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## Designing with Single Plate Connections

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**T**wo basic types of single plate connections are used for “simple framing” (where connection end restraint is ignored for member design): single plate shear connections and extended single plate shear connections. The first type is used for beam-to-beam and beam-to-column-flange connections, where the end of the supported beam frames close to the face of the supporting member. The second type is used for beam-to-beam and beam-to-column-web connections, where the end of the supported beam stops short of either the flanges of the supporting beam or the flanges of the column.

### **SINGLE PLATE SHEAR CONNECTIONS** **Support Conditions**

The behavior of single plate shear connections is affected by the support conditions, which are idealized as being either flexible or rigid. If the beam is supported by an ideal flexible support such as a beam, which is torsionally unrestrained, then the beam end rotation is entirely accommodated by rotation of the support. However if the beam is supported by a fully rigid support, such as the flange of a W-shape column, then the welded edge of the plate will remain vertical when loaded by a gravity shear force and rotation is accommodated by deformation within the connection. In the ideal flexible connection, the inflection point is at the face of the supporting member; but in the ideal rigid connection the inflection point moves away from the inflection point. Since “real” supports seldom behave exactly as flexible or rigid connections, redundant design procedures are necessary to provide a safe and efficient design.

### **New Tables and Concepts**

New tables are provided to include X-bolt capacities for ASD design. The

new ASD tables will also expand to include 9 to 12 rows of bolts for the single vertical column. These concepts are already provided in the AISC LRFD 3rd Edition Manual.

Tables are presented for both ASD and LRFD single plate connection capacities/strengths utilizing both ASTM A36 plate and A572 GR50 plate.

Design procedures with example calculations are presented for extended single plate shear connections to girders and column webs.

### **General Requirements for Connecting Plates, Bolts, and Welds**

The connection can have one or two vertical columns of bolts, with two to 12 horizontal bolt rows spaced at 3”-vertical pitch spacing. The horizontal bolt gage for the double-vertical columns of bolts may be 3” or 3 ½” as required to satisfy AISC minimum bolt-spacing requirements for standard holes or horizontal short slotted holes.

The horizontal and vertical bolt-edge distances for the beam web (Lh & Lv) and the shear plate (Edh & Edv) shall be the greater of 1.5 times the bolt diameter or 1-½” in the as-built condition. The horizontal beam-web end-edge distance (Lh) shall exceed this dimension by ¼” as detailed on shop fabrication drawings.

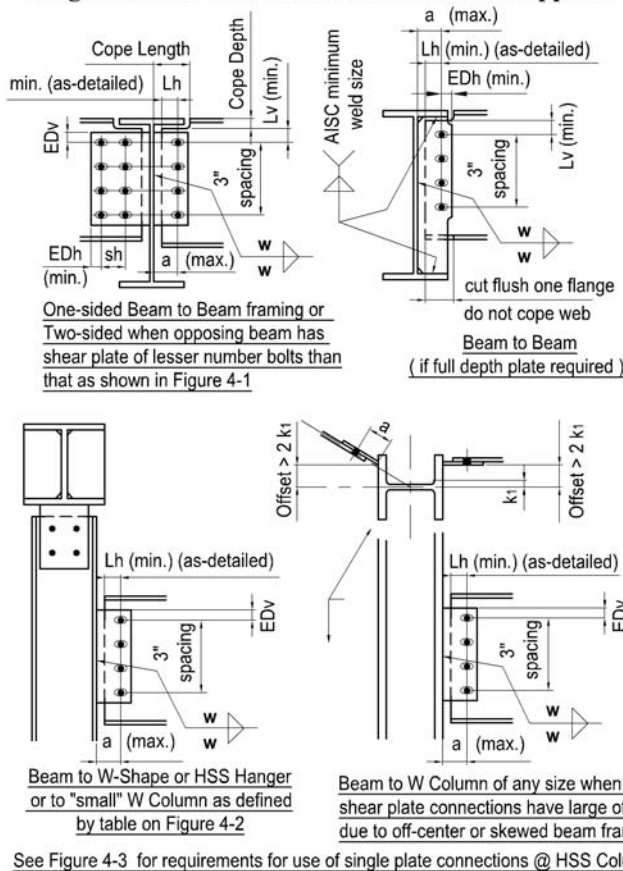
The horizontal distance from the face of the support to the first line of bolts shall be a minimum of 2½” to a maximum of 5¼”.

Bolts can have standard holes or short slots, and can be snug-tight or pretensioned.

Material for the shear plate can be either A36 or A572 GR50.

Welds for the shear plate to the supporting member must be double-fillet welds, equivalent-strength partial-penetration welds, or full-penetration welds using E70XX electrodes.

**Figure 3-1**  
**Single Plate Shear Connections at Flexible Supports**



To provide for stability during erection, it is recommended that the minimum plate length be at least one half of the T-dimension of the beam being supported. If the beam has no intermediate lateral support such that it is unsupported laterally between the connections at its ends, then the plate length shall be increased to at least accommodate one extra row of bolts beyond the above-mentioned minimum.

The plate thickness must satisfy plate buckling criteria required in Part 9 of the *AISC Manual* for local buckling of beams coped at both the top and bottom flanges. For rotational ductility, the maximum plate thicknesses must be limited as required for either single-vertical column or double-vertical column connections. When using bearing bolts with threads excluded from the shear plane, the minimum thickness is  $\frac{3}{8}$ " for  $\frac{3}{4}$ "- and  $\frac{7}{8}$ "-diameter bolts and  $\frac{1}{2}$ " for 1"- and  $1\frac{1}{8}$ "-diameter bolts.

### Limit State Considerations

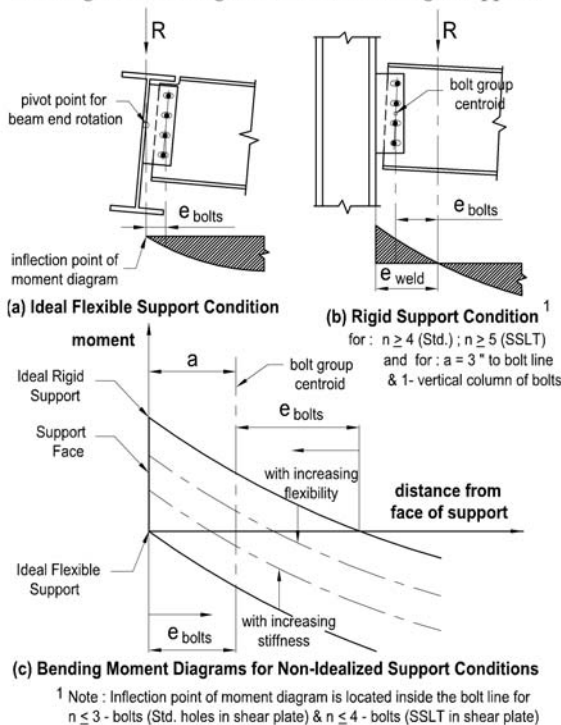
- Bolt shear considering bolt eccentricity
- Material bearing strength of the bolt group for both the plate and the beam web
- Plate shear yielding
- Plate shear fracture
- Plate block shear
- Plate flexural yielding due to bending using the plastic section modulus of the plate
- Plate flexural fracture due to bending
- Weld strength for plate to supporting member
- Block shear for coped beams
- Flexural yielding of the coped section of the beam
- Rotational demand of connection for rigid connections only

### EXTENDED SINGLE PLATE SHEAR CONNECTIONS

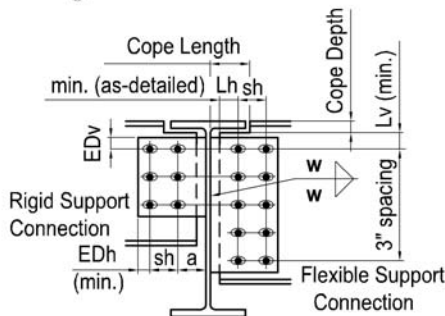
#### Types of Extended Single Plate Shear Connections

These connections are used for "simple framing" similar to the single plate shear connections. For the extended connections, it is necessary to consider the effects of the shear and moment forces in design of the supporting member. This is not necessary for the single plate shear connections. The extended connections are commonly used for simple beams framing to column webs when column stiffeners are required due to moment beam

**Figure 2-1**  
**Bending Moment Diagrams at Flexible & Rigid Supports**

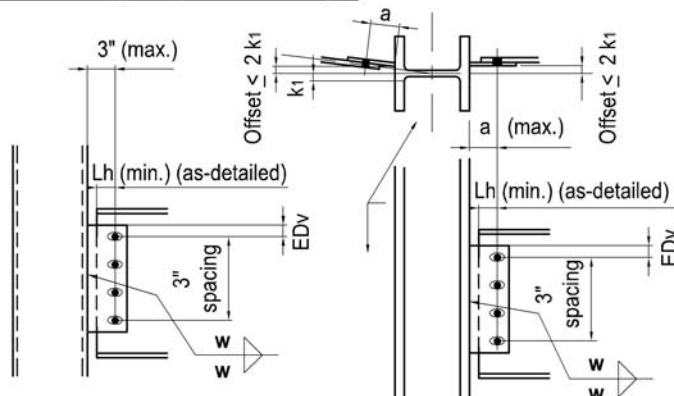


**Figure 4-1**  
**Single Plate Shear Connections at Rigid Supports**



Note For Coped Beams :  
 Check Connection Capacity Limited by Thickness of Beam Web & Maximum Size of Top Flange Cope from Flexible Support Tables. Values for beam webs thicker than that as shown in the Flexible Support Tables may be found by multiplying by the ratio of the web thicknesses. Note that the web thicknesses shown in Appendix A Tables are the least decimal thickness for a given nominal thickness.

**Two-sided beam to beam connection when opposing beam has shear plate larger by 2 or more number of bolt rows of same or more bolt columns of same or larger req'd. bolt size & type**



**Beam to HSS Column**  
 (single column of bolts only)

See Figure 4-3 for Requirements for use of Single Plate Connections at HSS Columns

Beam to "large" W-shape column as defined by table on Figure 4-2 with connections on centerline of column or with small offsets when beam framing is off-center or skewed.

connections to the column flange. They also can be used to simplify erection procedures for beams framing to column webs, even when column stiffeners are not required for moment beams to the column flange. These connections are sometimes used for framing to girder webs. This detail eliminates coping of the supported beams and simplifies the erection of the member. The coping of the beams can greatly reduce the strength of the supported beams when the girder flanges are wide.

### Support Conditions

Since the shear and moment forces affect the design of the supporting member, guidelines will be provided to

determine adequate column sizes for various beam end reactions.

### Unstiffened Extended Single Plate Connections

Use of unstiffened extended single plate connections is discouraged except for small shear forces. Tests have indicated that column-web distortions and twist in the unstiffened plates limit the strength of this type of connection.

### General Requirements for Connecting Plates, Bolts, and Welds:

- Bolt bearing considering bolt eccentricity
- Material bearing strength of the bolt group for both the extended plate and the beam web

- Extended plate shear yielding
- Extended plate shear fracture
- Extended plate block shear
- Extended plate flexural yielding due to bending using the elastic section modulus of the plate
- Extended plate flexural fracture due to bending
- Extended plate buckling
- Weld strength for the extended plate to the stiffener plates and the supporting member.
- Stiffener plate shear yielding
- Stiffener plate flexural bending
- Weld strength for the stiffener plates to the column flanges.★



**Figure 4-2**

Minimum Size of WF Column to use Rigid Support Single Plate Shear Connections								
# rows bolts	Rigid Support Single Plate Shear Connections with Single Vertical Column of Bolts							
	simple beam framing @ intermediate floor level ( not at top of column )				simple beam framing at top of column			
2	W8 x 24	W10 x 33	W12 x 40	W14 x 43	W8 x 24	W10 x 33	W12 x 40	W14 x 43
3	W8 x 24	W10 x 33	W12 x 40	W14 x 43	W8 x 31	W10 x 33	W12 x 40	W14 x 43
4	W8 x 35	W10 x 33	W12 x 40	W14 x 43	W8 x 58	W10 x 45	W12 x 40	W14 x 43
5	W8 x 67	W10 x 45	W12 x 40	W14 x 43		W10 x 77	W12 x 58	W14 x 43
6		W10 x 68	W12 x 50	W14 x 43		W10x112	W12 x 87	W14 x 68
7		W10x112	W12 x 79	W14 x 61			W12 x 136	W14 x 99
8			W12 x 106	W14 x 90			W12 x 170	W14 x 145
9			W12 x 152	W14 x 120			W12 x 230	W14 x 193
10			W12 x 190	W14 x 159			W12 x 279	W14 x 233
11			W12 x 252	W14 x 193				W14 x 311
12			W12 x 279	W14 x 233				W14 x 370

# rows bolts	Rigid Support Single Plate Shear Connections with Double Vertical Column of Bolts							
	simple beam framing @ intermediate floor level ( not at top of column )				simple beam framing at top of column			
2	W8 x 24	W10 x 33	W12 x 40	W14 x 43	W8 x 24	W10 x 33	W12 x 40	W14 x 43
3	W8 x 31	W10 x 33	W12 x 40	W14 x 43	W8 x 58	W10 x 39	W12 x 40	W14 x 43
4	W8 x 58	W10 x 45	W12 x 40	W14 x 43		W10 x 68	W12 x 50	W14 x 43
5		W10 x 77	W12 x 58	W14 x 48			W12 x 96	W14 x 74
6			W12 x 87	W14 x 74			W12 x 152	W14 x 120
7			W12 x 136	W14 x 109			W12 x 210	W14 x 176
8			W12 x 190	W14 x 145			W12 x 279	W14 x 233
9			W12 x 252	W14 x 211				W14 x 342
10			W12 x 305	W14 x 257				W14 x 398
11				W14 x 342				W14 x 500
12				W14 x 398				W14 x 605

Rigid Support - Supporting member possessing relatively high rotational stiffness which constrains the adjacent simple beam end rotation to occur primarily within the end connection, such as a beam-to column flange connection.

Note : The table above for minimum size of W-shape columns is based on the condition of one-sided beam framing and is conservative for two-sided framing when the W-shape is equal to or larger than that as shown in the table. One of the connections to W-shape columns smaller than that as shown in the table above may be considered rigid support at two-sided framing whenever the opposing beam has a shear plate larger by 2 or more number of bolt rows of same or more bolt columns of same or larger required bolt size & type.

**Figure 4-3**

**Requirements for use of Single Plate Connections at HSS Columns**

Shear Plate Weld Size w	Minimum Nominal Wall Thickness, in.			Nominal Wall Thickness of HSS (inches)	Maximum Width of HSS Square of Rectangular Column Flange (in.) <sup>1</sup>	
	Round	Square or Rectangular			Fy = 46 ksi	Fy = 50 ksi
	Fy = 35 ksi	Fy = 46 ksi	Fy = 50 ksi			
3/16	1/4	3/16	3/16	3/16	7	6
1/4	5/16	1/4	1/4	1/4	8	8
5/16	3/8	5/16	5/16	5/16	10	10
3/8	1/2	3/8	3/8	3/8	14	12
7/16	5/8	1/2	1/2	1/2	20	18
1/2	5/8	1/2	1/2	5/8	24	24
9/16		5/8	1/2		<sup>1</sup> Otherwise, single plate shear connections not permissible.	
5/8		5/8	5/8			

Reference: AISC Hollow Structural Sections Connections Manual, 1997, Table 4-9

Note: Connection shear capacities should be reduced by the ratio of the wall thicknesses when they are less than that as shown in the table above corresponding to the required weld size for the shear plate. Alternately, one may calculate the reduced connection shear capacity by the following equation:

$$\text{Reduced Capacity} = \frac{\text{Capacity of Single Plate Shear Connection}}{\text{Nominal wall thickness, in.}} \times \frac{(F_y)_{\text{HSS}}}{(44.35)}$$

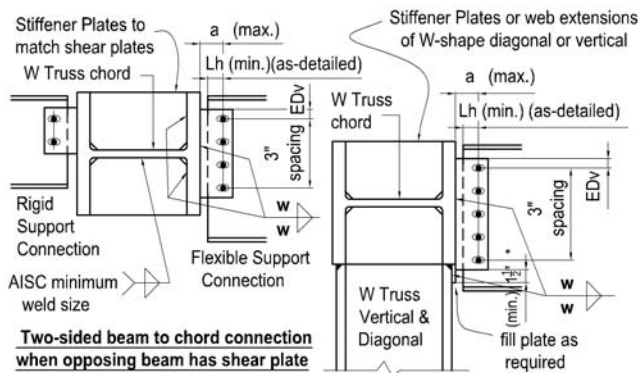
Single plate shear connections @ HSS columns are currently limited to a single vertical column of bolts and for a horizontal dimension from the face of the support to the weld line of : a = 3" (max.).

Single plate shear connections with dimensions to the bolt line greater than 3" or with connections with double column of bolts are currently not recommended at HSS columns pending future research studies.

**Figure 4-4**

**Single Plate Shear Connections at W-Shape Trusses**

**Rigid Support Connections**



**Two-sided beam to chord connection when opposing beam has shear plate larger by 2 or more number of bolt rows of same or more bolt columns of same or larger req'd. bolt size & type**

**Beam framing to Truss Chord between panel points of W Truss**

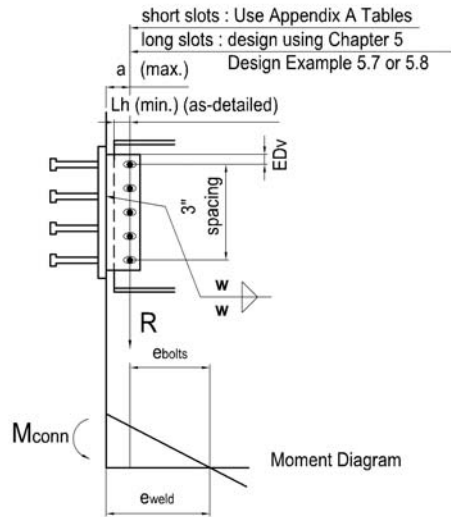
\* use smaller weld size & lengthen fill plate to provide weld of equal strength when it's thickness < (weld size + 1/16")

**Beam framing to truss chord or to truss vertical at panel point of W Truss on one or both sides of chord**

Note : Assume flexible support condition when beams framing to trusses do not satisfy the requirements above. In this case, the requirement of stiffener plates in the truss chords would not be dictated by the single plate framing condition.

**Figure 4-5**  
**Single Plate Shear Connections at Concrete Embeds**  
**Rigid Support Connections**

**Beam Framing to Embed Plate at concrete supports**

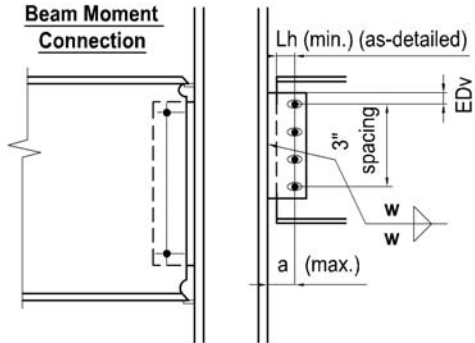


Note : Concrete anchors must be designed for a bending moment =  
 $M_{conn} = (R)(e_{weld})$ , in addition to shear force, R.  
 See design calculation tables in back of Appendix D,  
 pages D-17 thru D-24 for values of "e<sub>weld</sub>".

**Figure 4-6**  
**Single Plate Shear Connections opposite**  
**Type "FR" (Fully Restrained) Beam Framing**

**Simple Beam Framing opposite from a Moment Connection**

**Rigid Support Connection**



Beam with single plate shear connection of any size to any size of W-shape column may be considered a rigid support condition.

**Figure 6-1**  
**Typical Simple Beam Framing**  
**with Extended Shear Plate Connections**

