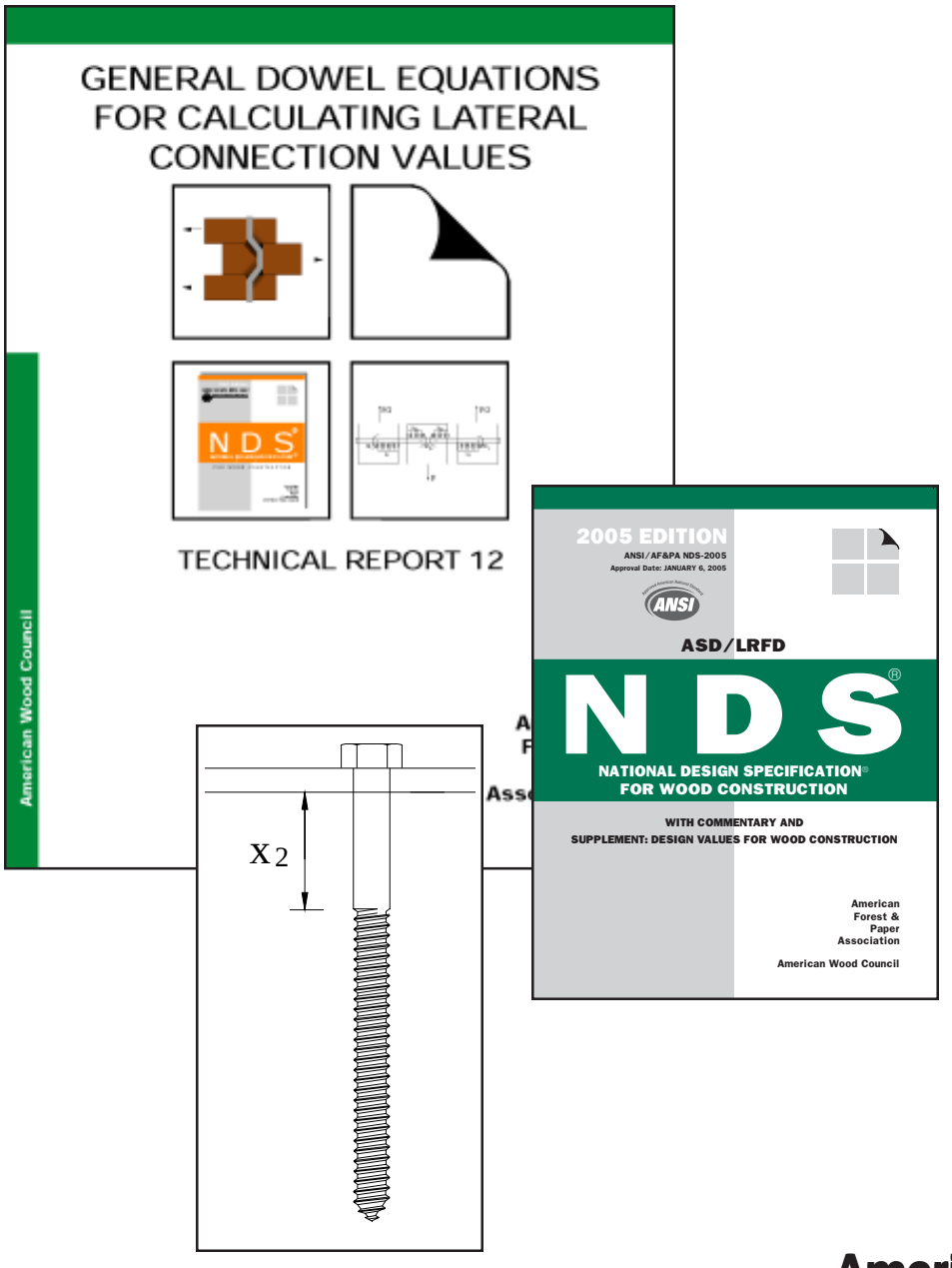
APPLICATION OF TECHNICAL REPORT 12 FOR LAG SCREW CONNECTIONS



American Wood Council

DESIGN AID No. 1

American Forest & Paper Association

DESIGN AID FOR APPPLICATION OF TECHNICAL REPORT 12 FOR LAG SCREW CONNECTIONS

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Introduction

In the 2001 and 2005 *National Design Specification® (NDS®) for Wood Construction*, calculation of reference lateral design values for lag screws and wood screws will typically require use of the fastener root diameter, D_r, unless a more detailed analysis is performed to account for the varying moment and bearing resistance of the fastener (*NDS* Section 11.3.2). This basis is intended to conservatively address calculation of reference lateral design values for full-body diameter lag screws and cut thread wood screws where the length of thread is often not known.

One alternate method of accounting for the moment and bearing resistance of the threaded portion of the fastener and moment acting along the length of the fastener is provided in AF&PA's *Technical Report 12 (TR12) - General Dowel Equations for Calculating Lateral Connection Values*. A general set of equations enables use of different diameters for bearing and moment resistance associated with the unthreaded shank and threaded portion of the screw.

Example calculations in this *Design Aid* are shown for lag screw connections; however, the design approach is also valid for wood screws. Example 1 addresses application of *TR12* for three lag screw connections having identical side and main members but different screw geometry. Example 2 addresses calculation for the required length of unthreaded shank into the main member such that diameter, D, is applicable for calculation of reference lateral design values.

Example 1. Application of *TR12* to lag screw connections

Problem Statement: Determine the reference design value for a single shear lag screw connection between sawn lumber members. Compare values for connection conditions described in Cases A, B, and C.

Given:

Lag screw diameter (NDS Appendix L):
D = 0.375 in., D_r = 0.265 in.

Wood parallel and perpendicular to grain dowel bearing strength (NDS Table 11.3.2):
$F_{e\parallel}$ = 5600 psi, $F_{e\perp}$ = 3650 psi

Bending yield strength, F_{yb} (NDS Appendix I):
F_{yb} = 45,000 psi

Side member bearing length (equal to side member thickness, t_s):
ℓ_s= 1.5 in.

Lag screw bearing length in the main member:
ℓ_m = 3 in.

Gap distance between side and main member:
g = 0 in.

Case A (See Table 1): Moment resistance and side and main member bearing are based on the unthreaded shank diameter. For this case, unthreaded shank diameter is equal to the fastener root diameter, D_r (e.g. $D_{shank} = D_r$)

Side Member:

$$q_s = F_{es}D_r$$

$$M_s = \frac{F_{yb}D_r^3}{6}$$

Main Member:

$$q_m = F_{em}D_r$$

$$M_m = \frac{F_{yb}D_r^3}{6}$$

Assumptions in Case A are consistent with those used to tabulate reference design values in the *NDS* for reduced body diameter lag screws. The value of dowel bearing strength perpendicular to grain, $F_{e\perp}$, is based on diameter, D. Although not used in this example, the slightly increased dowel bearing strength perpendicular to grain, $F_{e\perp}$, associated with the smaller unthreaded shank diameter can be used in calculation of side member bearing resistance.

Case B (See Table 1): Moment resistance is based on fastener root diameter, D_r, and bearing resistance is based on D.

Side Member:

$q_s = F_{es}D$

$$M_s = \frac{F_{yb}D_r^3}{6}$$

Main Member:

$q_m = F_{em}D$

$$M_m = \frac{F_{yb}D_r^3}{6}$$

Case C (See Table 1): Fastener moment resistance and bearing resistance are based on diameter, D (e.g. connection with unthreaded shank extending deep into the main member). Additional calculations will determine the length of unthreaded shank penetration into the main member (See Example 2 in this *Design Aid*).

Side Member:

$q_s = F_{es}D$

$$M_s = \frac{F_{yb}D^3}{6}$$

Main Member:

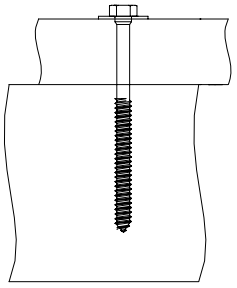
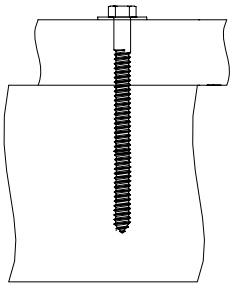
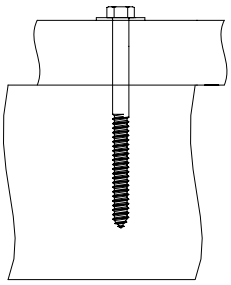
$q_m = F_{em}D$

$$M_m = \frac{F_{yb}D^3}{6}$$

Discussion

Yield Limit Equations in *NDS* Table 11.3.1A utilize only a single diameter to account for moment and bearing resistance of the fastener. Calculated reference design values based on the root diameter will often be conservative relative to those calculated using *TR12*. For example, application of *NDS* Yield Limit Equations for both Case A and Case B using fastener root diameter results in a reference design value of 201 lbs for $Z_{||}$. However, as shown in Table 1, the increased bearing area provided by the fully-threaded full body diameter lag screw increases the reference design value for Case B to 239 lbs.

Table 1. Comparison of design values for reduced body and full body diameter lag screws with varying thread and shank location in connected members.

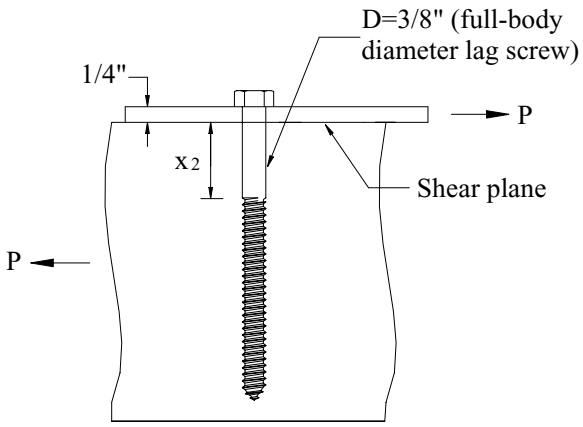
Side Member Thickness	Main Member Bearing Length	Lag Screw Diameter	Mode	Case A - Reduced body diameter lag screw (reduced body shank extends beyond shear plane)				Case B - Full body diameter lag screw (threads in shear plane)				Case C - Full body diameter lag screw (full body shank extends beyond shear plane)			
															
				G=0.5				G=0.5				G=0.5			
t_s	ℓ_m	D		$Z_{\|}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\|}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\|}$	$Z_{s\perp}$	$Z_{m\perp}$	$Z_{\perp}$
in.	in.	in.		lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
1-1/2	3	0.375	I_m	1113	890	580	580	1575	1260	821	821	1575	1260	821	821
			I_s	557	290	445	290	788	411	630	411	788	411	630	411
			II	420	304	246	219	595	431	348	310	595	431	348	310
			III_m	478	353	270	253	671	495	377	354	697	513	400	374
			III_s	260	153	191	143	357	207	262	194	406	249	297	232
			IV	201	143	143	130	239	170	170	155	403	286	286	260
			Reference Design Value, Z	**201**	**143**	**143**	**130**	**239**	**170**	**170**	**155**	**403**	**249**	**286**	**232**

Example 2. Full body diameter lag screws - calculation for length of unthreaded shank in main member

Problem Statement: Using *TR12*, find the minimum length of unthreaded shank in the main member needed to develop the full diameter reference design value.

Given: The 3/8" diameter full body diameter lag screw connection in Figure E2-1.

Figure E2-1. Example of a 3/8" diameter full body diameter lag screw connection.



Reference design value, $Z_{||}$, based on full body diameter, D (See Appendix A Supplemental Table 11K):

$Z_{||}$ = 530 lb. (Mode III_s)

Unadjusted yield mode value, P:

$P = Z_{||}\ R_d$ (1)

$P = (530\ lb)(3.2) = 1696\ lb.$

Main member bearing resistance, q_m:

$q_m = F_{e||}D$ (2)

$q_m = (5600psi)(0.375\ in.) = 2100\ pli$

Dowel moment resistance at shank, M_{shank}:

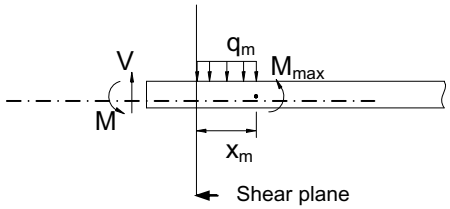
$$M_{shank} = \frac{F_{yb}D^3}{6} = 395.5\ in.\text{-}lbs \quad (3)$$

Dowel moment resistance at root, M_{root}:

$$M_{root} = \frac{F_{yb}D_r^3}{6} = 139.6\ in.\text{-}lb. \quad (4)$$

Solution: Determine the induced moment along the length of the dowel. Find the minimum distance, x_2, such that the induced moment in the dowel does not exceed the reduced moment capacity at the root, M_{root}.

Figure E2-2. Assumed dowel loading condition in the main member for Mode III_s.



Induced moment varies along the length of the dowel in the main member from a maximum value equal to M_{shank} to a minimum value equal to zero. Dowel moment resistance at the shank, M_{shank}, and at the root, M_{root}, are known.

The assumed dowel loading condition in the main member for Mode III_s is shown in Figure E2-2. Zero shear and maximum moment in the main member occur at distance, x_m, from the shear plane.

Location of zero shear, x_m, in main member:

$$x_m = \frac{P}{q_m} = \frac{1696}{2100} = 0.808\ in. \quad (5)$$

Maximum Moment, M_{max}:

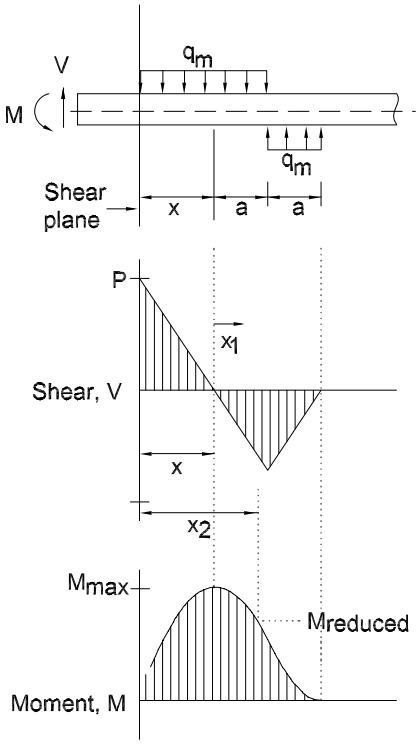
$M_{max} = M_{shank} = 395.5\ in.\text{-}lb.$

For moment beyond x_m, an alternate loading condition is constructed for the dowel where moment resistance is provided by wood bearing (see Figure E2-3). The minimum length of bearing, beyond x_m, to develop the maximum moment is:

$$2a = 2\left(\frac{M_{max}}{q_m}\right)^{0.5} = 0.868\ in. \quad (6)$$

From Figure E2-3, distance x_1 ranges from 0 to 2a. At $x_1 = 0$, moment is equal to M_{max}. At $x_1 = 2a$ moment is equal to zero.

Figure E2-3. Alternate loading condition for the dowel where moment resistance is provided by wood bearing.



Moment for the range $0 \le x_1 \le 2a$ can be calculated from Eq. 7 and Eq. 10 as follows:

Moment for $0 < x_1 \le a$:

$$M = M_{max} - \frac{q_m x_1^2}{2} \qquad (7)$$

Solving for x_1, the distance from the point of maximum moment, M_{max} to reduced moment, M, is:

$$x_1 = \left(\frac{2(M_{max} - M)}{q_m} \right)^{0.5} \qquad (8)$$

Distance x_2 from the shear plane to reduced moment, M, is:

$$x_2 = \frac{P}{q_m} + \left(\frac{2(M_{max} - M)}{q_m} \right)^{0.5} \qquad (9)$$

Moment for $a < x_1 \le 2a$:

$$M = \frac{q_m}{2}(2a - x_1)^2 \qquad (10)$$

Expressed in standard quadratic form:

$$x_1^2 - 4ax_1 + 4a^2 - \frac{2M}{q_m} = 0 \qquad (10A)$$

Solving for x_1, the distance from the point of maximum moment, M_{max}, to reduced moment, M, is:

$$x_1 = 2a - \left(\frac{2M}{q_m} \right)^{0.5} \qquad (11)$$

Distance x_2 from the shear plane to reduced moment, M, is:

$$x_2 = \frac{P}{q_m} + 2a - \left(\frac{2M}{q_m} \right)^{0.5} \qquad (12)$$

Minimum length, in terms of full body diameter, D, in main member: For M = 139.6 in.-lbs, which is equal to the dowel moment resistance at the root, M_{root}:

$x_1 = 0.503$ in. (from Eq. 8 or Eq. 11)

For $x_1 = 0.503$ in., the location where induced moment in the dowel is equal to reduced moment at the root occurs in the range $a < x_1 \le 2a$. The minimum unthreaded shank length in the main member, x_2, such that induced moment does not exceed reduced moment at the root is determined from Eq. 12:

$x_2 = 0.808 + 0.503 = 1.311$ in.

or, shown as number of lag screw diameters:

$x_2 = 3.5$ lag screw diameters *(i.e. calculated as 1.311 in. / 0.375 in. = 3.496 lag screw diameters).*

Tabulated values of x_2, in number of fastener diameters, are rounded up to the nearest 0.5 lag screw diameter.

Total unthreaded shank length must also account for side member thickness and, if applicable, washer thickness. For steel side plate equal to 1/4 in., total unthreaded shank length should not be less than 1.561 in. (i.e. 1.311 in. + 0.25 in. = 1.561 in.).

Appendix A. Supplemental Tables 11J and 11K: Lag Screws (full body diameter)

In the 2001 and 2005 *National Design Specification (NDS) for Wood Construction*, tabulated design values for lag screws are calculated in accordance with Table 11.3.1A Yield Limit Equations and Table 11.3.1B Reduction Terms based on the assumption that the lag screw root diameter, D_r, provides moment and bearing resistance. This calculation basis is intended to address connections where reduced body diameter lag screws (see *NDS* Appendix L) are used and accounts for the reduced moment capacity of fully-threaded lag screws.

Reference design values for full body diameter lag screws based on diameter D are provided in Supplemental Table 11J Lag Screws (full body diameter) for wood-to-wood connections and Supplemental Table 11K Lag Screws (full body diameter) for steel-to-wood connections.

Supplemental Tables 11J and 11K Lag Screw (full body diameter) reference design values are comparable to values tabulated in the *1997 NDS* and *1991 NDS* based on use of full body diameter, D, in calculations. Each design value is followed by the minimum length of unthreaded shank in the main member, in terms of fastener diameter (See Table A1). For example, "210 (3D)" represents a reference design value of 210 lb with minimum length of unthreaded shank in the main member equal to 3 times the lag screw diameter diameter, D, or 3 times 5/16 in. = 15/16 in.

In some cases the required length of unthreaded shank in the main member is zero fastener diameters (e.g. "(0D)"). This occurs where the design value is not limited by the moment capacity of the fastener in the main member such as Mode I_s.

The unthreaded shank length in the main member is depicted as dimension x_2 in Figure A1. An example calculation for length of unthreaded shank in the main member is provided in Example 2 of this *Design Aid*.

Figure A1. Typical full-body diameter lag screw connection.

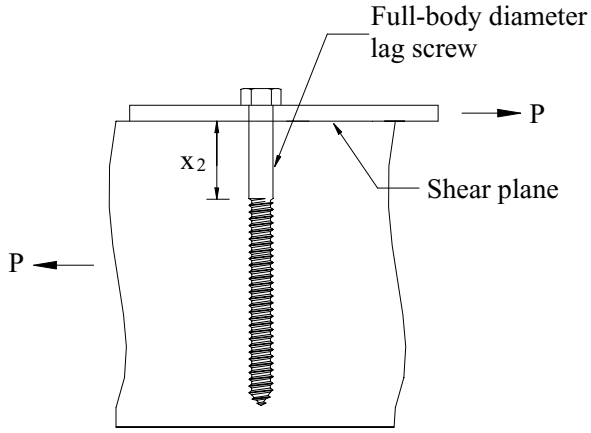


Table A1. Example of supplemental table format.

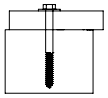
	Lag Screw Diameter	G=0.49 Douglas Fir-Larch (N)			
t_s in.	D in.	$Z_{\parallel}(x_2)$ lbs.	$Z_{s\perp}(x_2)$ lbs.	$Z_{m\perp}(x_2)$ lbs.	$Z_{\perp}(x_2)$ lbs.
1/2	1/4	160 (3.5D)	110 (3.5D)	120 (4D)	110 (4D)
	5/16	210 (3D)	120 (0D)	170 (4D)	120 (0D)

Reference design value

Minimum length of unthreaded full diameter shank in the main member. See dimension x_2 in Figure A1. The value "3D" indicates a minimum length of shank equal to 3 times the lag screw diameter, D.

Supplemental Table 11J LAG SCREWS (full body diameter): Reference Design Values (Z) for Single Shear (two member) Connections [1,2,3,4]

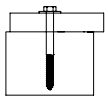
for Sawn Lumber or SCL with both members of identical specific gravity



Side Member Thickness	Lag Screw Diameter	G=0.67 Red Oak				G=0.55 Mixed Maple Southern Pine				G=0.50 Douglas Fir-Larch			
t_s	D	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)
in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1/2	1/4	190 (3D)	150 (3D)	150 (3D)	140 (3D)	170 (3.5D)	130 (3D)	130 (3.5D)	120 (3.5D)	160 (3.5D)	110 (3.5D)	120 (4D)	110 (4D)
	5/16	270 (2.5D)	190 (2.5D)	200 (3D)	190 (3D)	240 (3D)	140 (3D)	180 (3.5D)	140 (3.5D)	220 (3D)	130 (0D)	170 (4D)	130 (3.5D)
	3/8	330 (2.5D)	210 (2.5D)	250 (3D)	210 (3D)	290 (2.5D)	160 (0D)	220 (3.5D)	160 (0D)	260 (3D)	140 (0D)	200 (3.5D)	140 (0D)
5/8	1/4	200 (3D)	150 (3D)	160 (3.5D)	150 (3D)	180 (3.5D)	130 (3.5D)	140 (3.5D)	130 (3.5D)	170 (3.5D)	120 (3.5D)	130 (4D)	120 (4D)
	5/16	280 (3D)	210 (2.5D)	210 (3D)	200 (3D)	250 (3D)	180 (3D)	180 (3.5D)	170 (3.5D)	230 (3D)	160 (3D)	170 (4D)	160 (3.5D)
	3/8	350 (2.5D)	250 (2.5D)	260 (3D)	230 (3D)	310 (2.5D)	200 (2.5D)	220 (3.5D)	200 (3D)	290 (3D)	170 (2.5D)	210 (3.5D)	170 (3.5D)
3/4	1/4	210 (3D)	160 (3D)	170 (3.5D)	160 (3.5D)	190 (3.5D)	140 (3.5D)	140 (4D)	130 (3.5D)	180 (3.5D)	130 (3.5D)	130 (4D)	120 (4D)
	5/16	290 (3D)	210 (2.5D)	220 (3D)	210 (3D)	260 (3D)	180 (3D)	190 (3.5D)	170 (3.5D)	240 (3D)	170 (3D)	180 (4D)	160 (3.5D)
	3/8	360 (2.5D)	250 (2.5D)	270 (3D)	240 (3D)	320 (2.5D)	220 (2.5D)	230 (3.5D)	200 (3D)	300 (3D)	200 (2.5D)	220 (3.5D)	190 (3.5D)
1	1/4	250 (3.5D)	190 (3.5D)	200 (3.5D)	190 (3.5D)	210 (3.5D)	150 (3.5D)	160 (4D)	150 (4D)	200 (4D)	140 (3.5D)	150 (4.5D)	130 (4D)
	5/16	330 (3D)	240 (3D)	250 (3.5D)	230 (3D)	290 (3D)	200 (3D)	220 (4D)	190 (3.5D)	270 (3.5D)	180 (3D)	200 (4D)	170 (4D)
	3/8	410 (2.5D)	280 (2.5D)	300 (3D)	260 (3D)	350 (3D)	230 (2.5D)	260 (3.5D)	220 (3.5D)	330 (3D)	210 (2.5D)	240 (4D)	200 (3.5D)
1 1/4	1/4	260 (3.5D)	200 (3.5D)	200 (3.5D)	200 (3.5D)	230 (4D)	170 (3.5D)	180 (4.5D)	170 (4D)	220 (4D)	160 (3.5D)	170 (4.5D)	150 (4.5D)
	5/16	370 (3D)	270 (3D)	280 (3.5D)	260 (3.5D)	320 (3.5D)	220 (3D)	240 (4D)	210 (3.5D)	300 (3.5D)	200 (3D)	220 (4.5D)	190 (4D)
	3/8	460 (3D)	310 (2.5D)	340 (3.5D)	290 (3D)	390 (3D)	250 (2.5D)	290 (4D)	240 (3.5D)	360 (3D)	230 (3D)	270 (4D)	210 (3.5D)
1 1/2	1/4	260 (3.5D)	200 (3.5D)	200 (3.5D)	200 (3.5D)	230 (4D)	180 (3.5D)	180 (4.5D)	170 (4D)	220 (4D)	170 (4D)	170 (4.5D)	160 (4.5D)
	5/16	370 (3D)	280 (3D)	280 (3.5D)	270 (3.5D)	340 (3.5D)	240 (3.5D)	250 (4D)	230 (4D)	320 (3.5D)	220 (3.5D)	240 (4.5D)	200 (4D)
	3/8	470 (3D)	340 (2.5D)	340 (3.5D)	320 (3D)	420 (3D)	280 (3D)	300 (4D)	260 (3.5D)	400 (3D)	250 (3D)	290 (4D)	230 (3.5D)
	7/16	630 (2.5D)	400 (2.5D)	460 (3.5D)	380 (3D)	540 (3D)	330 (2.5D)	390 (4D)	310 (3.5D)	500 (3D)	300 (2.5D)	360 (4D)	280 (3.5D)
	1/2	770 (2.5D)	480 (2.5D)	560 (3.5D)	440 (3D)	660 (3D)	400 (2.5D)	470 (4D)	360 (3.5D)	610 (3D)	370 (2.5D)	430 (4D)	330 (3.5D)
	5/8	1070 (2.5D)	660 (2D)	760 (3.5D)	590 (3D)	940 (2.5D)	560 (2.5D)	640 (4D)	500 (3.5D)	880 (3D)	520 (2.5D)	590 (4D)	460 (3.5D)
	3/4	1450 (2.5D)	890 (2D)	990 (3.5D)	780 (3D)	1270 (2.5D)	660 (2.5D)	850 (4D)	660 (3.5D)	1200 (2.5D)	590 (2.5D)	790 (4D)	590 (3.5D)
	7/8	1890 (2.5D)	960 (2D)	1260 (3.5D)	960 (3D)	1680 (2.5D)	720 (0D)	1090 (4D)	720 (3.5D)	1590 (2.5D)	630 (0D)	1010 (4.5D)	630 (0D)
	1	2410 (2.5D)	1020 (0D)	1560 (3.5D)	1020 (3.5D)	2150 (2.5D)	770 (0D)	1350 (4D)	770 (0D)	2050 (2.5D)	680 (0D)	1270 (4.5D)	680 (0D)
1 3/4	1/4	260 (3.5D)	200 (3.5D)	200 (3.5D)	200 (3.5D)	230 (4D)	180 (3.5D)	180 (4.5D)	170 (4D)	220 (4D)	170 (4D)	170 (4.5D)	160 (4.5D)
	5/16	370 (3D)	280 (3D)	280 (3.5D)	270 (3.5D)	340 (3.5D)	250 (3.5D)	250 (4D)	230 (4D)	320 (3.5D)	240 (3.5D)	240 (4.5D)	220 (4.5D)
	3/8	470 (3D)	340 (2.5D)	340 (3.5D)	320 (3D)	420 (3D)	300 (3D)	300 (4D)	280 (3.5D)	400 (3D)	270 (3D)	290 (4D)	250 (4D)
	7/16	630 (2.5D)	440 (2.5D)	460 (3.5D)	410 (3D)	570 (3D)	360 (2.5D)	400 (4D)	330 (3.5D)	550 (3D)	330 (2.5D)	380 (4D)	300 (3.5D)
	1/2	830 (3D)	510 (2.5D)	590 (3.5D)	480 (3D)	720 (3D)	420 (2.5D)	510 (4D)	390 (3.5D)	670 (3D)	380 (2.5D)	470 (4.5D)	350 (3.5D)
	5/8	1160 (2.5D)	680 (2.5D)	820 (3.5D)	620 (3D)	1000 (3D)	580 (2.5D)	690 (4D)	520 (3.5D)	930 (3D)	530 (2.5D)	630 (4.5D)	470 (3.5D)
	3/4	1530 (2.5D)	900 (2D)	1050 (3.5D)	800 (3D)	1330 (2.5D)	770 (2.5D)	890 (4D)	680 (3.5D)	1250 (2.5D)	680 (2.5D)	830 (4.5D)	630 (3.5D)
	7/8	1970 (2.5D)	1120 (2D)	1320 (3.5D)	1020 (3D)	1730 (2.5D)	840 (2D)	1130 (4D)	840 (3.5D)	1640 (2.5D)	740 (0D)	1050 (4.5D)	740 (4D)
	1	2480 (2.5D)	1190 (2D)	1620 (3.5D)	1190 (3.5D)	2200 (2.5D)	890 (0D)	1390 (4D)	890 (3.5D)	2080 (2.5D)	790 (0D)	1300 (4.5D)	790 (0D)
2 1/2	1/4	260 (3.5D)	200 (3.5D)	200 (3.5D)	200 (3.5D)	230 (4D)	180 (3.5D)	180 (4.5D)	170 (4D)	220 (4D)	170 (4D)	170 (4.5D)	160 (4.5D)
	5/16	370 (3D)	280 (3D)	280 (3.5D)	270 (3.5D)	340 (3.5D)	250 (3.5D)	250 (4D)	230 (4D)	320 (3.5D)	240 (3.5D)	240 (4.5D)	220 (4.5D)
	3/8	470 (3D)	340 (2.5D)	340 (3.5D)	320 (3D)	420 (3D)	300 (3D)	300 (4D)	280 (3.5D)	400 (3D)	290 (3D)	290 (4D)	260 (4D)
	7/16	630 (2.5D)	460 (2.5D)	460 (3.5D)	420 (3.5D)	570 (3D)	400 (3D)	400 (4D)	370 (3.5D)	550 (3D)	380 (3D)	380 (4D)	340 (4D)
	1/2	830 (3D)	590 (2.5D)	590 (3.5D)	530 (3.5D)	750 (3D)	510 (3D)	520 (4D)	460 (4D)	720 (3D)	460 (3D)	490 (4.5D)	420 (4D)
	5/8	1290 (2.5D)	800 (2.5D)	880 (4D)	730 (3.5D)	1170 (3D)	650 (2.5D)	780 (4.5D)	590 (3.5D)	1120 (3D)	590 (2.5D)	730 (4.5D)	530 (4D)
	3/4	1840 (2.5D)	1000 (2D)	1240 (4D)	900 (3.5D)	1570 (3D)	830 (2.5D)	1060 (4.5D)	740 (3.5D)	1460 (3D)	770 (2.5D)	980 (4.5D)	680 (4D)
	7/8	2290 (2.5D)	1240 (2D)	1550 (4D)	1100 (3.5D)	1970 (2.5D)	1060 (2.5D)	1300 (4.5D)	920 (3.5D)	1840 (3D)	980 (2.5D)	1200 (4.5D)	850 (4D)
	1	2800 (2.5D)	1520 (2D)	1860 (4D)	1320 (3.5D)	2430 (2.5D)	1280 (2D)	1570 (4.5D)	1120 (4D)	2280 (2.5D)	1130 (2.5D)	1450 (4.5D)	1040 (4D)
3 1/2	1/4	260 (3.5D)	200 (3.5D)	200 (3.5D)	200 (3.5D)	230 (4D)	180 (3.5D)	180 (4.5D)	170 (4D)	220 (4D)	170 (4D)	170 (4.5D)	160 (4.5D)
	5/16	370 (3D)	280 (3D)	280 (3.5D)	270 (3.5D)	340 (3.5D)	250 (3.5D)	250 (4D)	230 (4D)	320 (3.5D)	240 (3.5D)	240 (4.5D)	220 (4.5D)
	3/8	470 (3D)	340 (2.5D)	340 (3.5D)	320 (3D)	420 (3D)	300 (3D)	300 (4D)	280 (3.5D)	400 (3D)	290 (3D)	290 (4D)	260 (4D)
	7/16	630 (2.5D)	460 (2.5D)	460 (3.5D)	420 (3.5D)	570 (3D)	400 (3D)	400 (4D)	370 (3.5D)	550 (3D)	380 (3D)	380 (4D)	340 (4D)
	1/2	830 (3D)	590 (2.5D)	590 (3.5D)	530 (3.5D)	750 (3D)	520 (3D)	520 (4D)	460 (4D)	720 (3D)	490 (3D)	490 (4.5D)	430 (4D)
	5/8	1290 (2.5D)	880 (2.5D)	880 (4D)	780 (3.5D)	1170 (3D)	780 (2.5D)	780 (4.5D)	680 (4D)	1120 (3D)	700 (3D)	730 (4.5D)	630 (4.5D)
	3/4	1860 (2.5D)	1190 (2.5D)	1240 (4D)	1080 (3.5D)	1690 (3D)	960 (2.5D)	1090 (4.5D)	850 (4D)	1610 (3D)	870 (2.5D)	1030 (5D)	780 (4D)
	7/8	2540 (2.5D)	1410 (2.5D)	1640 (4D)	1260 (3.5D)	2300 (3D)	1160 (2.5D)	1450 (4.5D)	1020 (4D)	2190 (3D)	1060 (2.5D)	1360 (5D)	930 (4D)
	1	3310 (2.5D)	1670 (2D)	2090 (4D)	1470 (3.5D)	2870 (3D)	1390 (2.5D)	1840 (5D)	1210 (4D)	2660 (3D)	1290 (2.5D)	1700 (5D)	1110 (4D)

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see NDS Table 10.3.1).
2. Tabulated lateral design values (Z) are for "**full body diameter**" lag screws (see NDS 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 $\geq$ 3/8"
3. When 4D$\leq$p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.
4. The term, (x_2), is the minimum length of unthreaded full diameter shank in the main member. A value of (3D) represents a minimum length of unthreaded shank in the main member equal to 3 times the lag screw diameter, D.

Supplemental Table 11J LAG SCREWS (full body diameter): Reference Design (Cont.) Values (Z) for Single Shear (two member) Connections [1,2,3,4]

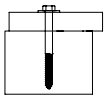


for Sawn Lumber or SCL with both members of identical specific gravity

Side Member Thickness	Lag Screw Diameter	G=0.49 Douglas Fir-Larch (N)				G=0.46 Douglas Fir(S) Hem-Fir(N)				G=0.43 Hem-Fir			
t_s	D	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)
in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1/2	1/4	160 (3.5D)	110 (3.5D)	120 (4D)	110 (4D)	150 (3.5D)	100 (3.5D)	110 (4D)	100 (4D)	150 (3.5D)	90 (3.5D)	110 (4.5D)	90 (4D)
	5/16	210 (3D)	120 (0D)	170 (4D)	120 (0D)	200 (3D)	110 (0D)	160 (4D)	110 (0D)	190 (3.5D)	100 (0D)	150 (4D)	100 (0D)
	3/8	260 (3D)	130 (0D)	200 (3.5D)	130 (0D)	240 (3D)	120 (0D)	190 (3.5D)	120 (0D)	230 (3D)	110 (0D)	180 (4D)	110 (0D)
5/8	1/4	160 (3.5D)	120 (3.5D)	120 (4D)	110 (4D)	160 (3.5D)	110 (3.5D)	120 (4D)	110 (4D)	150 (3.5D)	110 (3.5D)	110 (4.5D)	100 (4D)
	5/16	230 (3D)	150 (3D)	170 (4D)	150 (3.5D)	220 (3D)	140 (3D)	160 (4D)	140 (4D)	210 (3.5D)	130 (3D)	160 (4D)	130 (4D)
	3/8	290 (3D)	170 (2.5D)	210 (3.5D)	170 (3.5D)	280 (3D)	150 (0D)	200 (3.5D)	150 (3.5D)	270 (3D)	140 (0D)	190 (4D)	140 (3.5D)
3/4	1/4	170 (3.5D)	120 (3.5D)	130 (4D)	120 (4D)	170 (3.5D)	120 (3.5D)	130 (4.5D)	110 (4D)	160 (4D)	110 (3.5D)	120 (4.5D)	110 (4.5D)
	5/16	240 (3D)	170 (3D)	180 (4D)	160 (3.5D)	230 (3.5D)	160 (3D)	170 (4D)	150 (4D)	220 (3.5D)	150 (3D)	160 (4.5D)	140 (4D)
	3/8	300 (3D)	200 (2.5D)	210 (3.5D)	180 (3.5D)	290 (3D)	180 (2.5D)	200 (4D)	180 (3.5D)	270 (3D)	170 (3D)	190 (4D)	170 (3.5D)
1	1/4	200 (4D)	140 (3.5D)	150 (4.5D)	130 (4D)	190 (4D)	130 (3.5D)	140 (4.5D)	120 (4.5D)	180 (4D)	120 (3.5D)	130 (4.5D)	120 (4.5D)
	5/16	260 (3.5D)	180 (3D)	200 (4D)	170 (4D)	250 (3.5D)	170 (3D)	190 (4.5D)	160 (4D)	240 (3.5D)	160 (3D)	180 (4.5D)	150 (4D)
	3/8	320 (3D)	210 (2.5D)	240 (4D)	190 (3.5D)	310 (3D)	200 (3D)	220 (4D)	180 (3.5D)	300 (3D)	190 (3D)	210 (4D)	170 (4D)
1 1/4	1/4	220 (4D)	150 (4D)	170 (4.5D)	150 (4.5D)	210 (4D)	140 (4D)	160 (5D)	140 (4.5D)	200 (4D)	130 (4D)	150 (5D)	130 (4.5D)
	5/16	290 (3.5D)	190 (3D)	220 (4.5D)	180 (4D)	280 (3.5D)	180 (3.5D)	210 (4.5D)	170 (4D)	270 (3.5D)	170 (3.5D)	190 (4.5D)	160 (4.5D)
	3/8	360 (3D)	230 (3D)	260 (4D)	210 (3.5D)	340 (3D)	210 (3D)	250 (4D)	200 (3.5D)	320 (3D)	200 (3D)	230 (4.5D)	180 (4D)
1 1/2	1/4	220 (4D)	170 (4D)	170 (4.5D)	160 (4.5D)	210 (4D)	160 (4D)	160 (5D)	150 (4.5D)	210 (4.5D)	150 (4D)	150 (5D)	140 (5D)
	5/16	320 (3.5D)	210 (3.5D)	230 (4.5D)	200 (4D)	310 (4D)	200 (3.5D)	220 (4.5D)	190 (4.5D)	290 (4D)	180 (3.5D)	210 (5D)	170 (4.5D)
	3/8	400 (3.5D)	240 (3D)	280 (4D)	230 (4D)	380 (3.5D)	230 (3D)	270 (4.5D)	210 (4D)	360 (3.5D)	220 (3D)	260 (4.5D)	200 (4D)
	7/16	500 (3D)	300 (2.5D)	360 (4D)	270 (3.5D)	470 (3D)	280 (2.5D)	340 (4.5D)	260 (3.5D)	450 (3D)	260 (3D)	320 (4.5D)	240 (4D)
	1/2	610 (3D)	360 (2.5D)	420 (4D)	320 (3.5D)	580 (3D)	340 (2.5D)	400 (4.5D)	310 (4D)	550 (3D)	320 (2.5D)	380 (4.5D)	290 (4D)
	5/8	870 (3D)	520 (2.5D)	590 (4D)	450 (3.5D)	830 (3D)	470 (2.5D)	560 (4.5D)	430 (4D)	790 (3D)	420 (2.5D)	530 (4.5D)	410 (4D)
	3/4	1190 (2.5D)	560 (0D)	780 (4.5D)	560 (4D)	1140 (3D)	520 (0D)	740 (4.5D)	520 (4D)	1100 (3D)	460 (0D)	700 (4.5D)	460 (4D)
	7/8	1570 (2.5D)	600 (0D)	990 (4.5D)	600 (0D)	1520 (2.5D)	550 (0D)	950 (4.5D)	550 (0D)	1460 (3D)	500 (0D)	900 (5D)	500 (0D)
	1	2030 (2.5D)	650 (0D)	1240 (4.5D)	650 (0D)	1930 (2.5D)	600 (0D)	1190 (4.5D)	600 (0D)	1800 (3D)	540 (0D)	1130 (5D)	540 (0D)
1 3/4	1/4	220 (4D)	170 (4D)	170 (4.5D)	160 (4.5D)	210 (4D)	160 (4D)	160 (5D)	150 (4.5D)	210 (4.5D)	150 (4D)	150 (5D)	140 (5D)
	5/16	320 (3.5D)	230 (3.5D)	230 (4.5D)	220 (4.5D)	310 (4D)	220 (3.5D)	220 (4.5D)	200 (4.5D)	300 (4D)	200 (3.5D)	210 (5D)	190 (4.5D)
	3/8	400 (3.5D)	270 (3D)	280 (4D)	250 (4D)	390 (3.5D)	250 (3D)	270 (4.5D)	230 (4D)	370 (3.5D)	230 (3D)	260 (4.5D)	210 (4D)
	7/16	540 (3D)	320 (2.5D)	380 (4.5D)	290 (3.5D)	520 (3D)	300 (3D)	360 (4.5D)	270 (4D)	490 (3.5D)	280 (3D)	340 (4.5D)	250 (4D)
	1/2	660 (3D)	380 (2.5D)	460 (4.5D)	340 (4D)	620 (3D)	360 (2.5D)	440 (4.5D)	320 (4D)	590 (3D)	340 (2.5D)	410 (4.5D)	300 (4D)
	5/8	920 (3D)	530 (2.5D)	630 (4.5D)	470 (4D)	880 (3D)	500 (2.5D)	590 (4.5D)	440 (4D)	840 (3D)	480 (2.5D)	560 (4.5D)	410 (4D)
	3/4	1240 (2.5D)	660 (2.5D)	810 (4.5D)	620 (4D)	1190 (3D)	600 (2.5D)	780 (4.5D)	590 (4D)	1130 (3D)	540 (2.5D)	730 (5D)	540 (4D)
	7/8	1620 (2.5D)	700 (0D)	1030 (4.5D)	700 (4D)	1550 (2.5D)	640 (0D)	980 (4.5D)	640 (4D)	1490 (3D)	580 (0D)	930 (5D)	580 (4.5D)
	1	2060 (2.5D)	750 (0D)	1280 (4.5D)	750 (0D)	1990 (2.5D)	700 (0D)	1220 (4.5D)	700 (0D)	1910 (3D)	630 (0D)	1160 (5D)	630 (0D)
2 1/2	1/4	220 (4D)	170 (4D)	170 (4.5D)	160 (4.5D)	210 (4D)	160 (4D)	160 (5D)	150 (4.5D)	210 (4.5D)	150 (4D)	150 (5D)	140 (5D)
	5/16	320 (3.5D)	230 (3.5D)	230 (4.5D)	220 (4.5D)	310 (4D)	220 (3.5D)	220 (4.5D)	210 (4.5D)	300 (4D)	210 (3.5D)	210 (5D)	200 (4.5D)
	3/8	400 (3.5D)	280 (3D)	280 (4D)	260 (4D)	390 (3.5D)	270 (3D)	270 (4.5D)	250 (4D)	370 (3.5D)	260 (3D)	260 (4.5D)	230 (4.5D)
	7/16	540 (3D)	380 (3D)	380 (4.5D)	340 (4D)	530 (3.5D)	360 (3D)	360 (4.5D)	320 (4D)	510 (3.5D)	330 (3D)	340 (4.5D)	300 (4.5D)
	1/2	710 (3D)	440 (3D)	480 (4.5D)	410 (4D)	690 (3.5D)	420 (3D)	460 (4.5D)	380 (4D)	660 (3.5D)	390 (3D)	440 (5D)	350 (4.5D)
	5/8	1110 (3D)	580 (2.5D)	720 (4.5D)	520 (4D)	1050 (3D)	550 (2.5D)	690 (5D)	490 (4D)	1000 (3.5D)	510 (2.5D)	660 (5D)	450 (4.5D)
	3/4	1440 (3D)	750 (2.5D)	960 (5D)	660 (4D)	1370 (3D)	720 (2.5D)	910 (5D)	630 (4D)	1300 (3D)	670 (2.5D)	840 (5D)	580 (4.5D)
	7/8	1820 (3D)	960 (2.5D)	1180 (5D)	820 (4D)	1730 (3D)	920 (2.5D)	1110 (5D)	780 (4D)	1650 (3D)	830 (2.5D)	1040 (5D)	740 (4.5D)
	1	2250 (3D)	1080 (2.5D)	1420 (5D)	1020 (4D)	2160 (3D)	1000 (2.5D)	1360 (5D)	980 (4D)	2060 (3D)	900 (2.5D)	1270 (5D)	900 (4.5D)
3 1/2	1/4	220 (4D)	170 (4D)	170 (4.5D)	160 (4.5D)	210 (4D)	160 (4D)	160 (5D)	150 (4.5D)	210 (4.5D)	150 (4D)	150 (5D)	140 (5D)
	5/16	320 (3.5D)	230 (3.5D)	230 (4.5D)	220 (4.5D)	310 (4D)	220 (3.5D)	220 (4.5D)	210 (4.5D)	300 (4D)	210 (3.5D)	210 (5D)	200 (4.5D)
	3/8	400 (3.5D)	280 (3D)	280 (4D)	260 (4D)	390 (3.5D)	270 (3D)	270 (4.5D)	250 (4D)	370 (3.5D)	260 (3D)	260 (4.5D)	230 (4.5D)
	7/16	540 (3D)	380 (3D)	380 (4.5D)	340 (4D)	530 (3.5D)	360 (3D)	360 (4.5D)	320 (4D)	510 (3.5D)	340 (3D)	340 (4.5D)	300 (4.5D)
	1/2	710 (3D)	480 (3D)	480 (4.5D)	420 (4D)	690 (3.5D)	460 (3D)	460 (4.5D)	410 (4.5D)	660 (3.5D)	440 (3D)	440 (5D)	390 (4.5D)
	5/8	1110 (3D)	690 (3D)	720 (4.5D)	620 (4.5D)	1070 (3.5D)	650 (3D)	690 (5D)	580 (4.5D)	1040 (3.5D)	600 (3D)	660 (5D)	530 (4.5D)
	3/4	1600 (3D)	850 (2.5D)	1010 (5D)	750 (4D)	1540 (3D)	800 (2.5D)	970 (5D)	710 (4.5D)	1490 (3.5D)	740 (2.5D)	920 (5.5D)	650 (4.5D)
	7/8	2170 (3D)	1040 (2.5D)	1340 (5D)	900 (4D)	2060 (3D)	980 (2.5D)	1270 (5.5D)	850 (4.5D)	1950 (3D)	920 (2.5D)	1160 (5.5D)	790 (4.5D)
	1	2630 (3D)	1260 (2.5D)	1640 (5.5D)	1080 (4D)	2500 (3D)	1210 (2.5D)	1530 (5.5D)	1030 (4.5D)	2370 (3D)	1140 (2.5D)	1390 (5.5D)	970 (4.5D)

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see NDS Table 10.3.1).
2. Tabulated lateral design values (Z) are for "**full body diameter**" lag screws (see NDS 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 $\geq$ 3/8"
3. When 4D$\leq$p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.
4. The term, (x_2), is the minimum length of unthreaded full diameter shank in the main member. A value of (3D) represents a minimum length of unthreaded shank in the main member equal to 3 times the lag screw diameter, D.

Supplemental Table 11J LAG SCREWS (full body diameter): Reference Design (Cont.) Values (Z) for Single Shear (two member) Connections[1,2,3,4]

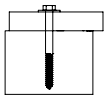


for Sawn Lumber or SCL with both members of identical specific gravity

Side Member Thickness	Lag Screw Diameter	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			
t_s	D	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)
in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1/2	1/4	150 (3.5D)	90 (3.5D)	110 (4.5D)	90 (4.5D)	130 (4D)	70 (0D)	100 (5D)	70 (0D)	130 (4D)	70 (0D)	100 (5D)	70 (0D)
	5/16	180 (3.5D)	100 (0D)	150 (4.5D)	100 (0D)	160 (3.5D)	80 (0D)	130 (4.5D)	80 (0D)	160 (3.5D)	80 (0D)	130 (4.5D)	80 (0D)
	3/8	220 (3D)	110 (0D)	180 (4D)	110 (0D)	190 (0D)	90 (0D)	160 (4.5D)	90 (0D)	190 (0D)	80 (0D)	150 (4.5D)	80 (0D)
5/8	1/4	150 (4D)	110 (3.5D)	110 (4.5D)	100 (4.5D)	140 (4D)	90 (4D)	100 (5D)	90 (4.5D)	140 (4D)	90 (4D)	100 (5D)	90 (5D)
	5/16	210 (3.5D)	120 (3D)	150 (4.5D)	120 (4D)	200 (3.5D)	100 (0D)	140 (4.5D)	100 (4.5D)	200 (3.5D)	100 (0D)	140 (5D)	100 (0D)
	3/8	260 (3D)	130 (0D)	190 (4D)	130 (4D)	240 (3D)	110 (0D)	170 (4.5D)	110 (0D)	240 (3D)	110 (0D)	170 (4.5D)	110 (0D)
3/4	1/4	160 (4D)	110 (3.5D)	120 (4.5D)	100 (4.5D)	140 (4D)	100 (4D)	110 (5D)	90 (4.5D)	140 (4D)	100 (4D)	100 (5D)	90 (5D)
	5/16	220 (3.5D)	150 (3D)	160 (4.5D)	140 (4D)	200 (3.5D)	120 (3.5D)	140 (4.5D)	120 (4.5D)	200 (3.5D)	120 (3.5D)	140 (5D)	120 (4.5D)
	3/8	270 (3D)	160 (3D)	190 (4D)	160 (4D)	250 (3D)	130 (0D)	170 (4.5D)	130 (4D)	250 (3D)	130 (0D)	170 (4.5D)	130 (4D)
1	1/4	170 (4D)	120 (3.5D)	130 (5D)	110 (4.5D)	160 (4D)	110 (4D)	120 (5D)	100 (5D)	160 (4D)	100 (4D)	110 (5.5D)	100 (5D)
	5/16	240 (3.5D)	160 (3.5D)	170 (4.5D)	140 (4D)	220 (3.5D)	140 (3.5D)	160 (5D)	130 (4.5D)	210 (4D)	140 (3.5D)	150 (5D)	130 (4.5D)
	3/8	290 (3D)	190 (3D)	210 (4D)	170 (4D)	270 (3.5D)	170 (3D)	190 (4.5D)	150 (4D)	260 (3.5D)	170 (3D)	180 (4.5D)	150 (4D)
1 1/4	1/4	200 (4D)	130 (4D)	150 (5D)	120 (4.5D)	180 (4.5D)	120 (4D)	130 (5.5D)	110 (5D)	170 (4.5D)	110 (4D)	120 (5.5D)	100 (5D)
	5/16	260 (3.5D)	170 (3.5D)	190 (5D)	150 (4.5D)	240 (4D)	150 (3.5D)	170 (5D)	140 (4.5D)	230 (4D)	150 (3.5D)	170 (5.5D)	130 (4.5D)
	3/8	320 (3.5D)	200 (3D)	230 (4.5D)	180 (4D)	290 (3.5D)	180 (3D)	210 (5D)	160 (4D)	290 (3.5D)	170 (3D)	200 (5D)	150 (4.5D)
1 1/2	1/4	200 (4.5D)	140 (4D)	150 (5D)	140 (5D)	190 (4.5D)	130 (4D)	140 (5.5D)	120 (5.5D)	190 (4.5D)	120 (4D)	130 (6D)	110 (5.5D)
	5/16	290 (4D)	180 (3.5D)	210 (5D)	170 (4.5D)	260 (4D)	160 (3.5D)	180 (5.5D)	150 (5D)	260 (4D)	160 (3.5D)	180 (5.5D)	140 (5D)
	3/8	350 (3.5D)	210 (3D)	250 (4.5D)	190 (4D)	320 (3.5D)	190 (3D)	230 (5D)	170 (4.5D)	310 (3.5D)	180 (3D)	220 (5D)	160 (4.5D)
	7/16	440 (3D)	260 (3D)	310 (4.5D)	230 (4D)	400 (3.5D)	230 (3D)	280 (5D)	210 (4D)	400 (3.5D)	230 (3D)	270 (5D)	200 (4.5D)
	1/2	540 (3D)	320 (2.5D)	370 (4.5D)	280 (4D)	500 (3.5D)	290 (3D)	340 (5D)	250 (4.5D)	490 (3.5D)	280 (3D)	330 (5D)	250 (4.5D)
	5/8	780 (3D)	410 (2.5D)	520 (4.5D)	400 (4D)	720 (3D)	350 (3D)	470 (5D)	350 (4.5D)	710 (3D)	330 (0D)	460 (5D)	330 (4.5D)
	3/4	1080 (3D)	450 (0D)	690 (4.5D)	450 (4D)	1010 (3D)	370 (0D)	630 (5D)	370 (0D)	990 (3D)	360 (0D)	610 (5D)	360 (0D)
	7/8	1440 (3D)	490 (0D)	890 (5D)	490 (0D)	1350 (3D)	410 (0D)	800 (5D)	410 (0D)	1330 (3D)	390 (0D)	780 (5.5D)	390 (0D)
	1	1760 (3D)	530 (0D)	1120 (5D)	530 (0D)	1560 (3D)	440 (0D)	980 (5.5D)	440 (0D)	1520 (3D)	420 (0D)	950 (5.5D)	420 (0D)
1 3/4	1/4	200 (4.5D)	150 (4D)	150 (5D)	140 (5D)	190 (4.5D)	140 (4.5D)	140 (5.5D)	130 (5.5D)	190 (4.5D)	130 (4.5D)	140 (6D)	120 (5.5D)
	5/16	300 (4D)	200 (3.5D)	210 (5D)	180 (4.5D)	280 (4D)	170 (3.5D)	200 (5.5D)	160 (5D)	270 (4D)	170 (3.5D)	190 (5.5D)	150 (5D)
	3/8	370 (3.5D)	230 (3D)	260 (4.5D)	210 (4D)	350 (3.5D)	200 (3D)	240 (5D)	180 (4.5D)	340 (4D)	190 (3D)	230 (5.5D)	170 (4.5D)
	7/16	480 (3.5D)	270 (3D)	340 (5D)	250 (4D)	430 (3.5D)	240 (3D)	300 (5D)	220 (4.5D)	430 (3.5D)	240 (3D)	290 (5D)	210 (4.5D)
	1/2	580 (3D)	330 (3D)	400 (5D)	290 (4D)	530 (3.5D)	300 (3D)	360 (5D)	260 (4.5D)	520 (3.5D)	290 (3D)	350 (5.5D)	250 (4.5D)
	5/8	820 (3D)	470 (2.5D)	550 (5D)	410 (4D)	760 (3D)	400 (3D)	500 (5D)	370 (4.5D)	740 (3D)	380 (3D)	480 (5.5D)	360 (4.5D)
	3/4	1120 (3D)	530 (2.5D)	720 (5D)	530 (4D)	1040 (3D)	430 (0D)	640 (5.5D)	430 (4.5D)	1020 (3D)	420 (0D)	620 (5.5D)	420 (4.5D)
	7/8	1470 (3D)	570 (0D)	920 (5D)	570 (0D)	1370 (3D)	470 (0D)	810 (5.5D)	470 (0D)	1350 (3D)	460 (0D)	790 (5.5D)	460 (0D)
	1	1890 (3D)	610 (0D)	1140 (5D)	610 (0D)	1760 (3D)	510 (0D)	990 (5.5D)	510 (0D)	1740 (3D)	490 (0D)	960 (5.5D)	490 (0D)
2 1/2	1/4	200 (4.5D)	150 (4D)	150 (5D)	140 (5D)	190 (4.5D)	140 (4.5D)	140 (5.5D)	130 (5.5D)	190 (4.5D)	140 (4.5D)	140 (6D)	130 (5.5D)
	5/16	300 (4D)	210 (3.5D)	210 (5D)	190 (5D)	280 (4D)	200 (4D)	200 (5.5D)	180 (5D)	270 (4D)	190 (4D)	190 (5.5D)	170 (5.5D)
	3/8	370 (3.5D)	260 (3.5D)	260 (4.5D)	230 (4.5D)	350 (3.5D)	240 (3.5D)	240 (5D)	210 (5D)	340 (4D)	230 (3.5D)	230 (5.5D)	200 (5D)
	7/16	500 (3.5D)	320 (3D)	340 (5D)	300 (4.5D)	470 (3.5D)	290 (3D)	310 (5D)	260 (4.5D)	470 (3.5D)	280 (3D)	310 (5.5D)	250 (5D)
	1/2	660 (3.5D)	380 (3D)	430 (5D)	340 (4.5D)	620 (3.5D)	330 (3D)	400 (5.5D)	300 (4.5D)	610 (3.5D)	320 (3D)	390 (5.5D)	290 (5D)
	5/8	980 (3.5D)	510 (2.5D)	650 (5.5D)	450 (4.5D)	890 (3.5D)	460 (3D)	550 (5.5D)	400 (4.5D)	870 (3.5D)	440 (3D)	530 (6D)	380 (4.5D)
	3/4	1280 (3D)	660 (2.5D)	820 (5D)	570 (4.5D)	1170 (3D)	600 (2.5D)	690 (5.5D)	510 (4.5D)	1150 (3.5D)	590 (2.5D)	670 (5.5D)	500 (4.5D)
	7/8	1630 (3D)	810 (2.5D)	1020 (5D)	730 (4.5D)	1490 (3D)	680 (2.5D)	860 (5.5D)	660 (4.5D)	1470 (3D)	660 (2.5D)	840 (5.5D)	650 (5D)
	1	2030 (3D)	880 (2.5D)	1240 (5D)	880 (4.5D)	1870 (3D)	730 (0D)	1040 (5.5D)	730 (5D)	1840 (3D)	700 (0D)	1010 (6D)	700 (5D)
3 1/2	1/4	200 (4.5D)	150 (4D)	150 (5D)	140 (5D)	190 (4.5D)	140 (4.5D)	140 (5.5D)	130 (5.5D)	190 (4.5D)	140 (4.5D)	140 (6D)	130 (5.5D)
	5/16	300 (4D)	210 (3.5D)	210 (5D)	190 (5D)	280 (4D)	200 (4D)	200 (5.5D)	180 (5D)	270 (4D)	190 (4D)	190 (5.5D)	170 (5.5D)
	3/8	370 (3.5D)	260 (3.5D)	260 (4.5D)	230 (4.5D)	350 (3.5D)	240 (3.5D)	240 (5D)	210 (5D)	340 (4D)	230 (3.5D)	230 (5.5D)	200 (5D)
	7/16	500 (3.5D)	340 (3D)	340 (5D)	300 (4.5D)	470 (3.5D)	310 (3.5D)	310 (5D)	270 (5D)	470 (3.5D)	310 (3.5D)	310 (5.5D)	270 (5D)
	1/2	660 (3.5D)	430 (3D)	430 (5D)	380 (4.5D)	620 (3.5D)	400 (3.5D)	400 (5.5D)	350 (5D)	610 (3.5D)	390 (3.5D)	390 (5.5D)	340 (5D)
	5/8	1020 (3.5D)	590 (3D)	650 (5.5D)	520 (4.5D)	960 (3.5D)	520 (3D)	610 (6D)	460 (5D)	950 (3.5D)	500 (3D)	590 (6D)	440 (5D)
	3/4	1480 (3.5D)	730 (2.5D)	910 (5.5D)	640 (4.5D)	1390 (3.5D)	650 (3D)	800 (6D)	560 (5D)	1370 (3.5D)	630 (3D)	780 (6D)	550 (5D)
	7/8	1920 (3.5D)	910 (2.5D)	1130 (5.5D)	780 (4.5D)	1740 (3.5D)	820 (2.5D)	970 (6D)	700 (5D)	1710 (3.5D)	800 (2.5D)	940 (6D)	680 (5D)
	1	2330 (3D)	1120 (2.5D)	1360 (5.5D)	950 (4.5D)	2120 (3.5D)	1020 (2.5D)	1150 (6D)	850 (5D)	2080 (3.5D)	980 (2.5D)	1110 (6D)	830 (5D)

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see NDS Table 10.3.1).
2. Tabulated lateral design values (Z) are for "**full body diameter**" lag screws (see NDS 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 $\geq$ 3/8"
3. When 4D≤p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.
4. The term, (x_2), is the minimum length of unthreaded full diameter shank in the main member. A value of (3D) represents a minimum length of unthreaded shank in the main member equal to 3 times the lag screw diameter, D.

Supplemental Table 11J LAG SCREWS (full body diameter): Reference Design (Cont.) Values (Z) for Single Shear (two member) Connections [1,2,3,4]

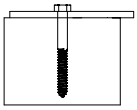


for Sawn Lumber or SCL with both members of identical specific gravity

Side Member Thickness	Lag Screw Diameter	G=0.35 Northern Species			
t_s	D	$Z_{\parallel}$ (x_2)	$Zs_{\perp}$ (x_2)	$Zm_{\perp}$ (x_2)	$Z_{\perp}$ (x_2)
in.	in.	lbs.	lbs.	lbs.	lbs.
1/2	1/4	120 (4D)	70 (0D)	100 (5D)	70 (0D)
	5/16	150 (0D)	80 (0D)	120 (5D)	80 (0D)
	3/8	180 (0D)	80 (0D)	150 (4.5D)	80 (0D)
5/8	1/4	130 (4D)	80 (4D)	100 (5D)	80 (5D)
	5/16	190 (3.5D)	90 (0D)	140 (5D)	90 (0D)
	3/8	230 (3.5D)	100 (0D)	160 (4.5D)	100 (0D)
3/4	1/4	140 (4D)	100 (4D)	100 (5D)	90 (5D)
	5/16	200 (3.5D)	110 (3.5D)	140 (5D)	110 (4.5D)
	3/8	240 (3.5D)	120 (0D)	170 (4.5D)	120 (4.5D)
1	1/4	150 (4.5D)	100 (4D)	110 (5.5D)	90 (5D)
	5/16	210 (4D)	140 (3.5D)	150 (5D)	120 (4.5D)
	3/8	260 (3.5D)	160 (3D)	180 (5D)	140 (4.5D)
1 1/4	1/4	170 (4.5D)	110 (4D)	120 (5.5D)	100 (5D)
	5/16	230 (4D)	140 (3.5D)	160 (5.5D)	130 (5D)
	3/8	280 (3.5D)	170 (3D)	190 (5D)	150 (4.5D)
1 1/2	1/4	190 (4.5D)	120 (4D)	130 (6D)	110 (5.5D)
	5/16	250 (4D)	150 (3.5D)	170 (5.5D)	140 (5D)
	3/8	300 (3.5D)	180 (3D)	210 (5D)	160 (4.5D)
	7/16	380 (3.5D)	220 (3D)	260 (5D)	200 (4.5D)
	1/2	480 (3.5D)	280 (3D)	320 (5D)	240 (4.5D)
	5/8	700 (3D)	320 (0D)	450 (5D)	320 (4.5D)
	3/4	970 (3D)	350 (0D)	590 (5.5D)	350 (0D)
	7/8	1280 (3D)	370 (0D)	730 (5.5D)	370 (0D)
	1	1460 (3D)	410 (0D)	920 (5.5D)	410 (0D)
1 3/4	1/4	190 (4.5D)	130 (4.5D)	130 (6D)	110 (5.5D)
	5/16	270 (4.5D)	160 (4D)	180 (6D)	150 (5D)
	3/8	330 (4D)	190 (3D)	230 (5.5D)	170 (4.5D)
	7/16	410 (3.5D)	230 (3D)	280 (5.5D)	210 (4.5D)
	1/2	510 (3.5D)	280 (3D)	340 (5.5D)	250 (4.5D)
	5/8	730 (3.5D)	370 (3D)	460 (5.5D)	350 (4.5D)
	3/4	1000 (3D)	410 (0D)	600 (5.5D)	410 (4.5D)
	7/8	1320 (3D)	430 (0D)	740 (5.5D)	430 (0D)
	1	1700 (3D)	470 (0D)	920 (5.5D)	470 (0D)
2 1/2	1/4	190 (4.5D)	130 (4.5D)	130 (6D)	120 (5.5D)
	5/16	270 (4.5D)	190 (4D)	190 (6D)	170 (5.5D)
	3/8	340 (4D)	230 (3.5D)	230 (5.5D)	200 (5D)
	7/16	460 (3.5D)	270 (3D)	300 (5.5D)	240 (5D)
	1/2	600 (3.5D)	320 (3D)	390 (5.5D)	280 (5D)
	5/8	850 (3.5D)	430 (3D)	510 (6D)	380 (5D)
	3/4	1120 (3.5D)	580 (3D)	650 (6D)	490 (5D)
	7/8	1430 (3D)	610 (2.5D)	790 (6D)	610 (5D)
	1	1800 (3D)	680 (0D)	970 (6D)	680 (5D)
3 1/2	1/4	190 (4.5D)	130 (4.5D)	130 (6D)	120 (5.5D)
	5/16	270 (4.5D)	190 (4D)	190 (6D)	170 (5.5D)
	3/8	340 (4D)	230 (3.5D)	230 (5.5D)	200 (5D)
	7/16	460 (3.5D)	300 (3.5D)	300 (5.5D)	260 (5D)
	1/2	600 (3.5D)	380 (3.5D)	390 (5.5D)	330 (5D)
	5/8	930 (3.5D)	490 (3D)	580 (6D)	430 (5D)
	3/4	1330 (3.5D)	620 (3D)	750 (6D)	540 (5D)
	7/8	1660 (3.5D)	770 (2.5D)	890 (6D)	650 (5D)
	1	2030 (3.5D)	950 (2.5D)	1070 (6D)	810 (5D)

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see NDS Table 10.3.1).
2. Tabulated lateral design values (Z) are for "**full body diameter**" lag screws (see NDS 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 $\geq$ 3/8"
3. When 4D≤p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.
4. The term, (x_2), is the minimum length of unthreaded full diameter shank in the main member. A value of (3D) represents a minimum length of unthreaded shank in the main member equal to 3 times the lag screw diameter, D.

Supplemental Table 11K LAG SCREWS (full body diameter): Reference Design Values (Z) for Single Shear (two member) Connections [1,2,3,4]

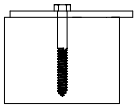


with 1/4" ASTM A36 steel side plate, or ASTM A653, Grade 33 steel side plate (for t_s<1/4")

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)	
t_s	D	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)
in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0.075	1/4	250 (3.5D)	190 (3.5D)	230 (4D)	170 (4D)	220 (4D)	160 (4.5D)	210 (4D)	150 (4.5D)	210 (4D)	150 (4.5D)
(14 gage)	5/16	350 (3D)	260 (3.5D)	320 (3.5D)	230 (4D)	310 (3.5D)	210 (4D)	310 (3.5D)	210 (4.5D)	300 (3.5D)	200 (4.5D)
	3/8	430 (2.5D)	310 (3D)	400 (3D)	270 (3.5D)	390 (3D)	250 (4D)	380 (3D)	250 (4D)	370 (3.5D)	240 (4D)
0.105	1/4	250 (3.5D)	190 (3.5D)	230 (4D)	170 (4D)	220 (4D)	160 (4.5D)	220 (4D)	160 (4.5D)	210 (4D)	150 (4.5D)
(12 gage)	5/16	360 (3D)	260 (3.5D)	330 (3.5D)	230 (4D)	320 (3.5D)	220 (4.5D)	310 (3.5D)	220 (4.5D)	300 (4D)	210 (4.5D)
	3/8	450 (3D)	310 (3D)	410 (3D)	280 (3.5D)	390 (3D)	260 (4D)	390 (3D)	260 (4D)	380 (3.5D)	250 (4D)
0.120	1/4	260 (3.5D)	200 (3.5D)	230 (4D)	170 (4D)	230 (4D)	160 (4.5D)	220 (4D)	160 (4.5D)	220 (4D)	150 (5D)
(11 gage)	5/16	360 (3D)	270 (3.5D)	330 (3.5D)	230 (4D)	320 (3.5D)	220 (4.5D)	320 (3.5D)	220 (4.5D)	310 (4D)	210 (4.5D)
	3/8	450 (3D)	320 (3D)	410 (3D)	280 (3.5D)	400 (3D)	260 (4D)	390 (3D)	260 (4D)	380 (3.5D)	250 (4D)
0.134	1/4	260 (3.5D)	200 (3.5D)	240 (4D)	180 (4D)	230 (4D)	170 (4.5D)	230 (4D)	170 (4.5D)	220 (4D)	160 (5D)
(10 gage)	5/16	370 (3D)	270 (3.5D)	340 (3.5D)	240 (4D)	320 (3.5D)	220 (4.5D)	320 (3.5D)	220 (4.5D)	310 (4D)	210 (4.5D)
	3/8	460 (3D)	320 (3D)	420 (3D)	280 (3.5D)	400 (3D)	270 (4D)	400 (3.5D)	260 (4D)	390 (3.5D)	250 (4D)
0.179	1/4	280 (3.5D)	220 (4D)	260 (4D)	190 (4.5D)	250 (4D)	180 (5D)	250 (4.5D)	180 (5D)	240 (4.5D)	170 (5D)
(7 gage)	5/16	390 (3D)	290 (3.5D)	360 (3.5D)	250 (4D)	340 (4D)	240 (4.5D)	340 (4D)	240 (4.5D)	330 (4D)	230 (4.5D)
	3/8	480 (3D)	340 (3.5D)	440 (3D)	300 (4D)	420 (3.5D)	280 (4D)	420 (3.5D)	280 (4D)	410 (3.5D)	270 (4.5D)
0.239	1/4	310 (4D)	240 (4D)	290 (4.5D)	220 (4.5D)	280 (4.5D)	200 (5D)	280 (4.5D)	200 (5D)	270 (4.5D)	190 (5.5D)
(3 gage)	5/16	430 (3.5D)	310 (4D)	390 (4D)	280 (4.5D)	380 (4D)	260 (4.5D)	380 (4D)	260 (5D)	370 (4D)	250 (5D)
	3/8	520 (3D)	370 (3.5D)	480 (3.5D)	330 (4D)	460 (3.5D)	310 (4.5D)	460 (3.5D)	310 (4.5D)	450 (3.5D)	290 (4.5D)
	7/16	680 (3D)	460 (3.5D)	620 (3D)	410 (4D)	600 (3.5D)	390 (4D)	600 (3.5D)	380 (4.5D)	580 (3.5D)	370 (4.5D)
	1/2	850 (3D)	570 (3.5D)	790 (3D)	500 (4D)	760 (3D)	470 (4.5D)	750 (3.5D)	460 (4.5D)	730 (3.5D)	450 (4.5D)
	5/8	1280 (2.5D)	810 (3.5D)	1180 (3D)	710 (4D)	1130 (3D)	660 (4.5D)	1120 (3D)	660 (4.5D)	1090 (3.5D)	630 (4.5D)
	3/4	1800 (2.5D)	1090 (3.5D)	1660 (3D)	950 (4D)	1590 (3D)	900 (4.5D)	1580 (3D)	880 (4.5D)	1530 (3D)	850 (5D)
	7/8	2430 (2.5D)	1410 (3.5D)	2230 (3D)	1240 (4.5D)	2140 (3D)	1160 (4.5D)	2120 (3D)	1140 (4.5D)	2060 (3D)	1090 (5D)
	1	3150 (2.5D)	1770 (4D)	2890 (3D)	1550 (4.5D)	2770 (3D)	1460 (4.5D)	2750 (3D)	1430 (5D)	2670 (3D)	1380 (5D)
1/4	1/4	350 (4D)	270 (4.5D)	320 (4.5D)	240 (5D)	310 (5D)	220 (5.5D)	300 (5D)	220 (5.5D)	290 (5D)	210 (5.5D)
	5/16	480 (3.5D)	360 (4D)	450 (4D)	320 (4.5D)	430 (4.5D)	300 (5D)	430 (4.5D)	290 (5D)	410 (4.5D)	280 (5.5D)
	3/8	590 (3D)	420 (3.5D)	550 (3.5D)	370 (4.5D)	530 (3.5D)	350 (4.5D)	520 (4D)	350 (4.5D)	510 (4D)	330 (5D)
	7/16	750 (3D)	510 (3.5D)	690 (3.5D)	460 (4D)	670 (3.5D)	430 (4.5D)	660 (3.5D)	420 (4.5D)	640 (3.5D)	410 (5D)
	1/2	930 (3D)	620 (3.5D)	860 (3D)	550 (4D)	830 (3.5D)	510 (4.5D)	820 (3.5D)	510 (4.5D)	800 (3.5D)	490 (5D)
	5/8	1370 (3D)	860 (3.5D)	1260 (3D)	760 (4.5D)	1210 (3.5D)	710 (4.5D)	1200 (3.5D)	700 (4.5D)	1160 (3.5D)	670 (5D)
	3/4	1900 (2.5D)	1140 (3.5D)	1740 (3D)	1000 (4.5D)	1670 (3D)	940 (4.5D)	1660 (3D)	930 (4.5D)	1610 (3.5D)	890 (5D)
	7/8	2530 (2.5D)	1460 (4D)	2320 (3D)	1280 (4.5D)	2220 (3D)	1210 (4.5D)	2200 (3D)	1180 (5D)	2140 (3D)	1130 (5D)
	1	3260 (2.5D)	1820 (4D)	2980 (3D)	1590 (4.5D)	2860 (3D)	1500 (5D)	2840 (3D)	1470 (5D)	2750 (3D)	1420 (5D)

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see NDS Table 10.3.1).
2. Tabulated lateral design values (Z) are for "**full body diameter**" lag screws (see NDS Appendix L) inserted in side grain with screw axis perpendicular to wood fibers; minimum screw penetration, p, into the main member equal to 8D; a dowel bearing strength (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 $\geq$ 3/8"
3. When 4D$\leq$p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.
4. The term, (x_2), is the minimum length of unthreaded full diameter shank in the main member. A value of (3D) represents a minimum length of unthreaded shank in the main member equal to 3 times the lag screw diameter, D.

Supplemental Table 11K LAG SCREWS (full body diameter): Reference Design (Cont.) Values (Z) for Single Shear (two member) Connections [1,2,3,4]



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=0.43 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	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)	$Z_\parallel$ (x_2)	$Z_\perp$ (x_2)
in.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0.075	1/4	200 (4D)	140 (5D)	200 (4.5D)	140 (5D)	190 (4.5D)	130 (5.5D)	190 (4.5D)	120 (5.5D)	180 (4.5D)	120 (5.5D)
(14 gage)	5/16	290 (4D)	190 (4.5D)	290 (4D)	190 (5D)	270 (4D)	170 (5D)	270 (4D)	170 (5.5D)	260 (4.5D)	170 (5.5D)
	3/8	360 (3.5D)	230 (4.5D)	360 (3.5D)	230 (4.5D)	340 (3.5D)	210 (5D)	330 (3.5D)	200 (5D)	330 (4D)	200 (5D)
0.105	1/4	210 (4.5D)	150 (5D)	210 (4.5D)	140 (5D)	190 (4.5D)	130 (5.5D)	190 (4.5D)	130 (5.5D)	190 (5D)	120 (6D)
(12 gage)	5/16	300 (4D)	200 (5D)	290 (4D)	190 (5D)	280 (4D)	180 (5.5D)	270 (4D)	180 (5.5D)	270 (4.5D)	170 (5.5D)
	3/8	370 (3.5D)	240 (4.5D)	360 (3.5D)	230 (4.5D)	340 (3.5D)	210 (5D)	340 (3.5D)	210 (5D)	330 (4D)	200 (5D)
0.120	1/4	210 (4.5D)	150 (5D)	210 (4.5D)	150 (5D)	200 (4.5D)	130 (5.5D)	200 (4.5D)	130 (6D)	190 (5D)	120 (6D)
(11 gage)	5/16	300 (4D)	200 (5D)	300 (4D)	200 (5D)	280 (4D)	180 (5.5D)	280 (4.5D)	180 (5.5D)	270 (4.5D)	170 (5.5D)
	3/8	370 (3.5D)	240 (4.5D)	370 (3.5D)	230 (4.5D)	350 (3.5D)	210 (5D)	340 (4D)	210 (5D)	340 (4D)	210 (5D)
0.134	1/4	220 (4.5D)	150 (5D)	210 (4.5D)	150 (5D)	200 (4.5D)	140 (5.5D)	200 (5D)	130 (6D)	200 (5D)	130 (6D)
(10 gage)	5/16	300 (4D)	200 (5D)	300 (4D)	200 (5D)	280 (4D)	180 (5.5D)	280 (4.5D)	180 (5.5D)	280 (4.5D)	180 (5.5D)
	3/8	380 (3.5D)	240 (4.5D)	370 (3.5D)	240 (4.5D)	350 (3.5D)	220 (5D)	350 (4D)	210 (5D)	340 (4D)	210 (5D)
0.179	1/4	230 (4.5D)	160 (5.5D)	230 (4.5D)	160 (5.5D)	220 (5D)	140 (6D)	220 (5D)	140 (6D)	210 (5D)	130 (6D)
(7 gage)	5/16	320 (4D)	220 (5D)	320 (4D)	210 (5D)	300 (4.5D)	200 (5.5D)	300 (4.5D)	190 (5.5D)	290 (4.5D)	180 (6D)
	3/8	400 (3.5D)	260 (4.5D)	390 (3.5D)	250 (4.5D)	370 (4D)	230 (5D)	370 (4D)	230 (5D)	360 (4D)	220 (5.5D)
0.239	1/4	260 (5D)	180 (5.5D)	260 (5D)	180 (6D)	250 (5.5D)	150 (6.5D)	240 (5.5D)	150 (6.5D)	240 (5.5D)	140 (6.5D)
(3 gage)	5/16	350 (4.5D)	240 (5.5D)	350 (4.5D)	240 (5.5D)	330 (4.5D)	210 (6D)	330 (4.5D)	200 (6D)	320 (5D)	190 (6D)
	3/8	440 (4D)	280 (5D)	430 (4D)	280 (5D)	410 (4D)	260 (5.5D)	410 (4D)	250 (5.5D)	400 (4D)	240 (5.5D)
	7/16	560 (3.5D)	350 (5D)	560 (3.5D)	340 (5D)	530 (4D)	320 (5.5D)	520 (4D)	310 (5.5D)	510 (4D)	300 (5.5D)
	1/2	710 (3.5D)	430 (5D)	700 (3.5D)	420 (5D)	660 (4D)	390 (5.5D)	660 (4D)	380 (5.5D)	650 (4D)	370 (5.5D)
	5/8	1060 (3.5D)	600 (5D)	1050 (3.5D)	600 (5D)	990 (3.5D)	550 (5.5D)	980 (3.5D)	520 (5.5D)	960 (4D)	500 (5.5D)
	3/4	1490 (3.5D)	810 (5D)	1470 (3.5D)	800 (5D)	1390 (3.5D)	700 (5.5D)	1380 (3.5D)	680 (5.5D)	1350 (3.5D)	660 (6D)
	7/8	1990 (3.5D)	1040 (5D)	1980 (3.5D)	1030 (5D)	1870 (3.5D)	880 (5.5D)	1850 (3.5D)	860 (6D)	1820 (3.5D)	800 (6D)
	1	2580 (3.5D)	1310 (5.5D)	2560 (3.5D)	1290 (5.5D)	2420 (3.5D)	1080 (6D)	2390 (3.5D)	1040 (6D)	2350 (3.5D)	1000 (6D)
1/4	1/4	280 (5D)	200 (6D)	280 (5D)	190 (6D)	270 (5.5D)	170 (6.5D)	260 (5.5D)	160 (6.5D)	260 (5.5D)	160 (6.5D)
	5/16	400 (4.5D)	260 (5.5D)	400 (4.5D)	260 (6D)	380 (5D)	220 (6.5D)	370 (5D)	220 (6.5D)	370 (5D)	210 (6.5D)
	3/8	490 (4D)	320 (5D)	490 (4D)	310 (5.5D)	460 (4.5D)	280 (6D)	460 (4.5D)	270 (6D)	450 (4.5D)	260 (6D)
	7/16	620 (4D)	390 (5D)	620 (4D)	380 (5D)	590 (4D)	340 (5.5D)	580 (4D)	330 (5.5D)	570 (4D)	320 (6D)
	1/2	770 (3.5D)	470 (5D)	770 (3.5D)	460 (5D)	720 (4D)	410 (5.5D)	720 (4D)	390 (6D)	710 (4D)	380 (6D)
	5/8	1130 (3.5D)	640 (5D)	1120 (3.5D)	630 (5D)	1060 (4D)	560 (5.5D)	1050 (4D)	540 (6D)	1030 (4D)	520 (6D)
	3/4	1560 (3.5D)	850 (5D)	1550 (3.5D)	840 (5D)	1460 (3.5D)	710 (6D)	1450 (3.5D)	690 (6D)	1420 (4D)	670 (6D)
	7/8	2070 (3.5D)	1080 (5.5D)	2050 (3.5D)	1070 (5.5D)	1940 (3.5D)	900 (6D)	1920 (3.5D)	870 (6D)	1890 (3.5D)	820 (6D)
	1	2670 (3.5D)	1340 (5.5D)	2640 (3.5D)	1310 (5.5D)	2490 (3.5D)	1090 (6D)	2470 (3.5D)	1060 (6D)	2420 (3.5D)	1020 (6D)

1. Tabulated lateral design values (Z) shall be multiplied by all applicable adjustment factors (see NDS Table 10.3.1).
2. Tabulated lateral design values (Z) are for "**full body diameter**" lag screws (see NDS Appendix L) inserted in side grain with screw axis perpendicular to wood fibers; minimum screw penetration, p, into the main member equal to 8D; a dowel bearing strength (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 $\geq$ 3/8"
3. When 4D$\leq$p<8D, tabulated lateral design values (Z) shall be multiplied by p/8D.
4. The term, (x_2), is the minimum length of unthreaded full diameter shank in the main member. A value of (3D) represents a minimum length of unthreaded shank in the main member equal to 3 times the lag screw diameter, D.

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