MECHANICAL CONNECTIONS

10.1 General

10.1.1 Scope

10.1.1.1 Chapter 10 applies to the engineering design of connections using bolts, lag screws, split ring or shear plate connectors, drift bolts, drift pins, wood screws, nails, spikes, timber rivets, metal connector plates or spike grids in sawn lumber, glued laminated timber, timber poles, timber piles, structural composite lumber, prefabricated wood I-joists, and wood structural panels. Except where specifically limited elsewhere herein, the provisions of Chapter 10 shall apply to all fastener types covered in Chapters 11, 12 and 13.

10.1.1.2 The requirements of 3.1.3, 3.1.4 and 3.1.5 shall be accounted for in the design of connections.

10.1.1.3 Connection design provisions in Chapters 10, 11, 12 and 13 shall not preclude the use of connections where it is demonstrated by analysis based on generally recognized theory, full scale or prototype loading tests, studies of model analogues or extensive experience in use that the connections will perform satisfactorily in their intended end uses (see 1.1.1.3).

10.1.2 Stresses in Members at Connections

Structural members shall be checked for load carrying capacity at connections in accordance with all applicable provisions of this standard including 3.1.2, 3.1.3 and 3.4.3.3. Local stresses in connections using multiple fasteners shall be checked in accordance with principles of engineering mechanics. One method for determining these stresses is provided in Appendix E.

10.1.3 Eccentric Connections

Eccentric connections that induce tension stress perpendicular to grain in the wood shall not be used unless appropriate engineering procedures or tests are employed in the design of such connections to insure that all applied loads will be safely carried by the members and connections. Connections similar to those in Figure 10A are examples of connections requiring appropriate engineering procedures or tests.

10.1.4 Mixed Fastener Connections

Methods of analysis and test data for establishing design values for connections made with more than one type of fastener have not been developed. Design values for mixed fastener connections shall be based on tests or other analysis (see 1.1.1.3).

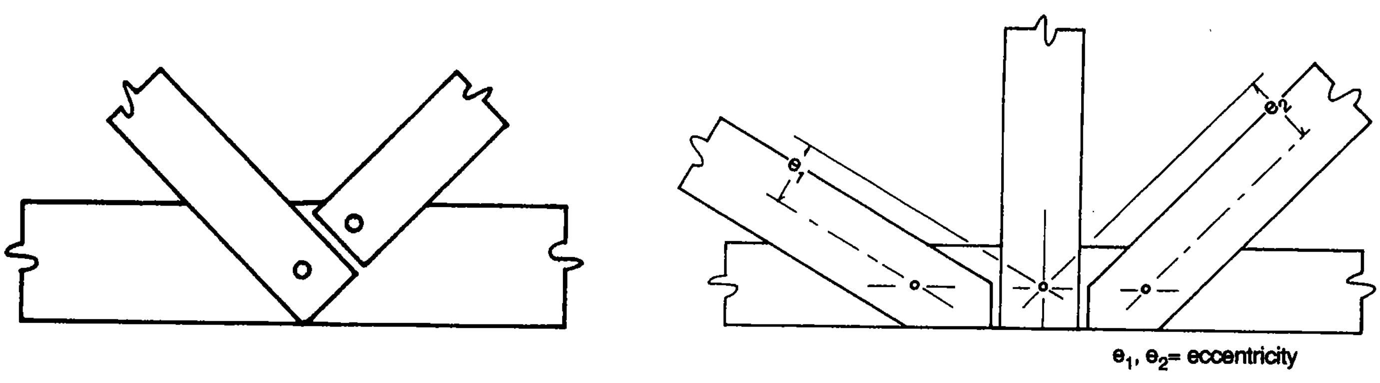
10.1.5 Connection Fabrication

Nominal lateral design values for connections in Chapters 11, 12 and 13 are based on:

(a) the assumption that the faces of the members are brought into contact when the fasteners are installed, and

(b) allowance for member shrinkage due to seasonal variations in moisture content (see 10.3.3).

Figure 10A Eccentric Connections



10.2 Design Values

10.2.1 Single Fastener Connections

10.2.1.1 Chapters 11, 12 and 13 contain tabulated nominal design values and design provisions for calculating nominal design values for various types of single fastener connections. Design values for connections in a given species apply to all grades of that species unless otherwise indicated. Dowel-type fastener connection design values for one species of wood are also applicable to other species having the same or higher dowel bearing strength, F_e.

10.2.1.2 Design provisions and nominal design values for dowel type fastener connections such as bolts, lag screws, wood screws, nails and spikes, drift bolts and drift pins are provided in Chapter 11.

10.2.1.3 Design provisions and nominal design values for split ring and shear plate connections are provided in Chapter 12.

10.2.1.4 Design provisions and nominal design values for timber rivet connections are provided in Chapter 13.

10.2.1.5 Wood-to wood connections involving spike grids for load transfer shall be designed in accordance with principles of engineering mechanics (see Reference 50 for additional information)

10.2.1.6 Metal plate connected wood truss construction shall be designed in accordance with ANSI/TPI 1.

10.2.2 Multiple Fastener Connections

When a connection contains two or more fasteners of the same type and similar size, each of which exhibits the same yield mode (see Appendix I), the total allowable design value for the connection shall be the sum of the allowable design values for each individual fastener

10.2.3 Design of Metal Parts

Metal plates, hangers, fasteners and other metal parts shall be designed in accordance with applicable metal design procedures to resist failure in tension, shear, bearing (metal on metal), bending and buckling (see References 39, 40 and 41). When the capacity of a connection is controlled by metal strength, rather than wood strength, allowable metal strength shall not be multiplied by the adjustment factors in this Specification. In addition, metal strength shall not be increased by wind and earthquake factors if design loads have already been reduced by load combination factors (see Reference 5 for additional information).

10.2.4 Design of Concrete or Masonry Parts

Concrete footers, walls and other concrete or masonry parts shall be designed in accordance with accepted practices (see References 1 and 2). When the capacity of a connection is controlled by concrete or masonry strength, rather than wood strength, allowable concrete or masonry strength shall not be multiplied by the adjustment factors in this Specification. In addition, concrete or masonry strength shall not be increased by wind and earthquake factors if design loads have already been reduced by load combination factors (see Reference 5 for additional information).

10.3 Adjustment of Design Values

10.3.1 Applicability of Adjustment Factors

Nominal design values (Z, W) shall be multiplied by all applicable adjustment factors to determine allowable design values (Z', W'). Table 10.3.1 specifies the adjustment factors which apply to nominal lateral design values (Z) and nominal withdrawal design values (W) for each fastener type. The actual load applied to a connection shall not exceed the allowable design value (Z', W') for the connection.

10.3.2 Load Duration Factor, C_D

Nominal 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/ma-

Table 10.3.1 Applicability of Adjustment Factors for Connections

		Load Duration Factor[1]	Wet Service Factor[2]	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]
Lateral Loads											
Dowel-type Fasteners	Z' = Z x	C_D	C_M	C_t	C_g	C_Δ	-	C_{eg}	-	C_{di}	C_{tn}
Split Ring and Shear Plate Connectors	P' = P x	C_D	C_M	C_t	C_g	C_Δ	C_d	-	C_{st}	-	-
	Q' = Q x	C_D	C_M	C_t	C_g	C_Δ	C_d	-	-	-	-
Timber Rivets	P' = P x	C_D^{4}	C_M	C_t	-	-	-	-	C_{st}^{5}	-	-
	Q' = Q x	C_D^{4}	C_M	C_t	-	C_Δ^{6}	-	-	C_{st}^{5}	-	-
Metal Plate Connectors	Z' = Z x	C_D	C_M	C_t	-	-	-	-	-	-	-
Spike Grids	Z' = Z x	C_D	C_M	C_t	-	C_Δ	-	-	-	-	-
Withdrawal Loads											
Nails, Spikes, Lag Screws, Wood Screws, and Drift Pins	W' = W x	C_D	C_M	C_t	-	-	-	C_{eg}	-	-	C_{tn}

1. The load duration factor, C_D, shall not exceed 1.6 for connections (see 10.3.2).
2. The wet service factor, C_M, shall not apply to toe-nails loaded in withdrawal (see 11.5.4.1).
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 11, 12 and 13.
4. The load duration factor, C_D, is only applied when wood capacity (P_w, Q_w) controls (see Chapter 13).
5. The metal side plate factor, C_{st}, is only applied when rivet capacity (P_r, Q_r) controls (see Chapter 13).
6. The geometry factor, C_Δ, is only applied when wood capacity, Q_w, controls (see Chapter 13).

sonry (see 10.2.3, 10.2.4 and Appendix B.3). The impact load duration factor shall not apply to connections.

10.3.3 Wet Service Factor, C_M

Nominal design values are for connections in wood seasoned to a moisture content of 19% or less and used under continuously dry conditions, as in most covered structures. For connections in wood that is unseasoned or partially seasoned, or when connections are exposed to wet service conditions in use, nominal design values shall be multiplied by the wet service factors, C_M, specified in Table 10.3.3.

10.3.4 Temperature Factor, C_t

Nominal design values shall be multiplied by the temperature factors, C_t, in Table 10.3.4 for connections that will experience sustained exposure to elevated temperatures up to 150°F (see Appendix C).

10.3.5 Fire Retardant Treatment

Allowable design values for connections in lumber and structural glued laminated timber pressure-treated with fire retardant chemicals shall be obtained from the company providing the treatment and redrying service (see 2.3.4). The impact load duration factor shall not apply to connections in wood pressure-treated with fire retardant chemicals (see Table 2.3.2).

Table 10.3.3 Wet Service Factors, C_M, for Connections

Fastener Type	Moisture Content: At Time of Fabrication	Moisture Content: In-Service	C_M
Lateral Loads			
Shear Plates & Split Rings[1]	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.8
	any	> 19%	0.7
Metal Connector Plates[2]	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.8
	any	> 19%	0.7
Dowel-type Fasteners	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.4[3]
	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	≤ 19%	≤ 19%	1.0
	> 19%	≤ 19%	0.25
	≤ 19%	> 19%	0.25
	> 19%	> 19%	1.0
Threaded Hardened Nails	any	any	1.0

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. For more information on metal connector plates see reference 9.
3. C_M = 0.7 for dowel type fasteners with diameter, D, less than 1/4". 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,

   C_M = 1.0.

Table 10.3.4 Temperature Factors, C_t, for Connections

In Service Moisture Conditions[1]	C_t: T≤100°F	C_t: 100°F<T≤125°F	C_t: 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 10.3.3.

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MECHANICAL CONNECTIONS

10.3.6 Group Action Factor, C_g

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

$$C_g = \left[\frac{m(1-m^{2n})}{n\left[(1+R_{EA}m^n)(1+m)-1+m^{2n}\right]}\right]\left[\frac{1+R_{EA}}{1-m}\right] \quad (10.3\text{-}1)$$

where:

C_g = 1.0 for dowel type fasteners with $D < 1/4"$. Nominal design values for timber rivet connections account for group action effects and do not require further modification by the group action factor.

n = number of fasteners in a row

R_{EA} = the lesser of $\frac{E_s A_s}{E_m A_m}$ or $\frac{E_m A_m}{E_s A_s}$

E_m = modulus of elasticity of main member, psi

E_s = modulus of elasticity of side members, psi

A_m = gross cross-sectional area of main member, in.^{2}

A_s = sum of gross cross-sectional areas of side members, in.^{2}

$m = u - \sqrt{u^2 - 1}$

$u = 1 + \gamma \frac{s}{2}\left[\frac{1}{E_m A_m} + \frac{1}{E_s A_s}\right]$

s = center to center spacing between adjacent fasteners in a row, in.

γ = load/slip modulus for a connection, lbs./in.

γ = 500,000 lbs./in. for 4" split ring or shear plate connectors

γ = 400,000 lbs./in. for 2-1/2" split ring or 2-5/8" shear plate connectors

$\gamma = (180{,}000)(D^{1.5})$ for dowel-type fasteners in wood-to-wood connections

$\gamma = (270{,}000)(D^{1.5})$ for dowel-type fasteners in wood-to-metal connections

D = diameter of bolt or lag screw, in.

Group action factors for various connection geometries are provided in Tables 10.3.6A, 10.3.6B, 10.3.6C and 10.3.6D.

10.3.6.2 For determining group action factors, a row of fasteners is defined as any of the following:

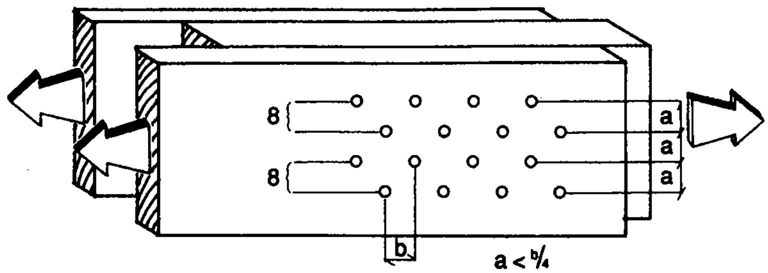
(a) Two or more split rings or shear plate connector units, as defined in 12.1.1, aligned with the direction of load.

(b) Two or more dowel-type fasteners of the same diameter loaded in single or multiple shear and aligned with the direction of load.

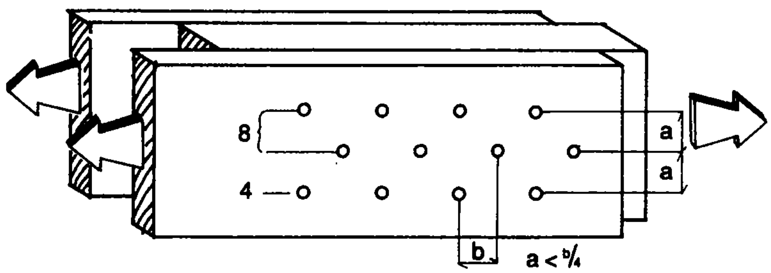
When fasteners in adjacent rows are staggered and the distance between adjacent rows is less than 1/4 the distance between the closest fasteners in adjacent rows measured parallel to the rows, the adjacent rows shall be considered as one row for purposes of determining group action factors. For groups of fasteners having an even number of rows, this principle shall apply to each pair of rows. For groups of fasteners having an odd number of rows, the most conservative interpretation shall apply (see Figure 10B).

10.3.6.3 Gross section areas shall be used, with no reductions for net section, when calculating A_m and A_s for determining group action factors. When a member is loaded perpendicular to grain its equivalent cross-sectional area shall be the product of the thickness of the member and the overall width of the fastener group (see Figure 10B). When only one row of fasteners is used, the width of the fastener group shall be the minimum parallel to grain spacing of the fasteners.

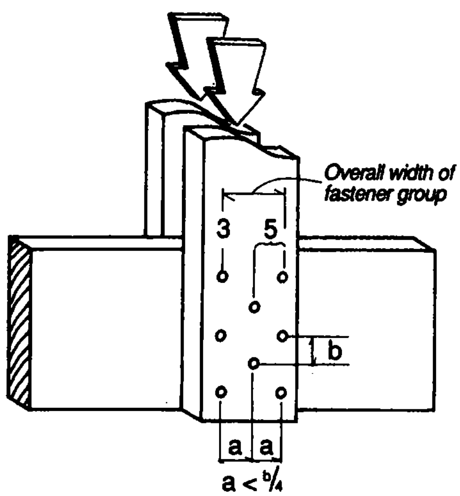
Figure 10B Group Action for Staggered Fasteners



Consider as 2 rows of 8 fasteners



Consider as 1 row of 8 fasteners and 1 row of 4 fasteners



Consider as 1 row of 5 fasteners and 1 row of 3 fasteners

Table 10.3.6A 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}	Number of fasteners in a row										
		2	3	4	5	6	7	8	9	10	11	12
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. When $A_s/A_m > 1.0$, 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.

Table 10.3.6B Group Action Factors, C_g, for 4" Split Ring or Shear Plate Connectors With Wood Side Members[2]

For s = 9", E = 1,400,000 psi

A_s/A_m[1]	A_s[1] in.^{2}	Number of fasteners in a row										
		2	3	4	5	6	7	8	9	10	11	12
0.5	5	0.90	0.73	0.59	0.48	0.41	0.35	0.31	0.27	0.25	0.22	0.20
	12	0.95	0.83	0.71	0.60	0.52	0.45	0.40	0.36	0.32	0.29	0.27
	20	0.97	0.88	0.78	0.69	0.60	0.53	0.47	0.43	0.39	0.35	0.32
	28	0.97	0.91	0.82	0.74	0.66	0.59	0.53	0.48	0.44	0.40	0.37
	40	0.98	0.93	0.86	0.79	0.72	0.65	0.59	0.54	0.49	0.45	0.42
	64	0.99	0.95	0.91	0.85	0.79	0.73	0.67	0.62	0.58	0.54	0.50
1	5	1.00	0.87	0.72	0.59	0.50	0.43	0.38	0.34	0.30	0.28	0.25
	12	1.00	0.93	0.83	0.72	0.63	0.55	0.48	0.43	0.39	0.36	0.33
	20	1.00	0.95	0.88	0.79	0.71	0.63	0.57	0.51	0.46	0.42	0.39
	28	1.00	0.97	0.91	0.83	0.76	0.69	0.62	0.57	0.52	0.47	0.44
	40	1.00	0.98	0.93	0.87	0.81	0.75	0.69	0.63	0.58	0.54	0.50
	64	1.00	0.98	0.95	0.91	0.87	0.82	0.77	0.72	0.67	0.62	0.58

1. When $A_s/A_m > 1.0$, use A_m/A_s and use A_m instead of A_s.
2. Tabulated group action factors (C_g) are conservative for 2-1/2" split ring connectors, 2-5/8" shear plate connectors, s < 9" or E > 1,400,000 psi.

Table 10.3.6C Group Action Factors, C_g, for Bolt or Lag Screw Connections With Steel Side Plates[1]

For D = 1", s = 4", E_{wood} = 1,400,000 psi, E_{steel} = 30,000,000 psi

A_m/A_s	A_m in²	Number of fasteners in a row										
		2	3	4	5	6	7	8	9	10	11	12
12	5	0.97	0.89	0.80	0.70	0.62	0.55	0.49	0.44	0.40	0.37	0.34
	8	0.98	0.93	0.85	0.77	0.70	0.63	0.57	0.52	0.47	0.43	0.40
	16	0.99	0.96	0.92	0.86	0.80	0.75	0.69	0.64	0.60	0.55	0.52
	24	0.99	0.97	0.94	0.90	0.85	0.81	0.76	0.71	0.67	0.63	0.59
	40	1.00	0.98	0.96	0.94	0.90	0.87	0.83	0.79	0.76	0.72	0.69
	64	1.00	0.99	0.98	0.96	0.94	0.91	0.88	0.86	0.83	0.80	0.77
	120	1.00	0.99	0.99	0.98	0.96	0.95	0.93	0.91	0.90	0.87	0.85
	200	1.00	1.00	0.99	0.99	0.98	0.97	0.96	0.95	0.93	0.92	0.90
18	5	0.99	0.93	0.85	0.76	0.68	0.61	0.54	0.49	0.44	0.41	0.37
	8	0.99	0.95	0.90	0.83	0.75	0.69	0.62	0.57	0.52	0.48	0.44
	16	1.00	0.98	0.94	0.90	0.85	0.79	0.74	0.69	0.65	0.60	0.56
	24	1.00	0.98	0.96	0.93	0.89	0.85	0.80	0.76	0.72	0.68	0.64
	40	1.00	0.99	0.97	0.95	0.93	0.90	0.87	0.83	0.80	0.77	0.73
	64	1.00	0.99	0.98	0.97	0.95	0.93	0.91	0.89	0.86	0.83	0.81
	120	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.93	0.92	0.90	0.88
	200	1.00	1.00	0.99	0.99	0.98	0.98	0.97	0.96	0.95	0.94	0.92
24	40	1.00	0.99	0.97	0.95	0.93	0.89	0.86	0.83	0.79	0.76	0.72
	64	1.00	0.99	0.98	0.97	0.95	0.93	0.91	0.88	0.85	0.83	0.80
	120	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.93	0.91	0.90	0.88
	200	1.00	1.00	0.99	0.99	0.98	0.98	0.97	0.96	0.95	0.93	0.92
30	40	1.00	0.98	0.96	0.93	0.89	0.85	0.81	0.77	0.73	0.69	0.65
	64	1.00	0.99	0.97	0.95	0.93	0.90	0.87	0.83	0.80	0.77	0.73
	120	1.00	0.99	0.99	0.97	0.96	0.94	0.92	0.90	0.88	0.85	0.83
	200	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.92	0.90	0.89
35	40	0.99	0.97	0.94	0.91	0.86	0.82	0.77	0.73	0.68	0.64	0.60
	64	1.00	0.98	0.96	0.94	0.91	0.87	0.84	0.80	0.76	0.73	0.69
	120	1.00	0.99	0.98	0.97	0.95	0.92	0.90	0.88	0.85	0.82	0.79
	200	1.00	0.99	0.99	0.98	0.97	0.95	0.94	0.92	0.90	0.88	0.86
42	40	0.99	0.97	0.93	0.88	0.83	0.78	0.73	0.68	0.63	0.59	0.55
	64	0.99	0.98	0.95	0.92	0.88	0.84	0.80	0.76	0.72	0.68	0.64
	120	1.00	0.99	0.97	0.95	0.93	0.90	0.88	0.85	0.81	0.78	0.75
	200	1.00	0.99	0.98	0.97	0.96	0.94	0.92	0.90	0.88	0.85	0.83
50	40	0.99	0.96	0.91	0.85	0.79	0.74	0.68	0.63	0.58	0.54	0.51
	64	0.99	0.97	0.94	0.90	0.85	0.81	0.76	0.72	0.67	0.63	0.59
	120	1.00	0.98	0.97	0.94	0.91	0.88	0.85	0.81	0.78	0.74	0.71
	200	1.00	0.99	0.98	0.96	0.95	0.92	0.90	0.87	0.85	0.82	0.79

1. Tabulated group action factors (C_g) are conservative for D < 1" or s < 4".

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Table 10.3.6D Group Action Factors, C_g, for 4" Shear Plate Connectors With Steel Side Plates[1]

For $s = 9"$, $E_{wood} = 1{,}400{,}000$ psi, $E_{steel} = 30{,}000{,}000$ psi

A_m/A_s	A_m in²	Number of fasteners in a row										
		2	3	4	5	6	7	8	9	10	11	12
12	5	0.91	0.75	0.60	0.50	0.42	0.36	0.31	0.28	0.25	0.23	0.21
	8	0.94	0.80	0.67	0.56	0.47	0.41	0.36	0.32	0.29	0.26	0.24
	16	0.96	0.87	0.76	0.66	0.58	0.51	0.45	0.40	0.37	0.33	0.31
	24	0.97	0.90	0.82	0.73	0.64	0.57	0.51	0.46	0.42	0.39	0.35
	40	0.98	0.94	0.87	0.80	0.73	0.66	0.60	0.55	0.50	0.46	0.43
	64	0.99	0.96	0.91	0.86	0.80	0.74	0.69	0.63	0.59	0.55	0.51
	120	0.99	0.98	0.95	0.91	0.87	0.83	0.79	0.74	0.70	0.66	0.63
	200	1.00	0.99	0.97	0.95	0.92	0.89	0.85	0.82	0.79	0.75	0.72
18	5	0.97	0.83	0.68	0.56	0.47	0.41	0.36	0.32	0.28	0.26	0.24
	8	0.98	0.87	0.74	0.62	0.53	0.46	0.40	0.36	0.32	0.30	0.27
	16	0.99	0.92	0.82	0.73	0.64	0.56	0.50	0.45	0.41	0.37	0.34
	24	0.99	0.94	0.87	0.78	0.70	0.63	0.57	0.51	0.47	0.43	0.39
	40	0.99	0.96	0.91	0.85	0.78	0.72	0.66	0.60	0.55	0.51	0.47
	64	1.00	0.97	0.94	0.89	0.84	0.79	0.74	0.69	0.64	0.60	0.56
	120	1.00	0.99	0.97	0.94	0.90	0.87	0.83	0.79	0.75	0.71	0.67
	200	1.00	0.99	0.98	0.96	0.94	0.91	0.89	0.86	0.82	0.79	0.76
24	40	1.00	0.96	0.91	0.84	0.77	0.71	0.65	0.59	0.54	0.50	0.46
	64	1.00	0.98	0.94	0.89	0.84	0.78	0.73	0.68	0.63	0.58	0.54
	120	1.00	0.99	0.96	0.94	0.90	0.86	0.82	0.78	0.74	0.70	0.66
	200	1.00	0.99	0.98	0.96	0.94	0.91	0.88	0.85	0.82	0.78	0.75
30	40	0.99	0.93	0.86	0.78	0.70	0.63	0.57	0.52	0.47	0.43	0.40
	64	0.99	0.96	0.90	0.84	0.78	0.71	0.66	0.60	0.56	0.51	0.48
	120	0.99	0.98	0.94	0.90	0.86	0.81	0.76	0.71	0.67	0.63	0.59
	200	1.00	0.98	0.96	0.94	0.91	0.87	0.83	0.79	0.76	0.72	0.68
35	40	0.98	0.91	0.83	0.74	0.66	0.59	0.53	0.48	0.43	0.40	0.36
	64	0.99	0.94	0.88	0.81	0.73	0.67	0.61	0.56	0.51	0.47	0.43
	120	0.99	0.97	0.93	0.88	0.82	0.77	0.72	0.67	0.62	0.58	0.54
	200	1.00	0.98	0.95	0.92	0.88	0.84	0.80	0.76	0.71	0.68	0.64
42	40	0.97	0.88	0.79	0.69	0.61	0.54	0.48	0.43	0.39	0.36	0.33
	64	0.98	0.92	0.84	0.76	0.69	0.62	0.56	0.51	0.46	0.42	0.39
	120	0.99	0.95	0.90	0.85	0.78	0.72	0.67	0.62	0.57	0.53	0.49
	200	0.99	0.97	0.94	0.90	0.85	0.80	0.76	0.71	0.67	0.62	0.59
50	40	0.95	0.86	0.75	0.65	0.56	0.49	0.44	0.39	0.35	0.32	0.30
	64	0.97	0.90	0.81	0.72	0.64	0.57	0.51	0.46	0.42	0.38	0.35
	120	0.98	0.94	0.88	0.81	0.74	0.68	0.62	0.57	0.52	0.48	0.45
	200	0.99	0.96	0.92	0.87	0.82	0.77	0.71	0.66	0.62	0.58	0.54

1. Tabulated group action factors (C_g) are conservative for 2-5/8" shear plate connectors or $s < 9"$.

DOWEL-TYPE FASTENERS

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

11

11.1 General

11.1.1 Terminology

11.1.1.1 "Edge distance" is the distance from the edge of a member to the center of the nearest fastener, measured perpendicular to grain. When a member is loaded perpendicular to grain, the loaded edge shall be defined as the edge in the direction toward which the fastener is acting. The unloaded edge shall be defined as the edge opposite the loaded edge (see Figure 11G).

11.1.1.2 "End distance" is the distance measured parallel to grain from the square-cut end of a member to the center of the nearest bolt (see Figure 11G).

11.1.1.3 "Spacing" is the distance between centers of fasteners measured along a line joining their centers (see Figure 11G).

11.1.1.4 A "row of fasteners" is defined as two or more fasteners aligned with the direction of load (see Figure 11G).

11.1.1.5 End distance, edge distance and spacing requirements herein are based on wood properties. Wood-to-metal and wood-to-concrete connections are subject to placement provisions as shown in 11.5.1, however, applicable end and edge distance and spacing requirements for metal and concrete, also apply (see 10.2.3 and 10.2.4).

11.1.2 Bolts

11.1.2.1 Installation requirements apply to bolts meeting requirements of ANSI/ASME Standard B18.2.1.

11.1.2.2 Holes shall be a minimum of 1/32" to a maximum of 1/16" larger than the bolt diameter. Holes shall be accurately aligned in main members and side plates. Bolts shall not be forcibly driven.

11.1.2.3 A metal plate, metal strap, or washer not less than a standard cut washer shall be between the wood and the bolt head and between the wood and the nut.

11.1.2.4 Edge distance, end distance, and fastener spacing required to develop full design values shall be in accordance with Table 11.5.1A-D.

11.1.3 Lag Screws

11.1.3.1 Installation requirements apply to lag screws meeting requirements of ANSI/ASME Standard B18.2.1. See Appendix L for lag screw dimensions.

11.1.3.2 Lead holes for lag screws loaded laterally and in withdrawal shall be bored as follows to avoid splitting of the wood member during connection fabrication:

(a) The clearance hole for the shank shall have the same diameter as the shank, and the same depth of penetration as the length of unthreaded shank.

(b) The lead hole for the threaded portion shall have a diameter equal to 65% to 85% of the shank diameter in wood with $G > 0.6$, 60% to 75% in wood with $0.5 < G \leq 0.6$, and 40% to 70% in wood with $G \leq 0.5$ (see Table 11.3.2A) and a length equal to at least the length of the threaded portion. The larger percentile in each range shall apply to lag screws of greater diameters.

11.1.3.3 Lead holes or clearance holes shall not be required for 3/8" and smaller diameter lag screws loaded primarily in withdrawal in wood with $G \leq 0.5$ (see Table 11.3.2A), provided that edge distances, end distances and spacing are sufficient to prevent unusual splitting.

11.1.3.4 The threaded portion of the lag screw shall be inserted in its lead hole by turning with a wrench, not by driving with a hammer.

11.1.3.5 No reduction to design values is anticipated if soap or other lubricant is used on the lag screw or in the lead holes to facilitate insertion and to prevent damage to the lag screw.

11.1.3.6 Minimum penetration (not including the length of the tapered tip) of the lag screw into the main member for single shear connections or the side member for double shear connections shall be four times the diameter, $p_{min} = 4D$.

11.1.3.7 Edge distance, end distance and fastener spacing required to develop full design values shall be in accordance with Table 11.5.1A-E.

11.1.4 Wood Screws

11.1.4.1 Installation requirements apply to wood screws meeting requirements of ANSI/ASME Standard B18.6.1.

11.1.4.2 Lead holes for wood screws loaded in withdrawal shall have a diameter equal to approximately 90% of the wood screw root diameter in wood with $G > 0.6$, and approximately 70% of the wood screw root diameter in wood with $0.5 < G \leq 0.6$. Wood with $G \leq 0.5$ (see Table 11.3.2A) is not required to have a lead hole for insertion of wood screws.

11.1.4.3 Lead holes for wood screws loaded laterally shall be bored as follows:

(a) For wood with G > 0.6 (see Table 11.3.2A), the part of the lead hole receiving the shank shall have about the same diameter as the shank and that receiving the threaded portion shall have about the same diameter as the screw at the root of the thread (see Reference 8).

(b) For G ≤ 0.6 (see Table 11.3.2A), the part of the lead hole receiving the shank shall be about 7/8 the diameter of the shank and that receiving the threaded portion shall be about 7/8 the diameter of the screw at the root of the thread (see Reference 8).

11.1.4.4 The wood screw shall be inserted in its lead hole by turning with a screw driver or other tool, not by driving with a hammer.

11.1.4.5 No reduction to design values is anticipated if soap or other lubricant is used on the wood screw or in the lead holes to facilitate insertion and to prevent damage to the wood screw.

11.1.4.6 Minimum penetration of the wood screw into the main member for single shear connections or the side member for double shear connections shall be six times the diameter, p_{min} = 6D.

11.1.4.7 Edge distances, end distances and spacings shall be sufficient to prevent splitting of the wood.

11.1.5 Nails and Spikes

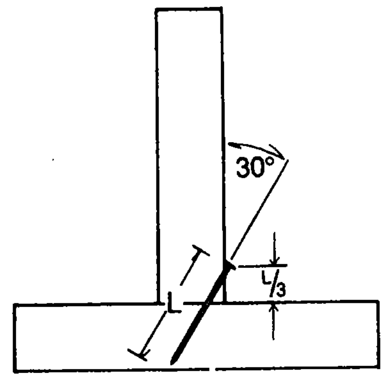
11.1.5.1 Installation requirements apply to common steel wire nails and spikes, box nails and threaded hardened-steel nails meeting requirements in ASTM F1667. Nail specifications for engineered construction shall include the minimum lengths and diameters for the nails and spikes to be used.

11.1.5.2 Threaded, hardened-steel nails and spikes shall be made of high carbon steel wire, headed, pointed, annularly or helically threaded, and heat-treated and tempered to provide greater yield strength than for common wire nails of corresponding size.

11.1.5.3 Nominal design values herein apply to nailed and spiked connections either with or without bored holes. When a bored hole is desired to prevent splitting of wood, the diameter of the bored hole shall not exceed 90% of the nail or spike diameter for wood with G > 0.6, nor 75% of the nail or spike diameter for wood with G ≤ 0.6 (see Table 11.3.2A).

11.1.5.4 Toe-nails shall be driven at an angle of approximately 30° with the member and started approximately 1/3 the length of the nail from the member end (see Figure 11A).

Figure 11A Toe-Nail Connection



11.1.5.5 Minimum penetration of the nail or spike into the main member for single shear connections or the side member for double shear connections shall be six times the diameter, p_{min} = 6D.

> **Exception:** Symmetric double shear connections when 12d or smaller nails extend at least three diameters beyond the side member and are clinched, and side members are at least 3/8" thick.

11.1.5.6 Edge distances, end distances and spacings shall be sufficient to prevent splitting of the wood.

11.1.6 Drift Bolts and Drift Pins

11.1.6.1 Lead holes shall be drilled 0" to 1/32" smaller than the actual pin diameter.

11.1.6.2 Additional penetration of pin into members shall be provided in lieu of the washer, head and nut on a common bolt (see References 52 and 53 for additional information).

11.1.6.3 Edge distance, end distance, and fastener spacing required to develop full design values shall be in accordance with Table 11.5.1A-D.

11.1.7 Other Dowel-Type Fasteners

When fastener type or connection fabrication and assembly requirements vary from those specified in 11.1.2, 11.1.3, 11.1.4, 11.1.5 and 11.1.6, provisions of 11.3 shall be permitted to be used in calculation of nominal lateral design values provided allowance is made to account for such variation. Edge distances, end distances and spacings shall be sufficient to prevent splitting of the wood.

11.2 Withdrawal Design Values

11.2.1 Lag Screws

11.2.1.1 The withdrawal design values, in lbs./in. of penetration, for a single lag screw inserted in side grain, with the lag screw axis perpendicular to the wood fibers, shall be determined from Table 11.2A or Equation 11.2-1, within the range of specific gravities and screw diameters given in Table 11.2A. Tabulated nominal design values, W, shall be multiplied by all applicable adjustment factors (see Table 10.3.1) to obtain allowable design values, W'.

$$W = 1800 G^{3/2} D^{3/4} \qquad (11.2\text{-}1)$$

11.2.1.2 When lag screws are loaded in withdrawal from end grain, nominal withdrawal design values, W, shall be multiplied by the end grain factor, $C_{eg} = 0.75$.

11.2.1.3 When lag screws are loaded in withdrawal, the allowable tensile strength of the lag screw at the net (root) section shall not be exceeded (see 10.2.3).

Table 11.2A Lag Screw Withdrawal Design Values (W)[1]

Tabulated withdrawal design values (W) are in pounds per inch of thread penetration into side grain of main member. Length of thread penetration in main member shall not include the length of the tapered tip (see Appendix L).

Specific Gravity G	Lag Screw Unthreaded Shank Diameter, D										
	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"	3/4"	7/8"	1"	1-1/8"	1-1/4"
0.73	397	469	538	604	668	789	905	1016	1123	1226	1327
0.71	381	450	516	579	640	757	868	974	1077	1176	1273
0.68	357	422	484	543	600	709	813	913	1009	1103	1193
0.67	349	413	473	531	587	694	796	893	987	1078	1167
0.58	281	332	381	428	473	559	641	719	795	869	940
0.55	260	307	352	395	437	516	592	664	734	802	868
0.51	232	274	314	353	390	461	528	593	656	716	775
0.50	225	266	305	342	378	447	513	576	636	695	752
0.49	218	258	296	332	367	434	498	559	617	674	730
0.47	205	242	278	312	345	408	467	525	580	634	686
0.46	199	235	269	302	334	395	453	508	562	613	664
0.44	186	220	252	283	312	369	423	475	525	574	621
0.43	179	212	243	273	302	357	409	459	508	554	600
0.42	173	205	235	264	291	344	395	443	490	535	579
0.41	167	198	226	254	281	332	381	428	473	516	559
0.40	161	190	218	245	271	320	367	412	455	497	538
0.39	155	183	210	236	261	308	353	397	438	479	518
0.38	149	176	202	227	251	296	340	381	422	461	498
0.37	143	169	194	218	241	285	326	367	405	443	479
0.36	137	163	186	209	231	273	313	352	389	425	460
0.35	132	156	179	200	222	262	300	337	373	407	441
0.31	110	130	149	167	185	218	250	281	311	339	367

1. Tabulated withdrawal design values (W) for lag screw connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).

11.2.2 Wood Screws

11.2.2.1 The withdrawal design value, in lb./in. of penetration, for a single wood screw (cut thread or rolled thread) inserted in side grain, with the wood screw axis perpendicular to the wood fibers, shall be determined from Table 11.2B or Equation 11.2-2, within the range of specific gravities and screw diameters given in Table 11.2B. Nominal design values, W, shall be multiplied by all applicable adjustment factors (see Table 10.3.1) to obtain allowable design values, W'.

$$W = 2850\, G^2 D \qquad (11.2\text{-}2)$$

11.2.2.2 Wood screws shall not be loaded in withdrawal from end grain of wood.

11.2.2.3 When wood screws are loaded in withdrawal, the allowable tensile strength of the wood screw at net (root) section shall not be exceeded (see 10.2.3).

11.2.3 Nails and Spikes

11.2.3.1 The withdrawal design value, in lb./in. of penetration, for a single nail or spike driven in the side grain of the main member, with the nail or spike axis perpendicular to the wood fibers, shall be determined from Table 11.2C or Equation 11.2-3, within the range of specific gravities and nail or spike diameters given in Table 11.2C. Nominal design values, W, shall be multiplied by all applicable adjustment factors (see Table 10.3.1) to obtain allowable design values, W'.

$$W = 1380\, G^{5/2} D \qquad (11.2\text{-}3)$$

11.2.3.2 Nails and spikes shall not be loaded in withdrawal from end grain of wood.

11.2.4 Drift Bolts and Drift Pins

Drift bolt and drift pin connections loaded in withdrawal shall be designed in accordance with principles of engineering mechanics.

Table 11.2B Cut Thread or Rolled Thread Wood Screw Withdrawal Design Values (W)[1]

Tabulated withdrawal design values (W) are in pounds per inch of thread penetration into side grain of main member. Thread length is approximately 2/3 the total wood screw length (see Appendix L).

Specific Gravity G	Wood Screw Number										
	6	7	8	9	10	12	14	16	18	20	24
0.73	209	229	249	268	288	327	367	406	446	485	564
0.68	181	199	216	233	250	284	318	352	387	421	489
0.58	132	144	157	169	182	207	232	256	281	306	356
0.51	102	112	121	131	141	160	179	198	217	237	275
0.49	94	103	112	121	130	147	165	183	201	219	254
0.46	83	91	99	107	114	130	146	161	177	193	224
0.43	73	79	86	93	100	114	127	141	155	168	196
0.41	66	72	78	85	91	103	116	128	141	153	178
0.39	60	65	71	77	82	93	105	116	127	138	161
0.37	54	59	64	69	74	84	94	104	114	125	145
0.35	48	53	57	62	66	75	84	93	102	111	130

1. Tabulated withdrawal design values (W) for wood screw connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).

Table 11.2C Nail and Spike Withdrawal Design Values (W)[1]

Tabulated withdrawal design values (W) are in pounds per inch of penetration into side grain of main member (see Appendix L).

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

1. Tabulated withdrawal design values (W) for nail or spike connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).

11.3 Lateral Design Values

11.3.1 Yield Limit Equations

For single shear and symmetric double shear connections using dowel-type fasteners (see Appendix I, Figure 11B and 11C) where:

(a) faces of the connected members are in contact
(b) the load acts perpendicular to the axis of the dowel
(c) edge distances, end distances and spacing are sufficient to develop full design values (see 11.5)
(d) the depth of fastener penetration in the main member for single shear connections or the side member holding the point for double shear connections is greater than or equal to the minimum penetration required (see 11.1)

The nominal design value, Z, shall be the minimum computed yield mode value using equations in Table 11.3.1A and B. Nominal design values for connections with bolts (see Tables 11A-I), lag screws (see Table 11J and K), wood screws (see Tables 11L and M) and nails and spikes (see Tables 11N-R) are calculated for common connection conditions in accordance with yield mode equations in Table 11.3.1A and B.

Table 11.3.1A Yield Limit Equations

Yield Mode	Single Shear		Double Shear	
I_m	$Z=\frac{D\ell_m F_{em}}{R_d}$	(11.3-1)	$Z=\frac{D\ell_m F_{em}}{R_d}$	(11.3-7)
I_s	$Z=\frac{D\ell_s F_{es}}{R_d}$	(11.3-2)	$Z=\frac{2D\ell_s F_{es}}{R_d}$	(11.3-8)
II	$Z=\frac{k_1 D\ell_s F_{es}}{R_d}$	(11.3-3)		
III_m	$Z=\frac{k_2 D\ell_m F_{em}}{(1+2R_e)R_d}$	(11.3-4)		
III_s	$Z=\frac{k_3 D\ell_s F_{em}}{(2+R_e)R_d}$	(11.3-5)	$Z=\frac{2k_3 D\ell_s F_{em}}{(2+R_e)R_d}$	(11.3-9)
IV	$Z=\frac{D^2}{R_d}\sqrt{\frac{2F_{em}F_{yb}}{3(1+R_e)}}$	(11.3-6)	$Z=\frac{2D^2}{R_d}\sqrt{\frac{2F_{em}F_{yb}}{3(1+R_e)}}$	(11.3-10)

Note:

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

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

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

D = diameter, in. (see 11.3.6)
F_{yb} = dowel bending yield strength, psi
R_d = reduction term (see Table 11.3.1B)
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 11.3.2)
F_{es} = side member dowel bearing strength, psi (see Table 11.3.2)

Table 11.3.1B Reduction Terms

Fastener Size	Yield Mode	Reduction Term, R_d
0.25" ≤ D ≤ 1"	I_m, I_s	4 K_θ
	II	3.6 K_θ
	III_m, III_s, IV	3.2 K_θ
D < 0.25"	I_m, I_s, II, III_m, III_s, IV	K_D[1]

Notes:

$K_\theta = 1 + 0.25(\theta/90)$

θ = maximum angle of load to grain (0° ≤ θ ≤ 90°) for any member in a connection

D = diameter, in. (see 11.3.6)

$K_D = 2.2$ for D ≤ 0.17"

$K_D = 10D + 0.5$ for 0.17" < D < 0.25"

[1] For threaded fasteners where nominal diameter (see Appendix L) is greater than or equal to 0.25" and root diameter is less than 0.25", $R_d = K_D K_\theta$.

11.3.2 Dowel Bearing Strength

11.3.2.1 Dowel bearing strengths, F_e, for parallel or perpendicular to grain loading are provided for dowel-type fasteners with 1/4" ≤ D ≤ 1" in Table 11.3.2. When fastener diameter, D < 1/4", a single dowel bearing strength, F_e, is used for both parallel and perpendicular to grain loading.

11.3.2.2 Dowel bearing strengths, F_e, for wood structural panels are provided in Table 11.3.2B.

11.3.2.3 Dowel bearing strengths, F_e, for structural composite lumber shall be obtained from the manufacturer's literature or code evaluation report.

11.3.2.4 When dowel-type fasteners with D ≥ 1/4" are inserted into the end grain of the main member, with the fastener axis parallel to the wood fibers, $F_{e\perp}$ shall be used in determination of the dowel bearing strength of the main member, F_{em}.

11.3.3 Dowel Bearing Strength at an Angle to Grain

When a member in a connection is loaded at an angle to grain, the dowel bearing strength, $F_{e\theta}$, for the member shall be determined as follows (see Appendix J):

$$F_{e\theta} = \frac{F_{e\parallel} F_{e\perp}}{F_{e\parallel} \sin^2\theta + F_{e\perp} \cos^2\theta}$$

where:

θ = angle between direction of load and direction of grain (longitudinal axis of member)

Figure 11B Single Shear Bolted Connection

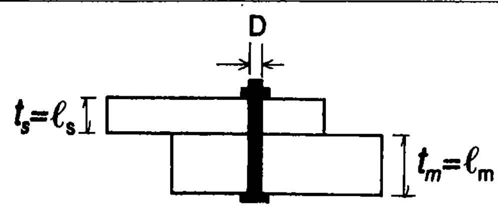
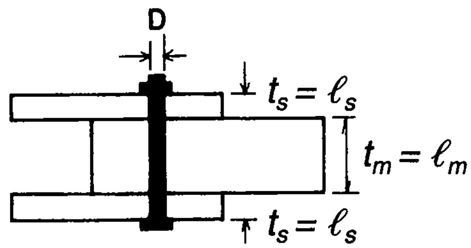


Figure 11C Double Shear Bolted Connections



11.3.4 Dowel Bearing Length

11.3.4.1 Dowel bearing length in the side member(s) and main member, ℓ_s and ℓ_m, represent the length of dowel bearing perpendicular to the application of load. The length of dowel bearing shall not include the tapered tip of a fastener for fastener penetration lengths less than 10D.

11.3.5 Dowel Bending Yield Strength

11.3.5.1 Tabulated nominal design values for bolts, lag screws, wood screws, nails and spikes are based on bending yield strengths provided in Tables 11A through 11R.

11.3.5.2 Dowel bending yield strengths, F_{yb}, used in calculation of nominal design values shall be based on yield strength derived using methods provided in ASTM F 1575 or the tensile yield strength derived using procedures of ASTM F 606.

11.3.6 Dowel Diameter

11.3.6.1 When used in Tables 11.3.1A and 11.3.1B, the fastener diameter shall be taken as D for unthreaded full-body fasteners and D_r for reduced body diameter fasteners or threaded fasteners except as provided in 11.3.6.2. For bolts defined in 11.1.2, the fastener diameter shall be taken as D (see Appendix L).

Table 11.3.2 Dowel Bearing Strengths

Specific[1] Gravity G	Dowel bearing strength in pounds per square inch (psi)[2]										
	Fe	Fe‖	Fe⊥								
	D<1/4"	D≥1/4"	D=1/4"	D=5/16"	D=3/8"	D=7/16"	D=1/2"	D=5/8"	D=3/4"	D=7/8"	D=1"
0.73	9300	8200	7750	6900	6300	5850	5450	4900	4450	4150	3850
0.72	9050	8050	7600	6800	6200	5750	5350	4800	4350	4050	3800
0.71	8850	7950	7400	6650	6050	5600	5250	4700	4300	3950	3700
0.70	8600	7850	7250	6500	5850	5500	5150	4600	4200	3900	3650
0.69	8400	7750	7100	6350	5800	5400	5050	4500	4100	3800	3550
0.68	8150	7600	6950	6250	5700	5250	4950	4400	4050	3750	3500
0.67	7950	7500	6850	6100	5550	5150	4850	4300	3950	3650	3400
0.66	7750	7400	6700	5950	5450	5050	4700	4200	3850	3550	3350
0.65	7500	7300	6550	5850	5350	4950	4600	4150	3750	3500	3250
0.64	7300	7150	6400	5700	5200	4850	4500	4050	3700	3400	3200
0.63	7100	7050	6250	5600	5100	4700	4400	3950	3600	3350	3100
0.62	6900	6950	6100	5450	5000	4600	4300	3850	3500	3250	3050
0.61	6700	6850	5950	5350	4850	4500	4200	3750	3450	3200	3000
0.60	6500	6700	5800	5200	4750	4400	4100	3700	3350	3100	2900
0.59	6300	6600	5700	5100	4650	4300	4000	3600	3300	3050	2850
0.58	6100	6500	5550	4950	4500	4200	3900	3500	3200	2950	2750
0.57	5900	6400	5400	4850	4400	4100	3800	3400	3100	2900	2700
0.56	5700	6250	5250	4700	4300	4000	3700	3350	3050	2800	2650
0.55	5550	6150	5150	4600	4200	3900	3650	3250	2950	2750	2550
0.54	5350	6050	5000	4450	4100	3750	3550	3150	2900	2650	2500
0.53	5150	5950	4850	4350	3950	3650	3450	3050	2800	2600	2450
0.52	5000	5800	4750	4250	3850	3550	3350	3000	2750	2550	2350
0.51	4800	5700	4600	4100	3750	3450	3250	2900	2650	2450	2300
0.50	4650	5600	4450	4000	3650	3400	3150	2800	2600	2400	2250
0.49	4450	5500	4350	3900	3550	3300	3050	2750	2500	2300	2150
0.48	4300	5400	4200	3750	3450	3200	3000	2650	2450	2250	2100
0.47	4150	5250	4100	3650	3350	3100	2900	2600	2350	2200	2050
0.46	4000	5150	3950	3550	3250	3000	2800	2500	2300	2100	2000
0.45	3800	5050	3850	3450	3150	2900	2700	2400	2200	2050	1900
0.44	3650	4950	3700	3300	3050	2800	2600	2350	2150	2000	1850
0.43	3500	4800	3600	3200	2950	2700	2550	2250	2050	1900	1800
0.42	3350	4700	3450	3100	2850	2600	2450	2200	2000	1850	1750
0.41	3200	4600	3350	3000	2750	2550	2350	2100	1950	1800	1650
0.40	3100	4500	3250	2900	2650	2450	2300	2050	1850	1750	1600
0.39	2950	4350	3100	2800	2550	2350	2200	1950	1800	1650	1550
0.38	2800	4250	3000	2700	2450	2250	2100	1900	1750	1600	1500
0.37	2650	4150	2900	2600	2350	2200	2050	1850	1650	1550	1450
0.36	2550	4050	2750	2500	2250	2100	1950	1750	1600	1500	1400
0.35	2400	3900	2650	2400	2150	2000	1900	1700	1550	1400	1350
0.34	2300	3800	2550	2300	2100	1950	1800	1600	1450	1350	1300
0.33	2150	3700	2450	2200	2000	1850	1750	1550	1400	1300	1200
0.32	2050	3600	2350	2100	1900	1750	1650	1500	1350	1250	1150
0.31	1900	3450	2250	2000	1800	1700	1600	1400	1300	1200	1100

1. Specific gravity based on weight and volume when oven-dry (see Table 11.3.2A). Different specific gravities (G) are possible for different grades of MSR and MEL lumber (see Table 4C, Footnote 2).
2. $F_{e\|} = 11200G$; $F_{e\perp} = 6100G^{1.45}\sqrt{D}$; F_e for D<1/4" = $16600\ G^{1.84}$; tabulated values are rounded to the nearest 50 psi.

$$F_{e\perp} = \frac{6100\,G^{1.45}}{\sqrt{D'}}$$

Example for D = 1/2" and G = 0.5 $F_{e\perp}$ = 3150 psi
for D = 1/4" and G = 0.73 $F_{e\perp}$ = 7,750 psi ✓

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Table 11.3.2A Assigned Specific Gravities

Species Combination	Specific[1] Gravity G
Aspen	0.39
Balsam Fir	0.36
Beech-Birch-Hickory	0.71
Coast Sitka Spruce	0.39
Cottonwood	0.41
Douglas Fir-Larch	0.50
Douglas Fir-Larch (North)	0.49
Douglas Fir-South	0.46
Eastern Hemlock	0.41
Eastern Hemlock-Balsam Fir	0.36
Eastern Hemlock-Tamarack	0.41
Eastern Hemlock-Tamarack (North)	0.47
Eastern Softwoods	0.36
Eastern Spruce	0.41
Eastern White Pine	0.36
Engelmann Spruce-Lodgepole Pine	0.38
Hem-Fir	0.43
Hem-Fir (North)	0.46
Mixed Maple	0.55
Mixed Oak	0.68
Mixed Southern Pine	0.51
Mountain Hemlock	0.47
Northern Pine	0.42
Northern Red Oak	0.68
Northern Species	0.35
Northern White Cedar	0.31
Ponderosa Pine	0.43
Red Maple	0.58
Red Oak	0.67
Red Pine	0.44
Redwood, close grain	0.44
Redwood, open grain	0.37
Sitka Spruce	0.43
Southern Pine	0.55
Spruce-Pine-Fir	0.42
Spruce-Pine-Fir (South)	0.36
Western Cedars	0.36
Western Cedars (North)	0.35
Western Hemlock	0.47
Western Hemlock (North)	0.46
Western White Pine	0.40
Western Woods	0.36
White Oak	0.73

Species Combinations of MSR and MEL Lumber	Specific[1] Gravity G
Douglas Fir-Larch	
E=1,900,000 psi and lower grades of MSR	0.50
E=2,000,000 psi grades of MSR	0.51
E=2,100,000 psi grades of MSR	0.52
E=2,200,000 psi grades of MSR	0.53
E=2,300,000 psi grades of MSR	0.54
E=2,400,000 psi grades of MSR	0.55
Engelmann Spruce-Lodgepole Pine	
1500f and lower grades of MSR	0.38
1650f and higher grades of MSR	0.46
Hem-Fir	
E=1,500,000 psi and lower grades of MSR	0.43
E=1,600,000 psi grades of MSR	0.44
E=1,700,000 psi grades of MSR	0.45
E=1,800,000 psi grades of MSR	0.46
E=1,900,000 psi grades of MSR	0.47
E=2,000,000 psi grades of MSR	0.48
E=2,100,000 psi grades of MSR	0.49
E=2,200,000 psi grades of MSR	0.50
E=2,300,000 psi grades of MSR	0.51
E=2,400,000 psi grades of MSR	0.52
Southern Pine	
E=1,700,000 psi and lower grades of MSR and MEL	0.55
E=1,800,000 psi and higher grades of MSR and MEL	0.57
Spruce-Pine-Fir	
E=1,700,000 psi and lower grades of MSR and MEL	0.42
E=1,800,000 psi and 1,900,000 psi grades of MSR and MEL	0.46
E=2,000,000 psi and higher grades of MSR and MEL	0.50

1. Specific gravity based on weight and volume when oven-dry. Different specific gravities (G) are possible for different grades of MSR and MEL lumber (see Table 4C, Footnote 2).

Table 11.3.2B Dowel Bearing Strengths for Wood Structural Panels

Wood Structural Panel	Specific[1] Gravity G	Dowel Bearing Strength, F_e, in Pounds Per Square Inch (psi)
Plywood		
Structural 1, Marine	0.50	4650
Other Grades[1]	0.42	3350
Oriented Strand Board		
All Grades	0.50	4650

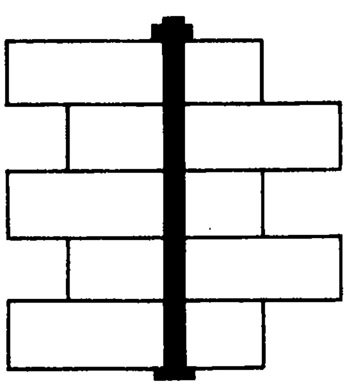
1. Use G = 0.42 when species of the plies is not known. When species of the plies is known, specific gravity listed for the actual species and the corresponding dowel bearing strength may be used, or the weighted average may be used for mixed species.

11.3.6.2 For threaded full-body fasteners (see Appendix L), D shall be permitted to be used in lieu of D_r when the bearing length of the threads does not exceed 1/4 of the full bearing length in the member holding the threads. Alternatively, a more detailed analysis accounting for the moment and bearing resistance of the threaded portion of the fastener shall be permitted (see Appendix I).

11.3.7 Asymmetric Three Member Connections, Double Shear

Nominal design values, Z, for asymmetric three member connections shall be the minimum computed yield mode value for symmetric double shear connections using the smaller dowel bearing length in the side member as ℓ_s and the minimum dowel diameter, D, occurring in either of the connection shear planes.

Figure 11D Multiple Shear Bolted Connection



11.3.8 Multiple Shear Connections

For a connection with four or more members (see Figure 11D), each shear plane shall be evaluated as a single shear connection. The nominal design value for the connection shall be the lowest nominal design value for any single shear plane, multiplied by the number of shear planes.

11.3.9 Load at an Angle to Fastener Axis

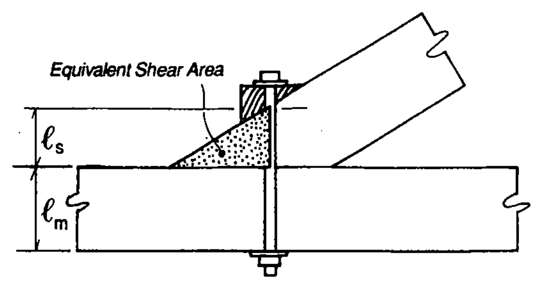
11.3.9.1 When the applied load in a single shear (two member) connection is at an angle (other than 90 degrees) with the fastener axis, the fastener lengths in the two members shall be designated ℓ_s and ℓ_m (see Figure 11E). The component of the load acting at 90° with the fastener axis shall not exceed the allowable design value, Z', for a connection in which two members at 90° with the fastener axis have thicknesses $t_s = \ell_s$ and $t_m = \ell_m$. Ample bearing area shall be provided to resist the load component acting parallel to the fastener axis.

11.3.9.2 For toe-nailed connections, use the minimum of t_s or L/3 for ℓ_s (see Figure 11A).

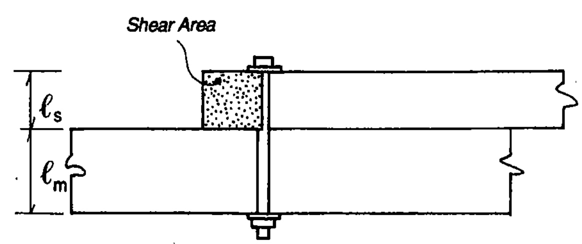
11.3.10 Drift Bolts and Drift Pins

Allowable lateral design values for drift bolts or drift pins driven in the side grain of wood shall not exceed 75% of the allowable lateral design values for common bolts of the same diameter and length in main member.

Figure 11E Shear Area for Bolted Connections



Angled member connection



Parallel member connection

11.4 Combined Lateral and Withdrawal Loads

11.4.1 Lag Screws and Wood Screws

When a lag screw or wood screw is subjected to combined lateral and withdrawal loading, as when the fastener is inserted perpendicular to the fiber and the load acts at an angle, α, to the wood surface (see Figure 11F), the allowable design value shall be determined as follows (see Appendix J):

$$Z'_{\alpha} = \frac{(W'p)Z'}{(W'p)\cos^2\alpha + Z'\sin^2\alpha}$$

where:

α = angle between wood surface and direction of applied load

p = length of thread penetration in main member, in.

11.4.2 Nails and Spikes

When a nail or spike is subjected to combined lateral and withdrawal loading, as when the nail or spike is inserted perpendicular to the fiber and the load acts at an angle, α, to the wood surface, the allowable design value shall be determined as follows:

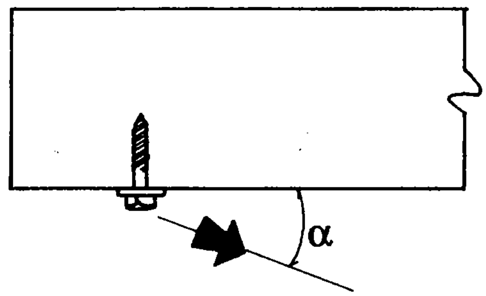
$$Z'_{\alpha} = \frac{(W'p)Z'}{(W'p)\cos\alpha + Z'\sin\alpha}$$

where:

α = angle between wood surface and direction of applied load

p = length of penetration in main member, in.

Figure 11F Combined Lateral and Withdrawal Loading



11.5 Adjustment of Design Values

11.5.1 Geometry Factor, C_Δ

11.5.1.1 When D < 1/4", C_Δ= 1.0.

11.5.1.2 When D ≥ 1/4" and the end distance or spacing provided for dowel-type fasteners is less than the minimum required for full design value, but greater than the minimum required for reduced design value, nominal design values shall be multiplied by the smallest applicable geometry factor, C_Δ, determined from the end distance and spacing requirements. The smallest geometry factor for any fastener in a group shall apply to all fasteners in the group. For multiple shear connections or for asymmetric three member connections, the smallest geometry factor, C_Δ, for any shear plane shall apply to all fasteners in the connection. Provisions for C_Δ are based on an assumption that edge distance and spacing between rows of fasteners is in accordance with Table 11.5.1A and Table 11.5.1D and applicable requirements of 11.1.

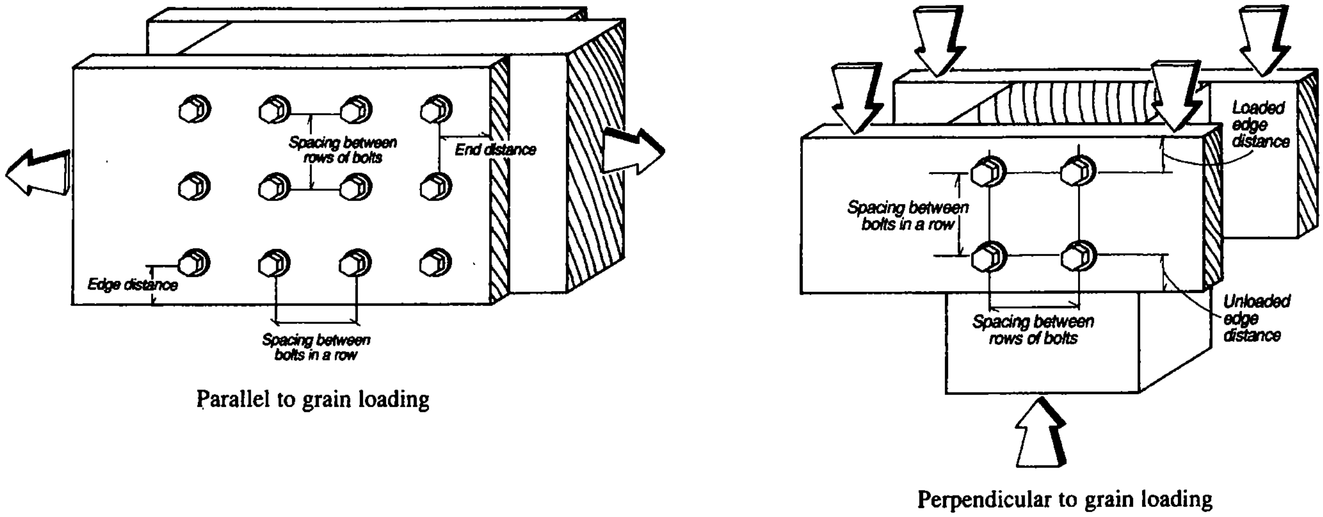
(a) When dowel-type fasteners are used and the actual end distance for parallel or perpendicu-

Table 11.5.1A Edge Distance Requirements[1,2]

Direction of Loading	Minimum Edge Distance
Parallel to Grain:	
when ℓ/D ≤ 6	1.5D
when ℓ/D > 6	1.5D or ½ the spacing between rows, whichever is greater
Perpendicular to Grain:	
loaded edge	4D
unloaded edge	1.5D

1. The ℓ/D ratio used to determine the minimum edge distance shall be the lesser of:
   (a) length of fastener in wood main member/D = ℓ_m/D
   (b) total length of fastener in wood side member(s)/D = ℓ_s/D
2. Heavy or medium concentrated loads shall not be suspended below the neutral axis of a single sawn lumber or glued laminated timber beam except where mechanical or equivalent reinforcement is provided to resist tension stresses perpendicular to grain (see 3.8.2 and 10.1.3).

Figure 11G Bolted Connection Geometry



lar to grain loading is greater than or equal to the minimum end distance (see Table 11.5.1B) for reduced design value, but less than the minimum end distance for full design value, the geometry factor, C_Δ, shall be determined as follows:

$$C_\Delta = \frac{\text{actual end distance}}{\text{minimum end distance for full design value}}$$

(b) For loading at an angle to the fastener, when dowel-type fasteners are used, the minimum shear area for full design value shall be equivalent to the shear area for a parallel member connection with minimum end distance for full design value (see Table 11.5.1B and Figure 11E). The minimum shear area for reduced design value shall be equivalent to ½ the minimum shear area for full design value. When the actual shear area is greater than or equal to the minimum shear area for reduced design value, but less than the minimum shear area for full design value, the geometry factor, C_Δ, shall be determined as follows:

$$C_\Delta = \frac{\text{actual shear area}}{\text{minimum shear area for full design value}}$$

Table 11.5.1B End Distance Requirements

Direction of Loading	Minimum End Distances, Design Value: Reduced	Minimum End Distances, Design Value: Full
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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(c) When 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 for reduced design value (see Table 11.5.1C), but less than the minimum spacing for full design value, the geometry factor, C_Δ, shall be determined as follows:

$$C_\Delta = \frac{\text{actual spacing}}{\text{minimum spacing for full design value}}$$

Table 11.5.1C Spacing Requirements for Fasteners in a Row

	Minimum Spacing	
Direction of Loading	Reduced Design Value	Full Design Value
Parallel to Grain	3D	4D
Perpendicular to Grain	3D	Required spacing for attached members

Table 11.5.1D Spacing Requirements Between Rows[1,2]

Direction of Loading	Minimum Spacing
Parallel to Grain	1.5D
Perpendicular to Grain:	
when $\ell/D \le 2$	2.5D
when $2 < \ell/D < 6$	$(5\ell + 10D)/8$
when $\ell/D \ge 6$	5D

1. The ℓ/D ratio used to determine the minimum spacing between rows shall be the lesser of:
   (a) length of fastener in wood main member/D = ℓ_m/D
   (b) total length of fastener in wood side member(s)/D = ℓ_s/D
2. The spacing between outer rows of fasteners paralleling the member on a single splice plate shall not exceed 5" (see Figure 11H).

11.5.2 End Grain Factor, C_{eg}

11.5.2.1 When lag screws are loaded in withdrawal from end grain, the nominal withdrawal design values, W, shall be multiplied by the end grain factor, $C_{eg} = 0.75$.

11.5.2.2 When dowel-type fasteners are inserted in the end grain of the main member, with the fastener axis parallel to the wood fibers, nominal lateral design values, Z, shall be multiplied by the end grain factor, $C_{eg} = 0.67$.

11.5.3 Diaphragm Factor, C_{di}

When nails or spikes are used in diaphragm construction, nominal lateral design values shall be multiplied by the diaphragm factor, $C_{di} = 1.1$.

11.5.4 Toe-Nail Factor, C_{tn}

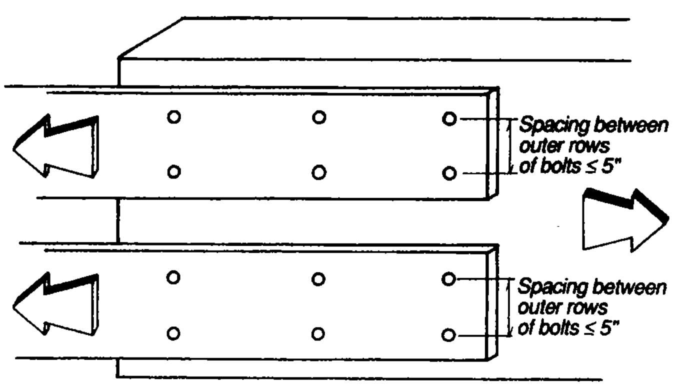
11.5.4.1 When toe-nailed connections are used, nominal withdrawal design values, W, for the nails or spikes shall be multiplied by the toe-nail factor, $C_{tn} = 0.67$. The wet service factor, C_M, shall not apply for toe-nails loaded in withdrawal.

11.5.4.2 When toe-nailed connections are used, nominal lateral design values, Z, shall be multiplied by the toe-nail factor, $C_{tn} = 0.83$.

Table 11.5.1E Edge and End Distance and Spacing Requirements for Lag Screws Loaded in Withdrawal and Not Loaded Laterally

Orientation	Minimum Distance/Spacing
Edge Distance	1.5D
End Distance	4D
Spacing	4D

Figure 11H Spacing Between Outer Rows of Bolts



11.6 Multiple Fasteners

11.6.1 When a connection contains multiple fasteners, fasteners shall be staggered symmetrically in members loaded perpendicular to grain whenever possible (see 3.1.2.2 and 10.3.6.2 for special design provisions when bolts, lag screws or drift pins are staggered).

11.6.2 When a multiple fastener connection is loaded at an angle to grain, the gravity axis of each member shall pass through the center of resistance of the group of fasteners to insure uniform stress in the main member and a uniform distribution of load to all fasteners.

BOLTS

Table 11A BOLTS: Design Values (Z) for Single Shear (two member) Connections[1,2]

for Sawn Lumber or SCL with both members of identical specific gravity

Thickness: Main Member t_m in.	Thickness: Side Member t_s in.	Bolt Diameter D in.	G=0.67 Red Oak $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.55 Mixed Maple Southern Pine $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.49 Douglas Fir-Larch (N) $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.46 Douglas Fir (S) Hem-Fir (N) $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.
1 1/2	1 1/2	1/2	650	420	420	330	530	330	330	250	480	300	300	220	470	290	290	210	440	270	270	190
		5/8	810	500	500	370	660	400	400	280	600	360	360	240	590	350	350	240	560	320	320	220
		3/4	970	580	580	410	800	460	460	310	720	420	420	270	710	400	400	260	670	380	380	240
		7/8	1130	660	660	440	930	520	520	330	850	470	470	290	830	460	460	280	780	420	420	250
		1	1290	740	740	470	1080	580	580	350	970	530	530	310	950	510	510	300	890	480	480	260
1 3/4	1 3/4	1/2	760	490	490	390	620	390	390	290	560	350	350	250	550	340	340	250	520	320	320	230
		5/8	940	590	590	430	770	470	470	330	700	420	420	280	690	410	410	280	650	380	380	250
		3/4	1130	680	680	480	930	540	540	360	850	480	480	310	830	470	470	300	780	440	440	280
		7/8	1320	770	770	510	1080	610	610	390	990	550	550	340	970	530	530	320	910	500	500	300
		1	1510	860	860	550	1240	680	680	410	1130	610	610	360	1110	600	600	350	1040	560	560	320
2 1/2	1 1/2	1/2	770	480	540	440	660	400	420	350	610	370	370	310	610	360	360	300	580	340	330	270
		5/8	1070	660	630	520	930	560	490	390	850	520	430	340	830	520	420	330	780	470	390	300
		3/4	1360	890	720	570	1120	660	560	430	1020	590	500	380	1000	560	480	360	940	520	450	330
		7/8	1590	960	800	620	1300	720	620	470	1190	630	550	410	1170	600	540	390	1090	550	500	360
		1	1820	1020	870	660	1490	770	680	490	1360	680	610	440	1330	650	590	420	1250	600	550	390
3 1/2	1 1/2	1/2	770	480	560	440	660	400	470	360	610	370	430	330	610	360	420	320	580	340	400	310
		5/8	1070	660	760	590	940	560	620	500	880	520	540	460	870	520	530	450	830	470	490	410
		3/4	1450	890	900	770	1270	660	690	580	1200	590	610	510	1190	560	590	490	1140	520	550	450
		7/8	1890	960	990	830	1680	720	770	630	1590	630	680	550	1570	600	650	530	1470	550	600	480
		1	2410	1020	1080	890	2010	770	830	670	1830	680	740	590	1790	650	710	560	1680	600	660	520
	1 3/4	1/2	830	510	590	480	720	420	510	390	670	380	470	350	660	380	460	340	620	360	440	320
		5/8	1160	680	820	620	1000	580	640	520	930	530	560	460	920	530	550	450	880	500	510	410
		3/4	1530	900	940	780	1330	770	720	580	1250	680	640	520	1240	660	620	500	1190	600	580	460
		7/8	1970	1120	1040	840	1730	840	810	640	1620	740	710	550	1590	700	690	530	1490	640	640	490
		1	2480	1190	1130	900	2030	890	880	670	1850	790	780	590	1820	750	760	570	1700	700	700	530
	3 1/2	1/2	830	590	590	530	750	520	520	460	720	490	490	430	710	480	480	420	690	460	460	410
		5/8	1290	880	880	780	1170	780	780	650	1120	700	700	560	1110	690	690	550	1070	650	650	500
		3/4	1860	1190	1190	950	1690	960	960	710	1610	870	870	630	1600	850	850	600	1540	800	800	560
		7/8	2640	1410	1410	1030	2170	1160	1160	780	1970	1060	1060	680	1940	1040	1040	650	1810	990	990	[illegible]
		1	3020	1870	1870	1100	2480	1360	1360	820	2260	1230	1230	720	2210	1190	1190	690	2070	1110	1110	640
5 1/4	1 1/2	5/8	1070	660	760	590	940	560	640	500	880	520	590	460	870	520	590	450	830	470	560	430
		3/4	1450	890	990	780	1270	660	850	660	1200	590	790	590	1190	560	780	560	1140	520	740	520
		7/8	1890	960	1260	960	1680	720	1060	720	1590	630	940	630	1570	600	900	600	1520	550	830	550
		1	2410	1020	1500	1020	2160	770	1140	770	2050	680	1010	680	2030	650	970	650	1930	600	910	600
	1 3/4	5/8	1160	680	820	620	1000	580	690	520	930	530	630	470	920	530	630	470	880	500	590	440
		3/4	1530	900	1050	800	1330	770	890	680	1250	680	830	630	1240	660	810	620	1190	600	780	590
		7/8	1970	1120	1320	1020	1730	840	1090	840	1640	740	960	740	1620	700	920	700	1550	640	850	640
		1	2480	1190	1530	1190	2200	890	1170	890	2080	790	1040	790	2060	750	1000	750	1990	700	930	700
	3 1/2	5/8	1290	880	880	780	1170	780	780	680	1120	700	730	630	1110	690	720	620	1070	650	690	580
		3/4	1860	1190	1240	1080	1690	960	1090	850	1610	870	1030	780	1600	850	1010	750	1540	800	970	710
		7/8	2640	1410	1640	1260	2300	1160	1380	1000	2190	1060	1230	870	2170	1040	1190	840	2060	950	1100	770
		1	3310	1670	1940	1420	2870	1390	1620	1060	2660	1290	1360	940	2630	1260	1320	900	2500	1210	1230	890
5 1/2	1 1/2	5/8	1070	660	760	590	940	560	640	500	880	520	590	460	870	520	590	450	830	470	560	430
		3/4	1450	890	990	780	1270	660	850	660	1200	590	790	590	1190	560	780	560	1140	520	740	520
		7/8	1890	960	1260	960	1680	720	1090	720	1590	630	980	630	1570	600	940	600	1520	550	860	550
		1	2410	1020	1660	1020	2150	770	1190	770	2050	680	1060	680	2030	650	1010	650	1930	600	940	600
	3 1/2	5/8	1290	880	880	780	1170	780	780	680	1120	700	730	630	1110	690	720	620	1070	650	690	580
		3/4	1860	1190	1240	1080	1690	960	1090	850	1610	870	1030	780	1600	850	1010	750	1540	800	970	710
		7/8	2540	1410	1640	1260	2300	1160	1410	1020	2190	1060	1260	910	2170	1040	1220	870	2060	950	1160	790
		1	3310	1670	1980	1470	2870	1390	1550	1100	2660	1290	1390	970	2630	1260	1340	930	2500	1210	1250	860
7 1/2	1 1/2	5/8	1070	660	760	590	940	560	640	500	880	520	590	460	870	520	590	450	830	470	560	430
		3/4	1450	890	990	780	1270	660	850	660	1200	590	790	590	1190	560	780	560	1140	520	740	520
		7/8	1890	960	1260	960	1680	720	1090	720	1590	630	1010	630	1570	600	990	600	1520	550	950	550
		1	2410	1020	1660	1020	2160	770	1350	770	2050	680	1270	680	2030	650	1240	650	1930	600	1190	600
	3 1/2	5/8	1290	880	880	780	1170	780	780	680	1120	700	730	630	1110	690	720	620	1070	650	690	580
		3/4	1860	1190	1240	1080	1690	960	1090	850	1610	870	1030	780	1600	850	1010	750	1540	800	970	710
		7/8	2640	1410	1640	1280	2300	1160	1450	1020	2190	1060	1360	930	2170	1040	1340	[illegible]	2060	[illegible]	1240	[illegible]
		1	3310	1670	2090	1470	2870	1390	1830	1210	2660	1290	1630	1110	2630	1260	1610	1080	2500	1210	1470	1030

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi.

Table 11A (Cont.) BOLTS: Design Values (Z) for Single Shear (two member) Connections[1,2]

for Sawn Lumber or SCL with both members of identical specific gravity

Thickness Main Member t_m in.	Thickness Side Member t_s in.	Bolt Diameter D in.	G=0.43 Hem-Fir $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.42 Spruce-Pine-Fir $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.37 Redwood (open grain) $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.36 Eastern Softwoods, Spruce-Pine-Fir(S), Western Cedars, Western Woods $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.35 Northern Species $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.
1 1/2	1 1/2	1/2	410	250	250	180	410	240	240	170	360	210	210	140	350	200	200	130	340	200	200	130
		5/8	520	300	300	190	510	290	290	190	450	250	250	160	440	240	240	150	420	240	240	150
		3/4	620	350	350	210	610	340	340	210	540	290	290	170	520	280	280	170	500	270	270	160
		7/8	720	390	390	230	710	380	380	220	630	330	330	190	610	320	320	180	590	310	310	170
		1	830	440	440	250	810	430	430	240	720	370	370	200	700	360	360	190	670	350	360	190
1 3/4	1 3/4	1/2	480	290	290	210	470	280	280	200	420	250	250	170	410	240	240	160	390	230	230	150
		5/8	600	350	350	230	590	340	340	220	520	290	290	190	510	280	280	180	490	270	270	170
		3/4	720	400	400	250	710	390	390	240	630	340	340	200	610	330	330	190	590	320	320	190
		7/8	840	460	460	270	830	450	450	260	730	390	390	220	710	380	380	210	690	360	360	200
		1	970	510	510	280	950	500	500	280	840	430	430	230	820	420	420	230	790	410	410	220
2 1/2	1 1/2	1/2	550	320	310	250	540	320	300	240	500	290	250	200	490	280	240	190	470	280	240	180
		5/8	730	420	360	270	710	410	350	270	630	350	300	220	610	330	290	210	590	320	280	210
		3/4	870	460	410	300	850	450	400	290	750	370	340	240	740	360	330	230	710	350	320	230
		7/8	1020	500	450	320	1000	490	440	310	880	410	380	250	860	390	370	250	830	370	350	240
		1	1180	540	500	330	1140	530	490	320	1010	440	420	260	980	420	410	270	940	410	390	260
3 1/2	1 1/2	1/2	550	320	380	290	540	320	370	280	500	290	320	250	490	280	300	250	480	280	290	240
		5/8	790	420	440	370	780	410	430	360	720	350	370	300	710	330	350	290	700	320	340	280
		3/4	1100	460	500	400	1080	450	480	390	1010	370	410	320	990	360	400	310	950	350	380	300
		7/8	1370	500	560	430	1240	490	540	420	1180	410	460	350	1160	390	440	340	1110	370	420	320
		1	1570	540	600	470	1530	530	590	460	1350	440	500	380	1320	420	480	370	1270	410	470	350
	1 3/4	1/2	590	340	400	300	580	330	390	290	530	300	330	260	520	290	320	250	510	280	310	250
		5/8	840	480	460	370	820	470	450	360	760	400	390	310	740	380	370	290	730	370	360	280
		3/4	1130	540	520	410	1120	530	510	400	1030	430	430	330	1000	420	420	320	970	410	410	310
		7/8	1390	580	580	440	1380	570	570	430	1200	470	480	360	1170	460	470	350	1130	430	440	320
		1	1590	630	640	480	1550	610	630	460	1370	510	530	380	1340	490	520	370	1290	470	500	360
	3 1/2	1/2	660	440	440	390	660	430	430	380	620	400	400	330	610	390	390	310	600	380	380	310
		5/8	1040	600	600	450	1020	590	590	440	960	520	520	370	950	500	500	350	930	490	490	340
		3/4	1450	740	740	500	1420	730	730	480	1250	650	650	400	1220	630	630	390	1180	620	620	370
		7/8	1890	910	910	540	1860	890	890	520	1450	770	770	440	1430	750	750	420	1370	720	720	390
		1	1930	1030	1030	580	1890	1000	1000	560	1570	870	870	470	1530	840	840	450	1570	810	810	430
5 1/4	1 1/2	5/8	790	420	530	410	780	410	520	400	720	350	470	350	710	330	460	330	700	320	450	320
		3/4	1100	460	690	460	1080	450	670	450	1010	370	560	370	990	360	540	360	970	350	530	350
		7/8	1460	500	750	500	1440	490	740	490	1350	410	620	410	1330	390	600	390	1280	370	580	370
		1	1800	540	820	540	1760	530	800	530	1560	440	670	440	1520	420	650	420	1460	410	630	410
	1 3/4	5/8	840	480	560	410	820	470	550	410	760	400	500	370	740	380	480	360	730	370	470	350
		3/4	1130	540	700	540	1120	530	680	530	1040	430	570	430	1020	420	560	420	1000	410	540	410
		7/8	1490	580	770	580	1470	570	750	570	1370	470	640	470	1350	460	620	460	1320	430	600	430
		1	1910	630	850	630	1890	610	820	610	1760	510	690	510	1740	490	670	490	1700	470	650	470
	3 1/2	5/8	1040	600	660	530	1020	590	650	520	960	520	610	460	960	500	590	440	930	490	580	430
		3/4	1490	740	900	640	1480	730	880	620	1390	650	750	520	1370	630	730	500	1330	620	710	480
		7/8	1950	920	1010	690	1920	910	990	670	1740	820	850	560	1710	800	830	550	1650	770	790	510
		1	2370	1140	1130	750	2330	1120	1100	730	2120	1020	940	600	2080	980	910	580	2030	950	880	560
5 1/2	1 1/2	5/8	790	420	530	410	780	410	520	400	720	350	470	350	710	330	460	330	700	320	450	320
		3/4	1100	460	700	460	1080	450	690	450	1010	370	580	370	990	360	570	360	970	350	550	350
		7/8	1460	500	780	500	1440	490	760	490	1350	410	650	410	1330	390	630	390	1280	370	590	370
		1	1800	540	860	540	1760	530	830	530	1560	440	700	440	1520	420	680	420	1460	410	650	410
	3 1/2	5/8	1040	600	660	530	1020	590	650	520	960	520	610	460	950	500	590	440	930	490	580	430
		3/4	1490	740	920	650	1480	730	900	640	1390	650	770	530	1370	630	750	520	1330	620	720	500
		7/8	1950	920	1030	720	1920	910	1010	700	1740	820	870	590	1710	800	850	570	1650	770	800	550
		1	2370	1140	1150	780	2330	1120	1120	760	2120	1020	950	630	2080	980	920	600	2030	950	890	580
7 1/2	1 1/2	5/8	790	420	530	410	780	410	520	400	720	350	470	350	710	330	460	330	700	320	450	320
		3/4	1100	460	700	460	1080	450	690	450	1010	370	630	370	990	360	620	360	970	350	600	350
		7/8	1460	500	900	500	1440	490	890	490	1360	410	810	410	1330	390	800	390	1280	370	770	370
		1	1800	540	1130	540	1760	530	1110	530	1560	440	920	440	1520	420	890	420	1460	410	860	410
	3 1/2	5/8	1040	600	660	530	1020	590	650	520	960	520	610	460	950	500	590	440	930	490	580	430
		3/4	1490	740	920	650	1480	730	910	640	1390	650	840	560	1370	630	820	550	1330	620	810	540
		7/8	1950	920	1210	790	1920	910	1180	740	1740	820	1010	700	1710	800	980	680	1650	780	920	650
		1	2370	1140	1640	970	2330	1120	1600	950	2120	1020	1100	820	2080	980	1070	790	2030	950	1030	760

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi.

BOLTS

DOWEL-TYPE FASTENERS

11

BOLTS

Table 11B BOLTS: Design Values (Z) for Single Shear (two member) Connections[1,2]

for Sawn Lumber or SCL with 1/4" ASTM A36 steel side plate

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)		G=0.43 Hem-Fir		G=0.42 Spruce-Pine-Fir		G=0.37 Redwood (open grain)		G=0.36 Eastern Softwoods Spruce-Pine-Fir(S) Western Cedars Western Woods		G=0.35 Northern Species	
t_m	t_s	D	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$
in.	in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1 1/2	1/4	1/2	730	420	620	350	580	310	580	310	550	290	520	280	510	270	470	240	460	240	450	230
		5/8	910	480	780	400	730	360	720	360	690	340	650	320	640	320	590	290	580	280	560	270
		3/4	1090	550	940	450	870	420	860	410	820	390	780	360	770	360	710	320	690	320	680	310
		7/8	1270	600	1090	510	1020	470	1010	450	960	430	910	410	900	400	820	370	810	360	790	350
		1	1460	650	1250	550	1170	510	1150	500	1100	480	1040	450	1030	450	940	400	930	400	900	390
1 3/4	1/4	1/2	810	460	690	370	640	340	630	330	600	310	570	290	560	280	510	250	500	250	490	240
		5/8	1020	520	870	430	800	390	790	380	750	360	710	340	700	330	640	300	630	290	610	280
		3/4	1220	590	1040	480	960	440	950	430	900	410	860	380	840	370	770	330	750	330	730	320
		7/8	1420	650	1210	540	1130	490	1110	480	1050	460	1000	420	980	420	890	380	880	370	850	360
		1	1630	710	1380	580	1290	540	1270	520	1200	500	1140	470	1120	460	1020	410	1000	410	980	400
2 1/2	1/4	1/2	930	600	860	470	830	410	820	400	780	380	740	350	720	340	650	300	640	290	620	280
		5/8	1370	670	1150	530	1050	470	1040	470	980	430	920	400	910	390	810	340	800	330	770	320
		3/4	1640	750	1370	590	1270	530	1250	520	1180	490	1110	450	1090	440	980	380	960	370	930	360
		7/8	1910	820	1600	650	1480	590	1450	570	1370	530	1290	490	1270	480	1140	420	1120	410	1080	400
		1	2190	880	1830	700	1690	640	1680	620	1570	580	1480	540	1450	530	1300	460	1280	450	1240	440
3 1/2	1/4	1/2	930	620	860	550	830	510	820	510	800	480	770	450	770	430	720	370	720	360	710	350
		5/8	1370	860	1260	690	1210	610	1200	600	1160	550	1130	500	1120	490	1060	420	1050	410	1020	400
		3/4	1900	990	1740	760	1670	680	1660	660	1580	610	1480	560	1450	540	1290	460	1260	450	1220	440
		7/8	2530	1070	2170	840	1990	740	1950	710	1840	660	1720	610	1690	590	1510	510	1480	500	1430	470
		1	2980	1150	2480	890	2270	800	2230	770	2100	730	1970	660	1930	650	1720	560	1690	540	1630	530
5 1/4	1/4	5/8	1370	860	1260	760	1210	710	1200	700	1160	670	1130	640	1120	630	1060	580	1050	560	1030	540
		3/4	1900	1140	1740	1000	1670	940	1660	930	1610	860	1560	770	1550	760	1460	640	1450	620	1420	600
		7/8	2530	1460	2320	1190	2220	1050	2200	1010	2140	920	2070	840	2050	820	1940	700	1920	680	1890	640
		1	3260	1660	2980	1270	2860	1130	2840	1080	2750	1010	2670	920	2640	890	2490	750	2450	730	2360	710
5 1/2	1/4	5/8	1370	860	1260	760	1210	710	1200	700	1160	670	1130	640	1120	630	1060	580	1050	570	1030	560
		3/4	1900	1140	1740	1000	1670	940	1660	930	1610	890	1560	810	1550	790	1460	660	1450	640	1420	620
		7/8	2530	1460	2320	1240	2220	1090	2200	1050	2140	960	2070	880	2050	860	1940	730	1920	710	1890	660
		1	3260	1730	2980	1520	2860	1170	2840	1130	2750	1050	2670	950	2640	930	2490	780	2470	760	2420	740
7 1/2	1/4	5/8	1370	860	1260	760	1210	710	1200	700	1160	670	1130	640	1120	630	1060	580	1050	570	1030	560
		3/4	1900	1140	1740	1000	1670	940	1660	930	1610	890	1560	850	1550	840	1460	760	1450	750	1420	740
		7/8	2530	1460	2320	1280	2220	1210	2200	1180	2140	1130	2070	1080	2050	1070	1940	960	1920	930	1890	870
		1	3260	1820	2980	1590	2860	1500	2840	1470	2750	1400	2670	1270	2640	1230	2490	1030	2470	1000	2420	960
9 1/2	1/4	3/4	1900	1140	1740	1000	1670	940	1660	930	1610	890	1560	850	1550	840	1460	760	1450	750	1420	740
		7/8	2530	1460	2320	1280	2220	1210	2200	1180	2140	1130	2070	1080	2050	1070	1940	980	1920	970	1890	930
		1	3260	1820	2980	1590	2860	1500	2840	1470	2750	1420	2670	1350	2640	1330	2490	1220	2470	1200	2420	1180
11 1/2	1/4	7/8	2530	1460	2320	1280	2220	1210	2200	1180	2140	1130	2070	1080	2050	1070	1940	980	1920	970	1890	930
		1	3260	1820	2980	1590	2860	1500	2840	1470	2750	1420	2670	1350	2640	1330	2490	1220	2470	1200	2420	1180
13 1/2	1/4	1	3260	1820	2980	1590	2860	1500	2840	1470	2750	1420	2670	1350	2640	1330	2490	1220	2470	1200	2420	1180

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi and dowel bearing strength (F_e) of 87,000 psi for ASTM A36 steel.

Table 11C BOLTS: Design Values (Z) for Single Shear (two member) Connections[1,2]

for Glued Laminated Timber main member with sawn lumber side member of identical specific gravity

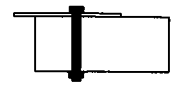
Thickness: Main Member t_m in.	Thickness: Side Member t_s in.	Bolt Diameter D in.	G=0.55 Southern Pine $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.46 Douglas Fir(S) $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.43 Hem-Fir $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.42 Spruce-Pine-Fir $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.	G=0.36 Spruce-Pine-Fir(S) Western Woods $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	$Z_{\perp}$ lbs.
2 1/2	1 1/2	1/2	-	-	-	-	610	370	370	310	580	340	330	270	550	320	310	250	540	320	300	240	490	280	240	190
		5/8	-	-	-	-	850	520	430	340	780	470	390	300	730	420	360	270	710	410	350	270	610	330	290	210
		3/4	-	-	-	-	1020	590	500	380	940	520	450	330	870	460	410	300	850	450	400	290	740	360	330	230
		7/8	-	-	-	-	1190	630	550	410	1090	550	500	360	1020	500	450	320	1000	490	440	310	860	390	370	250
		1	-	-	-	-	1360	680	610	440	1250	600	550	390	1160	540	500	350	1100	530	490	340	980	420	410	270
3	1 1/2	1/2	660	400	470	360	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/8	940	560	550	460	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/4	1270	660	620	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8	1520	720	690	540	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1	1740	770	750	580	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3 1/8	1 1/2	1/2	-	-	-	-	610	370	430	330	580	340	390	310	550	320	360	290	540	320	340	280	490	280	280	230
		5/8	-	-	-	-	880	520	500	410	830	470	450	370	790	420	410	330	780	410	400	320	710	330	330	260
		3/4	-	-	-	-	1200	590	570	460	1130	520	510	410	1060	460	460	360	1040	450	450	350	890	360	370	280
		7/8	-	-	-	-	1440	630	630	490	1320	550	560	430	1230	500	510	390	1210	490	500	380	1040	390	410	310
		1	-	-	-	-	1640	680	690	530	1510	600	620	470	1410	540	560	420	1380	530	550	410	1190	420	450	330
5	1 1/2	5/8	940	560	640	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/4	1270	660	850	660	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8	1680	720	1020	720	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1	2150	770	1100	770	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5 1/8	1 1/2	5/8	-	-	-	-	880	520	590	460	830	470	560	430	790	420	530	410	780	410	520	400	710	330	460	330
		3/4	-	-	-	-	1200	590	790	590	1140	520	740	520	1100	460	670	460	1080	450	660	450	990	360	530	360
		7/8	-	-	-	-	1590	630	920	630	1520	550	810	550	1460	500	740	500	1440	490	720	490	1330	390	590	390
		1	-	-	-	-	2050	680	990	680	1930	600	890	600	1800	540	810	540	1760	530	780	530	1520	420	640	420
6 3/4	1 1/2	5/8	940	560	640	500	880	520	590	460	830	470	560	430	790	420	530	410	780	410	520	400	710	330	460	330
		3/4	1270	660	850	660	1200	590	790	590	1140	520	740	520	1100	460	700	460	1080	450	690	450	990	360	620	360
		7/8	1680	720	1090	720	1590	630	1010	630	1520	550	950	550	1460	500	900	500	1440	490	890	490	1330	390	750	390
		1	2150	770	1350	770	2050	680	1270	680	1930	600	1140	600	1800	540	1030	540	1760	530	1000	530	1520	420	840	420

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi.

BOLTS

Table 11D BOLTS: Design Values (Z) for Single Shear (two member) Connections[1,2]

for Glued Laminated Timber with 1/4" ASTM A36 steel side plate

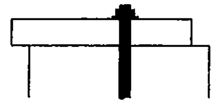


Thickness: Main Member t_m in.	Thickness: Side Member t_s in.	Bolt Diameter D in.	G=0.55 Southern Pine $Z_{\parallel}$ lbs.		G=0.50 Douglas Fir-Larch $Z_{\parallel}$ lbs.		G=0.46 Douglas Fir(S) Hem-Fir(N) $Z_{\parallel}$ lbs.		G=0.43 Hem-Fir $Z_{\parallel}$ lbs.		G=0.42 Spruce-Pine-Fir $Z_{\parallel}$ lbs.		G=0.36 Spruce-Pine-Fir(S) Western Woods $Z_{\parallel}$ lbs.	
			$Z_{\parallel}$ lbs.	$Z_{\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{\perp}$ lbs.	$Z_{\parallel}$ lbs.	$Z_{\perp}$ lbs.
2 1/2	1/4	1/2	-	-	830	410	780	380	740	350	720	340	640	290
		5/8	-	-	1050	470	980	430	920	400	910	390	800	330
		3/4	-	-	1270	530	1180	490	1110	450	1090	440	960	370
		[redacted]												
3	1/4	1/2	860	540	-	-	-	-	-	-	-	-	-	-
		5/8	1260	610	-	-	-	-	-	-	-	-	-	-
		3/4	1610	670	-	-	-	-	-	-	-	-	-	-
		[redacted]												
3 1/8	1/4	1/2	-	-	830	490	800	440	770	410	770	400	720	330
		5/8	-	-	1210	550	1160	500	1110	460	1090	450	960	380
		3/4	-	-	1540	620	1420	560	1340	510	1310	500	1150	420
		[redacted]												
5	1/4	5/8	1260	760	-	-	-	-	-	-	-	-	-	-
		3/4	1740	1000	-	-	-	-	-	-	-	-	-	-
		[redacted]												
5 1/8	1/4	5/8	-	-	1210	710	1160	670	1130	640	1120	630	1050	550
		3/4	-	-	1670	940	1610	840	1560	760	1550	740	1450	610
		[redacted]												
6 3/4	1/4	5/8	1260	760	1210	710	1160	670	1130	640	1120	630	1050	570
		3/4	1740	1000	1670	940	1610	890	1560	850	1550	840	1450	750
		[redacted]												
8 1/2	1/4	3/4	1740	1000	-	-	-	-	-	-	-	-	-	-
		7/8	2320	1280	-	-	-	-	-	-	-	-	-	-
		1	2980	1590	-	-	-	-	-	-	-	-	-	-
8 3/4	1/4	3/4	-	-	1670	940	1610	890	1560	850	1550	840	1450	750
		7/8	-	-	2220	1210	2140	1130	2070	1080	2050	1070	1920	970
		1	-	-	2860	1500	2750	1420	2670	1350	2640	1330	2470	1150
10 1/2	1/4	7/8	2320	1280	-	-	-	-	-	-	-	-	-	-
		1	2980	1590	-	-	-	-	-	-	-	-	-	-
10 3/4	1/4	7/8	-	-	2220	1210	2140	1130	2070	1080	2050	1070	1920	970
		1	-	-	2860	1500	2750	1420	2670	1350	2640	1330	2470	1200
12 1/4	1/4	7/8	-	-	2220	1210	2140	1130	2070	1080	2050	1070	1920	970
		1	-	-	2860	1500	2750	1420	2670	1350	2640	1330	2470	1200
14 1/4	1/4	1	-	-	2860	1500	2750	1420	2670	1350	2640	1330	2470	1200

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1)
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi and dowel bearing strength (F_e) of 87,000 psi for ASTM A36 steel.

Table 11E BOLTS: Design Values (Z) for Single Shear (two member) Connections[1,2,3,4]

for Sawn Lumber or SCL to concrete



Thickness: Embedment Depth in Concrete t_m in.	Thickness: Side Member t_s in.	Bolt Diameter D in.	G=0.67 Red Oak $Z_{\parallel}$ lbs.	G=0.67 Red Oak $Z_{\perp}$ lbs.	G=0.55 Mixed Maple Southern Pine $Z_{\parallel}$ lbs.	G=0.55 Mixed Maple Southern Pine $Z_{\perp}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\parallel}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\perp}$ lbs.	G=0.49 Douglas Fir-Larch (N) $Z_{\parallel}$ lbs.	G=0.49 Douglas Fir-Larch (N) $Z_{\perp}$ lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) $Z_{\parallel}$ lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) $Z_{\perp}$ lbs.
6.0 and greater	1 1/2	1/2	730	460	660	400	620	370	620	360	600	350
		5/8	1020	630	930	560	890	530	880	520	860	470
		3/4	1380	850	1270	660	1220	590	1210	560	1180	520
		7/8	1800	960	1670	720	1610	630	1600	600	1570	550
		1	2250	1020	2140	770	2060	680	2060	650	1930	600
	1 3/4	1/2	780	500	710	420	670	390	670	380	640	360
		5/8	1100	660	990	580	940	540	940	530	900	510
		3/4	1460	870	1330	770	1270	680	1260	660	1220	600
		7/8	1870	1120	1720	840	1660	740	1650	700	1610	640
		1	2360	1190	2190	890	2120	790	2100	760	2060	700
	2 1/2	1/2	760	560	760	510	730	460	720	450	710	430
		5/8	1220	770	1170	650	1140	600	1130	590	1080	560
		3/4	1760	970	1560	830	1480	780	1460	760	1410	730
		7/8	2190	1200	1960	1050	1870	990	1850	970	1790	920
		1	2670	1470	2420	1280	2310	1130	2290	1080	2220	1000
	3 1/2	1/2	780	550	750	520	780	490	720	490	710	470
		5/8	1220	850	1170	760	1140	710	1130	700	1110	660
		3/4	1760	1150	1680	950	1640	880	1630	860	1600	820
		7/8	2390	1370	2280	1160	2230	1070	2210	1050	2120	1000
		1	3130	1620	2850	1390	2700	1300	2670	1270	2570	1230

Thickness: Embedment Depth in Concrete t_m in.	Thickness: Side Member t_s in.	Bolt Diameter D in.	G=0.43 Hem-Fir $Z_{\parallel}$ lbs.	G=0.43 Hem-Fir $Z_{\perp}$ lbs.	G=0.42 Spruce-Pine-Fir $Z_{\parallel}$ lbs.	G=0.42 Spruce-Pine-Fir $Z_{\perp}$ lbs.	G=0.37 Redwood (open grain) $Z_{\parallel}$ lbs.	G=0.37 Redwood (open grain) $Z_{\perp}$ lbs.	G=0.36 Eastern Softwoods Spruce-Pine-Fir (S) Western Cedars Western Woods $Z_{\parallel}$ lbs.	G=0.36 Eastern Softwoods Spruce-Pine-Fir (S) Western Cedars Western Woods $Z_{\perp}$ lbs.	G=0.35 Northern Species $Z_{\parallel}$ lbs.	G=0.35 Northern Species $Z_{\perp}$ lbs.
6.0 and greater	1 1/2	1/2	570	330	570	330	530	300	520	290	510	290
		5/8	830	420	820	410	780	350	770	330	760	320
		3/4	1150	460	1140	450	1090	370	1080	360	1060	350
		7/8	1530	500	1520	490	1360	410	1330	390	1280	370
		1	1800	540	1780	530	1560	440	1520	420	1460	410
	1 3/4	1/2	620	350	610	340	570	310	560	300	550	300
		5/8	870	490	860	480	810	400	800	380	790	370
		3/4	1190	540	1170	530	1110	430	1100	420	1080	410
		7/8	1560	580	1550	570	1480	470	1460	460	1440	430
		1	2000	630	1990	610	1820	510	1770	490	1710	470
	2 1/2	1/2	700	400	690	390	670	350	670	340	660	330
		5/8	1040	530	1020	520	950	480	930	460	910	450
		3/4	1350	690	1340	680	1250	620	1230	600	1200	580
		7/8	1720	830	1700	810	1600	680	1580	660	1550	610
		1	2150	900	2130	880	2010	730	1990	700	1960	660
	3 1/2	1/2	700	460	690	450	670	420	670	400	660	400
		5/8	1090	610	1090	600	1050	540	1040	520	1030	510
		3/4	1570	760	1560	750	1490	670	1470	660	1430	650
		7/8	2030	940	2000	930	1850	850	1830	840	1780	810
		1	2460	1170	2430	1150	2260	1020	2230	980	2180	950

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi.
3. Tabulated lateral design values (Z) are based on dowel bearing strength (F_e) of 6,000 psi for concrete with minimum f'c=2000 psi.
4. 6" anchor embedment assumed.

BOLTS

Table 11F BOLTS: Design Values (Z) for Double Shear (three member) Connections[1,2]

for Sawn Lumber or SCL with both members of identical specific gravity

Thickness: Main Member t_m in.	Thickness: Side Member t_s in.	Bolt Diameter D in.	G=0.67 Red Oak $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	G=0.55 Mixed Maple Southern Pine $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	G=0.49 Douglas Fir-Larch (N) $Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) $Z_{\parallel}$ 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	[illegible]	[illegible]	[illegible]	2020	1440	720	1840	1260	[illegible]	1800	1210	600	1690	1100	550
		1	[illegible]	[illegible]	1020	[illegible]	1530	770	2100	1350	680	2060	1290	660	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	[illegible]	[illegible]	1120	[illegible]	[illegible]	840	2140	1470	[illegible]	2110	1410	[illegible]	1970	[illegible]	[illegible]
		1	[illegible]	[illegible]	1180	[illegible]	1790	890	2460	1580	[illegible]	2420	1510	[illegible]	2260	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	[illegible]	[illegible]	[illegible]	3360	1440	1200	3060	1260	1050	3010	1210	1010	2820	1100	920
		1	[illegible]	2040	[illegible]	3840	[illegible]	1290	3500	1350	[illegible]	3440	1290	[illegible]	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	[illegible]	1920	2240	3360	1440	1680	3180	1260	1470	3150	1210	1410	3030	1100	1290
		1	[illegible]	2040	[illegible]	4310	1530	1790	4090	1350	1580	4050	1290	1510	[illegible]	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	[illegible]	[illegible]	2240	3470	1660	1680	3270	1470	1470	3240	1410	1410	3110	1290	1290
		1	[illegible]	[illegible]	[illegible]	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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2070	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi.

BOLTS

DOWEL-TYPE FASTENERS

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Table 11F (Cont.) BOLTS: Design Values (Z) for Double Shear (three member) Connections[1,2]

for Sawn Lumber or SCL with both members of identical specific gravity

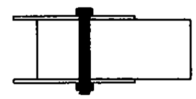
Thickness: Main Member	Thickness: Side Member	Bolt Diameter	G=0.43 Hem-Fir			G=0.42 Spruce-Pine-Fir			G=0.37 Redwood (open grain)			G=0.36 Eastern Softwoods Spruce-Pine-Fir (S) Western Cedars Western Woods			G=0.35 Northern Species		
t_m in.	t_s in.	D in.	$Z_{\parallel}$ lbs.	$Z_{s\perp}$ lbs.	$Z_{m\perp}$ 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	900	650	380	880	640	370	780	580	310	760	560	290	730	550	290
		5/8	1130	840	420	1100	830	410	970	690	350	950	660	330	910	640	320
		3/4	1350	920	460	1320	900	450	1170	740	370	1140	720	360	1100	700	350
		[redacted]															
1 3/4	1 3/4	1/2	1050	670	450	1030	660	430	910	590	360	890	580	340	850	570	330
		5/8	1310	950	490	1290	940	480	1130	810	400	1110	770	380	1070	740	370
		3/4	1580	1080	540	1540	1050	530	1360	870	430	1330	840	420	1280	810	410
		[redacted]															
2 1/2	1 1/2	1/2	1100	650	640	1080	640	610	990	580	510	980	560	490	950	550	480
		5/8	1590	840	700	1570	830	690	1450	690	580	1430	660	550	1390	640	530
		3/4	2190	920	770	2160	900	750	1950	740	620	1900	720	600	1830	700	580
		[redacted]															
3 1/2	1 1/2	1/2	1100	650	760	1080	640	740	990	580	670	980	560	660	950	550	640
		5/8	1590	840	980	1570	830	960	1450	690	810	1430	660	770	1390	640	740
		3/4	2190	920	1080	2160	900	1050	2010	740	870	1990	720	840	1940	700	810
		[redacted]															
	1 3/4	1/2	1180	670	820	1160	660	800	1060	590	720	1040	580	680	1010	570	670
		5/8	1670	950	980	1650	940	960	1510	810	810	1490	770	770	1450	740	740
		3/4	2270	1080	1080	2240	1050	1050	2070	870	870	2040	840	840	1990	810	810
		[redacted]															
	3 1/2	1/2	1330	880	880	1310	870	860	1230	800	720	1220	780	680	1200	760	670
		5/8	2070	1190	980	2050	1170	960	1930	1030	810	1900	1000	770	1870	970	740
		3/4	2980	1490	1080	2950	1460	1050	2720	1290	870	2660	1270	840	2560	1240	810
		[redacted]															
5 1/4	1 1/2	5/8	1590	840	1050	1570	830	1040	1450	690	940	1430	660	920	1390	640	900
		3/4	2190	920	1400	2160	900	1380	2010	740	1250	1990	720	1230	1940	700	1210
		[redacted]															
	1 3/4	5/8	1670	950	1110	1650	940	1100	1510	810	990	1490	770	970	1450	740	940
		3/4	2270	1080	1460	2240	1050	1440	2070	870	1300	2040	840	1260	1990	810	1220
		[redacted]															
	3 1/2	5/8	2070	1190	1320	2050	1170	1310	1930	1030	1210	1900	1000	1150	1870	970	1120
		3/4	2980	1490	1610	2950	1460	1580	2770	1290	1300	2740	1270	1260	2660	1240	1220
		[redacted]															
5 1/2	1 1/2	5/8	1590	840	1050	1570	830	1040	1450	690	940	1430	660	920	1390	640	900
		3/4	2190	920	1400	2160	900	1380	2010	740	1250	1990	720	1230	1940	700	1210
		[redacted]															
	3 1/2	5/8	2070	1190	1320	2050	1170	1310	1930	1030	1210	1900	1000	1180	1870	970	1160
		3/4	2980	1490	1690	2950	1460	1650	2770	1290	1360	2740	1270	1320	2660	1240	1280
		[redacted]															
7 1/2	1 1/2	5/8	1590	840	1050	1570	830	1040	1450	690	940	1430	660	920	1390	640	900
		3/4	2190	920	1400	2160	900	1380	2010	740	1250	1990	720	1230	1940	700	1210
		[redacted]															
	3 1/2	5/8	2070	1190	1320	2050	1170	1310	1930	1030	1210	1900	1000	1180	1870	970	1160
		3/4	2980	1490	1850	2950	1460	1820	2770	1290	1670	2740	1270	1650	2660	1240	1620
		[redacted]															

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi.

BOLTS

Table 11G BOLTS: Design Values (Z) for Double Shear (three member) Connections[1,2]

for Sawn Lumber or SCL with 1/4" ASTM A36 steel side plate



Thickness: Main Member t_m in.	Thickness: Side Member t_s in.	Bolt Diameter D in.	G=0.67 Red Oak $Z_{\parallel}$ lbs.	G=0.67 Red Oak $Z_{\perp}$ lbs.	G=0.55 Mixed Maple Southern Pine $Z_{\parallel}$ lbs.	G=0.55 Mixed Maple Southern Pine $Z_{\perp}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\parallel}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\perp}$ lbs.	G=0.49 Douglas Fir-Larch (N) $Z_{\parallel}$ lbs.	G=0.49 Douglas Fir-Larch (N) $Z_{\perp}$ lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) $Z_{\parallel}$ lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) $Z_{\perp}$ lbs.	G=0.43 Hem-Fir $Z_{\parallel}$ lbs.	G=0.43 Hem-Fir $Z_{\perp}$ lbs.	G=0.42 Spruce-Pine-Fir $Z_{\parallel}$ lbs.	G=0.42 Spruce-Pine-Fir $Z_{\perp}$ lbs.	G=0.37 Redwood (open grain) $Z_{\parallel}$ lbs.	G=0.37 Redwood (open grain) $Z_{\perp}$ lbs.	G=0.36 Eastern Softwoods Spruce-Pine-Fir(S) Western Cedars Western Woods $Z_{\parallel}$ lbs.	G=0.36 Eastern Softwoods Spruce-Pine-Fir(S) Western Cedars Western Woods $Z_{\perp}$ lbs.	G=0.35 Northern Species $Z_{\parallel}$ lbs.	G=0.35 Northern Species $Z_{\perp}$ lbs.
1 1/2	1/4	1/2	1410	730	1150	550	1050	470	1030	460	970	420	900	380	880	370	780	310	760	290	730	290
		5/8	1760	810	1440	610	1310	530	1290	520	1210	470	1130	420	1100	410	970	350	950	330	910	320
		3/4	2110	890	1730	660	1580	590	1550	560	1450	520	1350	460	1320	450	1170	370	1140	360	1100	350
		7/8	2460	960	2020	720	1840	630	1800	600	1690	550	1580	500	1540	490	1360	410	1330	[illegible]	[illegible]	[illegible]
		1	2810	1020	2310	770	2100	680	2060	650	1930	600	1800	540	1760	[illegible]	[illegible]	[illegible]	1520	420	[illegible]	[illegible]
1 3/4	1/4	1/2	1640	850	1350	640	1230	550	1200	530	1130	490	1050	450	1030	430	910	360	890	340	850	330
		5/8	2050	940	1680	710	1530	610	1500	600	1410	550	1310	490	1290	480	1130	400	1110	380	1070	370
		3/4	2460	1040	2020	770	1840	680	1800	660	1690	600	1580	540	1540	530	1360	430	1330	420	1280	410
		7/8	2870	1120	2350	840	2140	740	2110	700	1970	640	1840	580	1800	570	1590	470	1550	460	1490	430
		1	3280	1190	2690	890	2450	790	2410	750	2250	700	2100	630	2060	610	1820	510	1770	490	1710	470
2 1/2	1/4	1/2	1870	1210	1720	910	1650	790	1640	760	1590	700	1500	640	1470	610	1300	510	1270	490	1220	480
		5/8	2740	1340	2400	1020	2190	880	2150	860	2010	780	1880	700	1840	690	1620	580	1580	550	1520	530
		3/4	3520	1480	2880	1110	2630	980	2580	940	2410	860	2250	770	2200	750	1950	620	1900	600	1830	580
		7/8	4100	1600	3360	1200	3060	1050	3010	1010	2820	920	2630	830	2570	810	2270	680	2210	660	2130	640
		1	4690	1700	3840	1280	3500	1130	3440	1080	3220	1000	3000	900	2940	880	2590	730	2530	700	2440	680
3 1/2	1/4	1/2	1870	1240	1720	1100	1650	1030	1640	1010	1590	970	1540	890	1530	860	1450	720	1430	680	1410	670
		5/8	2740	1720	2510	1420	2410	1230	2390	1200	2330	1090	2260	980	2230	960	2110	810	2090	770	2060	740
		3/4	3800	2070	3480	1550	3340	1370	3320	1310	3220	1210	3120	1080	3080	1050	2720	870	2660	840	2560	810
		7/8	5060	2240	4630	1680	4290	1470	4210	1410	3940	1290	3680	1160	3600	1130	3180	950	3100	920	2990	880
		1	6520	2380	5380	1790	4900	1680	4810	1510	4510	1400	4200	1260	4110	1230	3630	1020	3540	980	3410	[illegible]
5 1/4	1/4	5/8	2740	1720	2510	1510	2410	1420	2390	1400	2330	1340	2260	1280	2230	1270	2110	1170	2090	1140	2060	1120
		3/4	3800	2290	3480	2000	3340	1890	3320	1850	3220	1780	3120	1610	3090	1580	2920	1300	2890	1260	2840	1220
		7/8	5060	2930	4630	2530	4440	2210	4410	2110	4280	1930	4150	1760	4110	1700	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		1	6520	3570	5960	2680	5720	2360	5670	2260	5510	2100	5330	1890	5280	1840	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5 1/2	1/4	5/8	2740	1720	2510	1510	2410	1420	2390	1400	2330	1340	2260	1280	2230	1270	2110	1170	2090	1140	2060	1120
		3/4	3800	2290	3480	2000	3340	1890	3320	1850	3220	1780	3120	1690	3090	1650	2920	1360	2890	1320	2840	1280
		7/8	5060	2980	4630	2570	4440	2310	4410	2210	4280	2020	4150	1830	4110	1780	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		1	6520	3640	5960	2810	5720	2480	5670	2370	5510	2200	5330	1980	5280	1930	4990	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7 1/2	1/4	5/8	2740	1720	2510	1510	2410	1420	2390	1400	2330	1340	2260	1280	2230	1270	2110	1170	2090	1140	2060	1120
		3/4	3800	2290	3480	2000	3340	1890	3320	1850	3220	1780	3120	1690	3090	1670	2920	1530	2890	1500	2840	1480
		7/8	5060	2930	4630	2570	4440	2410	4410	2360	4280	2260	4150	2160	4110	2130	3880	1960	3840	1930	3770	1840
		1	6520	3640	5960	3180	5720	3000	5670	2940	5510	2840	5330	2700	5280	2630	4990	2180	4930	2100	4850	2030
9 1/2	1/4	3/4	3800	2290	3480	2000	3340	1890	3320	1850	3220	1780	3120	1690	3090	1670	2920	1530	2890	1500	2840	1480
		7/8	5060	2930	4630	2570	4440	2410	4410	2360	4280	2260	4150	2160	4110	2130	3880	1960	3840	1930	3770	1870
		1	6520	3640	5960	3180	5720	3000	5670	2940	5510	2840	5330	2700	5280	2660	4990	2440	4930	2400	4850	2350
11 1/2	1/4	7/8	5060	2930	4630	2570	4440	2410	4410	2360	4280	2260	4150	2160	4110	2130	3880	1960	3840	1930	3770	1870
		1	6520	3640	5960	3180	5720	3000	5670	2940	5510	2840	5330	2700	5280	2660	4990	2440	4930	2400	4850	2350
13 1/2	1/4	1	6520	3640	5960	3180	5720	3000	5670	2940	5510	2840	5330	2700	5280	2660	4990	2440	4930	2400	4850	2350

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi and a dowel bearing strength (F_e) of 87,000 psi for ASTM A36 steel.

Table 11H BOLTS: Design Values (Z) for Double Shear (three member) Connections[1,2]

for Glued Laminated Timber main member with sawn lumber side member of identical species

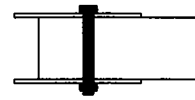
Thickness: Main Member	Thickness: Side Member	Bolt Diameter	G=0.55 Southern Pine			G=0.50 Douglas Fir-Larch			G=0.46 Douglas Fir(S) Hem-Fir(N)			G=0.43 Hem-Fir			G=0.42 Spruce-Pine-Fir			G=0.36 Spruce-Pine-Fir(S) Western Woods		
t_m	t_s	D	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$
in.	in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
2 1/2	1 1/2	1/2	-	-	-	1230	730	790	1160	680	700	1100	650	640	1080	640	610	980	560	490
		5/8	-	-	-	1760	1040	880	1660	940	780	1590	840	700	1570	830	690	1430	660	550
		3/4	-	-	-	2400	1170	980	2280	1040	860	2190	920	770	2160	900	750	1900	720	600
		7/8	-	-	-	3080	1260	1050	2820	1100	920	2640	1000	840	2570	970	810	2240	790	660
		1	-	-	-	3600	1350	1120	3220	1200	1000	3000	1080	900	2940	1050	880	2530	840	700
3	1 1/2	1/2	1320	800	940	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5/8	1870	1130	1220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/4	2550	1330	1330	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8	3360	1440	1540	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1	4310	1530	1530	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3 1/8	1 1/2	1/2	-	-	-	1230	730	860	1160	680	810	1100	650	760	1080	640	740	980	560	610
		5/8	-	-	-	1760	1040	1090	1660	940	980	1590	840	880	1570	830	860	1430	660	680
		3/4	-	-	-	2400	1170	1220	2280	1040	1080	2190	920	960	2160	900	940	1990	720	750
		7/8	-	-	-	3160	1260	1310	3030	1100	1150	2920	1000	1040	2880	970	1010	2660	790	820
		1	-	-	-	4090	1350	1410	3860	1200	1250	3600	1080	1130	3530	1050	1090	3040	840	880
5	1 1/2	5/8	1870	1130	1290	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		3/4	2550	1330	1690	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7/8	3360	1440	2170	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1	4310	1530	2550	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5 1/8	1 1/2	5/8	-	-	-	1760	1040	1190	1660	940	1110	1590	840	1050	1570	830	1040	1430	660	920
		3/4	-	-	-	2400	1170	1580	2280	1040	1480	2190	920	1400	2160	900	1380	1990	720	1230
		7/8	-	-	-	3160	1260	2030	3030	1100	1880	2920	1000	1700	2880	970	1660	2660	790	1350
		1	-	-	-	4090	1350	2310	3860	1200	2050	3600	1080	1850	3530	1050	1790	3040	840	1440
6 3/4	1 1/2	5/8	1870	1130	1290	1760	1040	1190	1660	940	1110	1590	840	1050	1570	830	1040	1430	660	920
		3/4	2550	1330	1690	2400	1170	1580	2280	1040	1480	2190	920	1400	2160	900	1380	1990	720	1230
		7/8	3360	1440	2170	3160	1260	2030	3030	1100	1900	2920	1000	1800	2880	970	1780	2660	790	1600
		1	4310	1530	2700	4090	1350	2530	3860	1200	2390	3600	1080	2270	3530	1050	2240	3040	840	1890

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi.

BOLTS

Table 11I BOLTS: Design Values (Z) for Double Shear (three member) Connections[1,2]

for Glued Laminated Timber with 1/4" ASTM A36 steel side plate



Thickness: Main Member t_m in.	Thickness: Side Member t_s in.	Bolt Diameter D in.	G=0.55 Southern Pine $Z_{\parallel}$ lbs.	G=0.55 Southern Pine $Z_{\perp}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\parallel}$ lbs.	G=0.50 Douglas Fir-Larch $Z_{\perp}$ lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) $Z_{\parallel}$ lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) $Z_{\perp}$ lbs.	G=0.43 Hem-Fir $Z_{\parallel}$ lbs.	G=0.43 Hem-Fir $Z_{\perp}$ lbs.	G=0.42 Spruce-Pine-Fir $Z_{\parallel}$ lbs.	G=0.42 Spruce-Pine-Fir $Z_{\perp}$ lbs.	G=0.36 Spruce-Pine-Fir(S) Western Woods $Z_{\parallel}$ lbs.	G=0.36 Spruce-Pine-Fir(S) Western Woods $Z_{\perp}$ lbs.
2 1/2	1/4	1/2	-	-	1650	790	1590	700	1500	640	1470	610	1270	490
		5/8	-	-	2190	880	2010	780	1880	700	1840	690	1580	550
		3/4	-	-	2630	980	2410	860	2250	770	2200	750	1900	600
		7/8	-	-	3060	1050	2820	920	2630	830	2570	810	2210	660
		1	-	-	3500	1130	3220	1000	3000	900	2840	880	2530	700
3	1/4	1/2	1720	1100	-	-	-	-	-	-	-	-	-	-
		5/8	2510	1220	-	-	-	-	-	-	-	-	-	-
		3/4	3460	1330	-	-	-	-	-	-	-	-	-	-
		7/8	4040	1440	-	-	-	-	-	-	-	-	-	-
		1	4610	1530	-	-	-	-	-	-	-	-	-	-
3 1/8	1/4	1/2	-	-	1650	980	1590	880	1540	800	1530	770	1430	610
		5/8	-	-	2410	1090	2330	980	2260	880	2230	860	1980	680
		3/4	-	-	3280	1220	3020	1080	2810	960	2750	940	2370	750
		7/8	-	-	3830	1310	3520	1150	3280	1040	3210	1010	2770	820
		1	-	-	4380	1410	4020	1250	3750	1130	3670	1090	3180	880
5	1/4	5/8	2510	1510	-	-	-	-	-	-	-	-	-	-
		3/4	3480	2000	-	-	-	-	-	-	-	-	-	-
		7/8	4630	2410	-	-	-	-	-	-	-	-	-	-
		1	5960	2550	-	-	-	-	-	-	-	-	-	-
5 1/8	1/4	5/8	-	-	2410	1420	2330	1340	2260	1280	2230	1270	2090	1120
		3/4	-	-	3340	1890	3220	1770	3120	1580	3090	1540	2890	1230
		7/8	-	-	4440	2150	4280	[illegible]	4150	1700	4110	[illegible]	3840	[illegible]
		1	-	-	5720	2310	5510	[illegible]	5330	1850	5280	[illegible]	4930	[illegible]
6 3/4	1/4	5/8	2510	1510	2410	1420	2330	1340	2260	1280	2230	1270	2090	1140
		3/4	3480	2000	3340	1890	3220	1780	3120	1690	3090	1670	2890	1500
		7/8	4630	2570	4440	2410	4280	2260	4150	2160	4110	2130	3840	1770
		1	5960	3180	5720	3000	5510	2700	5330	2430	5280	2360	4930	[illegible]
8 1/2	1/4	3/4	3480	2000	-	-	-	-	-	-	-	-	-	-
		7/8	4630	2570	-	-	-	-	-	-	-	-	-	-
		1	5960	3180	-	-	-	-	-	-	-	-	-	-
8 3/4	1/4	3/4	-	-	3340	1890	3220	1780	3120	1690	3090	1670	2890	1500
		7/8	-	-	4440	2410	4280	2260	4150	2160	4110	2130	3840	1930
		1	-	-	5720	3000	5510	2840	5330	2700	5280	2660	4930	2400
10 1/2	1/4	7/8	4630	2570	-	-	-	-	-	-	-	-	-	-
		1	5960	3180	-	-	-	-	-	-	-	-	-	-
10 3/4	1/4	7/8	-	-	4440	2410	4280	2260	4150	2160	4110	2130	3840	1930
		1	-	-	5720	3000	5510	2840	5330	2700	5280	2660	4930	2400
12 1/4	1/4	7/8	-	-	4440	2410	4280	2260	4150	2160	4110	2130	3840	1930
		1	-	-	5720	3000	5510	2840	5330	2700	5280	2660	4930	2400
14 1/4	1/4	1	-	-	5720	3000	5510	2840	5330	2700	5280	2660	4930	2400

1. Tabulated lateral design values (Z) for bolted connections shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "full diameter" bolts (see Appendix L) with bending yield strength (F_{yb}) of 45,000 psi and dowel bearing strength (F_e) of 87,000 psi for ASTM A36 steel.

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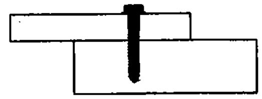
LAG SCREWS

Table 11J LAG SCREWS: Design Values (Z) for Single Shear (two member) Connections[1,2,3]

for Sawn Lumber or SCL with both members of identical specific gravity



Side Member Thickness	Lag Screw 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_s	D	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$
in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1/2	1/4	150	110	110	110	130	90	100	90	120	90	90	80	120	90	90	80	110	80	90	80
	5/16	170	130	130	120	150	110	120	100	150	100	110	100	140	100	110	90	140	100	100	90
	3/8	180	130	130	120	160	110	110	100	150	100	110	90	150	90	110	90	140	90	100	90
5/8	1/4	160	120	130	120	140	100	110	100	130	90	100	90	130	90	100	90	120	90	90	80
	5/16	190	140	140	130	160	110	120	110	150	110	110	100	150	100	110	100	150	100	110	90
	3/8	190	130	140	120	170	110	120	100	160	100	110	100	160	100	110	90	150	100	110	90
3/4	1/4	180	140	140	130	150	110	120	110	140	100	110	100	140	100	110	90	130	90	100	90
	5/16	210	150	160	140	180	120	130	120	170	110	120	100	160	110	120	100	160	100	110	100
	3/8	210	140	160	130	180	120	130	110	170	110	120	100	170	110	120	100	160	100	110	90
1	1/4	180	140	140	140	160	120	120	120	150	120	120	110	150	110	110	110	150	110	110	100
	5/16	230	170	170	160	210	140	150	130	190	130	140	120	190	120	140	120	180	120	130	110
	3/8	230	160	170	160	210	130	150	120	200	120	140	110	190	120	140	110	180	110	130	100
1 1/4	1/4	180	140	140	140	160	120	120	120	150	120	120	110	150	110	110	110	150	110	110	100
	5/16	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	130	140	120
	3/8	230	170	170	160	210	150	150	140	200	140	140	130	200	130	140	120	190	120	140	120
1 1/2	1/4	180	140	140	140	160	120	120	120	150	120	120	110	150	110	110	110	150	110	110	100
	5/16	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	140	140	130
	3/8	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	140	140	120
	7/16	360	260	260	240	320	220	230	200	310	200	210	180	310	190	210	180	300	180	[illegible]	[illegible]
	1/2	460	310	320	280	410	250	290	230	390	220	270	200	390	220	260	200	370	210	[illegible]	[illegible]
	5/8	700	410	600	370	600	340	420	310	560	310	380	280	550	310	380	270	530	290	[illegible]	[illegible]
	3/4	950	550	660	490	830	470	560	410	770	440	510	380	760	430	510	370	730	400	480	360
	7/8	1240	720	830	630	1080	560	710	540	1020	490	660	490	1010	470	650	470	970	430	610	430
	1	1550	800	1010	780	1360	600	870	600	1290	530	810	530	1280	500	790	500	1230	470	760	470
1 3/4	1/4	180	140	140	140	160	120	120	120	150	120	120	110	150	110	110	110	150	110	110	100
	5/16	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	140	140	130
	3/8	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	140	140	120
	7/16	360	260	260	240	320	230	230	210	310	210	210	190	310	210	210	190	[illegible]	[illegible]	[illegible]	[illegible]
	1/2	460	320	320	290	410	270	290	250	390	240	270	220	390	240	280	220	[illegible]	[illegible]	[illegible]	[illegible]
	5/8	740	440	600	400	660	360	440	320	610	430	420	290	600	320	410	290	[illegible]	[illegible]	[illegible]	[illegible]
	3/4	1030	580	720	520	890	480	600	430	830	450	550	390	820	440	540	380	780	420	510	360
	7/8	1320	740	890	650	1150	630	750	550	1070	570	700	510	1060	550	680	490	1010	500	650	470
	1	1630	910	1070	790	1420	700	910	670	1340	610	850	610	1320	590	830	590	1270	550	790	550
2 1/2	1/4	180	140	140	140	160	120	120	120	150	120	120	110	150	110	110	110	150	110	110	100
	5/16	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	140	140	130
	3/8	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	140	140	120
	7/16	360	260	260	240	320	230	230	210	310	210	210	190	310	210	210	190	300	200	[illegible]	[illegible]
	1/2	460	320	320	290	410	290	290	260	390	270	270	240	390	260	260	230	[illegible]	[illegible]	[illegible]	[illegible]
	5/8	740	500	500	450	670	430	440	390	640	390	420	350	630	380	410	340	610	[illegible]	[illegible]	[illegible]
	3/4	1110	680	740	610	1010	550	650	490	960	500	610	450	950	490	600	430	920	460	580	410
	7/8	1550	830	1000	740	1370	690	880	600	1280	630	830	550	1260	620	810	530	1190	580	770	500
	1	1940	980	1270	860	1660	830	1080	720	1550	770	990	660	1520	750	970	640	1450	720	920	620
3 1/2	1/4	180	140	140	140	160	120	120	120	150	120	120	110	150	110	110	110	150	110	110	100
	5/16	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	140	140	130
	3/8	230	170	170	160	210	150	150	140	200	140	140	130	200	140	140	130	190	140	140	120
	7/16	360	260	260	240	320	230	230	210	310	210	210	190	310	210	210	190	300	200	200	[illegible]
	1/2	460	320	320	290	410	290	290	260	390	270	270	240	390	260	260	230	[illegible]	[illegible]	[illegible]	[illegible]
	5/8	740	500	500	450	670	440	440	390	640	420	420	360	630	410	410	360	610	[illegible]	[illegible]	[illegible]
	3/4	1110	740	740	650	1010	650	650	560	960	600	610	520	950	580	600	510	920	550	580	490
	7/8	1550	990	1000	860	1400	800	880	710	1340	720	830	640	1320	700	810	620	1280	660	780	570
	1	2020	1140	1270	1010	1830	930	1120	810	1740	850	1060	740	1730	830	1040	720	1670	790	1000	680

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "reduced diameter body" lag screws (see Appendix L) inserted in side grain with screw axis perpendicular to wood fibers; minimum screw penetration, p, into the main member equal to 8D; screw bending yield strengths (F_{yb}): F_{yb} = 70,000 psi for D = 1/4"; F_{yb} = 60,000 psi for D = 5/16"; F_{yb} = 45,000 psi for D ≥ 3/8"
3. When 4D≤p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.

Table 11J (Cont.) LAG SCREWS: Design Values (Z) for Single Shear (two member) Connections[1,2,3]

for Sawn Lumber or SCL with both members of identical specific gravity

Side Member Thickness	Lag Screw Diameter	G=0.43 Hem-Fir				G=0.42 Spruce-Pine-Fir				G=0.37 Redwood (open grain)				G=0.36 Eastern Softwoods Spruce-Pine-Fir (S) Western Cedars Western Woods				G=0.35 Northern Species			
t_s	D	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$
in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1/2	1/4	110	80	80	70	110	80	80	70	100	70	70	60	100	70	70	60	90	70	70	60
	5/16	130	90	100	80	130	90	90	80	120	80	90	80	120	80	90	70	120	80	80	70
	3/8	140	80	100	80	130	80	90	80	120	60	90	60	120	60	80	60	120	60	80	60
5/8	1/4	120	80	90	80	110	80	90	70	110	70	80	70	100	70	80	60	100	70	70	60
	5/16	140	90	100	90	140	90	100	90	130	80	90	80	130	80	90	80	120	80	90	70
	3/8	140	90	100	80	140	90	100	80	130	80	90	70	130	70	90	70	120	70	90	70
3/4	1/4	130	90	100	80	120	80	90	80	110	80	80	70	110	70	80	70	110	70	80	70
	5/16	150	100	110	90	150	100	110	90	130	90	100	80	130	90	90	80	130	80	90	80
	3/8	150	100	110	90	150	90	110	90	140	90	100	80	130	80	90	70	130	80	90	70
1	1/4	140	100	110	90	140	100	100	90	130	90	100	80	130	80	90	80	130	80	90	70
	5/16	170	110	130	100	170	110	120	100	150	90	110	90	150	90	110	80	150	90	100	80
	3/8	170	100	120	100	170	100	120	90	150	90	110	80	150	90	110	80	150	90	100	80
1 1/4	1/4	140	110	110	100	140	100	100	100	130	100	100	90	130	90	90	90	130	90	90	80
	5/16	180	120	130	110	180	120	130	110	170	100	120	100	170	100	120	90	160	100	110	90
	3/8	190	120	130	110	180	110	130	100	170	100	120	90	170	100	120	90	170	90	110	80
1 1/2	1/4	140	110	110	100	140	100	100	100	130	100	100	90	130	90	90	90	130	90	90	80
	5/16	180	130	130	120	180	130	130	120	170	110	120	110	170	110	120	100	160	110	110	100
	3/8	190	130	130	120	180	130	130	110	170	110	120	100	170	110	120	100	170	100	110	90
	7/16	290	170	190	150	280	180	190	150	260	140	180	130	260	140	170	130	250	140	170	120
	1/2	350	190	240	180	350	190	240	170	310	170	210	150	310	160	210	150	300	160	200	140
	5/8	500	280	340	240	490	270	330	240	450	250	300	210	440	240	290	210	430	240	280	200
	3/4	700	360	450	330	690	350	440	330	630	290	400	290	620	280	390	280	610	270	380	270
	7/8	930	390	580	390	910	380	570	380	850	320	520	320	840	310	510	310	820	290	490	290
	1	1180	420	720	420	1160	410	710	410	1080	340	640	340	1070	330	630	330	1050	320	620	320
1 3/4	1/4	140	110	110	100	140	100	100	100	130	100	100	90	130	90	90	90	130	90	90	80
	5/16	180	130	130	120	180	130	130	120	170	120	120	110	170	120	120	110	160	110	110	100
	3/8	190	130	130	120	180	130	130	110	170	120	120	100	170	120	120	100	170	110	110	100
	7/16	290	180	190	160	280	180	190	160	270	160	180	140	260	150	170	140	260	140	170	130
	1/2	360	210	240	190	360	200	240	180	340	180	220	160	340	170	220	150	330	170	210	150
	5/8	540	290	360	250	530	280	360	250	480	250	320	220	480	250	310	210	460	240	300	210
	3/4	740	400	480	340	730	390	470	340	670	330	420	300	660	320	420	300	640	310	410	290
	7/8	970	450	610	440	950	440	600	440	880	370	540	370	870	360	530	360	850	330	520	330
	1	1210	490	750	490	1200	480	740	480	1110	400	670	400	1090	380	650	380	1070	370	640	370
2 1/2	1/4	140	110	110	100	140	100	100	100	130	100	100	90	130	90	90	90	130	90	90	80
	5/16	180	130	130	120	180	130	130	120	170	120	120	110	170	120	120	110	160	110	110	100
	3/8	190	130	130	120	180	130	130	110	170	120	120	100	170	120	120	100	170	110	110	100
	7/16	290	190	190	170	280	190	190	170	270	180	180	150	260	170	170	150	260	170	170	150
	1/2	360	240	240	210	360	240	240	210	340	220	220	190	340	210	220	190	330	200	210	180
	5/8	590	330	380	290	580	320	370	290	550	290	340	250	540	280	340	240	530	270	330	240
	3/4	890	430	550	380	880	420	540	370	800	380	500	320	780	370	490	320	760	360	480	310
	7/8	1130	550	730	470	1110	540	710	460	1010	490	640	420	990	480	620	410	970	470	600	390
	1	1380	680	870	580	1360	670	850	570	1240	570	760	510	1220	550	750	500	1190	530	730	490
3 1/2	1/4	140	110	110	100	140	100	100	100	130	100	100	90	130	90	90	90	130	90	90	80
	5/16	180	130	130	120	180	130	130	120	170	120	120	110	170	120	120	110	160	110	110	100
	3/8	190	130	130	120	180	130	130	110	170	120	120	100	170	120	120	100	170	110	110	100
	7/16	290	190	190	170	280	190	190	170	270	180	180	150	260	170	170	150	260	170	170	150
	1/2	360	240	240	210	360	240	240	210	340	220	220	190	340	220	220	190	330	210	210	180
	5/8	590	380	380	320	580	370	370	320	550	340	340	290	540	330	340	280	530	320	330	280
	3/4	890	500	550	440	880	490	540	430	830	430	500	370	820	420	490	370	800	410	480	360
	7/8	1240	610	750	530	1220	600	740	520	1150	530	680	460	1140	520	670	450	1110	500	650	430
	1	1610	740	950	630	1600	720	940	620	1480	650	860	550	1450	630	850	540	1410	620	830	520

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "reduced diameter body" lag screws (see Appendix L) inserted in side grain with screw axis perpendicular to wood fibers; minimum screw penetration, p, into the main member equal to 8D; screw bending yield strengths (F_{yb}): F_{yb} = 70,000 psi for D = 1/4"; F_{yb} = 60,000 psi for D = 5/16"; F_{yb} = 45,000 psi for D ≥ 3/8"
3. When 4D≤p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.

LAG SCREWS

DOWEL-TYPE FASTENERS

11

LAG SCREWS

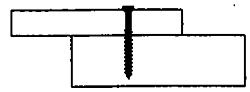
Table 11K LAG SCREWS: Design Values (Z) for Single Shear (two member) Connections[1,2,3]

with 1/4" ASTM A36 steel side plate, or ASTM A653, Grade 33 steel side plate (for t_s<1/4")

Side Member Thickness	Lag Screw Diameter	G=0.67 Red Oak		G=0.55 Mixed Maple Southern Pine		G=0.5 Douglas Fir-Larch		G=0.49 Douglas Fir-Larch (N)		G=0.46 Douglas Fir(S) Hem-Fir(N)		G=0.43 Hem-Fir		G=0.42 Spruce-Pine-Fir		G=0.37 Redwood (open grain)		G=0.36 Eastern Softwoods Spruce-Pine-Fir (S) Western Cedars Western Woods		G=0.35 Northern Species	
t_s	D	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{\perp}$
in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0.075	1/4	170	130	160	120	150	110	150	110	150	100	140	100	140	100	130	90	130	90	130	90
(14 gage)	5/16	220	160	200	140	190	130	190	130	190	130	180	120	180	120	170	110	170	110	160	100
	3/8	220	160	200	140	200	130	190	130	190	120	180	120	180	120	170	110	170	100	170	100
0.105	1/4	180	140	170	130	160	120	160	120	160	110	150	110	150	110	140	100	140	100	140	90
(12 gage)	5/16	230	170	210	150	200	140	200	140	190	130	190	130	190	120	180	110	170	110	170	110
	3/8	230	160	210	140	200	140	200	130	200	130	190	120	190	120	180	110	180	110	170	110
0.120	1/4	190	150	180	130	170	120	170	120	160	120	160	110	160	110	150	100	150	100	140	100
(11 gage)	5/16	230	170	210	150	210	140	200	140	200	140	190	130	190	130	180	120	180	120	180	110
	3/8	240	170	220	150	210	140	210	140	200	130	200	130	190	120	180	110	180	110	180	110
0.134	1/4	200	150	180	140	180	130	170	130	170	120	160	120	160	110	150	110	150	100	150	100
(10 gage)	5/16	240	180	220	160	210	150	210	140	200	140	200	130	200	130	190	120	180	120	180	120
	3/8	240	170	220	150	220	140	210	140	210	140	200	130	200	130	190	120	190	120	180	110
0.179	1/4	220	170	210	150	200	150	200	140	190	140	190	130	190	130	180	120	170	120	170	120
(7 gage)	5/16	260	190	240	170	230	160	230	160	230	150	220	150	220	150	210	130	200	130	200	130
	3/8	270	190	250	170	240	160	240	160	230	150	220	140	220	140	210	130	210	130	200	130
0.239	1/4	240	180	220	160	210	150	210	150	200	140	190	140	190	130	180	120	180	120	180	120
(3 gage)	5/16	300	220	280	190	270	180	260	180	260	170	250	160	250	160	230	150	230	150	230	140
	3/8	310	220	280	190	270	180	270	180	260	170	250	160	250	160	240	140	230	140	230	140
	[redacted]																				
	3/4	1110	670	1020	590	980	560	970	550	950	530	920	500	910	500	860	450	850	450	840	440
	7/8	1510	880	1390	780	1330	730	1320	710	1280	690	1250	650	1230	650	1170	590	1160	590	1140	570
	1	1940	1100	1780	960	1710	910	1700	890	1650	860	1600	820	1590	810	1500	740	1480	730	1460	710
1/4	1/4	240	180	220	160	210	150	210	150	200	140	200	140	190	130	180	120	180	120	180	120
	5/16	310	220	280	200	270	180	270	180	260	170	250	170	250	160	230	150	230	150	230	140
	3/8	320	220	290	190	280	180	270	180	270	170	260	160	250	160	240	150	240	140	230	140
	[redacted]																				
	3/4	1200	730	1100	640	1060	600	1050	590	1020	570	990	540	980	530	930	490	920	480	900	470
	7/8	1600	930	1470	820	1410	770	1400	750	1360	720	1320	690	1310	680	1240	630	1220	620	1200	600
	1	2040	1150	1870	1000	1800	950	1780	930	1730	900	1680	850	1660	840	1570	770	1550	760	1530	740

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for "reduced body diameter" lag screws (see Appendix L) inserted in side grain with screw axis perpendicular to wood fibers; minimum screw penetration, p, into the main member equal to 8D; dowel bearing strengths (F_e) of 61,850 psi for ASTM A653, Grade 33 steel and 87,000 psi for ASTM A36 steel and screw bending yield strengths (F_{yb}): F_{yb} = 70,000 psi for D = 1/4"; F_{yb} = 60,000 psi for D = 5/16"; F_{yb} = 45,000 psi for D ≥ 3/8"
3. When 4D≤p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.

Table 11L WOOD SCREWS: Design Values (Z) for Single Shear (two member) Connections[1,2,3]



for Sawn Lumber or SCL with both members of identical specific gravity

Side Member Thickness t_s in.	Wood Screw Diameter D in.	Wood Screw Number	G=0.67 Red Oak lbs.	G=0.55 Mixed Maple Southern Pine lbs.	G=0.5 Douglas Fir-Larch lbs.	G=0.49 Douglas Fir-Larch (N) lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) lbs.	G=0.43 Hem-Fir lbs.	G=0.42 Spruce-Pine-Fir lbs.	G=0.37 Redwood (open grain) lbs.	G=0.36 Eastern Softwoods Spruce-Pine-Fir (S) Western Cedars Western Woods lbs.	G=0.35 Northern Species lbs.
1/2	0.138	6	88	67	59	57	53	48	47	41	40	38
	0.151	7	96	73	65	63	58	53	52	45	44	42
	0.164	8	106	82	72	70	66	60	59	51	50	48
	[redacted]											
	0.242	14	167	133	119	116	109	101	99	87	85	83
5/8	0.138	6	94	75	66	63	58	53	51	43	42	41
	0.151	7	104	82	72	69	64	58	56	48	46	45
	[redacted]											
	0.216	12	172	132	117	114	106	97	94	82	80	77
	0.242	14	184	142	126	123	114	105	102	89	87	84
3/4	0.138	6	94	78	72	70	65	58	56	47	46	44
	[redacted]											
	0.190	10	152	122	106	103	95	86	83	70	69	66
	0.216	12	191	144	126	122	113	103	100	85	83	80
	0.242	14	203	154	135	131	122	111	108	93	91	87
1	[redacted]											
	0.177	9	141	117	107	105	100	93	90	75	73	69
	0.190	10	152	127	116	114	108	100	97	80	78	74
	0.216	12	192	160	147	143	131	118	114	96	93	89
1 1/4	[redacted]											
	0.164	8	120	100	91	89	85	79	78	69	68	66
	0.177	9	141	117	107	105	100	93	91	81	80	77
	0.190	10	152	127	116	114	108	101	99	88	86	83
1 1/2	[redacted]											
	0.151	7	104	87	79	78	74	69	67	60	59	57
	0.164	8	120	100	91	89	85	79	78	69	68	66
	0.177	9	141	117	107	105	100	93	91	81	80	77
1 3/4	[redacted]											
	0.151	7	104	87	79	78	74	69	67	60	59	57
	0.164	8	120	100	91	89	85	79	78	69	68	66
	0.177	9	141	117	107	105	100	93	91	81	80	77
	[redacted]											

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for rolled thread wood screws (see Appendix L) inserted in side grain with screw axis perpendicular to wood fibers; minimum screw penetration, p, into the main member equal to 10D ; and screw bending yield strengths (F_{yb}):
   F_{yb} = 100,000 psi for 0.099"≤D≤0.142" F_{yb} = 90,000 psi for 0.142"<D≤0.177" F_{yb} = 80,000 psi for 0.177"<D≤0.236" F_{yb} = 70,000 psi for 0.236"<D≤0.273"
3. When 6D≤p<10D, tabulated lateral design values (Z) shall be multiplied by p/10D.

WOOD SCREWS

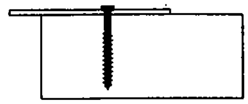
DOWEL-TYPE FASTENERS

11

WOOD SCREWS

Table 11M WOOD SCREWS: Design Values (Z) for Single Shear (two member) Connections[1,2,3]

with ASTM A653, Grade 33 steel side plate

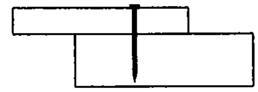


Side Member Thickness t_s in.	Wood Screw Diameter D in.	Wood Screw Number	G=0.67 Red Oak lbs.	G=0.55 Mixed Maple Southern Pine lbs.	G=0.5 Douglas Fir-Larch lbs.	G=0.49 Douglas Fir-Larch (N) lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) lbs.	G=0.43 Hem-Fir lbs.	G=0.42 Spruce-Pine-Fir lbs.	G=0.37 Redwood (open grain) lbs.	G=0.36 Eastern Softwoods Spruce-Pine-Fir (S) Western Cedars Western Woods lbs.	G=0.35 Northern Species lbs.
0.036 (20 gage)	0.138	6	88	75	70	68	65	61	60	54	53	51
	0.151	7	98	83	77	75	72	68	66	59	58	57
	0.164	8	113	96	89	87	83	78	76	68	67	65
0.048 (18 gage)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.060 (16 gage)	0.138	6	91	78	72	71	68	64	63	56	55	54
	0.151	7	101	86	80	78	75	70	69	62	61	59
	0.164	8	115	99	91	90	85	80	79	71	70	68
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.075 (14 gage)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.151	7	104	90	83	81	78	73	72	65	64	62
	0.164	8	119	102	94	93	88	83	82	74	72	70
	0.177	9	138	118	110	107	102	97	95	85	84	81
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.105 (12 gage)	0.138	6	104	90	83	82	78	74	72	65	64	62
	0.151	7	114	98	91	90	86	81	79	72	70	69
	0.164	8	128	111	103	101	96	91	89	80	79	77
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.242	14	212	183	169	166	159	150	147	132	130	126
0.120 (11 gage)	0.138	6	109	95	88	86	83	78	77	69	68	66
	0.151	7	120	104	96	95	90	85	84	76	74	72
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.216	12	201	174	161	158	151	143	140	126	124	121
	0.242	14	219	188	175	171	164	154	151	136	134	130
0.134 (10 gage)	0.138	6	115	100	93	91	87	82	81	73	72	70
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.190	10	172	149	138	136	130	122	120	108	107	104
	0.216	12	208	180	167	164	157	148	145	131	129	125
	0.242	14	225	194	180	177	169	160	156	141	139	135
0.179 (7 gage)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.177	9	183	159	147	144	137	128	126	112	110	107
	0.190	10	197	171	158	155	148	139	136	121	119	116
	0.216	12	234	203	189	185	177	167	164	149	146	142
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.239 (3 gage)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.164	8	159	135	125	122	116	109	107	96	94	91
	0.177	9	187	159	147	144	137	128	126	112	110	107
	0.190	10	202	172	158	155	148	139	136	121	119	116
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for rolled thread wood screws (see Appendix L) inserted in side grain with screw axis perpendicular to wood fibers; minimum screw penetration, p, into the main member equal to 10D; dowel bearing strength (F_e) of 61,850 psi for ASTM A653, Grade 33 steel and screw bending yield strengths (F_{yb}):
   F_{yb} = 100,000 psi for 0.099"≤D≤0.142" F_{yb} = 90,000 psi for 0.142"<D≤0.177" F_{yb} = 80,000 psi for 0.177"<D≤0.236" F_{yb} = 70,000 psi for 0.236"<D≤0.273"
3. When 6D≤p<10D, tabulated lateral design values (Z) shall be multiplied by p/10D.

Table 11N COMMON WIRE, BOX, or SINKER NAILS: Design Values (Z) for Single Shear (two member) Connections[1,2,3,4]

for Sawn Lumber or SCL with both members of identical specific gravity



Side Member Thickness t_s in.	Nail Diameter D in.	Common Wire Nail (Pennyweight)	Box Nail (Pennyweight)	Sinker Nail (Pennyweight)	G=0.67 Red Oak lbs.	G=0.55 Mixed Maple Southern Pine lbs.	G=0.5 Douglas Fir-Larch lbs.	G=0.49 Douglas Fir-Larch (N) lbs.	G=0.46 Douglas Fir(S) Hem-Fir(N) lbs.	G=0.43 Hem-Fir lbs.	G=0.42 Spruce-Pine-Fir lbs.	G=0.37 Redwood (open grain) lbs.	G=0.36 Eastern Softwoods Spruce-Pine-Fir (S) Western Cedars Western Woods lbs.	G=0.35 Northern Species lbs.
3/4	0.099		6d	7d	73	61	55	54	51	48	47	39	38	36
	0.113	6d	8d	8d	94	79	72	71	65	58	57	47	46	44
	[redacted]													
	0.135		16d	12d	135	108	94	91	84	76	74	63	61	58
	0.148	10d	20d	16d	154	121	105	102	94	85	83	70	69	66
	0.162	16d	40d		183	138	121	117	108	99	96	82	80	77
	[redacted]													
	0.225	40d			229	178	158	154	144	132	129	112	110	106
	0.244	50d		60d	234	182	162	158	147	136	132	115	113	109
1	0.099		6d	7d	73	61	55	54	51	48	47	42	41	40
	[redacted]													
	0.131	8d			127	106	97	95	90	84	82	68	66	63
	0.135		16d	12d	135	113	103	101	96	89	86	71	69	66
	0.148	10d	20d	16d	154	128	118	115	109	99	96	80	77	74
	[redacted]													
	0.207	30d		40d	243	192	167	162	149	135	131	111	109	104
	0.225	40d			268	202	177	171	159	144	140	120	117	112
	0.244	50d		60d	274	207	181	175	162	148	143	123	120	115
1 1/4	[redacted]													
	0.128		10d		121	101	93	91	86	80	79	70	69	67
	0.131	8d[4]			127	106	97	95	90	84	82	73	72	70
	0.135		16d	12d	135	113	103	101	96	89	88	78	76	74
	[redacted]													
	0.192	20d		30d	222	185	170	166	157	145	140	116	113	108
	0.207	30d		40d	243	203	186	182	169	152	147	123	119	114
	0.225	40d			268	224	200	193	177	160	155	130	127	121
1 1/2	[redacted]													
	0.120			10d	107	89	81	80	76	71	69	62	60	59
	0.128		10d		121	101	93	91	86	80	79	70	69	67
	0.131	8d[4]			127	106	97	95	90	84	82	73	72	70
	[redacted]													
	0.177			20d	213	178	163	159	151	141	138	123	121	117
	0.192	20d		30d	222	185	170	166	157	147	144	128	126	120
	0.207	30d		40d	243	203	186	182	172	161	158	135	131	125
	[redacted]													
1 3/4	0.120			10d[4]	107	89	81	80	76	71	69	62	60	59
	0.128		10d[4]		121	101	93	91	86	80	79	70	69	67
	[redacted]													
	0.177			20d	213	178	163	159	151	141	138	123	121	117
	0.192	20d		30d	222	185	170	166	157	147	144	128	126	122
	0.207	30d		40d	243	203	186	182	172	161	158	140	137	133
	[redacted]													

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see Table 10.3.1).
2. Tabulated lateral design values (Z) are for common wire, box and sinker nails (see Appendix L) inserted in side grain with nail axis perpendicular to wood fibers; minimum nail penetration, p, into the main member equal to 10D; and nail bending yield strengths (F_{yb}):
   F_{yb} = 100,000 psi for 0.099"≤D≤0.142" F_{yb} = 90,000 psi for 0.142"<D≤0.177" F_{yb} = 80,000 psi for 0.177"<D≤0.236" F_{yb} = 70,000 psi for 0.236"<D≤0.273"
3. When 6D≤p<10D, tabulated lateral design values (Z) shall be multiplied by p/10D.
4. Nail lenth is insufficient to provide 10D penetration. Tabulated lateral design values (Z) shall be adjusted per footnote 3.

12.1 General

12.1.1 Terminology

A connector unit shall be defined as one of the following:

(a) One split ring with its bolt or lag screw in single shear (see Figure 12A).

(b) Two shear plates used back to back in the contact faces of a wood-to-wood connection with their bolt or lag screw in single shear (see Figures 12B and 12C).

(c) One shear plate with its bolt or lag screw in single shear used in conjunction with a steel strap or shape in a wood-to-metal connection (see Figures 12B and 12C).

Figure 12A Split Ring Connector

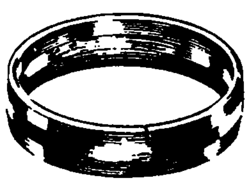


Figure 12B Pressed Steel Shear Plate Connector

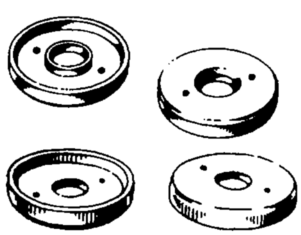
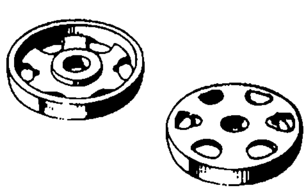


Figure 12C Malleable Iron Shear Plate Connector



12.1.2 Quality of Split Ring and Shear Plate Connectors

12.1.2.1 Design provisions and design values herein apply to split ring and shear plate connectors of the following quality:

(a) Split rings manufactured from SAE 1010 hot rolled carbon steel. Each ring shall form a closed true circle with the principal axis of the cross section of the ring metal parallel to the geometric axis of the ring. The ring shall fit snugly in the precut groove. This shall be accomplished with a ring, the metal section of which is beveled from the central portion toward the edges to a thickness less than at midsection, or by any other method which will accomplish equivalent performance. It shall be cut through in one place in its circumference to form a tongue and slot (see Figure 12A).

(b) Shear plate connectors:

(1) 2-5/8" Pressed Steel Type—Pressed steel shear plates manufactured from SAE 1010 hot rolled carbon steel. Each plate shall be a true circle with a flange around the edge, extending at right angles to the face of the plate and extending from one face only, the plate portion having a central bolt hole, with an integral hub concentric to the hole or without an integral hub, and two small perforations on opposite sides of the hole and midway from the center and circumference (see Figure 12B).

(2) 4" Malleable Iron Type—Malleable iron shear plates manufactured according to Grade 32510 of ASTM Standard A47. Each casting shall consist of a perforated round plate with a flange around the edge extending at right angles to the face of the plate and projecting from one face only, the plate portion having a central bolt hole with an integral hub extending from the same face as the flange (see Figure 12C).

12.1.2.2 Dimensions for typical split ring and shear plate connectors are provided in Appendix K. Dimensional tolerances of split ring and shear plate connectors shall not be greater than those conforming to standard practices for the machine operations involved in manufacturing the connectors.

12.1.2.3 Bolts used with split ring and shear plate connectors shall conform to 11.1.2. The bolt shall have an unreduced nominal or shank (body) diameter in accordance with ANSI/ASME Standard B18.2.1.

12.1.2.4 When lag screws are used in place of bolts, the lag screws shall conform to 11.1.3 and the shank of the lag screw shall have the same diameter as the bolt specified for the split ring or shear plate connector (see Tables 12.2A and 12.2B). The lag screw shall have an unreduced nominal or shank (body) diameter and threads in accordance with ANSI/ASME Standard B18.2.1.

12.1.3 Fabrication and Assembly

12.1.3.1 The grooves, daps and bolt holes specified in Appendix K shall be accurately cut or bored, and shall be oriented in contacting faces. Since split ring and shear plate connectors from different manufacturers differ slightly in shape and cross section, cutter heads shall be designed to produce daps and grooves conforming accurately to the dimensions and shape of the particular split ring or shear plate connectors used.

12.1.3.2 When lag screws are used in place of bolts, the hole for the unthreaded shank shall be the same diameter as the shank. The diameter of the hole for the threaded portion of the lag screw shall be approximately 70% of the shank diameter, or as specified in 11.1.3.2.

12.1.3.3 In installation of split ring or shear plate connectors and bolts or lag screws, a nut shall be placed on each bolt, and washers, not smaller than the size specified in Appendix K, shall be placed between the outside wood member and the bolt or lag screw head and between the outside wood member and nut. When an outside member of a shear plate connection is a steel strap or shape, the washer is not required, except when a longer bolt or lag screw is used, in which case, the washer prevents the metal plate or shape from bearing on the threaded portion of the bolt or lag screw.

12.1.3.4 Tabulated nominal design values for split ring and shear plate connectors are based on the assumption that the faces of the members are brought into contact when the connector units are installed, and allow for seasonal variations after the wood has reached the moisture content normal to the conditions of service. When split ring or shear plate connectors are installed in wood which is not seasoned to the moisture content normal to the conditions of service, the connections shall be tightened by turning down the nuts periodically until moisture equilibrium is reached.

12.2 Design Values

12.2.1 Tabulated Nominal Design Values

12.2.1.1 Tables 12.2A and 12.2B contain design values for a single split ring or shear plate connector unit with bolt in single shear, installed in the side grain of two wood members (see Table 12A) with sufficient member thicknesses, edge distances, end distances, and spacing to develop tabulated nominal design values. Tabulated nominal design values (P, Q) shall be multiplied by all applicable adjustment factors (see Table 10.3.1) to obtain allowable design values (P', Q').

Table 12A Species Groups for Split Ring and Shear Plate Connectors

Species Group	Specific Gravity, G
A	$G \geq 0.60$
B	$0.49 \leq G < 0.60$
C	$0.42 \leq G < 0.49$
D	$G < 0.42$

12.2.1.2 Allowable design values (P', Q') for shear plate connectors shall not exceed the limiting design values specified in Footnote 2 of Table 12.2B. The limiting design values in Footnote 2 of Table 12.2B shall not be multiplied by adjustment factors in this Specification since they are based on strength of metal rather than strength of wood (see 10.2.3).

12.2.2 Thickness of Wood Members

12.2.2.1 Tabulated nominal design values shall not be used for split ring or shear plate connectors installed in any piece of wood of a net thickness less than the minimum specified in Tables 12.2A and 12.2B.

12.2.2.2 Design values for split ring or shear plate connectors installed in any piece of wood of net thickness intermediate between the minimum thickness and that required for maximum design value, as specified in Tables 12.2A and 12.2B, shall be obtained by linear interpolation.

Table 12.2A Split Ring Connector Unit Design Values

Tabulated design values[1] apply to ONE split ring and bolt in single shear.

Split ring diameter	Bolt diameter	Number of faces of member with connectors on same bolt	Net thickness of member	Loaded parallel to grain (0°) Design value, P, per connector unit and bolt, lbs.				Loaded perpendicular to grain (90°) Design value, Q, per connector unit and bolt, lbs.			
inches	inches		inches	Group A species	Group B species	Group C species	Group D species	Group A species	Group B species	Group C species	Group D species
2-1/2	1/2	1	1" minimum	2630	2270	1900	1640	1900	1620	1350	1160
			1-1/2" or thicker	3160	2730	2290	1960	2280	1940	1620	1390
		2	1-1/2" minimum	2430	2100	1760	1510	1750	1500	1250	1070
			2" or thicker	3160	2730	2290	1960	2280	1940	1620	1390
4	3/4	1	1" minimum	4090	3510	2920	2520	2840	2440	2040	1760
			1-1/2"	6020	5160	4280	3710	4180	3590	2990	2580
			1-5/8" or thicker	6140	5260	4380	3790	4270	3660	3050	2630
		2	1-1/2" minimum	4110	3520	2940	2540	2980	2450	2040	1760
			2"	4950	4250	3540	3050	3440	2960	2460	2120
			2-1/2"	5830	5000	4160	3600	4050	3480	2890	2500
			3" or thicker	6140	5260	4380	3790	4270	3660	3050	2630

1. Tabulated lateral design values (P,Q) for split ring connector units shall be multiplied to all applicable adjustment factors (see Table 10.3.1).

Table 12.2B Shear Plate Connector Unit Design Values

Tabulated design values[1,2,3] apply to ONE shear plate and bolt in single shear.

Shear plate diameter	Bolt diameter	Number of faces of member with connectors on same bolt	Net thickness of member	Loaded parallel to grain (0°) Design value, P, per connector unit and bolt, lbs.				Loaded perpendicular to grain (90°) Design value, Q, per connector unit and bolt, lbs.			
inches	inches		inches	Group A species	Group B species	Group C species	Group D species	Group A species	Group B species	Group C species	Group D species
2-5-8	3/4	1	1-1/2" minimum	3110*	2670	2220	2010	2170	1860	1550	1330
		2	1-1/2" minimum	2420	2080	1730	1500	1690	1450	1210	1040
			2"	3190*	2730	2270	1960	2220	1910	1580	1370
			2-1/2" or thicker	3330*	2860	2380	2060	2320	1990	1650	1440
4	3/4 or 7/8	1	1-1/2" minimum	4370	3750	3130	2700	3040	2620	2170	1860
			1-3/4" or thicker	5090*	4360	3640	3140	3540	3040	2530	2200
		2	1-3/4" minimum	3390	2910	2420	2090	2360	2020	1680	1410
			2"	3790	3240	2700	2330	2640	2260	1880	1630
			2-1/2"	4310	3690	3080	2660	3000	2550	2140	1850
			3"	4830*	4140	3450	2980	3360	2880	2400	2060
			3-1/2" or thicker	5030*	4320	3600	3110	3500	3000	2510	2160

1. Tabulated lateral design values (P,Q) for shear plate connector units shall be multiplied to all applicable adjustment factors (see Table 10.3.1).
2. Allowable design values for shear plate connector units shall not exceed the following:
   (a) 2-5/8" shear plate .... 2900 pounds
   (b) 4" shear plate with 3/4" bolt .... 4400 pounds
   (c) 4" shear plate with 7/8" bolt .... 6000 pounds
   The design values in Footnote 2 shall be permitted to be increased in accordance with the American Institute of Steel Construction (AISC) Manual of Steel Construction, 9th edition, Section A5.2 "Wind and Seismic Stresses", except when design loads have already been reduced by load combination factors (see NDS 10.2.3).
3. Loads followed by an asterisk (*) exceed those permitted by Footnote 2, but are needed for determination of design values for other angles of load to grain. Footnote 2 limitations apply in all cases.

12.2.3 Penetration Depth Factor, C_d

When lag screws instead of bolts are used with split ring or shear plate connectors, tabulated nominal design values shall be multiplied by the appropriate penetration depth factor, C_d, specified in Table 12.2.3. Lag screw penetration into the member receiving the point shall not be less than the minimum penetration for reduced design value specified in Table 12.2.3. When the actual lag screw penetration into the member receiving the point is greater than the minimum penetration for reduced design value, but less than the minimum penetration for full design value, the penetration depth factor, C_d, shall be determined by linear interpolation. The penetration depth factor shall not exceed unity, $C_d \leq 1.0$.

12.2.4 Metal Side Plate Factor, C_{st}

When metal side members are used in place of wood side members, the tabulated nominal design values parallel to grain, P, for 4" shear plate connectors shall be multiplied by the appropriate metal side plate factor specified in Table 12.2.4.

Table 12.2.4 Metal Side Plate Factors, C_{st}, for 4" Shear Plate Connectors Loaded Parallel to Grain

Species Grouping	C_{st}
A	1.18
B	1.11
C	1.05
D	1.00

The allowable design values parallel to grain, P', shall not exceed the limiting design values given in Footnote 2 of Table 12.2B (see 12.2.1.2).

12.2.5 Load at Angle to Grain

12.2.5.1 When a load acts in the plane of the wood surface at an angle to grain other than 0° or 90°, the allowable design value, N', for a split ring or shear plate connector unit shall be determined as follows (see Appendix J):

$$N' = \frac{P'Q'}{P'\sin^2\theta + Q'\cos^2\theta} \qquad (12.2\text{-}1)$$

where:

θ = angle between direction of load and direction of grain (longitudinal axis of member)

Table 12.2.3 Penetration Depth Factors, C_d, for Split Ring and Shear Plate Connectors Used with Lag Screws

	Side Member	Penetration	Penetration of Lag Screw into Main Member (number of shank diameters) — Species Group (see Table 10A): Group A	Group B	Group C	Group D	Penetration Depth Factor C_d
2-1/2" Split Ring 4" Split Ring 4" Shear Plate	Wood or Metal	Minimum for Full Design Value	7	8	10	11	1.0
		Minimum for Reduced Design Value	3	3-1/2	4	4-1/2	0.75
2-5/8" Shear Plate	Wood	Minimum for Full Design Value	4	5	7	8	1.0
		Minimum for Reduced Design Value	3	3-1/2	4	4-1/2	0.75
	Metal	Minimum for Full Design Value	3	3-1/2	4	4-1/2	1.0

12.2.5.2 Allowable design values at an angle to grain, N', for shear plate connectors shall not exceed the limiting design values specified in Footnote 2 of Table 12.2.B (see 12.2.1.2).

12.2.6 Split Ring and Shear Plate Connectors in End Grain

12.2.6.1 When split ring or shear plate connectors are installed in a surface that is not parallel to the general direction of the grain of the member, such as the end of a square-cut member, or the sloping surface of a member cut at an angle to its axis, or the surface of a glued laminated timber cut at an angle to the direction of the laminations, the following terminology shall apply:

- "Side grain surface" means a surface parallel to the general direction of the wood fibers ($\alpha = 0°$), such as the top, bottom and sides of a straight beam.
- "Sloping surface" means a surface cut at an angle, α, other than 0° or 90° to the general direction of the wood fibers.
- "Square-cut surface" means a surface perpendicular to the general direction of the wood fibers ($\alpha = 90°$).
- "Axis of cut" defines the direction of a sloping surface relative to the general direction of the wood fibers. For a sloping cut symmetrical about one of the major axes of the member, as in Figures 12D, 12G, 12H and 12I the axis of cut is parallel to a major axis. For an asymmetrical sloping surface (i.e., one that slopes relative to both major axes of the member), the axis of cut is the direction of a line defining the intersection of the sloping surface with any plane that is both normal to the sloping surface and also is aligned with the general direction of the wood fibers (see Figure 12E).

α = the least angle formed between a sloping surface and the general direction of the wood fibers (i.e., the acute angle between the axis of cut and the general direction of the fibers. Sometimes called the slope of the cut. See Figures 12D through 12I)

φ = the angle between the direction of applied load and the axis of cut of a sloping surface, measured in the plane of the sloping surface (see Figure 12I)

P' = allowable design value for a split ring or shear plate connector unit in a side grain surface, loaded parallel to grain ($\alpha = 0°$, $\varphi = 0°$)

Q' = allowable design value for a split ring or shear plate connector unit in a side grain surface, loaded perpendicular to grain ($\alpha = 0°$, $\varphi = 90°$)

Q'_{90} = allowable design value for a split ring or shear plate connector unit in a square-cut surface, loaded in any direction in the plane of the surface ($\alpha = 90°$)

P'_{α} = allowable design value for a split ring or shear plate connector unit in a sloping surface, loaded in a direction parallel to the axis of cut ($0° < \alpha < 90°$, $\varphi = 0°$)

Q'_{α} = allowable design value for a split ring or shear plate connector unit in a sloping surface, loaded in a direction perpendicular to the axis of cut ($0° < \alpha < 90°$, $\varphi = 90°$)

N'_{α} = allowable design value for a split ring or shear plate connector unit in a sloping surface, when direction of load is at an angle φ from the axis of cut.

Figure 12D Axis of Cut for Symmetrical Sloping End Cut

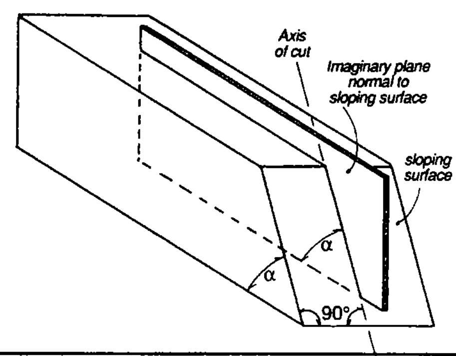
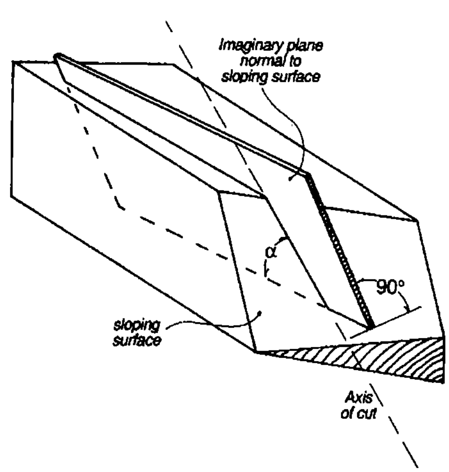


Figure 12E Axis of Cut for Asymmetrical Sloping End Cut

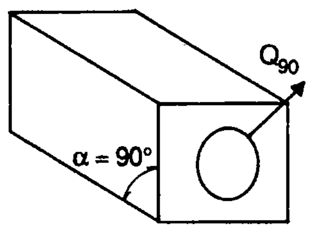


12.2.6.2 When split ring or shear plate connectors are installed in square-cut end grain or sloping surfaces, allowable design values shall be determined as follow (see 10.2.2):

(a) Square-cut surface; loaded in any direction ($\alpha = 90°$, see Figure 12F).

$$Q'_{90} = 0.60\,Q' \tag{12.2-2}$$

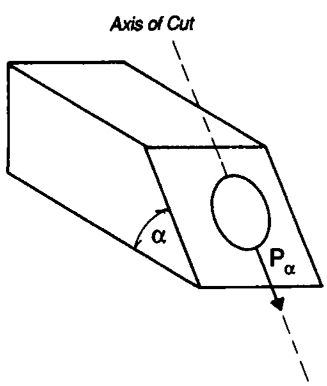
Figure 12F Square End Cut



(b) Sloping surface, loaded parallel to axis of cut ($0° < \alpha < 90°$, $\varphi = 0°$, see Figure 12G).

$$P'_\alpha = \frac{P'Q'_{90}}{P'\sin^2\alpha + Q'_{90}\cos^2\alpha} \tag{12.2-3}$$

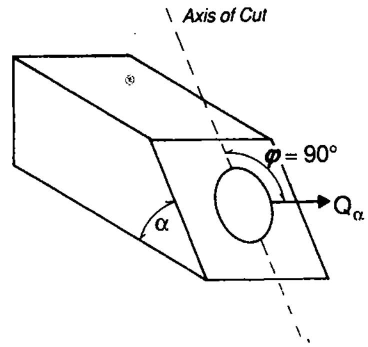
Figure 12G Sloping End Cut with Load Parallel to Axis of Cut (φ = 0°)



(c) Sloping surface; loaded perpendicular to axis of cut ($0° < \alpha < 90°$, $\varphi = 90°$, see Figure 12H).

$$Q'_\alpha = \frac{Q'Q'_{90}}{Q'\sin^2\alpha + Q'_{90}\cos^2\alpha} \tag{12.2-4}$$

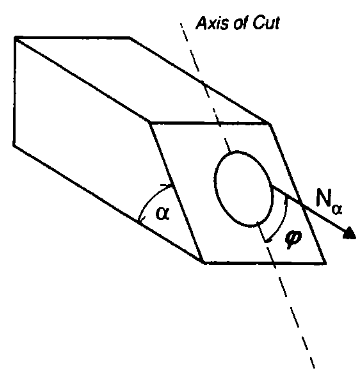
Figure 12H Sloping End Cut with Load Perpendicular to Axis of Cut (φ = 90°)



(d) Sloping surface; loaded at angle j to axis of cut ($0° < \alpha < 90°$, $0° < \varphi < 90°$, see Figure 12I).

$$N'_\alpha = \frac{P'_\alpha Q'_\alpha}{P'_\alpha \sin^2\varphi + Q'_\alpha \cos^2\varphi} \tag{12.2-5}$$

Figure 12I Sloping End Cut with Load at an Angle φ to Axis of Cut



12.3 Placement of Split Ring and Shear Plate Connectors

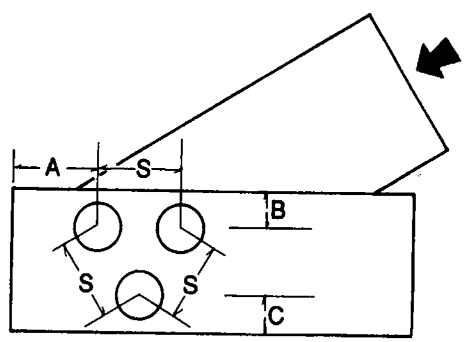
12.3.1 Terminology

12.3.1.1 "Edge distance" is the distance from the edge of a member to the center of the nearest split ring or shear plate connector, measured perpendicular to grain. When a member is loaded perpendicular to grain, the loaded edge shall be defined as the edge toward which the load is acting. The unloaded edge shall be defined as the edge opposite the loaded edge (see Figure12J).

12.3.1.2 "End distance" is the distance measured parallel to grain from the square-cut end of a member to the center of the nearest split ring or shear plate connector (see Figure 12J). If the end of a member is not cut at a right angle to its longitudinal axis, the end distance, measured parallel to the longitudinal axis from any point on the center half of the transverse connector diameter, shall not be less than the end distance required for a square-cut member. In no case shall the perpendicular distance from the center of a connector to the sloping end cut of a member, be less than the required edge distance (see Figure 12K).

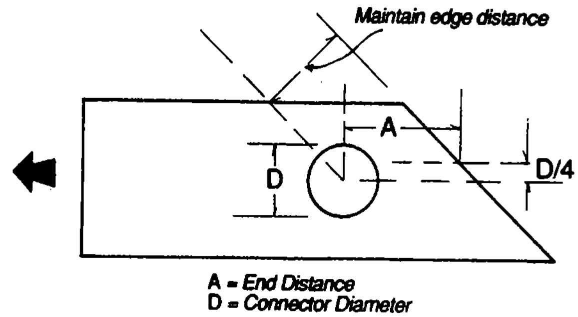
12.3.1.3 "Spacing" is the distance between centers of split ring or shear plate connectors measured along a line joining their centers (see Figure 12J).

Figure 12J Connection Geometry for Split Rings and Shear Plates



A = End Distance
B = Unloaded Edge Distance
C = Loaded Edge Distance
S = Spacing

Figure 12K End Distance for Members with Sloping End Cut



A = End Distance
D = Connector Diameter

12.3.2 Geometry Factor, C_Δ

Tabulated nominal design values are for split ring and shear plate connectors with edge distance, end distance and spacing greater than or equal to the minimum required for full design value. When the edge distance, end distance or spacing provided is less than the minimum required for full design value, tabulated nominal design values shall be multiplied by the smallest applicable geometry factor, C_Δ,determined from the edge distance, end distance and spacing requirements for split ring and shear plate connectors (see 12.3.3, 12.3.4 and 12.3.5). The smallest geometry factor for any split ring or shear plate connector in a group shall apply to all split ring and shear plate connectors in the group.

12.3.3 Edge Distance

12.3.3.1 Members Loaded Parallel or Perpendicular to Grain. Minimum edge distances and associated geometry factors, C_Δ, for split ring and shear plate connectors installed in side grain and loaded parallel or perpendicular to grain are provided in Table 12.3. When the actual loaded edge distance is greater than or equal to the minimum loaded edge distance for reduced design value, but less than the minimum loaded edge distance for full design value, the geometry factor, C_Δ, shall be determined by linear interpolation.

12.3.3.2 Members Loaded at Angle to Grain. When members are loaded at an angle to grain, θ, other than 0° or 90°, the minimum loaded edge distances for reduced design value and the minimum unloaded edge distances in Table 12.3 shall apply for all angles of load to grain.

SPLIT RING AND SHEAR PLATE CONNECTORS

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Minimum loaded edge distances for full design value shall be determined as follows:

(a) When $45° \leq \theta \leq 90°$, the minimum loaded edge distance for full design value for perpendicular to grain loading shall apply.

(b) When $0° \leq \theta < 45°$, the minimum loaded edge distance for full design value shall be determined by linear interpolation between the minimum loaded edge distance for reduced design value and the minimum loaded edge distance for full design value for perpendicular to grain loading.

When a member is loaded at an angle to grain, θ, other than 0° or 90°, the geometry factor, C_Δ, based on edge distance requirements shall apply to both the tabulated nominal parallel and perpendicular to grain design values (P, Q).

12.3.4 End Distance

12.3.4.1 Members Loaded Parallel or Perpendicular to Grain. Minimum end distances and associated geometry factors, C_Δ, for split ring and shear plate connectors installed in side grain and loaded parallel or perpendicular to grain are provided in Table 12.3. When the actual end distance is greater than or equal to the minimum end distance for reduced design value, but less than the minimum end distance for full design value, the geometry factor, C_Δ, shall be determined by linear interpolation.

12.3.4.2 Members Loaded at Angle to Grain. When members are loaded at an angle to grain, θ, other than 0° or 90°, minimum end distances for reduced design value and minimum end distances for full design value shall be determined by linear interpolation between tabulated end distances for parallel and perpendicular to grain loading.

12.3.5 Spacing

12.3.5.1 Members Loaded Parallel or Perpendicular to Grain. Minimum parallel and perpendicular to grain spacings and associated geometry factors, C_Δ, for split ring and shear plate connectors installed in side grain and loaded parallel or perpendicular to grain are provided in Table 12.3. When the line joining the centers of two adjacent split ring or shear plate connectors is at an angle to grain other than 0° or 90°, the minimum spacing for reduced design value and the minimum spacing for full design value shall be determined in accordance with the graphical method specified in References 50 and 52. When the actual spacing between split ring or shear plate connectors is greater than the minimum spacing for reduced design value, but less than the minimum spacing for full design value, the geometry factor, C_Δ, shall be determined by linear interpolation.

12.3.5.2 Members Loaded at Angle to Grain. When members are loaded at an angle to grain, θ, other than 0° or 90°, the minimum spacing for reduced design value and minimum spacing for full design value shall be determined in accordance with the graphical method specified in References 50 and 52.

12.3.6 Split Ring and Shear Plate Connectors in End Grain

12.3.6.1 The provisions for edge distance, end distance and spacing given in 12.3.3, 12.3.4 and 12.3.5 for split ring and shear plate connectors installed in side grain shall apply to split ring and shear plate connectors installed in square-cut surfaces and sloping surfaces as follows (see 12.2.6 for definitions and terminology):

(a) Square-cut surface, loaded in any direction - apply provisions for perpendicular to grain loading.

(b) Sloping surface with a from 45° to 90°, loaded in any direction - apply provisions for perpendicular to grain loading.

(c) Sloping surface with a less than 45°, loaded parallel to axis of cut - apply provisions for parallel to grain loading.

(d) Sloping surface with a less than 45°, loaded perpendicular to axis of cut - apply provisions for perpendicular to grain loading.

(e) Sloping surface with a less than 45°, loaded at angle ϕ to axis of cut - apply provisions for members loaded at angles to grain other than 0° or 90°.

12.3.6.2 When split ring or shear plate connectors are installed in end grain, the members shall be designed for shear parallel to grain in accordance with 3.4.3.3.

12.3.7 Multiple Split Ring or Shear Plate Connectors

12.3.7.1 When a connection contains two or more split ring or shear plate connector units which are in the same shear plane, are aligned in the direction of load and on separate bolts or lag screws, the group action factor, C_g, shall be as specified in 10.3.6 and the total allowable design value for the connection shall be as specified in 10.2.2.

12.3.7.2 If grooves for two sizes of split rings are cut concentric in the same wood surface, split ring connectors shall be installed in both grooves and the design value shall be taken as the design value for the larger split ring connector.

Table 12.3 Geometry Factors, C_Δ, for Split Ring and Shear Plate Connectors

		2-1/2" Split Ring Connectors & 2-5/8" Shear Plate Connectors				4" Split Ring Connectors & 4" Shear Plate Connectors			
		Parallel to grain loading		Perpendicular to grain loading		Parallel to grain loading		Perpendicular to grain loading	
		Minimum for Reduced Design Value	Minimum for Full Design Value	Minimum for Reduced Design Value	Minimum for Full Design Value	Minimum for Reduced Design Value	Minimum for Full Design Value	Minimum for Reduced Design Value	Minimum for Full Design Value
Edge Distance	Unloaded Edge	1-3/4"	1-3/4"	1-3/4"	1-3/4"	2-3/4"	2-3/4"	2-3/4"	2-3/4"
	C_Δ	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Loaded Edge	1-3/4"	1-3/4"	1-3/4"	2-3/4"	2-3/4"	2-3/4"	2-3/4"	3-3/4"
	C_Δ	1.0	1.0	0.83	1.0	1.0	1.0	0.83	1.0
End Distance	Tension Member	2-3/4"	5-1/2"	2-3/4"	5-1/2"	3-1/2"	7"	3-1/2"	7"
	C_Δ	0.625	1.0	0.625	1.0	0.625	1.0	0.625	1.0
	Compression Member	2-1/2"	4"	2-3/4"	5-1/2"	3-1/4"	5-1/2"	3-1/2"	7"
	C_Δ	0.625	1.0	0.625	1.0	0.625	1.0	0.625	1.0
Spacing	Spacing parallel to grain	3-1/2"	6-3/4"	3-1/2"	3-1/2"	5"	9"	5"	5"
	C_Δ	0.5	1.0	1.0	1.0	0.5	1.0	1.0	1.0
	Spacing perpendicular to grain	3-1/2"	3-1/2"	3-1/2"	4-1/4"	5"	5"	5"	6"
	C_Δ	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0