SPLIT RING AND SHEAR PLATE CONNECTORS

13

13.1 General

13.1.1 Scope

Chapter 13 applies to the engineering design of connections using split ring connectors or shear plate connectors in sawn lumber, structural glued laminated timber, and structural composite lumber. Design of split ring and shear plate connections in cross-laminated timber is beyond the scope of these provisions.

13.1.2 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 13A).

(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 13B and 13C).

(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 13B and 13C).

Figure 13A Split Ring Connector

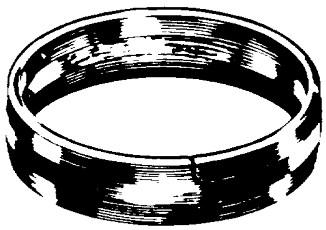


Figure 13B Pressed Steel Shear Plate Connector

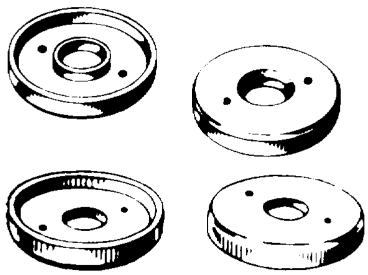
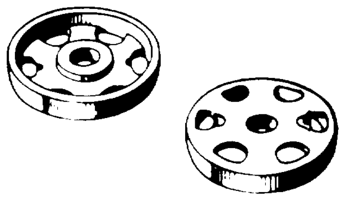


Figure 13C Malleable Iron Shear Plate Connector



13.1.3 Quality of Split Ring and Shear Plate Connectors

13.1.3.1 Design provisions and reference 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 (Reference 37). 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 13A).

(b) Shear plate connectors:

(1) 2-5/8" Pressed Steel Type—Pressed steel shear plates manufactured from SAE 1010 (Reference 37) 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 13B).

(2) 4" Malleable Iron Type—Malleable iron shear plates manufactured according to Grade 32510 of ASTM Standard A47 (Reference 11). 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 13C).

13.1.3.2 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.

13.1.3.3 Bolts used with split ring and shear plate connectors shall conform to 12.1.3. The bolt shall have an unreduced nominal or shank (body) diameter in accordance with ANSI/ASME Standard B18.2.1 (Reference 7).

13.1.3.4 Where lag screws are used in place of bolts, the lag screws shall conform to 12.1.3 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 13.2A and 13.2B). The lag screw shall have an unreduced nominal or shank (body) diameter and threads in accordance with ANSI/ASME Standard B18.2.1 (see Reference 7).

13.1.4 Fabrication and Assembly

13.1.4.1 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.

13.1.4.2 Where 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 12.1.4.2.

13.1.4.3 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. Where an outside member of a shear plate connection is a steel strap or shape, the washer is not required, except where 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.

13.1.4.4 Reference 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. Where 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.

13.2 Reference Design Values

13.2.1 Reference Design Values

13.2.1.1 Tables 13.2A and 13.2B contain reference 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 (Table 13A) with sufficient member thicknesses, edge distances, end distances, and spacing to develop reference design values. Reference design values (P, Q) shall be multiplied by all applicable adjustment factors (see Table 11.3.1) to obtain adjusted design values (P', Q').

13.2.1.2 Adjusted design values (P', Q') for shear plate connectors shall not exceed the limiting reference design values specified in Footnote 2 of Table 13.2B. The limiting reference design values in Footnote 2 of Table 13.2B shall not be multiplied by adjustment factors in this Specification since they are based on strength of metal rather than strength of wood (see 11.2.3).

Table 13A 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	$G < 0.42$

Table 13.2A Split Ring Connector Unit Reference 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.			
in.	in.		in.	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 11.3.1).

Table 13.2B Shear Plate Connector Unit Reference 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.			
in.	in.		in.	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 11.3.1).
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 11.2.3).
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.

13.2.2 Thickness of Wood Members

13.2.2.1 Reference 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 13.2A and 13.2B.

13.2.2.2 Reference 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 reference design value, as specified in Tables 13.2A and 13.2B, shall be obtained by linear interpolation.

13.2.3 Penetration Depth Factor, C_d

Where lag screws instead of bolts are used with split ring or shear plate connectors, reference design values shall be multiplied by the appropriate penetration depth factor, C_d, specified in Table 13.2.3. Lag screw penetration into the member receiving the point shall not be less than the minimum penetration specified in Table 13.2.3. Where the actual lag screw penetration into the member receiving the point is greater than the minimum penetration, but less than the minimum penetration for $C_d = 1.0$, the penetration depth factor, C_d, shall be determined by linear interpolation. The penetration depth factor shall not exceed unity, $C_d \leq 1.0$.

13.2.4 Metal Side Plate Factor, C_{st}

Where metal side members are used in place of wood side members, the reference design values parallel to grain, P, for 4" shear plate connectors shall be multiplied by the appropriate metal side plate factor specified in Table 13.2.4.

Table 13.2.4 Metal Side Plate Factors, C_{st}, for 4" Shear Plate Connectors Loaded Parallel to Grain

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

The adjusted design values parallel to grain, P', shall not exceed the limiting reference design values given in Footnote 2 of Table 13.2B (see 13.2.1.2).

13.2.5 Load at Angle to Grain

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

$$N' = \frac{P'Q'}{P' \sin^2\theta + Q' \cos^2\theta} \qquad (13.2\text{-}1)$$

where:

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

13.2.5.2 Adjusted design values at an angle to grain, N', for shear plate connectors shall not exceed the limiting reference design values specified in Footnote 2 of Table 13.2.B (see 13.2.1.2).

Table 13.2.3 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 13A) 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 $C_d = 1.0$	7	8	10	11	1.0
		Minimum for $C_d = 0.75$	3	3-1/2	4	4-1/2	0.75
2-5/8" Shear Plate	Wood	Minimum for $C_d = 1.0$	4	5	7	8	1.0
		Minimum for $C_d = 0.75$	3	3-1/2	4	4-1/2	0.75
	Metal	Minimum for $C_d = 1.0$	3	3-1/2	4	4-1/2	1.0

13.2.6 Split Ring and Shear Plate Connectors in End Grain

13.2.6.1 Where 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 structural 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 13D, 13G, 13H, and 13I, 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 13E).

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 13D through 13I).

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 13I).

P' = adjusted 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' = adjusted 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} = adjusted 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} = adjusted 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} = adjusted 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} = adjusted design value for a split ring or shear plate connector unit in a sloping surface, where direction of load is at an angle φ from the axis of cut.

Figure 13D Axis of Cut for Symmetrical Sloping End Cut

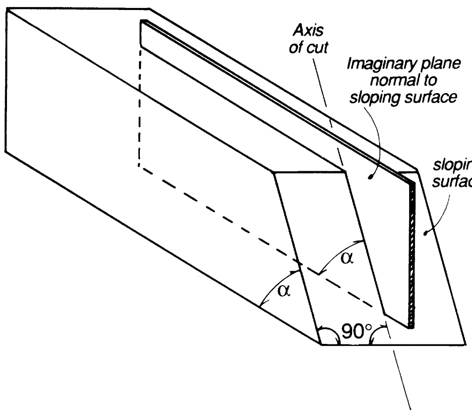
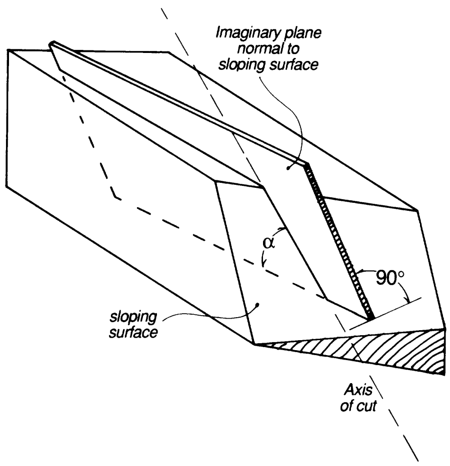


Figure 13E Axis of Cut for Asymmetrical Sloping End Cut



SPLIT RING AND SHEAR PLATE CONNECTORS

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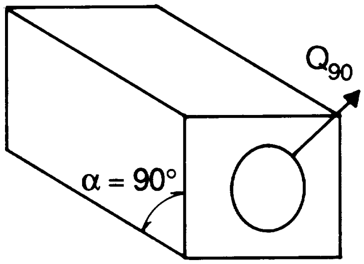
13.2.6.2 Where split ring or shear plate connectors are installed in square-cut end grain or sloping surfaces, adjusted design values shall be determined as follows (see 11.2.2):

(a) Square-cut surface; loaded in any direction ($\alpha = 90°$, see Figure 13F).

$$Q_{90}' = 0.60Q' \quad (13.2\text{-}2)$$

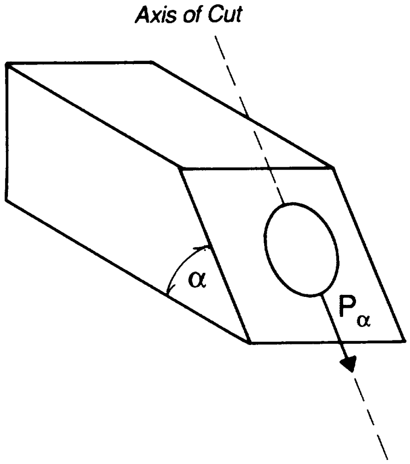
Figure 13F Square End Cut



(b) Sloping surface; loaded parallel to axis of cut ($0° < \alpha < 90°$, $\varphi = 0°$, see Figure 13G).

$$P'_{\alpha} = \frac{P'Q_{90}'}{P'\sin^2\alpha + Q_{90}'\cos^2\alpha} \quad (13.2\text{-}3)$$

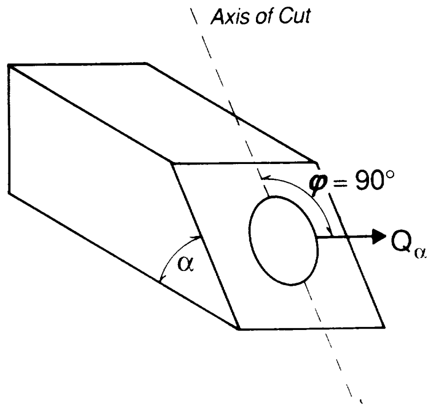
Figure 13G Sloping End Cut with Load Parallel to Axis of Cut ($\varphi = 0°$)



(c) Sloping surface; loaded perpendicular to axis of cut ($0° < \alpha < 90°$, $\varphi = 90°$, see Figure 13H).

$$Q'_{\alpha} = \frac{Q'Q_{90}'}{Q'\sin^2\alpha + Q_{90}'\cos^2\alpha} \quad (13.2\text{-}4)$$

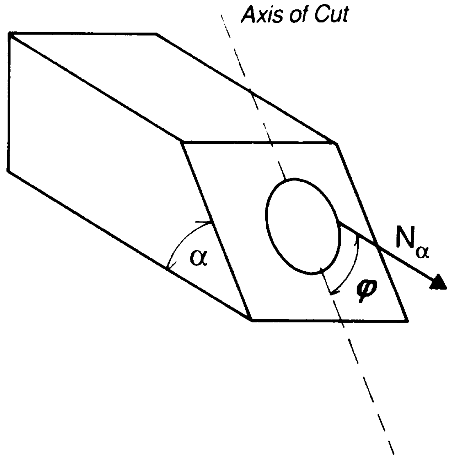
Figure 13H Sloping End Cut with Load Perpendicular to Axis of Cut ($\varphi = 90°$)



(d) Sloping surface; loaded at angle φ to axis of cut ($0° < \alpha < 90°$, $0° < \varphi < 90°$, see Figure 13I).

$$N'_{\alpha} = \frac{P_{\alpha}'Q_{\alpha}'}{P_{\alpha}'\sin^2\varphi + Q_{\alpha}'\cos^2\varphi} \quad (13.2\text{-}5)$$

Figure 13I Sloping End Cut with Load at an Angle φ to Axis of Cut



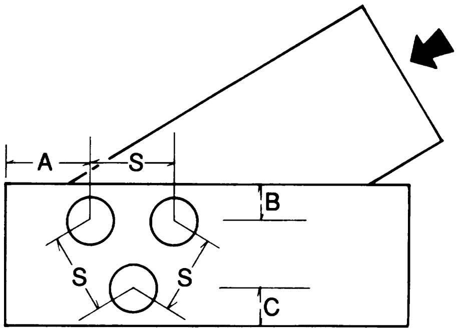
13.3 Placement of Split Ring and Shear Plate Connectors

13.3.1 Terminology

13.3.1.1 "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. Where 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 Figure 13J).

13.3.1.2 "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 13J). 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 13K).

Figure 13J Connection Geometry for Split Rings and Shear Plates

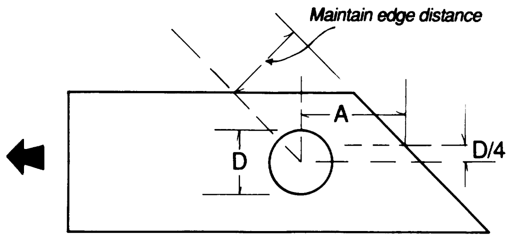


A = End Distance
B = Unloaded Edge Distance
C = Loaded Edge Distance
S = Spacing

13.3.1.3 "Connector axis" is a line joining the centers of any two adjacent connectors located in the same face of a member (see Figure 13L).

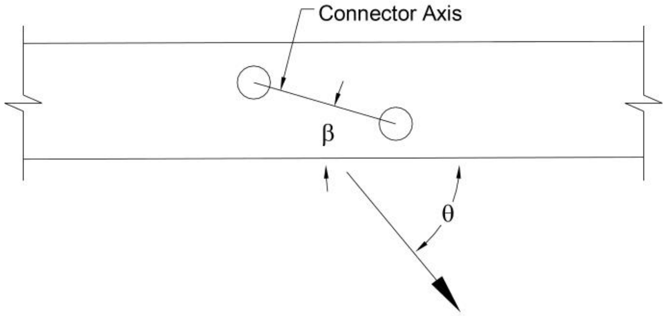
13.3.1.4 "Spacing" is the distance between centers of split ring or shear plate connectors measured along their connector axis (see Figure 13J).

Figure 13K End Distance for Members with Sloping End Cut



A = End Distance
D = Connector Diameter

Figure 13L Connector Axis and Load Angle



13.3.2 Geometry Factor, C_Δ, for Split Ring and Shear Plate Connectors in Side Grain

Reference design values are for split ring and shear plate connectors installed in side grain with edge distance, end distance, and spacing greater than or equal to the minimum required for $C_\Delta = 1.0$. Where the edge distance, end distance, or spacing provided is less than the minimum required for $C_\Delta = 1.0$, reference 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. 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. Edge distance, end distance, and spacing shall not be less than the minimum values specified in 13.3.2.1 and 13.3.2.2.

13.3.2.1 Connectors Loaded Parallel or Perpendicular to Grain. For split ring and shear plate connectors loaded parallel or perpendicular to grain, minimum values for edge distance, end distance, and spacing are provided in Table 13.3 with their associated geometry factors, C_Δ.

Where the actual value is greater than or equal to the minimum value, but less than the minimum value for $C_\Delta = 1.0$, the geometry factor, C_Δ, shall be determined by linear interpolation.

13.3.2.2. Connectors Loaded at an Angle to Grain. For split rings and shear plate connectors where the angle between the direction of load and the direction of grain, θ, is other than 0° or 90°, separate geometry factors for edge distance and end distance shall be determined for the parallel and perpendicular to grain components of the resistance.

For split ring and shear plate connectors loaded at an angle to grain, θ, other than 0° or 90°, the minimum spacing for $C_\Delta = 1.0$ shall be determined in accordance with Equation 13.3-1.

$$S_\beta = \frac{S_A S_B}{\sqrt{S_A^2 \sin^2\beta + S_B^2 \cos^2\beta}} \qquad (13.3\text{-}1)$$

where:

S_β = minimum spacing along connector axis

S_A = factor from Table 13.3.2.2

S_B = factor from Table 13.3.2.2

β = angle of connector axis to the grain

Table 13.3.2.2 Factors for Determining Minimum Spacing Along Connector Axis for $C_\Delta = 1.0$

Connector	Angle of Load to Grain[1] (degrees)	S_A in.	S_B in.
2-1/2" split ring or 2-5/8" shear plate	0	6.75	3.50
	15	6.00	3.75
	30	5.13	3.88
	45	4.25	4.13
	60-90	3.5	4.25
4" split ring or 4" shear plate	0	9.00	5.00
	15	8.00	5.25
	30	7.00	5.50
	45	6.00	5.75
	60-90	5.00	6.00

1. Interpolation shall be permitted for intermediate angles of load to grain.

The minimum spacing shall be 3.50" for 2-1/2" split rings and 2-5/8" shear plates and shall be 5.0" for 4" split ring or shear plate connectors. For this minimum spacing, $C_\Delta = 0.5$.

Where the actual spacing between split ring or shear plate connectors is greater than the minimum spacing but less than the minimum spacing for $C_\Delta = 1.0$, the geometry factor, C_Δ, shall be determined by linear interpolation. The geometry factor calculated for spacing shall be applied to reference design values for both parallel and perpendicular-to-grain components of the resistance.

13.3.3 Geometry Factor, C_Δ, for Split Ring and Shear Plate Connectors in End Grain

For split ring and shear plate connectors installed in end grain, a single geometry factor shall be determined and applied to reference design values for both parallel and perpendicular to grain components of the resistance. Edge distance, end distance, and spacing shall not be less than the minimum values specified in 13.3.3.1 and 13.3.3.2.

13.3.3.1 The provisions for geometry factors, C_Δ, for split ring and shear plate connectors installed in square-cut surfaces and sloping surfaces shall be as follows (see 13.2.6 for definitions and terminology):

(a) Square-cut surface, loaded in any direction (see Figure 13F) - provisions for perpendicular to grain loading for connectors installed in side grain shall apply except for end distance provisions.

(b) Sloping surface loaded parallel to axis of cut (see Figure 13G).

(b.1) Spacing. The minimum spacing parallel to the axis of cut for $C_\Delta = 1.0$ shall be determined in accordance with Equation 13.3-2.

The minimum spacing parallel to the axis of cut shall be 3.5" for 2-1/2" split rings and 2-5/8" shear plates and shall be 5.0" for 4" split ring or shear plate connectors. For this minimum spacing, $C_\Delta = 0.5$.

Where the actual spacing parallel to the axis of cut between split ring or shear plate connectors is greater than the minimum spacing for $C_\Delta = 0.5$, but less than the minimum spacing for $C_\Delta = 1.0$, the geometry factor, C_Δ shall be determined by linear interpolation.

$$S_\alpha = \frac{S_{\parallel} S_{\perp}}{\sqrt{S_{\parallel}^2 \sin^2 \alpha + S_{\perp}^2 \cos^2 \alpha}} \quad (13.3\text{-}2)$$

where:

S_α = minimum spacing parallel to axis of cut

$S_{\parallel}$ = factor from Table 13.3.3.1-1

$S_{\perp}$ = factor from Table 13.3.3.1-1

α = angle of sloped cut (see Figure 13G)

Table 13.3.3.1-1 Factors for Determining Minimum Spacing Along Axis of Cut of Sloping Surfaces

Connector	Geometry Factor	$S_{\parallel}$ in.	$S_{\perp}$ in.
2-1/2" split ring or 2-5/8" shear plate	$C_\Delta = 1.0$	6.75	4.25
4" split ring or 4" shear plate	$C_\Delta = 1.0$	9.0	6.0

(b.2) Loaded Edge Distance. The minimum loaded edge distance parallel to the axis of cut for $C_\Delta = 1.0$ shall be determined in accordance with Equation 13.3-3.

For split rings, the minimum loaded edge distance parallel to the axis of cut for $C_\Delta = 0.70$ shall be determined in accordance with Equation 13.3-3. For shear plates, the minimum loaded edge distance parallel to the axis of cut for $C_\Delta = 0.83$ shall be determined in accordance with Equation 13.3-3.

Where the actual loaded edge distance parallel to the axis of cut is greater than the minimum loaded edge distance parallel to the axis of cut for $C_\Delta = 0.70$ for split rings or for $C_\Delta = 0.83$ for shear plates, but less than the minimum loaded edge distance parallel to the axis of cut for $C_\Delta = 1.0$, the geometry factor, C_Δ, shall be determined by linear interpolation.

$$E_\alpha = \frac{E_{\parallel} E_{\perp}}{\sqrt{E_{\parallel}^2 \sin^2 \alpha + E_{\perp}^2 \cos^2 \alpha}} \quad (13.3\text{-}3)$$

where:

E_α = minimum loaded edge distance parallel to axis of cut

$E_{\parallel}$ = factor from Table 13.3.3.1-2

$E_{\perp}$ = factor from Table 13.3.3.1-2

α = angle of sloped cut (see Figure 13G)

Table 13.3.3.1-2 Factors for Determining Minimum Loaded Edge Distance for Connectors in End Grain

Connector	Geometry Factor	$E_{\parallel}$ in.	$E_{\perp}$ in.
2-1/2" split ring	$C_\Delta = 1.0$	5.5	2.75
	$C_\Delta = 0.70$	3.3	1.5
2-5/8" shear plate	$C_\Delta = 1.0$	5.5	2.75
	$C_\Delta = 0.83$	4.25	1.5
4" split ring	$C_\Delta = 1.0$	7.0	3.75
	$C_\Delta = 0.70$	4.2	2.5
4" shear plate	$C_\Delta = 1.0$	7.0	3.75
	$C_\Delta = 0.83$	5.4	2.5

(b.3) Unloaded Edge Distance. The minimum unloaded edge distance parallel to the axis of cut for $C_\Delta = 1.0$, shall be determined in accordance with Equation 13.3-4.

The minimum unloaded edge distance parallel to the axis of cut for $C_\Delta = 0.63$ shall be determined in accordance with Equation 13.3-4.

Where the actual unloaded edge distance parallel to the axis of cut is greater than the minimum unloaded edge distance for $C_\Delta = 0.63$, but less than the minimum unloaded edge distance for $C_\Delta = 1.0$, the geometry factor, C_Δ, shall be determined by linear interpolation.

$$U_\alpha = \frac{U_{\|}U_{\perp}}{\sqrt{U_{\|}^2 \sin^2\alpha + U_{\perp}^2 \cos^2\alpha}} \quad (13.3\text{-}4)$$

where:

U_α = minimum unloaded edge distance parallel to axis of cut

$U_{\|}$ = factor from Table 13.3.3.1-3

$U_{\perp}$ = factor from Table 13.3.3.1-3

α = angle of sloped cut (see Figure 13G)

Table 13.3.3.1-3 Factors for Determining Minimum Unloaded Edge Distance Parallel to Axis of Cut

Connector	Geometry Factor	$U_{\|}$ in.	$U_{\perp}$ in.
2-1/2" split ring or 2-5/8" shear plate	$C_\Delta = 1.0$	4.0	1.75
	$C_\Delta = 0.63$	2.5	1.5
4" split ring or 4" shear plate	$C_\Delta = 1.0$	5.5	2.75
	$C_\Delta = 0.63$	3.25	2.5

(b.4) Geometry factors for unloaded edge distance perpendicular to the axis of cut and for spacing perpendicular to the axis of cut shall be determined following the provisions for unloaded edge distance and perpendicular-to-grain spacing for connectors installed in side grain and loaded parallel to grain.

(c) Sloping surface loaded perpendicular to axis of cut (see Figure 13H) - provisions for perpendicular to grain loading for connectors installed in end grain shall apply, except that:

(1) The minimum end distance parallel to the axis of cut for $C_\Delta = 1.0$ shall be determined in accordance with Equation 13.3-5.

(2) The minimum end distance parallel to the axis of cut for $C_\Delta = 0.63$ shall be determined in accordance with Equation 13.3-5.

(3) Where the actual end distance parallel to the axis of cut is greater than the minimum end distance for $C_\Delta = 0.63$, but less than the minimum unloaded edge distance for $C_\Delta = 1.0$, the geometry factor, C_Δ, shall be determined by linear interpolation.

$$e_\alpha = \frac{E_{\|}U_{\perp}}{\sqrt{E_{\|}^2 \sin^2\alpha + U_{\perp}^2 \cos^2\alpha}} \quad (13.3\text{-}5)$$

where:

e_α = minimum end distance parallel to axis of cut

$E_{\|}$ = factor from Table 13.3.3.1-4

$U_{\perp}$ = factor from Table 13.3.3.1-4

α = angle of sloped cut (see Figure 13G)

Table 13.3.3.1-4 Factors for Determining Minimum End Distance Parallel to Axis of Cut

Connector	Geometry Factor	$E_{\|}$ in.	$U_{\perp}$ in.
2-1/2" split ring or 2-5/8" shear plate	$C_\Delta = 1.0$	5.5	1.75
	$C_\Delta = 0.63$	2.75	1.5
4" split ring or 4" shear plate	$C_\Delta = 1.0$	7.0	2.75
	$C_\Delta = 0.63$	3.5	2.5

(d) Sloping surface loaded at angle φ to axis of cut (see Figure 13I) - separate geometry factors, C_Δ, shall be determined for the components of resistance parallel and perpendicular to the axis of cut prior to applying Equation 13.2-5.

13.3.3.2 Where 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.

13.3.4 Multiple Split Ring or Shear Plate Connectors

13.3.4.1 Where 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 11.3.6 and the total adjusted design value for the connection shall be as specified in 11.2.2.

13.3.4.2 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 reference design value shall be taken as the reference design value for the larger split ring connector.

13.3.4.3 Local stresses in connections using multiple fasteners shall be evaluated in accordance with principles of engineering mechanics (see 11.1.2).

Table 13.3 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 Value	Minimum for $C_\Delta = 1.0$	Minimum Value	Minimum for $C_\Delta = 1.0$	Minimum Value	Minimum for $C_\Delta = 1.0$	Minimum Value	Minimum for $C_\Delta = 1.0$
Edge Distance	Unloaded Edge	1-1/2"	1-3/4"	1-1/2"	1-3/4"	2-1/2"	2-3/4"	2-1/2"	2-3/4"
	C_Δ	0.88	1.0	0.88	1.0	0.93	1.0	0.93	1.0
	Loaded Edge	–	–	1-1/2"	2-3/4"	–	–	2-1/2"	3-3/4"
	C_Δ for Split Rings	–	–	0.70	1.0	–	–	0.70	1.0
	C_Δ for Shear Plates	–	–	0.83	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	0.63	1.0	0.63	1.0	0.63	1.0	0.63	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	0.63	1.0	0.63	1.0	0.63	1.0	0.63	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