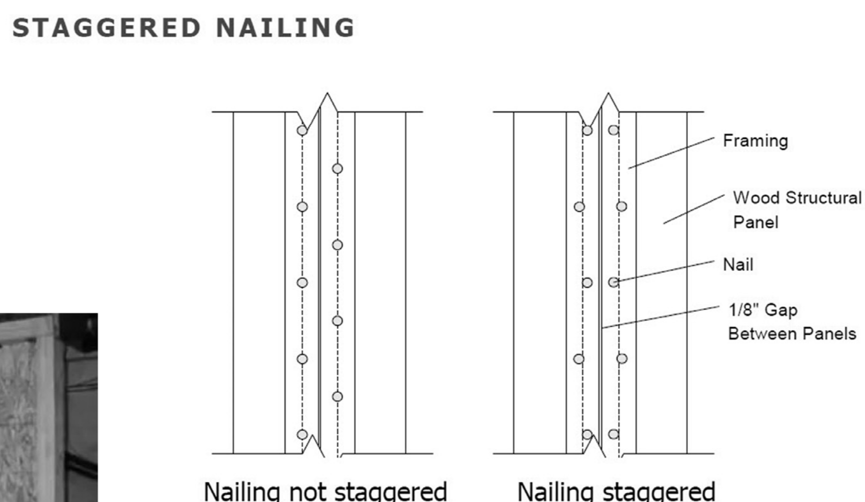
- shear walls



Connection Details

Seismic forces

- shear walls



Connection Details

Seismic forces
- shear walls

3X AT ADJOINING PANEL EDGE

Section 4.3.7.1(4). 3x framing also required at adjoining panel edges where:

- Nail spacing of 2 in. o.c.
- 10d common nails having penetration of more than 1-1/2 in. at 3 in. o.c. or less
- Nominal unit shear capacity on either side exceeds 700 plf in SDC D, E, or F

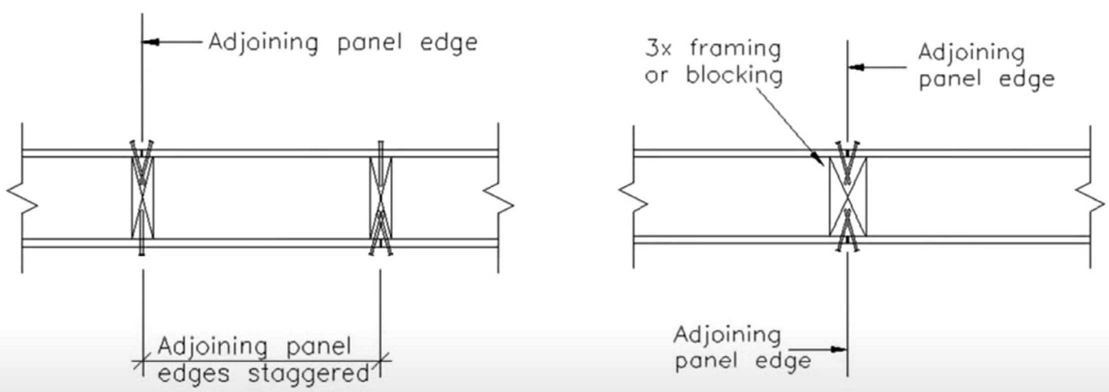
Exception: (2) 2x framing permitted in lieu of (1) 3x where fastened in accordance with the NDS to transfer the induced shear between members.

Connection Details

Seismic forces
- shear walls

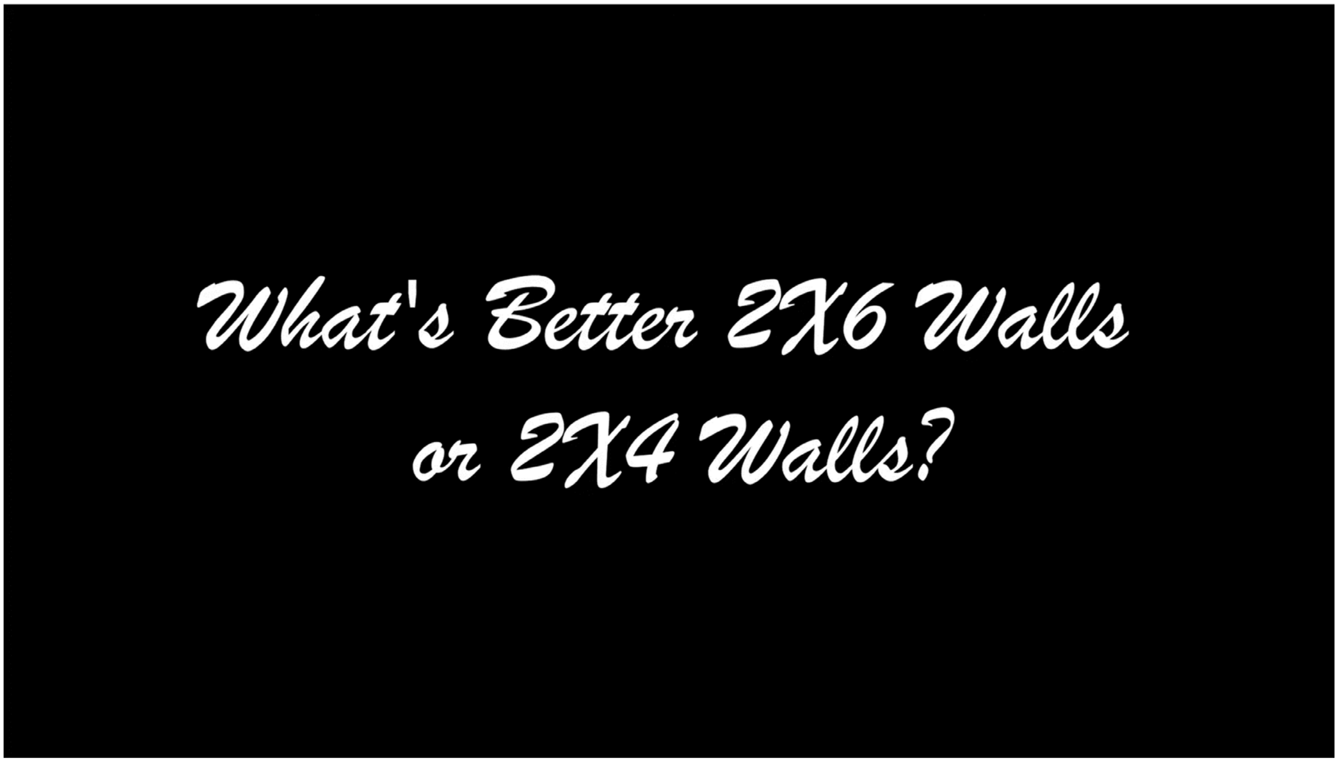
CH. 4 - SHEAR WALLS SHEATHED ON 2 SIDES

Adjoining Panel Edge Details



a. Adjoining panel edges staggered b. Adjoining panel edges not staggered

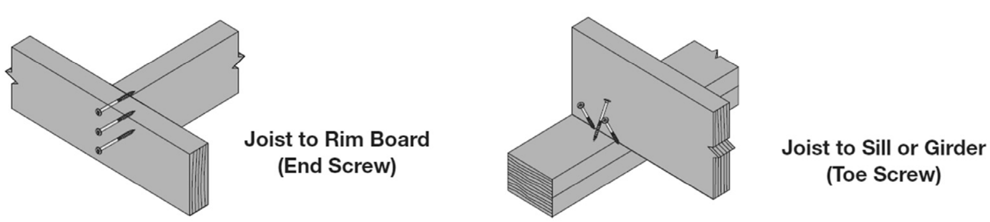
Stud Wall Construction



Residential Details
IRC & IBC

Floor

Floor

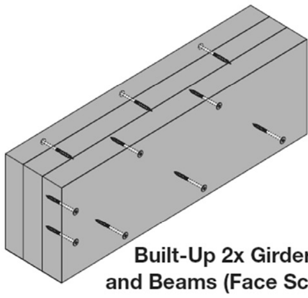


Connection Application	Fastener Quantities			
	IRC		IBC	
	Nails per Table R602.3 (1)	Equivalent SDWS Framing Screws	Nails per Table 2304.10.1	Equivalent SDWS Framing Screws
Joist to band joist (end screw)	(3) 16d common end nail	(3) SDWS16300	(3) 16d common	(3) SDWS16300
Joist to sill or girder (toe screw)	(3) 8d box	(3) SDWS16212	(3) 8d common	(3) SDWS16212

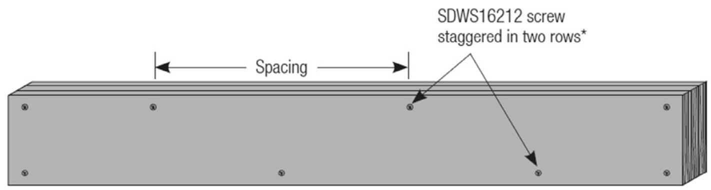
Residential Details
IRC & IBC

Beams

Beam



Built-Up 2x Girders and Beams (Face Screw)



Beam Assembly Detail*

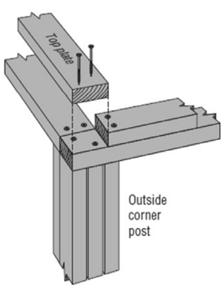
Connection Application	Fastener Quantities and Spacing			
	IRC		IBC	
	Nails per Table R602.3 (1)	Equivalent SDWS Framing Screws	Nails per Table 2304.10.1	Equivalent SDWS Framing Screws
Built-up 2x girders and beams (face screw)	10d box 32" o.c. (24" o.c. per 2015)	SDWS16212 32" o.c.	10d box 24" o.c.	SDWS16212 24" o.c.

*Fastening pattern shown applies to each ply of the built-up 2x beam.

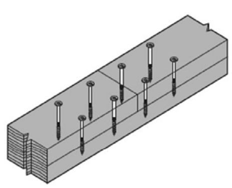
Residential Details
IRC & IBC

Walls

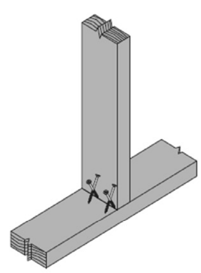
Walls



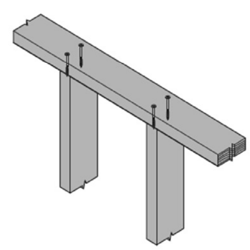
Double Top Plate at Corners



Double Top Plate Laps (Face Screw)



Stud to Sole Plate (Toe Screw)



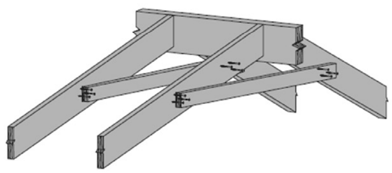
Top or Sole Plate to Stud (End Screw)

Connection Application	Fastener Quantities			
	IRC		IBC	
	Nails per Table R602.3 (1)	Equivalent SDWS Framing Screws	Nails per Table 2304.10.1	Equivalent SDWS Framing Screws
Top or sole plate to stud (end screw)	(2) 16d box	(2) SDWS16212	(2) 16d common	(2) SDWS16300
Stud to sole plate (toe screw)	(2) 16d box	(2) SDWS16212	(4) 8d common	(4) SDWS16212
Double top plate laps (face screw)	(8) 16d box	(8) SDWS16212	(8) 16d common	(8) SDWS16300
Double top plate at corners and intersections (face screw)	(2) 10d box	(2) SDWS16212	(2) 16d common	(2) SDWS16212
Double studs (face screw)	10d box 24" o.c.	SDWS16212 24" o.c.	16d box 24" o.c.	SDWS16300 24" o.c.

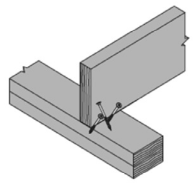
Residential Details
IRC & IBC

Ceiling

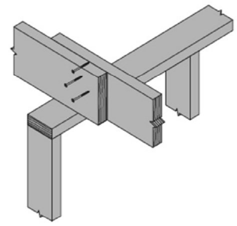
Ceiling



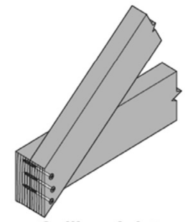
Collar Tie to Rafter (Face Screw)



Ceiling Joist to Plate (Toe Screw)



Ceiling Joist, Laps Over Partitions (Face Screw)



Ceiling Joist to Parallel Rafter (Face Screw)

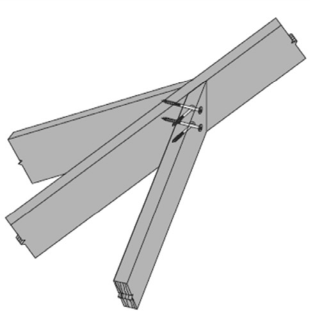
Connection Application	Fastener Quantities			
	IRC		IBC	
	Nails per Table R602.3 (1) and R802.5.2	Equivalent SDWS Framing Screws	Nails per Table 2304.10.1	Equivalent SDWS Framing Screws
Ceiling joist to plate (toe screw)	(3) 8d box	(3) SDWS16212	(3) 8d common	(3) SDWS16212
Ceiling joists, lap over partitions (face screw)	(3 min*) 10d box	(3 min*) SDWS16212	(3 min*) 16d common	(3 min*) SDWS16300
Collar tie to rafter (face screw)	(3) 10d box	(3) SDWS16212	(3) 10d common	(3) SDWS16300
Ceiling joist to parallel rafters (face screw)	(3) 16d common*	(3) SDWS16300*	(3 min*) 16d common	(3 min*) SDWS16300

*Quantities vary based on project conditions. The SDWS16300 is a 1-for-1 replacement for 16d common nails.

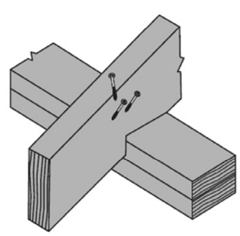
Residential Details
IRC & IBC

Roof

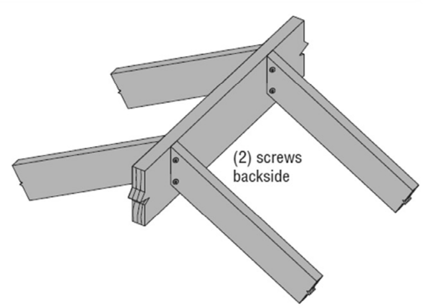
Roof



Jack Rafter to Hip (Toe Screw)



Roof Rafter to Plate (Toe Screw)



Roof Rafter to 2x Ridge Board (Toe Screw)

Connection Application	Fastener Quantities			
	IRC		IBC	
	Nails per Table R602.3 (1)	Equivalent SDWS Framing Screws	Nails per Table 2304.10.1	Equivalent SDWS Framing Screws
Roof rafter to plate (toe screw)	(3) 10d common	(3) SDWS16212	(3) 8d common	(3) SDWS16212
Roof rafter to 2x ridge board (toe screw)	(4) 16d box	(4) SDWS16212	(2) 16d common	(2) SDWS16300
Jack rafter to hip (toe screw)	(4) 16d box	(4) SDWS16212	(3) 10d common	(3) SDWS16300

Simpson Strong-Tie Connectors

Framing Details