PART 10

DESIGN OF SIMPLE SHEAR CONNECTIONS

SCOPE

The specification requirements and other design considerations summarized in this Part apply to the design of simple shear connections. For the design of flexible moment connections, see Part 11. For the design of fully restrained (FR) moment connections, see Part 12.

FORCE TRANSFER

The required strength (end reaction), R_u or R_a, is determined by analysis as indicated in AISC *Specification* Section B3. Per AISC *Specification* Section J1.2, the ends of members with simple shear connections are normally assumed to be free to rotate under load. While simple shear connections do actually possess some rotational restraint (see curve A in Figure 10–1), this small amount can be neglected and the connection idealized as completely flexible. The simple shear connections shown in this Manual are suitable to accommodate the end rotations required per AISC *Specification* Section J1.2.

Support rotation is acceptably limited for most framing details involving simple shear connections without explicit consideration. The case of a bare spandrel girder supporting infill beams, however, may require consideration to verify that an acceptable level of support rotational stiffness is present. Sumner (2003) showed that a nominal interconnection between the top flange of the girder and the top flange of the framing beam is sufficient to limit support rotation.

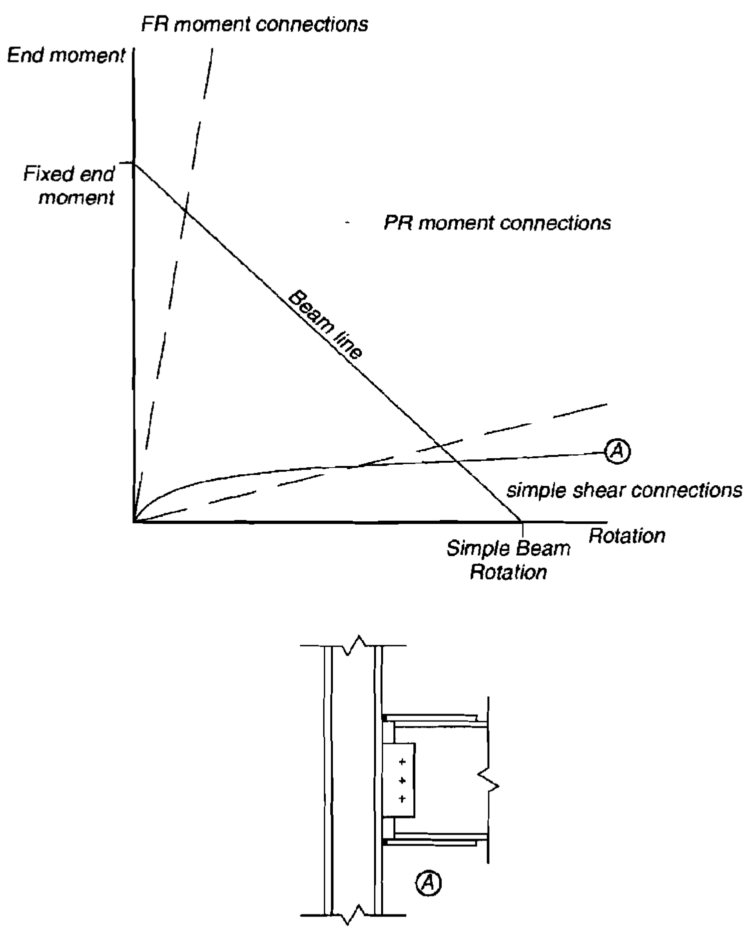


Figure 10–1. Illustration of typical moment rotation curve for simple shear connection.

COMPARING CONNECTION ALTERNATIVES

Two-Sided Connections

Two-sided connections, such as double-angle and shear end-plate connections, offer the following advantages:

1. suitability for use when the end reaction is large;
2. compact connections (usually, the entire connection is contained within the flanges of the supported beam); and,
3. eccentricity perpendicular to the beam axis need not be considered for workable gages (see Table 1–7).

Note that two-sided connections may require additional consideration for erectability, as discussed in "Constructability Considerations" below.

Seated Connections

Unstiffened and stiffened seated connections offer the following advantages:

1. seats can be shop attached to the support, simplifying erection;
2. ample erection clearance is provided;
3. excellent safety during erection since double connections often can be eliminated; and,
4. the bay length of the structure is easily maintained (seated connections may be preferable when maintaining bay length is a concern for repetitive bays of framing).

Note that seated connections can cause erection interference when floors are close, beams are deep, or seats protrude excessively from the column face. The practice of leaning or tilting the columns to erect a column-web connection is difficult, unsafe and should always be avoided.

One-Sided Connections

One-sided connections such as single-plate, single-angle and tee connections offer the following advantages:

1. shop attachment of connection elements to the support, simplifying shop fabrication and erection;
2. reduced material and shop labor requirements;
3. ample erection clearance is provided; and,
4. excellent safety during erection since double connections often can be eliminated.

CONSTRUCTABILITY CONSIDERATIONS

Double Connections

A double connection occurs in field-bolted construction when beams or girders frame opposite each other. Double connections are of concern to OSHA when they occur in the web of a column (see Figure 10–2) or the web of a beam that frames continuously over the top of a column[1] and all field bolts take the same open holes. A positive connection must be

[1]This requirement applies only at the location of the column, not at locations away from the column.

made and maintained for the first member to be erected while the second member to be erected is brought into its final position. Conditions requiring the connector to hang one beam temporarily on a partially inserted bolt or drift pin are not allowed by OSHA.

Framing details can be configured using staggered angles or other similar details to provide a means to make a positive connection for the first member while the second member is brought into its final position. Alternatively, a temporary erection seat, as shown in Figure 10–2, can be provided. The erection seat, usually an angle, is sized and attached to the column web to support the dead weight of the member, unless additional loading is indicated in the contract documents. It is located to clear the bottom flange of the supported member by approximately $^3/_8$ in. to accommodate mill, fabrication, and erection tolerances.

The sequence of erection is most important in determining the need for erection seats. If the erection sequence is known, the erection seat is provided on the side needing the support. If the erection sequence is not known, a seat can be provided on both sides of the column web. Temporary erection seats may be reused at other locations after the connection(s) are made, but need not be removed unless they create an interference or removal is required in the contract documents.

See also the discussion under "Special Considerations for Simple Shear Connections."

Accessibility in Column Webs

Because of bolting and welding clearances, double-angle, shear end-plate, single-plate, single-angle, and tee shear connections may not be suitable for connections to the webs of W-shape and similar columns, particularly for W8 columns, unless gages are reduced. Such connections may be impossible for W6, W5, and W4 columns.

There is also an accessibility concern for entering and tightening the field bolts when the connection material is shop-attached to the supporting column web and contained within the column flanges.

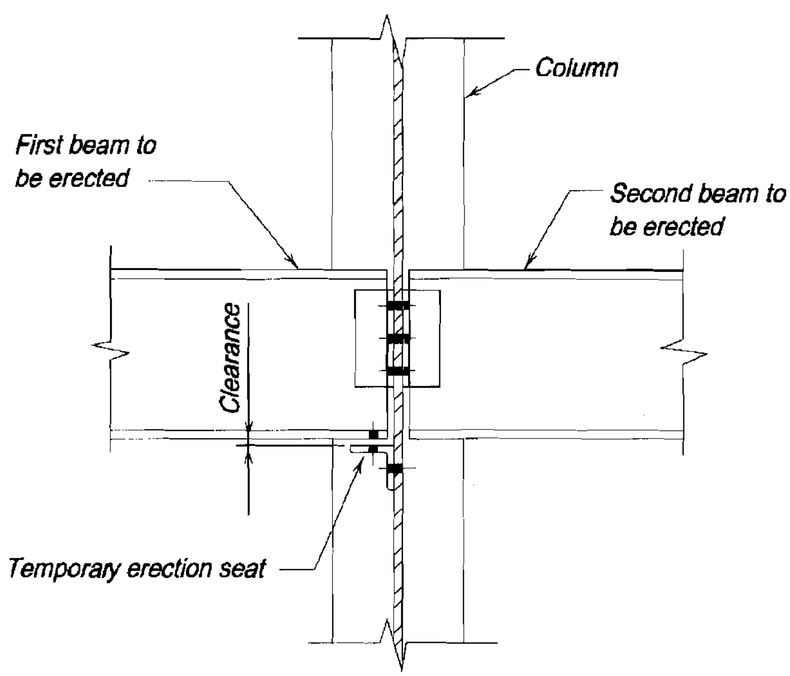


Figure 10–2. Erection seat.

Field-Welded Connections

In field-welded connections, temporary erection bolts are usually provided to support the member until final welding is performed. A minimum of 2 bolts (one bolt in bracing members) must be placed for erection safety per OSHA requirements. Additional erection bolts may be required for loads during erection, to assist in pulling the connection angles up tightly against the web of the supporting beam prior to welding or for other reasons. Temporary erection bolts may be reused at other locations after final welding, but need not be removed unless they create an interference or removal is required in the contract documents.

Riding the Fillet

The detailed dimensions of connection elements must be compatible with the *T*-dimension of an uncoped beam and the remaining web depth, exclusive of fillets, of a coped beam. Note that the angle may encroach upon the fillet(s), as given in Figure 10–3.

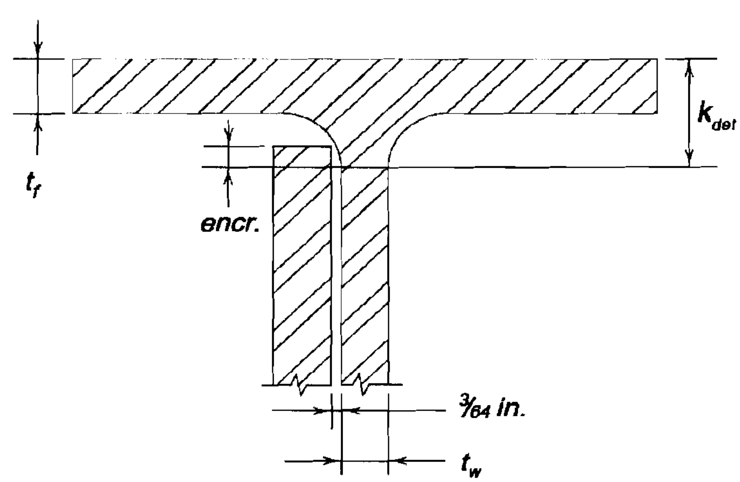
DOUBLE-ANGLE CONNECTIONS

A double-angle connection is made with two angles, one on each side of the web of the beam to be supported, as illustrated in Figure 10–4. These angles may be bolted or welded to the supported beam as well as to the supporting member.

When the angles are welded to the support, adequate flexibility must be provided in the connection. As illustrated in Figure 10–4c, line welds are placed along the toes of the angles with a return at the top per AISC Specification Section J2.2b. Note that welding across the entire top of the angles must be avoided as it would inhibit the flexibility and, therefore, the necessary end rotation of the connection. The performance of the resulting connection would not be as intended for simple shear connections.

Available Strength

The available strength of a double-angle connection is determined from the applicable limit states for bolts (see Part 7), welds (see Part 8), and connecting elements (see Part 9). In all cases, the available strength, ϕR_n or R_n/Ω, must equal or exceed the required strength, R_u or R_a.



$k_{det} - t_f$	Encr.
in.	in.
5/16	1/8
3/8 to 1/2	3/16
9/16 to 13/16	1/4
7/8 to 1 1/4	5/16
1 5/16 and 1 3/8	3/8

Figure 10–3. Fillet encroachment (riding the fillet).

For the workable gages shown in Table 1–7 and standard or short-slotted holes, eccentricity in double-angle connections may be neglected, except in the case of a double vertical row of bolts through the web of the supported beam. Eccentricity should always be considered in the design of welds for double-angle connections.

Recommended Angle Length and Thickness

To provide for stability during erection, it is recommended that the minimum angle length be one-half the *T*-dimension of the beam to be supported. The maximum length of the connection angles must be compatible with the *T*-dimension of an uncoped beam and the

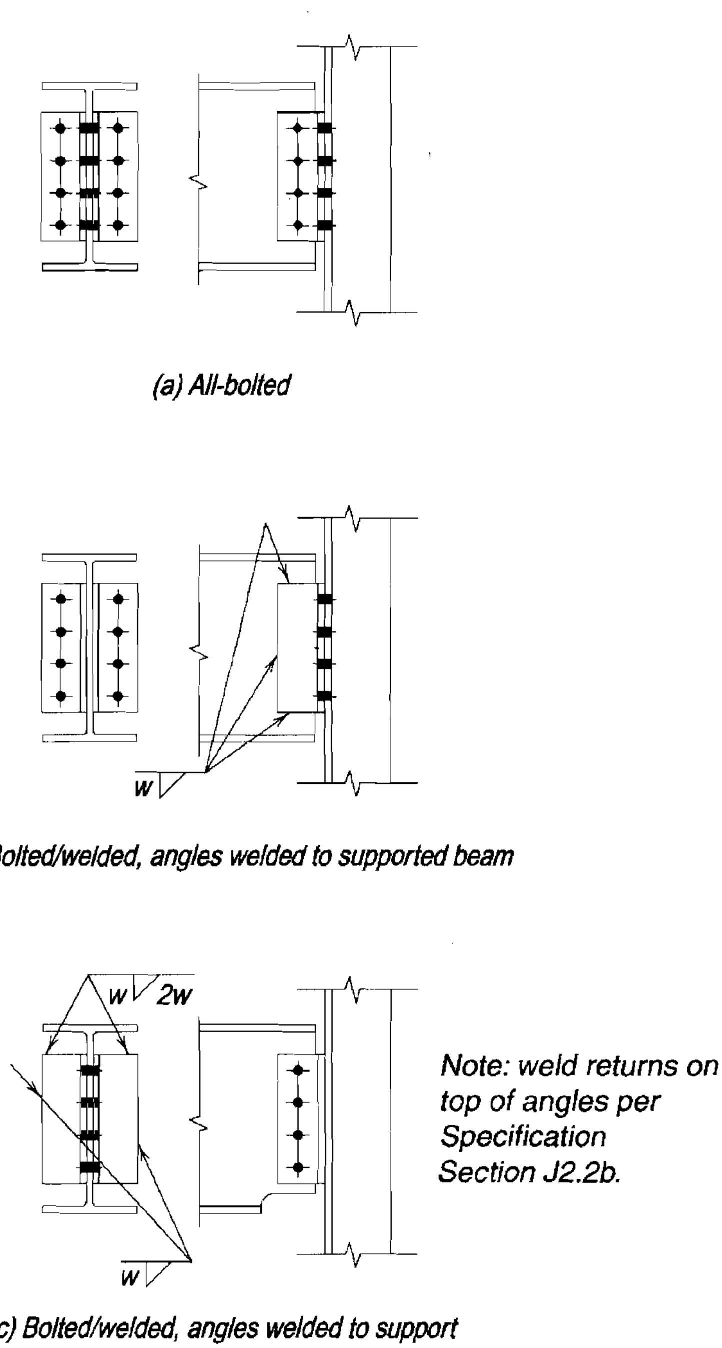


Figure 10–4. Double-angle connections.

remaining web depth, exclusive of fillets, of a coped beam. Note that the angle may encroach upon the fillet(s), as given in Figure 10–3.

To provide for flexibility, the maximum angle thickness for use with workable gages should be limited to $^5/_8$ in. Alternatively, the shear-connection ductility checks illustrated in Part 9 can be used to justify other combinations of gage and angle thickness.

Shop and Field Practices

When framing to a girder web, both angles are usually shop-attached to the web of the supported beam. When framing to a column web, both angles should be shop-attached to the supported beam, when possible, and the associated constructability considerations should be addressed (see the preceding discussion under "Constructability Considerations").

When framing to a column flange, both angles can be shop-attached to the column flange or the supported beam. In the former case, this is a knifed connection, as illustrated in Figure 10–4c, which requires an erection clearance, as illustrated in Figure 10–5a, and that the bottom flange be coped away. Also, provision must be made for possible mill variation in

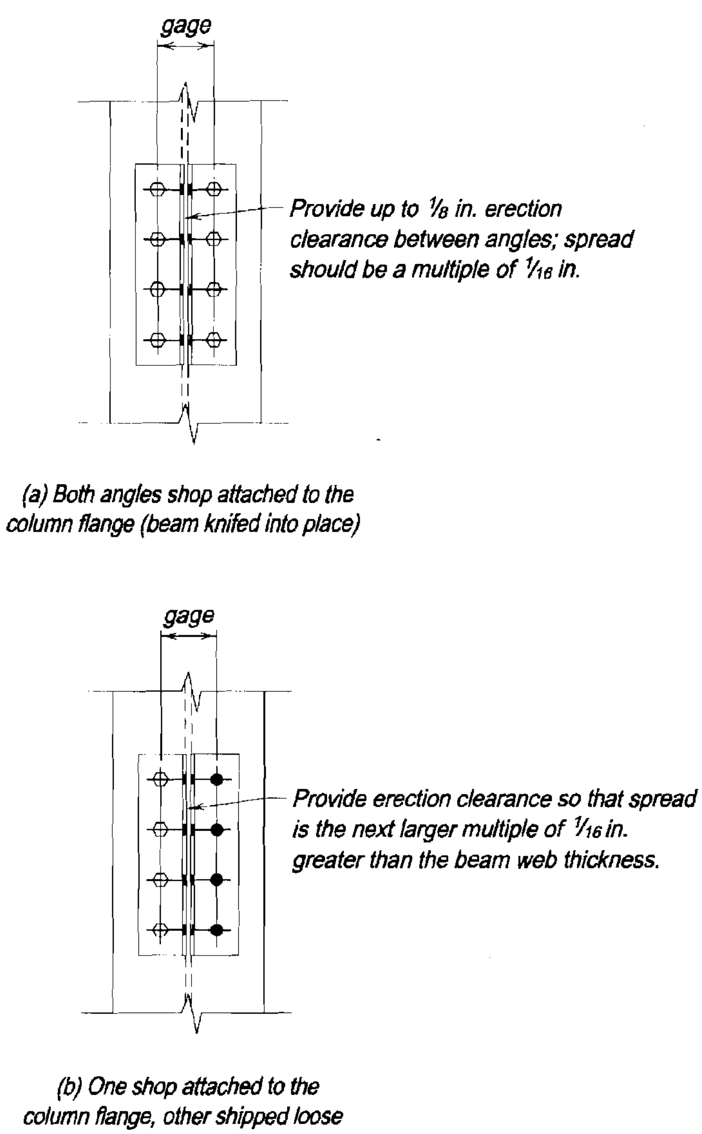


Figure 10–5. Erection clearances for double-angle connections.

the depth of the columns, particularly in fairly long runs (i.e., six or more bays of framing). If both angles are shop-attached to the beam web, the beam length can be shortened to provide for mill overrun with shims furnished at the appropriate intervals to fill the resulting gaps or to provide for mill underrun. If both angles are shop-attached to the column flange, the erected beam is knifed into place and play in the open holes is normally sufficient to provide for the necessary adjustment. Alternatively, short-slotted holes can also be used.

When special requirements preclude the use of any of the foregoing practices, one angle could be shop-attached to the support and the other shipped loose. In this case, the spread between the outstanding legs should equal the decimal beam web thickness plus a clearance that will produce an opening to the next higher $^{1}/_{16}$-in. increment, as illustrated in Figure 10–5b. Alternatively, short-slotted holes in the support leg of the angle eliminate the need to provide for variations in web thickness. Note that the practice of shipping one angle loose is not desirable because it requires additional material handling as well as added erection costs and difficulty.

Table 10–1. All-Bolted Double-Angle Connections

Table 10–1 is a design aid for all-bolted double-angle connections. Available strengths are tabulated for supported and supporting member material with $F_y = 50$ ksi and $F_u = 65$ ksi and angle material with $F_y = 36$ ksi and $F_u = 58$ ksi. All values, including slip-critical bolt available strengths, are for comparison with the LRFD load combination for LRFD design and the ASD load combination for ASD design.

Tabulated bolt and angle available strengths consider the limit states of bolt shear, bolt bearing on the angles, shear yielding of the angles, shear rupture of the angles, and block shear rupture of the angles. Values are tabulated for 2 through 12 rows of $^{3}/_{4}$-in., $^{7}/_{8}$-in, and 1-in. diameter ASTM A325, F1852, and A490 bolts at 3-in. spacing. For calculation purposes, angle edge distances, L_{ev} and L_{eh}, are assumed to be $1^{1}/_{4}$ in.

Tabulated beam web available strengths, per in. of web thickness, consider the limit-state of bolt bearing on the beam web. For beams coped at the top flange only, the limit-state of block shear rupture is also considered. Additionally, for beams coped at both the top and bottom flanges, the tabulated values consider the limit-states of shear yielding and shear rupture of the beam web. Values are tabulated for beam web edge distances L_{ev} from $1^{1}/_{4}$ in. to 3 in. and for beam end distances, L_{eh}, of $1^{1}/_{2}$ in. and $1^{3}/_{4}$ in. For calculation purposes, these end distances have been reduced to $1^{1}/_{4}$ in. and $1^{1}/_{2}$ in., respectively, to account for possible underrun in beam length. For coped members, the limit states of flexural yielding and local buckling must be checked independently per Part 9. When required, web reinforcement of coped members is treated as in Part 9.

Tabulated supporting member available strengths, per in. of flange or web thickness, consider the limit-state of bolt bearing on the support. Note that resistance and safety factors are not noted in these tables, as they vary by limit state.

Table 10–2. Bolted/Welded Double-Angle Connections

Tables 10–2 is a design aid arranged to permit substitution of welds for bolts in connections designed with Tables 10–1. Electrode strength is assumed to be 70 ksi. Holes for erection bolts may be placed as required in angle legs that are to be field-welded.

Welds A may be used in place of bolts through the supported-beam web legs of the double angles or welds B may be used in place of bolts through the support legs of the double angles. Although it is permissible to use welds A and B from Table 10–2 in combination to obtain all-welded connections, it is recommended that such connections be selected from Table 10–3. This table will allow increased flexibility in the selection of angle lengths and connection strengths because Table 10–2 conforms to the bolt spacing and edge distance requirements for the all-bolted double-angle connections of Table 10–1.

Weld available strengths are tabulated for the limit-state of weld shear. Available strengths for welds A are determined by the instantaneous center of rotation method using Table 8–8 with $\theta = 0°$. Available strengths for welds B are determined by the elastic method. With the neutral axis assumed at one-sixth the depth of the angles measured downward and the tops of the angles in compression against each other through the beam web, the available strength, ϕR_n or R_n/Ω, of these welds is determined by

LRFD	ASD
$\phi R_n = 2 \times \dfrac{1.392DL}{\sqrt{1+\dfrac{12.96e^2}{L^2}}}$	$\dfrac{R_n}{\Omega} = 2 \times \dfrac{0.928DL}{\sqrt{1+\dfrac{12.96e^2}{L^2}}}$

where

D = number of sixteenths-of-an-inch in the weld size.
L = length of the connection angles, in.
e = width of the leg of the connection angle attached to the support, in.

The tabulated minimum thicknesses of the supported beam web for welds A and the support for welds B match the shear rupture strength of these elements with the strength of the weld metal. As derived in Part 9, the minimum supported beam web thickness for welds A (two lines of weld) is

$$t_{min} = \frac{6.19D}{F_u}$$

and the minimum supporting flange or web thickness welds B (one line of weld) is

$$t_{min} = \frac{3.09D}{F_u}$$

When welds B line up on opposite sides of the support, the minimum thickness is the sum of the thicknesses required for each weld. In either case, when less than the minimum material thickness is present, the tabulated weld available strength must be reduced by the ratio of the thickness provided to the minimum thickness.

When Table 10–2 is used, the minimum angle thickness is the weld size plus $^1/_{16}$ in., but not less than the angle thickness determined from Table 10–1. The angle length L must be as tabulated in Table 10–2. In general, 2L4×3$^1/_2$ will accommodate workable gages, with the 4-in. leg attached to the supporting member. The width of web legs in Case I may be optionally reduced from 3$^1/_2$ in. to 3 in. The width of outstanding legs in Case II may be optionally reduced from 4 in. to 3 in. for values of L from 5$^1/_2$ through 17$^1/_2$ in.

Table 10–3. All-Welded Double-Angle Connections

Table 10–3 is a design aid for all-welded double-angle connections. Electrode strength is assumed to be 70 ksi. Holes for erection bolts may be placed as required in angle legs that are to be field-welded.

Weld available strengths are tabulated for the limit-state of weld shear. Available strengths for welds A are determined by the instantaneous center of rotation method using Table 8–8 with $\theta = 0°$. Available strengths for welds B are determined by the elastic method as discussed previously for bolted/welded double-angle connections.

The tabulated minimum thicknesses of the supported beam web for welds A and the support for welds B match the shear rupture strength of these elements with the strength of the weld metal and are determined as discussed previously for Table 10–2. When welds B line up on opposite sides of the support, the minimum thickness is the sum of the thicknesses required for each weld. When less than the minimum material thickness is present, the tabulated weld available strength must be reduced by the ratio of the thickness provided to the minimum thickness.

When Table 10–3 is used, the minimum angle thickness must be equal to the weld size plus $^1/_{16}$ in. The angle length, L, must be as tabulated in Table 10–3. 2L4×3 should be used for angle lengths equal to or greater than 18 in. 2L3×3 should be used otherwise.

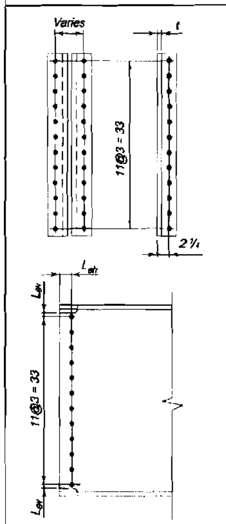
Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10-1
All-Bolted Double-Angle Connections

3/4-in. Bolts

12 Rows

W44



Bolt and Angle Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	197	295	246	369	254	382	254	382
	X	—	197	295	246	369	295	443	318	477
	SC Class A	STD	177	266	177	266	177	266	177	266
		OVS	128	192	128	192	128	192	128	192
		SSLT	151	226	151	226	151	226	151	226
	SC Class B	STD	197	295	246	369	253	380	253	380
		OVS	183	274	183	274	183	274	183	274
		SSLT	195	293	215	323	215	323	215	323
A490	N	—	197	295	246	369	295	443	318	477
	X	—	197	295	246	369	295	443	393	590
	SC Class A	STD	197	295	221	332	221	332	221	332
		OVS	160	240	160	240	160	240	160	240
		SSLT	188	282	188	282	188	282	188	282
	SC Class B	STD	197	295	246	369	295	443	316	475
		OVS	196	294	229	343	229	343	229	343
		SSLT	195	293	244	366	269	403	269	403

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	498	747	506	759	468	702	476	714	495	743	503	755
	1 3/8	500	751	509	763	470	706	479	718	497	746	506	758
	1 1/2	503	754	511	767	473	709	481	722	500	750	508	762
	1 5/8	505	758	514	770	475	713	483	725	502	753	510	766
	2	513	769	521	781	483	724	491	736	510	764	518	777
	3	532	798	540	810	502	753	510	765	529	794	537	806
Coped at Both Flanges	1 1/4	488	731	488	731	458	687	458	687	488	731	488	731
	1 3/8	492	739	492	739	463	695	463	695	492	739	492	739
	1 1/2	497	746	497	746	468	702	468	702	497	746	497	746
	1 5/8	502	753	502	753	473	709	473	709	502	753	502	753
	2	513	769	517	775	483	724	488	731	510	764	517	775
	3	532	798	540	810	502	753	510	765	529	794	537	806
Uncoped		702	1050	702	1050	702	1050	702	1050	702	1050	702	1050

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	1400	2110

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi F_u = 65 ksi
Angle	F_y = 36 ksi F_u = 58 ksi

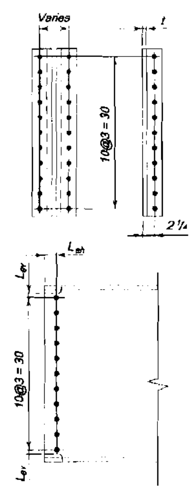
Table 10–1 (continued)
All-Bolted Double-Angle Connections

3/4-in. Bolts

Bolt and Angle Available Strength, kips

11 Rows

W44, 40



ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	181	271	226	338	233	350	233	350
	X	—	181	271	226	338	271	406	292	437
	SC Class A	STD	162	244	162	244	162	244	162	244
		OVS	117	176	117	176	117	176	117	176
		SSLT	138	207	138	207	138	207	138	207
	SC Class B	STD	181	271	226	338	232	348	232	348
		OVS	168	251	168	251	168	251	168	251
		SSLT	179	269	197	296	197	296	197	296
A490	N	—	181	271	226	338	271	406	292	437
	X	—	181	271	226	338	271	406	361	542
	SC Class A	STD	181	271	203	305	203	305	203	305
		OVS	147	220	147	220	147	220	147	220
		SSLT	173	259	173	259	173	259	173	259
	SC Class B	STD	181	271	226	338	271	406	290	435
		OVS	80	269	210	314	210	314	210	314
		SSLT	179	269	224	336	247	370	247	370

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	457	685	465	697	429	644	437	656	454	680	462	693
	1 3/8	459	689	467	701	431	647	440	659	456	684	464	696
	1 1/2	462	692	470	704	434	651	442	663	458	688	467	700
	1 5/8	464	696	472	708	436	654	444	667	461	691	469	704
	2	471	707	479	719	444	665	452	678	468	702	476	714
	3	491	736	499	748	463	695	471	707	488	732	496	744
Coped at Both Flanges	1 1/4	446	669	446	669	419	629	419	629	446	669	446	669
	1 3/8	451	676	451	676	424	636	424	636	451	676	451	676
	1 1/2	456	684	456	684	429	644	429	644	456	684	456	684
	1 5/8	461	691	461	691	434	651	434	651	461	691	461	691
	2	471	707	475	713	444	665	449	673	468	702	475	713
	3	491	736	499	748	463	695	471	707	488	732	496	744
Uncoped		644	965	644	965	644	965	644	965	644	965	644	965

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	1290	1930

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

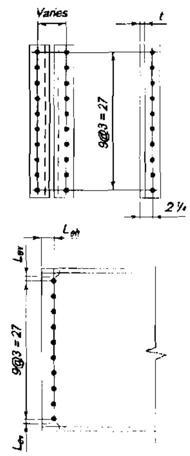
* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi F_u = 65 ksi
Angle	F_y = 36 ksi F_u = 58 ksi

Table 10-1 (continued)
All-Bolted Double-Angle Connections

3/4-in. Bolts

Bolt and Angle Available Strength, kips



10 Rows W44, 40, 36	ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
	A325/ F1852	N	—	164	246	205	308	212	318	212	318
		X	—	164	246	205	308	246	370	265	398
		SC Class A	STD	148	221	148	221	148	221	148	221
			OVS	107	160	107	160	107	160	107	160
			SSLT	126	188	126	188	126	188	126	188
		SC Class B	STD	164	246	205	308	211	316	211	316
			OVS	152	229	152	229	152	229	152	229
			SSLT	163	244	179	269	179	269	179	269
	A490	N	—	164	246	205	308	246	370	265	398
		X	—	164	246	205	308	246	370	329	493
		SC Class A	STD	164	246	185	277	185	277	185	277
			OVS	133	200	133	200	133	200	133	200
			SSLT	157	235	157	235	157	235	157	235
		SC Class B	STD	164	246	205	308	246	370	264	396
			OVS	163	245	190	286	190	286	190	286
			SSLT	163	244	204	306	224	336	224	336

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	415	623	423	635	390	585	398	597	412	618	420	630
	1 3/8	418	626	426	639	392	589	401	601	415	622	423	634
	1 1/2	420	630	428	642	395	592	403	605	417	626	425	638
	1 5/8	423	634	431	646	397	596	405	608	419	629	428	641
	2	430	645	438	657	405	607	413	619	427	640	435	652
	3	449	674	457	686	424	636	432	648	446	669	454	682
Coped at Both Flanges	1 1/4	405	607	405	607	380	570	380	570	405	607	405	607
	1 3/8	410	614	410	614	385	578	385	578	410	614	410	614
	1 1/2	414	622	414	622	390	585	390	585	414	622	414	622
	1 5/8	419	629	419	629	395	592	395	592	419	629	419	629
	2	430	645	434	651	405	607	410	614	427	640	434	651
	3	449	674	457	686	424	636	432	648	446	669	454	682
Uncoped		585	878	585	878	585	878	585	878	585	878	585	878

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	1170	1760

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

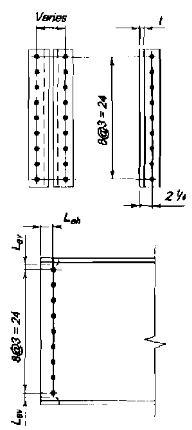
* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	Angle
F_y = 50 ksi	F_y = 36 ksi
F_u = 65 ksi	F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

3/4-in. Bolts

Bolt and Angle Available Strength, kips

9 Rows W44, 40, 36, 33	ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
	A325/ F1852	N	—	148	222	185	278	191	286	191	286
		X	—	148	222	185	278	222	333	239	358
		SC Class A	STD	133	199	133	199	133	199	133	199
			OVS	96	144	96	144	96	144	96	144
			SSLT	113	169	113	169	113	169	113	169
		SC Class B	STD	148	222	185	278	190	285	190	285
			OVS	137	206	137	206	137	206	137	206
			SSLT	147	220	161	242	161	242	161	242
	A490	N	—	148	222	185	278	222	333	239	358
		X	—	148	222	185	278	222	333	296	444
		SC Class A	STD	148	222	166	249	166	249	166	249
			OVS	120	180	120	180	120	180	120	180
			SSLT	141	212	141	212	141	212	141	212
		SC Class B	STD	148	222	185	278	222	333	237	356
			OVS	147	221	171	257	171	257	171	257
			SSLT	147	220	183	275	202	303	202	303

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	374	561	382	573	351	527	359	539	371	556	379	568
	1 3/8	376	564	384	576	353	530	362	542	373	560	381	572
	1 1/2	379	568	387	580	356	534	364	546	376	563	384	576
	1 5/8	381	572	389	584	358	537	366	550	378	567	386	579
	2	388	583	397	595	366	548	374	561	385	578	393	590
	3	408	612	416	624	385	578	393	590	405	607	413	619
Coped at Both Flanges	1 1/4	363	545	363	545	341	512	341	512	363	545	363	545
	1 3/8	368	552	368	552	346	519	346	519	368	552	368	552
	1 1/2	373	559	373	559	351	527	351	527	373	559	373	559
	1 5/8	378	567	378	567	356	534	356	534	378	567	378	567
	2	388	583	392	589	366	548	371	556	385	578	392	589
	3	408	612	416	624	385	578	393	590	405	607	413	619
Uncoped		526	790	526	790	526	790	526	790	526	790	526	790

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	1050	1580

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

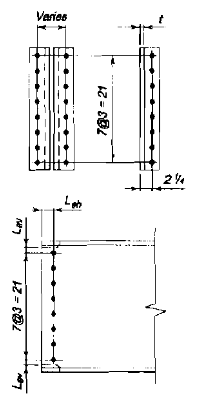
* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

3/4-in. Bolts

Bolt and Angle Available Strength, kips



8 Rows W44, 40, 36, 33, 30	ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
	A325/ F1852	N	—	132	198	165	247	170	254	170	254
		X	—	132	198	165	247	198	297	212	318
		SC Class A	STD	118	177	118	177	118	177	118	177
			OVS	85.3	128	85.3	128	85.3	128	85.3	128
			SSLT	100	151	100	151	100	151	100	151
		SC Class B	STD	132	198	165	247	169	253	169	253
			OVS	122	183	122	183	122	183	122	183
			SSLT	131	196	143	215	143	215	143	215
	A490	N	—	132	198	165	247	198	297	212	318
		X	—	132	198	165	247	198	297	264	396
		SC Class A	STD	132	198	148	221	148	221	148	221
			OVS	107	160	107	160	107	160	107	160
			SSLT	126	188	126	188	126	188	126	188
		SC Class B	STD	132	198	165	247	198	297	211	316
			OVS	131	197	152	229	152	229	152	229
			SSLT	131	196	163	245	179	269	179	269

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type / L_{ev}, in.		STD L_{eh}* 1 1/2 ASD	STD 1 1/2 LRFD	STD 1 3/4 ASD	STD 1 3/4 LRFD	OVS 1 1/2 ASD	OVS 1 1/2 LRFD	OVS 1 3/4 ASD	OVS 1 3/4 LRFD	SSLT 1 1/2 ASD	SSLT 1 1/2 LRFD	SSLT 1 3/4 ASD	SSLT 1 3/4 LRFD
Coped at Top Flange Only	1 1/4	332	498	340	511	312	468	320	480	329	494	337	506
	1 3/8	335	502	343	514	314	472	323	484	332	498	340	510
	1 1/2	337	506	345	518	317	475	325	488	334	501	342	513
	1 5/8	340	509	348	522	319	479	327	491	337	505	345	517
	2	347	520	355	533	327	490	335	502	344	516	352	528
	3	366	550	375	562	346	519	354	531	363	545	372	557
Coped at Both Flanges	1 1/4	322	483	322	483	302	453	302	453	322	483	322	483
	1 3/8	327	490	327	490	307	461	307	461	327	490	327	490
	1 1/2	332	497	332	497	312	468	312	468	332	497	332	497
	1 5/8	336	505	336	505	317	475	317	475	336	505	336	505
	2	347	520	351	527	327	490	332	497	344	516	351	527
	3	366	550	375	562	346	519	354	531	363	545	372	557
Uncoped		468	702	468	702	468	702	468	702	468	702	468	702

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	936	1400

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

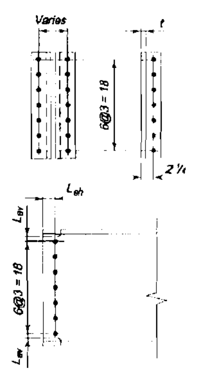
* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

3/4-in. Bolts

7 Rows — W44, 40, 36, 33, 30, 27, 24



Bolt and Angle Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	116	174	145	217	148	223	148	223
	X	—	116	174	145	217	174	260	186	278
	SC Class A	STD	103	155	103	155	103	155	103	155
		OVS	74.7	112	74.7	112	74.7	112	74.7	112
		SSLT	87.9	132	87.9	132	87.9	132	87.9	132
	SC Class B	STD	116	174	145	217	148	221	148	221
		OVS	107	160	107	160	107	160	107	160
		SSLT	114	172	126	188	126	188	126	188
A490	N	—	116	174	145	217	174	260	186	278
	X	—	116	174	145	217	174	260	231	347
	SC Class A	STD	116	174	129	194	129	194	129	194
		OVS	93.3	140	93.3	140	93.3	140	93.3	140
		SSLT	110	165	110	165	110	165	110	165
	SC Class B	STD	116	174	145	217	174	260	185	277
		OVS	115	172	133	200	133	200	133	200
		SSLT	114	172	143	214	157	235	157	235

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	291	436	299	449	273	410	281	422	288	432	296	444
	1 3/8	293	440	301	452	275	413	284	425	290	435	298	448
	1 1/2	296	444	304	456	278	417	286	429	293	439	301	451
	1 5/8	298	447	306	459	280	420	288	433	295	443	303	455
	2	306	458	314	470	288	431	296	444	302	454	311	466
	3	325	488	333	500	307	461	315	473	322	483	330	495
Coped at Both Flanges	1 1/4	280	420	280	420	263	395	263	395	280	420	280	420
	1 3/8	285	428	285	428	268	402	268	402	285	428	285	428
	1 1/2	290	435	290	435	273	410	273	410	290	435	290	435
	1 5/8	295	442	295	442	278	417	278	417	295	442	295	442
	2	306	458	310	464	288	431	293	439	302	454	310	464
	3	325	488	333	500	307	461	315	473	322	483	330	495
Uncoped		410	614	410	614	410	614	410	614	410	614	410	614

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	**819**	**1230**

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

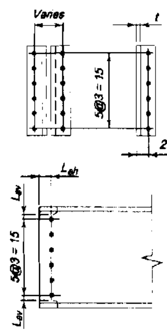
* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam		Angle	
F_y = 50 ksi	F_u = 65 ksi	F_y = 36 ksi	F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

¾-in. Bolts

Bolt and Angle Available Strength, kips

6 Rows W40, 36, 33, 30, 27, 24, 21	ASTM Desig.	Thread Cond.	Hole Type	¼ ASD	¼ LRFD	5/16 ASD	5/16 LRFD	⅜ ASD	⅜ LRFD	½ ASD	½ LRFD
	A325/ F1852	N	—	**99.5**	149	**124**	187	**127**	191	**127**	191
		X	—	**99.5**	149	**124**	187	**149**	224	**159**	239
		SC Class A	STD	**88.6**	133	**88.6**	133	**88.6**	133	**88.6**	133
			OVS	**64**	96	**64**	96	**64**	96	**64**	96
			SSLT	**75.3**	113	**75.3**	113	**75.3**	113	**75.3**	113
		SC Class B	STD	**99.5**	149	**124**	187	**127**	190	**127**	190
			OVS	**91.4**	137	**91.4**	137	**91.4**	137	**91.4**	137
			SSLT	**98.2**	147	**108**	161	**108**	161	**108**	161
	A490	N	—	**99.5**	149	**124**	187	**149**	224	**159**	239
		X	—	**99.5**	149	**124**	187	**149**	224	**199**	298
		SC Class A	STD	**99.5**	149	**111**	166	**111**	166	**111**	166
			OVS	**80**	120	**80**	120	**80**	120	**80**	120
			SSLT	**94.1**	141	**94.1**	141	**94.1**	141	**94.1**	141
		SC Class B	STD	**99.5**	149	**124**	187	**149**	224	**158**	237
			OVS	**98.6**	148	**114**	171	**114**	171	**114**	171
			SSLT	**98.2**	147	**123**	184	**134**	202	**134**	202

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1½		1¾		1½		1¾		1½		1¾	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1¼	**249**	374	**258**	386	**234**	351	**242**	363	**246**	370	**255**	382
	1⅜	**252**	378	**260**	390	**236**	355	**245**	367	**249**	373	**257**	385
	1½	**254**	381	**262**	394	**239**	358	**247**	371	**251**	377	**259**	389
	1⅝	**257**	385	**265**	397	**241**	362	**249**	374	**254**	381	**262**	393
	2	**264**	396	**272**	408	**249**	373	**257**	385	**261**	392	**269**	404
	3	**284**	425	**292**	438	**268**	402	**276**	414	**281**	421	**289**	433
Coped at Both Flanges	1¼	**239**	358	**239**	358	**224**	336	**224**	336	**239**	358	**239**	358
	1⅜	**244**	366	**244**	366	**229**	344	**229**	344	**244**	366	**244**	366
	1½	**249**	373	**249**	373	**234**	351	**234**	351	**249**	373	**249**	373
	1⅝	**254**	380	**254**	380	**239**	358	**239**	358	**254**	380	**254**	380
	2	**264**	396	**268**	402	**249**	373	**254**	380	**261**	392	**268**	402
	3	**284**	425	**292**	438	**268**	402	**276**	414	**281**	421	**289**	433
Uncoped		**351**	526	**351**	526	**351**	526	**351**	526	**351**	526	**351**	526

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	**702**	**1050**

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

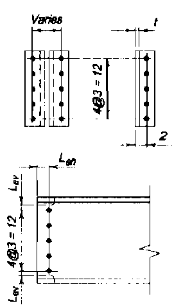
* Tabulated values include ¼-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued) All-Bolted Double-Angle Connections

$^3/_4$-in. Bolts

Bolt and Angle Available Strength, kips

5 Rows	ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness $^1/_4$ ASD	$^1/_4$ LRFD	$^5/_{16}$ ASD	$^5/_{16}$ LRFD	$^3/_8$ ASD	$^3/_8$ LRFD	$^1/_2$ ASD	$^1/_2$ LRFD
W30, 27, 24, 21, 18											
	A325/ F1852	N	—	83.3	125	104	156	106	159	106	159
		X	—	83.3	125	104	156	125	187	133	199
		SC Class A	STD	73.8	111	73.8	111	73.8	111	73.8	111
			OVS	53.3	80.0	53.3	80.0	53.3	80.0	53.3	80.0
			SSLT	62.8	94.1	62.8	94.1	62.8	94.1	62.8	94.1
		SC Class B	STD	83.3	125	104	156	105	158	105	158
			OVS	76.2	114	76.2	114	76.2	114	76.2	114
			SSLT	82.0	123	89.6	134	89.6	134	89.6	134
	A490	N	—	83.3	125	104	156	125	187	133	199
		X	—	83.3	125	104	156	125	187	166	249
		SC Class A	STD	83.3	125	92.3	138	92.3	138	92.3	138
			OVS	66.7	100	66.7	100	66.7	100	66.7	100
			SSLT	78.4	118	78.4	118	78.4	118	78.4	118
		SC Class B	STD	83.3	125	104	156	125	187	132	198
			OVS	82.4	124	95.2	143	95.2	143	95.2	143
			SSLT	82.0	123	102	154	112	168	112	168

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1½		1¾		1½		1¾		1½		1¾	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1¼	208	312	216	324	195	293	203	305	205	307	213	320
	1⅜	210	316	219	328	197	296	206	308	207	311	216	323
	1½	213	319	221	332	200	300	208	312	210	315	218	327
	1⅝	215	323	223	335	202	303	210	316	212	318	220	331
	2	223	334	231	346	210	314	218	327	220	329	228	342
	3	242	363	250	375	229	344	237	356	239	359	247	371
Coped at Both Flanges	1¼	197	296	197	296	185	278	185	278	197	296	197	296
	1⅜	202	303	202	303	190	285	190	285	202	303	202	303
	1½	207	311	207	311	195	293	195	293	207	311	207	311
	1⅝	212	318	212	318	200	300	200	300	212	318	212	318
	2	223	334	227	340	210	314	215	322	220	329	227	340
	3	242	363	250	375	229	344	237	356	239	359	247	371
Uncoped		293	439	293	439	293	439	293	439	293	439	293	439

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	585	878

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include ¼-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

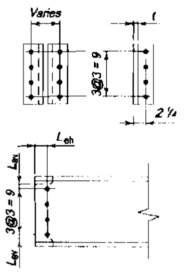
Table 10–1 (continued)
All-Bolted Double-Angle Connections

3/4-in. Bolts

Bolt and Angle Available Strength, kips

4 Rows

W24, 21, 18, 16



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	67.1	101	83.9	126	84.8	127	84.8	127
	X	—	67.1	101	83.9	126	101	151	106	159
	SC Class A	STD	59.1	88.6	59.1	88.6	59.1	88.6	59.1	88.6
		OVS	42.7	64.0	42.7	64.0	42.7	64.0	42.7	64.0
		SSLT	50.2	75.3	50.2	75.3	50.2	75.3	50.2	75.3
	SC Class B	STD	67.1	101	83.9	126	84.4	127	84.4	127
		OVS	61.0	91.4	61.0	91.4	61.0	91.4	61.0	91.4
		SSLT	65.8	98.7	71.7	108	71.7	108	71.7	108
A490	N	—	67.1	101	83.9	126	101	151	106	159
	X	—	67.1	101	83.9	126	101	151	133	199
	SC Class A	STD	67.1	101	73.8	111	73.8	111	73.8	111
		OVS	53.3	80.0	53.3	80.0	53.3	80.0	53.3	80.0
		SSLT	62.8	94.1	62.8	94.1	62.8	94.1	62.8	94.1
	SC Class B	STD	67.1	101	83.9	126	101	151	105	158
		OVS	65.3	97.9	76.2	114	76.2	114	76.2	114
		SSLT	65.8	98.7	82.2	123	89.6	134	89.6	134

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
	L_{eh}*	1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	167	250	175	262	156	234	164	246	164	245	172	257
	1 3/8	169	254	177	266	158	238	167	250	166	249	174	261
	1 1/2	171	257	180	269	161	241	169	254	168	253	177	265
	1 5/8	174	261	182	273	163	245	171	257	171	256	179	268
	2	181	272	189	284	171	256	179	268	178	267	186	279
	3	201	301	209	313	190	285	198	297	198	296	206	309
Coped at Both Flanges	1 1/4	156	234	156	234	146	219	146	219	156	234	156	234
	1 3/8	161	241	161	241	151	227	151	227	161	241	161	241
	1 1/2	166	249	166	249	156	234	156	234	166	249	166	249
	1 5/8	171	256	171	256	161	241	161	241	171	256	171	256
	2	181	272	185	278	171	256	176	263	178	267	185	278
	3	201	301	209	313	190	285	198	297	198	296	206	309
Uncoped		234	351	234	351	234	351	234	351	234	351	234	351

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	468	702

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam F_y = 50 ksi, F_u = 65 ksi

Angle F_y = 36 ksi, F_u = 58 ksi

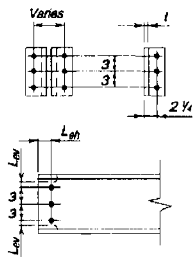
Table 10-1 (continued)
All-Bolted Double-Angle Connections

3/4-in. Bolts

Bolt and Angle Available Strength, kips

3 Rows

W18, 16, 14, 12, 10+
+Ltd. to W10x12, 15, 17, 19, 22, 26, 30



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	50.9	76.4	63.6	95.4	63.6	95.4	63.6	95.4
	X	—	50.9	76.4	63.7	95.5	76.4	115	79.5	119
	SC Class A	STD	44.3	66.4	44.3	66.4	44.3	66.4	44.3	66.4
		OVS	32.0	48.0	32.0	48.0	32.0	48.0	32.0	48.0
		SSLT	37.7	56.5	37.7	56.5	37.7	56.5	37.7	56.5
	SC Class B	STD	50.9	76.4	63.3	94.9	63.3	94.9	63.3	94.9
		OVS	45.7	68.6	45.7	68.6	45.7	68.6	45.7	68.6
		SSLT	49.6	74.4	53.8	80.7	53.8	80.7	53.8	80.7
A490	N	—	50.9	76.4	63.7	95.5	76.4	115	79.5	119
	X	—	50.9	76.4	63.7	95.5	76.4	115	99.4	149
	SC Class A	STD	50.9	76.4	55.4	83.1	55.4	83.1	55.4	83.1
		OVS	40.0	60.0	40.0	60.0	40.0	60.0	40.0	60.0
		SSLT	47.1	70.6	47.1	70.6	47.1	70.6	47.1	70.6
	SC Class B	STD	50.9	76.4	63.7	95.5	76.4	115	79.1	119
		OVS	47.9	71.8	57.1	85.7	57.1	85.7	57.1	85.7
		SSLT	49.6	74.4	62.0	92.9	67.2	101	67.2	101

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	125	188	133	200	117	176	125	188	122	183	130	195
	1 3/8	128	191	136	204	119	179	128	191	125	187	133	199
	1 1/2	130	195	138	207	122	183	130	195	127	190	135	203
	1 5/8	132	199	141	211	124	186	132	199	129	194	138	206
	2	140	210	148	222	132	197	140	210	137	205	145	217
	3	159	239	167	251	151	227	159	239	156	234	164	246
Coped at Both Flanges	1 1/4	115	172	115	172	107	161	107	161	115	172	115	172
	1 3/8	119	179	119	179	112	168	112	168	119	179	119	179
	1 1/2	124	186	124	186	117	176	117	176	124	186	124	186
	1 5/8	129	194	129	194	122	183	122	183	129	194	129	194
	2	140	210	144	216	132	197	137	205	137	205	144	216
	3	159	239	167	251	151	227	159	239	156	234	164	246
Uncoped		175	263	175	263	175	263	175	263	175	263	175	263

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	351	526

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	Angle
F_y = 50 ksi	F_y = 36 ksi
F_u = 65 ksi	F_u = 58 ksi

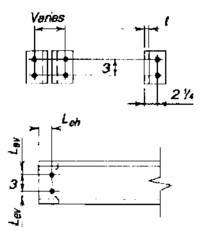
Table 10–1 (continued)
All-Bolted Double-Angle Connections

3/4-in. Bolts

Bolt and Angle Available Strength, kips

2 Rows

W12, 10, 8



ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	**32.6**	48.9	**40.8**	61.2	**42.4**	63.6	**42.4**	63.6
	X	—	**32.6**	48.9	**40.8**	61.2	**48.9**	73.4	**53.0**	79.5
	SC Class A	STD	**29.5**	44.3	**29.5**	44.3	**29.5**	44.3	**29.5**	44.3
		OVS	**21.3**	32.0	**21.3**	32.0	**21.3**	32.0	**21.3**	32.0
		SSLT	**25.1**	37.7	**25.1**	37.7	**25.1**	37.7	**25.1**	37.7
	SC Class B	STD	**32.6**	48.9	**40.8**	61.2	**42.2**	63.3	**42.2**	63.3
		OVS	**30.5**	45.7	**30.5**	45.7	**30.5**	45.7	**30.5**	45.7
		SSLT	**32.6**	48.9	**35.9**	53.8	**35.9**	53.8	**35.9**	53.8
A490	N	—	**32.6**	48.9	**40.8**	61.2	**48.9**	73.4	**53.0**	79.5
	X	—	**32.6**	48.9	**40.8**	61.2	**48.9**	73.4	**65.3**	97.9
	SC Class A	STD	**32.6**	48.9	**36.9**	55.4	**36.9**	55.4	**36.9**	55.4
		OVS	**26.7**	40.0	**26.7**	40.0	**26.7**	40.0	**26.7**	40.0
		SSLT	**31.4**	47.1	**31.4**	47.1	**31.4**	47.1	**31.4**	47.1
	SC Class B	STD	**32.6**	48.9	**40.8**	61.2	**48.9**	73.4	**52.7**	79.1
		OVS	**30.5**	45.7	**38.1**	57.1	**38.1**	57.1	**38.1**	57.1
		SSLT	**32.6**	48.9	**40.8**	61.2	**44.8**	67.2	**44.8**	67.2

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
	L_{eh}*	1½		1¾		1½		1¾		1½		1¾	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1¼	**83.7**	126	**91.4**	137	**78.0**	117	**86.1**	129	**80.6**	121	**88.8**	133
	1⅜	**86.1**	129	**94.3**	141	**80.4**	121	**88.6**	133	**83.1**	125	**91.2**	137
	1½	**88.6**	133	**96.7**	145	**82.9**	124	**91.0**	137	**85.5**	128	**93.6**	140
	1⅝	**91.0**	137	**99.1**	149	**85.3**	128	**93.4**	140	**88.0**	132	**96.1**	144
	2	**98.3**	147	**106**	160	**92.6**	139	**101**	151	**95.3**	143	**103**	155
	3	**116**	175	**117**	175	**112**	168	**117**	175	**113**	170	**117**	175
Coped at Both Flanges	1¼	**73.1**	110	**73.1**	110	**68.3**	102	**68.3**	102	**73.1**	110	**73.1**	110
	1⅜	**78.0**	117	**78.0**	117	**73.1**	110	**73.1**	110	**78.0**	117	**78.0**	117
	1½	**82.9**	124	**82.9**	124	**78.0**	117	**78.0**	117	**82.9**	124	**82.9**	124
	1⅝	**87.8**	132	**87.8**	132	**82.9**	124	**82.9**	124	**87.8**	132	**87.8**	132
	2	**98.3**	147	**102**	154	**92.6**	139	**97.5**	146	**95.3**	143	**102**	154
	3	**116**	175	**117**	175	**112**	168	**117**	175	**113**	170	**117**	175
Uncoped		**117**	176	**117**	176	**117**	176	**117**	176	**117**	176	**117**	176

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	**234**	351

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include ¼-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	Angle
F_y = 50 ksi	F_y = 36 ksi
F_u = 65 ksi	F_u = 58 ksi

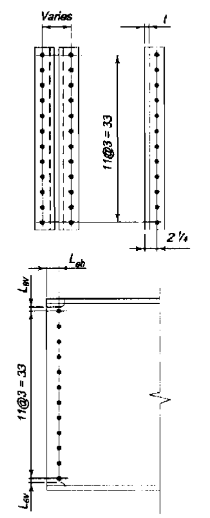
Table 10-1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips

12 Rows

W44



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	196	294	245	367	294	441	346	520
	X	—	196	294	245	367	294	441	392	587
	SC Class A	STD	196	294	245	367	247	370	247	370
		OVS	178	267	178	267	178	267	178	267
		SSLT	194	292	210	315	210	315	210	315
	SC Class B	STD	196	294	245	367	294	441	346	520
		OVS	191	287	239	359	255	382	255	382
		SSLT	194	292	243	365	292	438	300	450
A490	N	—	196	294	245	367	294	441	392	587
	X	—	196	294	245	367	294	441	392	587
	SC Class A	STD	196	294	245	367	294	441	310	465
		OVS	191	287	224	336	224	336	224	336
		SSLT	194	292	243	365	264	395	264	395
	SC Class B	STD	196	294	245	367	294	441	392	587
		OVS	191	287	239	359	287	431	320	480
		SSLT	194	292	243	365	292	438	377	565

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	468	702	476	714	438	657	446	669	465	697	473	710
	1 3/8	470	706	479	718	440	661	449	673	467	701	476	713
	1 1/2	473	709	481	722	443	664	451	676	470	705	478	717
	1 5/8	475	713	483	725	445	668	453	680	472	708	480	721
	2	483	724	491	736	453	679	461	691	480	719	488	732
	3	502	753	510	765	472	708	480	720	499	749	507	761
Coped at Both Flanges	1 1/4	458	687	458	687	429	644	429	644	458	687	458	687
	1 3/8	463	695	463	695	434	651	434	651	463	695	463	695
	1 1/2	468	702	468	702	439	658	439	658	468	702	468	702
	1 5/8	473	709	473	709	444	665	444	665	472	708	473	709
	2	483	724	488	731	453	679	458	687	480	719	488	731
	3	502	753	510	765	472	708	480	720	499	749	507	761
Uncoped		819	1230	819	1230	819	1230	819	1230	819	1230	819	1230

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	1640	2460

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	Angle
F_y = 50 ksi	F_y = 36 ksi
F_u = 65 ksi	F_u = 58 ksi

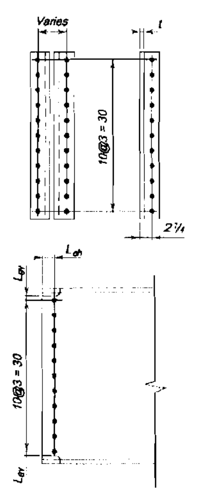
Table 10–1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips

11 Rows

W44, 40



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	180	269	225	337	269	404	317	476
	X	—	180	269	225	337	269	404	359	539
	SC Class A	STD	180	269	225	337	226	339	226	339
		OVS	163	245	163	245	163	245	163	245
		SSLT	178	267	192	288	192	288	192	288
	SC Class B	STD	180	269	225	337	269	404	317	476
		OVS	175	263	219	328	233	350	233	350
		SSLT	178	267	223	334	267	401	275	412
A490	N	—	180	269	225	337	269	404	359	539
	X	—	180	269	225	337	269	404	359	539
	SC Class A	STD	180	269	225	337	269	404	284	426
		OVS	175	263	205	308	205	308	205	308
		SSLT	178	267	223	334	242	362	242	362
	SC Class B	STD	180	269	225	337	269	404	359	539
		OVS	175	263	219	328	263	394	293	440
		SSLT	178	267	223	334	267	401	345	518

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	429	644	437	656	401	602	410	614	426	639	434	651
	1 3/8	431	647	440	659	404	606	412	618	428	643	437	655
	1 1/2	434	651	442	663	406	609	414	622	431	646	439	658
	1 5/8	436	654	444	667	409	613	417	625	433	650	441	662
	2	444	665	452	678	416	624	424	636	441	661	449	673
	3	463	695	471	707	436	653	444	665	460	690	468	702
Coped at Both Flanges	1 1/4	419	629	419	629	392	589	392	589	419	629	419	629
	1 3/8	424	636	424	636	397	596	397	596	424	636	424	636
	1 1/2	429	644	429	644	402	603	402	603	429	644	429	644
	1 5/8	434	651	434	651	407	611	407	611	433	650	434	651
	2	444	665	449	673	416	624	422	633	441	661	449	673
	3	463	695	471	707	436	653	444	665	460	690	468	702
Uncoped		751	1130	751	1130	751	1130	751	1130	751	1130	751	1130

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	1500	2250

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	Angle
F_y = 50 ksi, F_u = 65 ksi	F_y = 36 ksi, F_u = 58 ksi

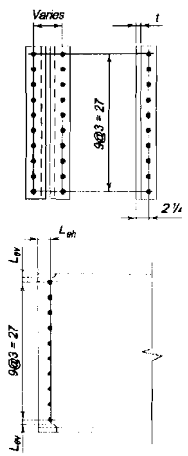
Table 10–1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips

10 Rows

W44, 40, 36



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	163	245	204	306	245	368	289	433
	X	—	163	245	204	306	245	368	327	490
	SC Class A	STD	163	245	204	306	206	308	206	308
		OVS	149	223	149	223	149	223	149	223
		SSLT	162	243	175	262	175	262	175	262
	SC Class B	STD	163	245	204	306	245	368	289	433
		OVS	159	238	198	298	212	318	212	318
		SSLT	162	243	203	304	243	365	250	375
A490	N	—	163	245	204	306	245	368	327	490
	X	—	163	245	204	306	245	368	327	490
	SC Class A	STD	163	245	204	306	245	368	258	388
		OVS	159	238	187	280	187	280	187	280
		SSLT	162	243	203	304	220	329	220	329
	SC Class B	STD	163	245	204	306	245	368	327	490
		OVS	159	238	198	298	238	357	267	400
		SSLT	162	243	203	304	243	365	314	471

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	390	585	398	597	365	547	373	559	387	580	395	593
	1 3/8	392	589	401	601	367	551	375	563	389	584	398	596
	1 1/2	395	592	403	605	370	555	378	567	392	588	400	600
	1 5/8	397	596	405	608	372	558	380	570	394	591	402	604
	2	405	607	413	619	379	569	388	581	402	602	410	615
	3	424	636	432	648	399	598	407	611	421	632	429	644
Coped at Both Flanges	1 1/4	380	570	380	570	356	534	356	534	380	570	380	570
	1 3/8	385	578	385	578	361	541	361	541	385	578	385	578
	1 1/2	390	585	390	585	366	548	366	548	390	585	390	585
	1 5/8	395	592	395	592	371	556	371	556	394	591	395	592
	2	405	607	410	614	379	569	385	578	402	602	410	614
	3	424	636	432	648	399	598	407	611	421	632	429	644
Uncoped		683	1020	683	1020	683	1020	683	1020	683	1020	683	1020

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	1370	2050

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

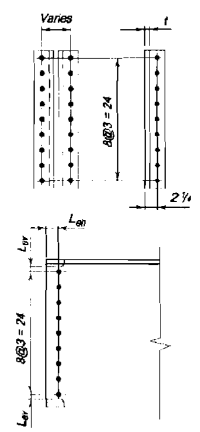
Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

9 Rows

W44, 40, 36, 33



Bolt and Angle Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	147	221	184	276	221	331	260	390
	X	—	147	221	184	276	221	331	294	442
	SC Class A	STD	147	221	184	276	185	278	185	278
		OVS	134	201	134	201	134	201	134	201
		SSLT	146	219	157	236	157	236	157	236
	SC Class B	STD	147	221	184	276	221	331	260	390
		OVS	142	214	178	267	191	287	191	287
		SSLT	146	219	182	273	219	328	225	337
A490	N	—	147	221	184	276	221	331	294	442
	X	—	147	221	184	276	221	331	294	442
	SC Class A	STD	147	221	184	276	221	331	233	349
		OVS	142	214	168	252	168	252	168	252
		SSLT	146	219	182	273	198	297	198	297
	SC Class B	STD	147	221	184	276	221	331	294	442
		OVS	142	214	178	267	214	321	240	360
		SSLT	146	219	182	273	219	328	282	424

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	351	527	359	539	328	492	336	505	348	522	356	534
	1 3/8	353	530	362	542	331	496	339	508	350	526	359	538
	1 1/2	356	534	364	546	333	500	341	512	353	529	361	541
	1 5/8	358	537	366	550	336	503	344	516	355	533	363	545
	2	366	548	374	561	343	514	351	527	363	544	371	556
	3	385	578	393	590	362	544	371	556	382	573	390	585
Coped at Both Flanges	1 1/4	341	512	341	512	319	479	319	479	341	512	341	512
	1 3/8	346	519	346	519	324	486	324	486	346	519	346	519
	1 1/2	351	527	351	527	329	494	329	494	351	527	351	527
	1 5/8	356	534	356	534	334	501	334	501	355	533	356	534
	2	366	548	371	556	343	514	349	523	363	544	371	556
	3	385	578	393	590	362	544	371	556	382	573	390	585
Uncoped		614	921	614	921	614	921	614	921	614	921	614	921

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	1230	1840

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam F_y = 50 ksi, F_u = 65 ksi

Angle F_y = 36 ksi, F_u = 58 ksi

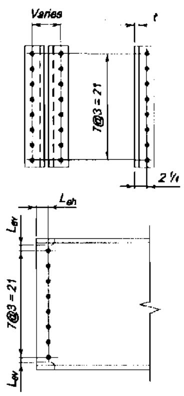
Table 10-1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips

8 Rows

W44, 40, 36, 33, 30



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/F1852	N	—	131	197	164	246	197	295	231	346
	X	—	131	197	164	246	197	295	262	393
	SC Class A	STD	131	197	164	246	165	247	165	247
		OVS	119	178	119	178	119	178	119	178
		SSLT	130	194	140	210	140	210	140	210
	SC Class B	STD	131	197	164	246	197	295	231	346
		OVS	126	189	158	237	170	255	170	255
		SSLT	130	194	162	243	194	292	200	300
A490	N	—	131	197	164	246	197	295	262	393
	X	—	131	197	164	246	197	295	262	393
	SC Class A	STD	131	197	164	246	197	295	207	310
		OVS	126	189	149	224	149	224	149	224
		SSLT	130	194	162	243	176	264	176	264
	SC Class B	STD	131	197	164	246	197	295	262	393
		OVS	126	189	158	237	189	284	213	320
		SSLT	130	194	162	243	194	292	251	377

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	312	468	320	480	292	438	300	450	309	463	317	476
	1 3/8	314	472	323	484	294	441	302	453	311	467	320	479
	1 1/2	317	475	325	488	297	445	305	457	314	471	322	483
	1 5/8	319	479	327	491	299	449	307	461	316	474	324	487
	2	327	490	335	502	306	459	314	472	324	485	332	498
	3	346	519	354	531	326	489	334	501	343	515	351	527
Coped at Both Flanges	1 1/4	302	453	302	453	283	424	283	424	302	453	302	453
	1 3/8	307	461	307	461	288	431	288	431	307	461	307	461
	1 1/2	312	468	312	468	293	439	293	439	312	468	312	468
	1 5/8	317	475	317	475	297	446	297	446	316	474	317	475
	2	327	490	332	497	306	459	312	468	324	485	332	497
	3	346	519	354	531	326	489	334	501	343	515	351	527
Uncoped		546	819	546	819	546	819	546	819	546	819	546	819

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/OVS/SSLT	1090	1640

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

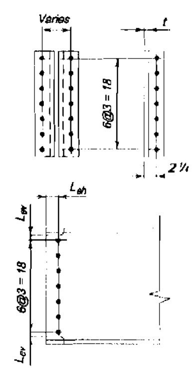
Beam: F_y = 50 ksi, F_u = 65 ksi
Angle: F_y = 36 ksi, F_u = 58 ksi

Table 10-1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips

7 Rows
W44, 40, 36, 33, 30, 27, 24



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/F1852	N	—	115	172	144	215	172	258	202	303
	X	—	115	172	144	215	172	258	230	344
	SC Class A	STD	115	172	144	215	144	216	144	216
		OVS	104	156	104	156	104	156	104	156
		SSLT	113	170	122	184	122	184	122	184
	SC Class B	STD	115	172	144	215	172	258	202	303
		OVS	110	165	137	206	149	223	149	223
		SSLT	113	170	142	213	170	255	175	262
A490	N	—	115	172	144	215	172	258	230	344
	X	—	115	172	144	215	172	258	230	344
	SC Class A	STD	115	172	144	215	172	258	181	271
		OVS	110	165	131	196	131	196	131	196
		SSLT	113	170	142	213	154	231	154	231
	SC Class B	STD	115	172	144	215	172	258	230	344
		OVS	110	165	137	206	165	247	187	280
		SSLT	113	170	142	213	170	255	220	329

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1½		1¾		1½		1¾		1½		1¾	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1¼	273	410	281	422	255	383	263	395	270	405	278	417
	1⅜	275	413	284	425	258	386	266	399	272	409	281	421
	1½	278	417	286	429	260	390	268	402	275	412	283	424
	1⅝	280	420	288	433	262	394	271	406	277	416	285	428
	2	288	431	296	444	270	405	278	417	285	427	293	439
	3	307	461	315	473	289	434	297	446	304	456	312	468
Coped at Both Flanges	1¼	263	395	263	395	246	369	246	369	263	395	263	395
	1⅜	268	402	268	402	251	377	251	377	268	402	268	402
	1½	273	410	273	410	256	384	256	384	273	410	273	410
	1⅝	278	417	278	417	261	391	261	391	277	416	278	417
	2	288	431	293	439	270	405	275	413	285	427	293	439
	3	307	461	315	473	289	434	297	446	304	456	312	468
Uncoped		478	717	478	717	478	717	478	717	478	717	478	717

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/OVS/SSLT	956	1430

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

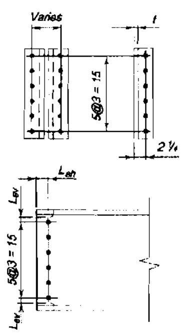
* Tabulated values include ¼-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	Angle
F_y = 50 ksi	F_y = 36 ksi
F_u = 65 ksi	F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips



6 Rows W40, 36, 33, 30, 27, 24, 21	ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
	A325/ F1852	N	—	98.6	148	123	185	148	222	173	260
		X	—	98.6	148	123	185	148	222	197	296
		SC Class A	STD	98.6	148	123	185	123	185	123	185
			OVS	89.2	134	89.2	134	89.2	134	89.2	134
			SSLT	97.3	146	105	157	105	157	105	157
		SC Class B	STD	98.6	148	123	185	148	222	173	260
			OVS	93.5	140	117	175	127	191	127	191
			SSLT	97.3	146	122	182	146	219	150	225
	A490	N	—	98.6	148	123	185	148	222	197	296
		X	—	98.6	148	123	185	148	222	197	296
		SC Class A	STD	98.6	148	123	185	148	222	155	233
			OVS	93.5	140	112	168	112	168	112	168
			SSLT	97.3	146	122	182	132	198	132	198
		SC Class B	STD	98.6	148	123	185	148	222	197	296
			OVS	93.5	140	117	175	140	210	160	240
			SSLT	97.3	146	122	182	146	219	188	282

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
	L_{eh}*												
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	234	351	242	363	219	328	227	340	231	346	239	359
	1 3/8	236	355	245	367	221	332	229	344	233	350	242	362
	1 1/2	239	358	247	371	223	335	232	347	236	354	244	366
	1 5/8	241	362	249	374	226	339	234	351	238	357	246	370
	2	249	373	257	385	233	350	241	362	246	368	254	381
	3	268	402	276	414	253	379	261	391	265	398	273	410
Coped at Both Flanges	1 1/4	224	336	224	336	210	314	210	314	224	336	224	336
	1 3/8	229	344	229	344	215	322	215	322	229	344	229	344
	1 1/2	234	351	234	351	219	329	219	329	234	351	234	351
	1 5/8	239	358	239	358	224	336	224	336	238	357	239	358
	2	249	373	254	380	233	350	239	358	246	368	254	380
	3	268	402	276	414	253	379	261	391	265	398	273	410
Uncoped		409	614	409	614	409	614	409	614	409	614	409	614

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	819	1230

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

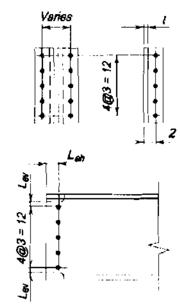
* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips

5 Rows W30, 27, 24, 21, 18	ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
	A325/ F1852	N	—	82.4	124	103	155	124	185	144	216
		X	—	82.4	124	103	155	124	185	165	247
		SC Class A	STD	82.4	124	103	154	103	154	103	154
			OVS	74.3	111	74.3	111	74.3	111	74.3	111
			SSLT	81.1	122	87.4	131	87.4	131	87.4	131
		SC Class B	STD	82.4	124	103	155	124	185	144	216
			OVS	77.2	116	96.5	145	106	159	106	159
			SSLT	81.1	122	101	152	122	182	125	187
	A490	N	—	82.4	124	103	155	124	185	165	247
		X	—	82.4	124	103	155	124	185	165	247
		SC Class A	STD	82.4	124	103	155	124	185	129	194
			OVS	77.2	116	93.3	140	93.3	140	93.3	140
			SSLT	81.1	122	101	152	110	165	110	165
		SC Class B	STD	82.4	124	103	155	124	185	165	247
			OVS	77.2	116	96.5	145	116	174	133	200
			SSLT	81.1	122	101	152	122	182	157	235

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	195	293	203	305	182	273	190	285	192	288	200	300
	1 3/8	197	296	206	308	184	277	193	289	194	292	203	304
	1 1/2	200	300	208	312	187	280	195	293	197	295	205	307
	1 5/8	202	303	210	316	189	284	197	296	199	299	207	311
	2	210	314	218	327	197	295	205	307	207	310	215	322
	3	229	344	237	356	216	324	224	336	226	339	234	351
Coped at Both Flanges	1 1/4	185	278	185	278	173	260	173	260	185	278	185	278
	1 3/8	190	285	190	285	178	267	178	267	190	285	190	285
	1 1/2	195	293	195	293	183	274	183	274	195	293	195	293
	1 5/8	200	300	200	300	188	282	188	282	199	299	200	300
	2	210	314	215	322	197	295	202	303	207	310	215	322
	3	229	344	237	356	216	324	224	336	226	339	234	351
Uncoped		341	512	341	512	341	512	341	512	341	512	341	512

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	683	1020

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

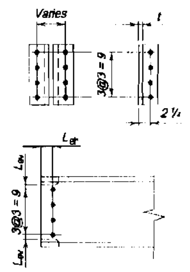
Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued) All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips

4 Rows — W24, 21, 18, 16



ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	65.3	97.9	81.6	122	97.9	147	115	173
	X	—	65.3	97.9	81.6	122	97.9	147	131	196
	SC Class A	STD	65.3	97.9	81.6	122	82.3	123	82.3	123
		OVS	59.4	89.2	59.4	89.2	59.4	89.2	59.4	89.2
		SSLT	64.9	97.3	69.9	105	69.9	105	69.9	105
	SC Class B	STD	65.3	97.9	81.6	122	97.9	147	115	173
		OVS	60.9	91.4	76.1	114	84.9	127	84.9	127
		SSLT	64.9	97.3	81.1	122	97.3	146	99.9	150
A490	N	—	65.3	97.9	81.6	122	97.9	147	131	196
	X	—	65.3	97.9	81.6	122	97.9	147	131	196
	SC Class A	STD	65.3	97.9	81.6	122	97.9	147	103	155
		OVS	60.9	91.4	74.7	112	74.7	112	74.7	112
		SSLT	64.9	97.3	81.1	122	87.9	132	87.9	132
	SC Class B	STD	65.3	97.9	81.6	122	97.9	147	131	196
		OVS	60.9	91.4	76.1	114	91.4	137	107	160
		SSLT	64.9	97.3	81.1	122	97.3	146	126	188

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	156	234	164	246	145	218	154	230	153	229	161	242
	1 3/8	158	238	167	250	148	222	156	234	155	233	164	245
	1 1/2	161	241	169	254	150	225	158	238	158	237	166	249
	1 5/8	163	245	171	257	153	229	161	241	160	240	168	253
	2	171	256	179	268	160	240	168	252	168	251	176	264
	3	190	285	198	297	180	269	188	282	187	281	195	293
Coped at Both Flanges	1 1/4	146	219	146	219	137	205	137	205	146	219	146	219
	1 3/8	151	227	151	227	141	212	141	212	151	227	151	227
	1 1/2	156	234	156	234	146	219	146	219	156	234	156	234
	1 5/8	161	241	161	241	151	227	151	227	160	240	161	241
	2	171	256	176	263	160	240	166	249	168	251	176	263
	3	190	285	198	297	180	269	188	282	187	281	195	293
Uncoped		273	410	273	410	273	410	273	410	273	410	273	410

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	546	819

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	Angle
F_y = 50 ksi, F_u = 65 ksi	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

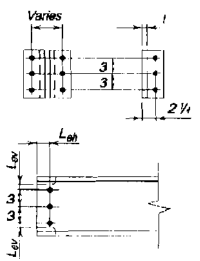
7/8-in. Bolts

Bolt and Angle Available Strength, kips

3 Rows

W18, 16, 14, 12, 10⁺

⁺Ltd. to W10x12, 15, 17, 19, 22, 26, 30



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	47.9	71.8	59.8	89.7	71.8	108	86.6	130
	X	—	47.9	71.8	59.8	89.7	71.8	108	95.7	144
	SC Class A	STD	47.9	71.8	59.8	89.7	61.7	92.5	61.7	92.5
		OVS	44.6	66.9	44.6	66.9	44.6	66.9	44.6	66.9
		SSLT	47.9	71.8	52.4	78.7	52.4	78.7	52.4	78.7
	SC Class B	STD	47.9	71.8	59.8	89.7	71.8	108	86.6	130
		OVS	44.6	66.9	55.7	83.6	63.7	95.5	63.7	95.5
		SSLT	47.9	71.8	59.8	89.7	71.8	108	74.9	112
A490	N	—	47.9	71.8	59.8	89.7	71.8	108	95.7	144
	X	—	47.9	71.8	59.8	89.7	71.8	108	95.7	144
	SC Class A	STD	47.9	71.8	59.8	89.7	71.8	108	77.5	116
		OVS	44.6	66.9	55.7	83.6	56	84	56	84
		SSLT	47.9	71.8	59.8	89.7	65.9	98.8	65.9	98.8
	SC Class B	STD	47.9	71.8	59.8	89.7	71.8	108	95.7	144
		OVS	44.6	66.9	55.7	83.6	66.9	100	80	120
		SSLT	47.9	71.8	59.8	89.7	71.8	108	94.1	141

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	117	176	125	188	109	163	117	176	114	171	122	183
	1 3/8	119	179	128	191	111	167	119	179	116	175	125	187
	1 1/2	122	183	130	195	114	171	122	183	119	178	127	190
	1 5/8	124	186	132	199	116	174	124	186	121	182	129	194
	2	132	197	140	210	124	185	132	197	129	193	137	205
	3	151	227	159	239	143	215	151	227	148	222	156	234
Coped at Both Flanges	1 1/4	107	161	107	161	99.9	150	99.9	150	107	161	107	161
	1 3/8	112	168	112	168	105	157	105	157	112	168	112	168
	1 1/2	117	176	117	176	110	165	110	165	117	176	117	176
	1 5/8	122	183	122	183	115	172	115	172	121	182	122	183
	2	132	197	137	205	124	185	129	194	129	193	137	205
	3	151	227	159	239	143	215	151	227	148	222	156	234
Uncoped		205	307	205	307	205	307	205	307	205	307	205	307

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	409	614

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

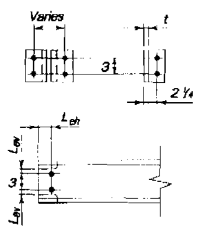
Beam	Angle
F_y = 50 ksi F_u = 65 ksi	F_y = 36 ksi F_u = 58 ksi

Table 10-1 (continued)
All-Bolted Double-Angle Connections

7/8-in. Bolts

Bolt and Angle Available Strength, kips

2 Rows — W12, 10, 8



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	30.5	45.7	38.1	57.1	45.7	68.5	57.7	86.6
	X	—	30.5	45.7	38.1	57.1	45.7	68.5	60.9	91.4
	SC Class A	STD	30.5	45.7	38.1	57.1	41.1	61.7	41.1	61.7
		OVS	28.3	42.4	29.7	44.6	29.7	44.6	29.7	44.6
		SSLT	30.5	45.7	35.0	52.4	35.0	52.4	35.0	52.4
	SC Class B	STD	30.5	45.7	38.1	57.1	45.7	68.5	57.7	86.6
		OVS	28.3	42.4	35.3	53.0	42.4	63.6	42.5	63.7
		SSLT	30.5	45.7	38.1	57.1	45.7	68.5	49.9	74.9
A490	N	—	30.5	45.7	38.1	57.1	45.7	68.5	60.9	91.4
	X	—	30.5	45.7	38.1	57.1	45.7	68.5	60.9	91.4
	SC Class A	STD	30.5	45.7	38.1	57.1	45.7	68.5	51.7	77.5
		OVS	28.3	42.4	35.3	53.0	37.3	56.0	37.3	56.0
		SSLT	30.5	45.7	38.1	57.1	43.9	65.9	43.9	65.9
	SC Class B	STD	30.5	45.7	38.1	57.1	45.7	68.5	60.9	91.4
		OVS	28.3	42.4	35.3	53.0	42.4	63.6	53.3	80.0
		SSLT	30.5	45.7	38.1	57.1	45.7	68.5	60.9	91.4

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2 ASD	1 1/2 LRFD	1 3/4 ASD	1 3/4 LRFD	1 1/2 ASD	1 1/2 LRFD	1 3/4 ASD	1 3/4 LRFD	1 1/2 ASD	1 1/2 LRFD	1 3/4 ASD	1 3/4 LRFD
Coped at Top Flange Only	1 1/4	78.0	117	86.1	129	72.3	108	80.4	121	75.0	112	83.1	125
	1 3/8	80.4	121	88.6	133	74.8	112	82.9	124	77.4	116	85.5	128
	1 1/2	82.9	124	91.0	137	77.2	116	85.3	128	79.8	120	88.0	132
	1 5/8	85.3	128	93.4	140	79.6	119	87.8	132	82.3	123	90.4	136
	2	92.6	139	101	151	86.9	130	95.1	143	89.6	134	97.7	147
	3	112	168	120	180	106	160	115	172	109	164	117	176
Coped at Both Flanges	1 1/4	68.3	102	68.3	102	63.4	95.1	63.4	95.1	68.3	102	68.3	102
	1 3/8	73.1	110	73.1	110	68.3	102	68.3	102	73.1	110	73.1	110
	1 1/2	78.0	117	78.0	117	73.1	110	73.1	110	78.0	117	78.0	117
	1 5/8	82.9	124	82.9	124	78.0	117	78.0	117	82.3	123	82.9	124
	2	92.6	139	97.5	146	86.9	130	92.6	139	89.6	134	97.5	146
	3	112	168	120	180	106	160	115	172	109	164	117	176
Uncoped		137	205	137	205	137	205	137	205	137	205	137	205

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ OVS/ SSLT	273	410

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

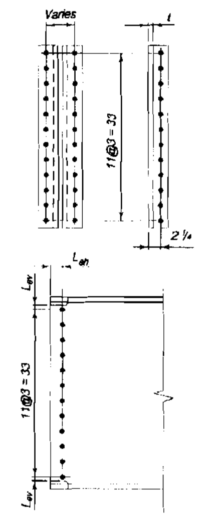
* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10-1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

12 Rows — W44



Bolt and Angle Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	191	287	239	359	287	431	383	574
	X	—	191	287	239	359	287	431	383	574
	SC Class A	STD	191	287	239	359	287	431	323	484
		OVS	172	258	215	322	233	350	233	350
		SSLT	191	287	239	359	274	411	274	411
	SC Class B	STD	191	287	239	359	287	431	383	574
		OVS	172	258	215	322	258	387	333	500
		SSLT	191	287	239	359	287	431	383	574
A490	N	—	191	287	239	359	287	431	383	574
	X	—	191	287	239	359	287	431	383	574
	SC Class A	STD	191	287	239	359	287	431	383	574
		OVS	172	258	215	322	258	387	293	439
		SSLT	191	287	239	359	287	431	344	516
	SC Class B	STD	191	287	239	359	287	431	383	574
		OVS	172	258	215	322	258	387	344	515
		SSLT	191	287	239	359	287	431	383	574

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
L_{eh}*		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	438	657	446	669	393	589	401	601	434	651	442	663
	1 3/8	440	661	449	673	395	593	403	605	436	654	444	667
	1 1/2	443	664	451	676	398	597	406	609	439	658	447	670
	1 5/8	445	668	453	680	400	600	408	612	441	662	449	674
	2	453	679	461	691	407	611	416	623	449	673	457	685
	3	472	708	480	720	427	640	435	653	468	702	476	714
Coped at Both Flanges	1 1/4	429	644	429	644	385	578	385	578	429	644	429	644
	1 3/8	434	651	434	651	390	585	390	585	434	651	434	651
	1 1/2	439	658	439	658	395	592	395	592	439	658	439	658
	1 5/8	444	665	444	665	400	600	400	600	441	662	444	665
	2	453	679	458	687	407	611	414	622	449	673	457	685
	3	472	708	480	720	427	640	435	653	468	702	476	714
Uncoped		909	1360	909	1360	829	1240	829	1240	909	1360	909	1360

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	1820	2730
OVS	1660	2490

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

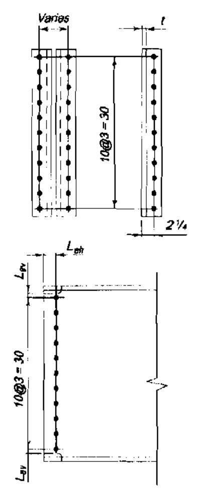
Beam	Angle
F_y = 50 ksi, F_u = 65 ksi	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

11 Rows

W44, 40



Bolt and Angle Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/F1852	N	—	175	263	219	328	263	394	350	525
	X	—	175	263	219	328	263	394	350	525
	SC Class A	STD	175	263	219	328	263	394	296	444
		OVS	157	236	196	295	214	321	214	321
		SSLT	175	263	219	328	251	377	251	377
	SC Class B	STD	175	263	219	328	263	394	350	525
		OVS	157	236	196	295	236	354	305	458
		SSLT	175	263	219	328	263	394	350	525
A490	N	—	175	263	219	328	263	394	350	525
	X	—	175	263	219	328	263	394	350	525
	SC Class A	STD	175	263	219	328	263	394	350	525
		OVS	157	236	196	295	236	354	268	402
		SSLT	175	263	219	328	263	394	316	473
	SC Class B	STD	175	263	219	328	263	394	350	525
		OVS	157	236	196	295	236	354	314	471
		SSLT	175	263	219	328	263	394	350	525

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
	L_{eh}*	1½		1¾		1½		1¾		1½		1¾	
	L_{ev}, in.	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1¼	401	602	410	614	360	540	368	552	397	596	405	608
	1⅜	404	606	412	618	362	544	371	556	400	600	408	612
	1½	406	609	414	622	365	547	373	559	402	603	410	615
	1⅝	409	613	417	625	367	551	375	563	405	607	413	619
	2	416	624	424	636	375	562	383	574	412	618	420	630
	3	436	653	444	665	394	591	402	603	431	647	440	659
Coped at Both Flanges	1¼	392	589	392	589	352	528	352	528	392	589	392	589
	1⅜	397	596	397	596	357	536	357	536	397	596	397	596
	1½	402	603	402	603	362	543	362	543	402	603	402	603
	1⅝	407	611	407	611	367	550	367	550	405	607	407	611
	2	416	624	422	633	375	562	381	572	412	618	420	630
	3	436	653	444	665	394	591	402	603	431	647	440	659
Uncoped		834	1250	834	1250	761	1140	761	1140	834	1250	834	1250

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/SSLT	1670	2500
OVS	1520	2280

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include ¼-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

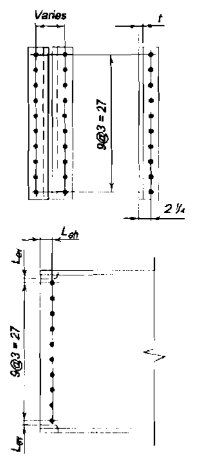
Table 10–1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

Bolt and Angle Available Strength, kips

10 Rows

W44, 40, 36



ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	159	238	198	298	238	357	318	476
	X	—	159	238	198	298	238	357	318	476
	SC Class A	STD	159	238	198	298	238	357	269	403
		OVS	142	214	178	267	194	291	194	291
		SSLT	159	238	198	298	229	343	229	343
	SC Class B	STD	159	238	198	298	238	357	318	476
		OVS	142	214	178	267	214	321	278	416
		SSLT	159	238	198	298	238	357	318	476
A490	N	—	159	238	198	298	238	357	318	476
	X	—	159	238	198	298	238	357	318	476
	SC Class A	STD	159	238	198	298	238	357	318	476
		OVS	142	214	178	267	214	321	244	366
		SSLT	159	238	198	298	238	357	287	430
	SC Class B	STD	159	238	198	298	238	357	318	476
		OVS	142	214	178	267	214	321	285	427
		SSLT	159	238	198	298	238	357	318	476

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type	L_{ev}, in.	STD, L_{eh}* = 1½ ASD	STD 1½ LRFD	STD 1¾ ASD	STD 1¾ LRFD	OVS 1½ ASD	OVS 1½ LRFD	OVS 1¾ ASD	OVS 1¾ LRFD	SSLT 1½ ASD	SSLT 1½ LRFD	SSLT 1¾ ASD	SSLT 1¾ LRFD
Coped at Top Flange Only	1¼	365	547	373	559	327	491	335	503	361	541	369	553
	1⅜	367	551	375	563	329	494	338	506	363	545	371	557
	1½	370	555	378	567	332	498	340	510	366	548	374	561
	1⅝	372	558	380	570	334	502	342	514	368	552	376	564
	2	379	569	388	581	342	512	350	525	375	563	384	575
	3	399	598	407	611	361	542	369	554	395	592	403	605
Coped at Both Flanges	1¼	356	534	356	534	319	479	319	479	356	534	356	534
	1⅜	361	541	361	541	324	486	324	486	361	541	361	541
	1½	366	548	366	548	329	494	329	494	366	548	366	548
	1⅝	371	556	371	556	334	501	334	501	368	552	371	556
	2	379	569	385	578	342	512	349	523	375	563	384	575
	3	399	598	407	611	361	542	369	554	395	592	403	605
Uncoped		758	1140	758	1140	692	1040	692	1040	758	1140	758	1140

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	1520	2270
OVS	1380	2080

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

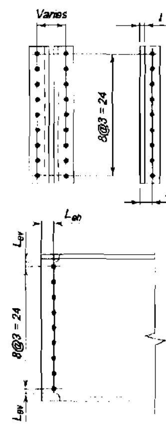
* Tabulated values include ¼-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi F_u = 65 ksi
Angle	F_y = 36 ksi F_u = 58 ksi

Table 10–1 (continued) All-Bolted Double-Angle Connections

1-in. Bolts

Bolt and Angle Available Strength, kips

9 Rows / W44, 40, 36, 33	ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
	A325/ F1852	N	—	142	214	178	267	214	321	285	427
		X	—	142	214	178	267	214	321	285	427
		SC Class A	STD	142	214	178	267	214	321	242	363
			OVS	128	192	160	240	175	262	175	262
			SSLT	142	214	178	267	206	309	206	309
		SC Class B	STD	142	214	178	267	214	321	285	427
			OVS	128	192	160	240	192	288	250	375
			SSLT	142	214	178	267	214	321	285	427
	A490	N	—	142	214	178	267	214	321	285	427
		X	—	142	214	178	267	214	321	285	427
		SC Class A	STD	142	214	178	267	214	321	285	427
			OVS	128	192	160	240	192	288	219	329
			SSLT	142	214	178	267	214	321	258	387
		SC Class B	STD	142	214	178	267	214	321	285	427
			OVS	128	192	160	240	192	288	256	383
			SSLT	142	214	178	267	214	321	285	427

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	328	492	336	505	294	441	302	453	324	486	332	498
	1 3/8	331	496	339	508	297	445	305	457	327	490	335	502
	1 1/2	333	500	341	512	299	449	307	461	329	494	337	506
	1 5/8	336	503	344	516	301	452	310	464	332	497	340	509
	2	343	514	351	527	309	463	317	475	339	508	347	520
	3	362	544	371	556	328	492	336	505	358	537	366	550
Coped at Both Flanges	1 1/4	319	479	319	479	286	430	286	430	319	479	319	479
	1 3/8	324	486	324	486	291	437	291	437	324	486	324	486
	1 1/2	329	494	329	494	296	444	296	444	329	494	329	494
	1 5/8	334	501	334	501	301	452	301	452	332	497	334	501
	2	343	514	349	523	309	463	316	473	339	508	347	520
	3	362	544	371	556	328	492	336	505	358	537	366	550
Uncoped		683	1020	683	1020	624	936	624	936	683	1020	683	1020

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	1370	2050
OVS	1250	1870

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

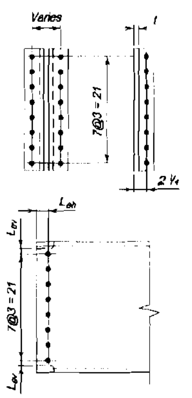
Table 10–1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

Bolt and Angle Available Strength, kips

8 Rows

W44, 40, 36, 33, 30



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	126	189	158	237	189	284	252	378
	X	—	126	189	158	237	189	284	252	378
	SC Class A	STD	126	189	158	237	189	284	215	323
		OVS	113	170	141	212	155	233	155	233
		SSLT	126	189	158	237	183	274	183	274
	SC Class B	STD	126	189	158	237	189	284	252	378
		OVS	113	170	141	212	170	254	222	333
		SSLT	126	189	158	237	189	284	252	378
A490	N	—	126	189	158	237	189	284	252	378
	X	—	126	189	158	237	189	284	252	378
	SC Class A	STD	126	189	158	237	189	284	252	378
		OVS	113	170	141	212	170	254	195	293
		SSLT	126	189	158	237	189	284	229	344
	SC Class B	STD	126	189	158	237	189	284	252	378
		OVS	113	170	141	212	170	254	226	339
		SSLT	126	189	158	237	189	284	252	378

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	292	438	300	450	261	392	269	404	288	431	296	444
	1 3/8	294	441	302	453	264	395	272	408	290	435	298	447
	1 1/2	297	445	305	457	266	399	274	411	293	439	301	451
	1 5/8	299	449	307	461	269	403	277	415	295	442	303	455
	2	306	459	314	472	276	414	284	426	302	453	310	466
	3	326	489	334	501	295	443	303	455	322	483	330	495
Coped at Both Flanges	1 1/4	283	424	283	424	254	380	254	380	283	424	283	424
	1 3/8	288	431	288	431	258	388	258	388	288	431	288	431
	1 1/2	293	439	293	439	263	395	263	395	293	439	293	439
	1 5/8	297	446	297	446	268	402	268	402	295	442	297	446
	2	306	459	312	468	276	414	283	424	302	453	310	466
	3	326	489	334	501	295	443	303	455	322	483	330	495
Uncoped		607	910	607	910	556	834	556	834	607	910	607	910

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	1210	1820
OVS	1110	1670

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

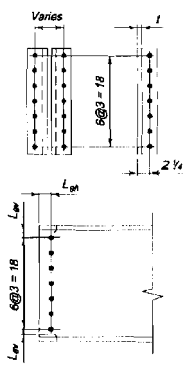
Beam	Angle
F_y = 50 ksi, F_u = 65 ksi	F_y = 36 ksi, F_u = 58 ksi

Table 10-1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

7 Rows

W44, 40, 36, 33, 30, 27, 24



Bolt and Angle Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	110	165	137	206	165	247	220	330
	X	—	110	165	137	206	165	247	220	330
	SC Class A	STD	110	165	137	206	165	247	188	282
		OVS	98.4	148	123	185	136	204	136	204
		SSLT	110	165	137	206	160	240	160	240
	SC Class B	STD	110	165	137	206	165	247	220	330
		OVS	98.4	148	123	185	148	221	194	291
		SSLT	110	165	137	206	165	247	220	330
A490	N	—	110	165	137	206	165	247	220	330
	X	—	110	165	137	206	165	247	220	330
	SC Class A	STD	110	165	137	206	165	247	220	330
		OVS	98.4	148	123	185	148	221	171	256
		SSLT	110	165	137	206	165	247	201	301
	SC Class B	STD	110	165	137	206	165	247	220	330
		OVS	98.4	148	123	185	148	221	197	295
		SSLT	110	165	137	206	165	247	220	330

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
	L_{eh}*	1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
	L_{ev}, in.	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	255	383	263	395	228	342	236	355	251	377	259	389
	1 3/8	258	386	266	399	231	346	239	358	254	380	262	392
	1 1/2	260	390	268	402	233	350	241	362	256	384	264	396
	1 5/8	262	394	271	406	236	353	244	366	258	388	267	400
	2	270	405	278	417	243	364	251	377	266	399	274	411
	3	289	434	297	446	262	394	271	406	285	428	293	440
Coped at Both Flanges	1 1/4	246	369	246	369	221	331	221	331	246	369	246	369
	1 3/8	251	377	251	377	225	338	225	338	251	377	251	377
	1 1/2	256	384	256	384	230	346	230	346	256	384	256	384
	1 5/8	261	391	261	391	235	353	235	353	258	388	261	391
	2	270	405	275	413	243	364	250	375	266	399	274	411
	3	289	434	297	446	262	394	271	406	285	428	293	440
Uncoped		531	797	531	797	487	731	487	731	531	797	531	797

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	1060	1590
OVS	975	1460

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

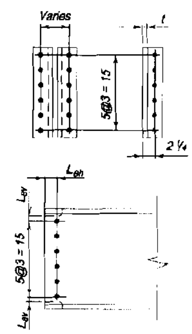
* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi, F_u = 65 ksi
Angle	F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

Bolt and Angle Available Strength, kips



6 Rows: W40, 36, 33, 30, 27, 24, 21 — ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	93.5	140	117	175	140	210	187	281
	X	—	93.5	140	117	175	140	210	187	281
	SC Class A	STD	93.5	140	117	175	140	210	161	242
		OVS	83.7	126	105	157	117	175	117	175
		SSLT	93.5	140	117	175	137	206	137	206
	SC Class B	STD	93.5	140	117	175	140	210	187	281
		OVS	83.7	126	105	157	126	188	167	250
		SSLT	93.5	140	117	175	140	210	187	281
A490	N	—	93.5	140	117	175	140	210	187	281
	X	—	93.5	140	117	175	140	210	187	281
	SC Class A	STD	93.5	140	117	175	140	210	187	281
		OVS	83.7	126	105	157	126	188	146	219
		SSLT	93.5	140	117	175	140	210	172	258
	SC Class B	STD	93.5	140	117	175	140	210	187	281
		OVS	83.7	126	105	157	126	188	167	251
		SSLT	93.5	140	117	175	140	210	187	281

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
	L_{eh}*	1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
	L_{ev}, in.	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	219	328	227	340	195	293	204	305	215	322	223	334
	1 3/8	221	332	229	344	198	297	206	309	217	325	225	338
	1 1/2	223	335	232	347	200	300	208	313	219	329	228	341
	1 5/8	226	339	234	351	203	304	211	316	222	333	230	345
	2	233	350	241	362	210	315	218	327	229	344	237	356
	3	253	379	261	391	230	344	238	356	249	373	257	385
Coped at Both Flanges	1 1/4	210	314	210	314	188	282	188	282	210	314	210	314
	1 3/8	215	322	215	322	193	289	193	289	215	322	215	322
	1 1/2	219	329	219	329	197	296	197	296	219	329	219	329
	1 5/8	224	336	224	336	202	303	202	303	222	333	224	336
	2	233	350	239	358	210	315	217	325	229	344	237	356
	3	253	379	261	391	230	344	238	356	249	373	257	385
Uncoped		456	684	456	684	419	629	419	629	456	684	456	684

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	912	1370
OVS	839	1260

Notes:

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	F_y = 50 ksi F_u = 65 ksi
Angle	F_y = 36 ksi F_u = 58 ksi

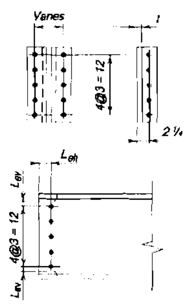
Table 10–1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

Bolt and Angle Available Strength, kips

5 Rows

W30, 27, 24, 21, 18



ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	77.2	116	96.5	145	116	174	154	232
	X	—	77.2	116	96.5	145	116	174	154	232
	SC Class A	STD	77.2	116	96.5	145	116	174	134	202
		OVS	69.1	104	86.3	129	97.2	146	97.2	146
		SSLT	77.2	116	96.5	145	114	171	114	171
	SC Class B	STD	77.2	116	96.5	145	116	174	154	232
		OVS	69.1	104	86.3	129	104	155	138	207
		SSLT	77.2	116	96.5	145	116	174	154	232
A490	N	—	77.2	116	96.5	145	116	174	154	232
	X	—	77.2	116	96.5	145	116	174	154	232
	SC Class A	STD	77.2	116	96.5	145	116	174	154	232
		OVS	69.1	104	86.3	129	104	155	122	183
		SSLT	77.2	116	96.5	145	116	174	143	215
	SC Class B	STD	77.2	116	96.5	145	116	174	154	232
		OVS	69.1	104	86.3	129	104	155	138	207
		SSLT	77.2	116	96.5	145	116	174	154	232

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1½		1¾		1½		1¾		1½		1¾	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1¼	182	273	190	285	163	244	171	256	178	267	186	279
	1⅜	184	277	193	289	165	247	173	260	180	271	189	283
	1½	187	280	195	293	167	251	176	263	183	274	191	286
	1⅝	189	284	197	296	170	255	178	267	185	278	193	290
	2	197	295	205	307	177	266	185	278	193	289	201	301
	3	216	324	224	336	197	295	205	307	212	318	220	330
Coped at Both Flanges	1¼	173	260	173	260	155	232	155	232	173	260	173	260
	1⅜	178	267	178	267	160	239	160	239	178	267	178	267
	1½	183	274	183	274	165	247	165	247	183	274	183	274
	1⅝	188	282	188	282	169	254	169	254	185	278	188	282
	2	197	295	202	303	177	266	184	276	193	289	201	301
	3	216	324	224	336	197	295	205	307	212	318	220	330
Uncoped		380	570	380	570	351	527	351	527	380	570	380	570

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	761	1140
OVS	702	1050

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include ¼-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

Beam	Angle
F_y = 50 ksi	F_y = 36 ksi
F_u = 65 ksi	F_u = 58 ksi

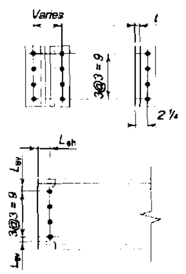
Table 10–1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

Bolt and Angle Available Strength, kips

4 Rows

W24, 21, 18, 16



ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/ F1852	N	—	60.9	91.4	76.1	114	91.4	137	122	183
	X	—	60.9	91.4	76.1	114	91.4	137	122	183
	SC Class A	STD	60.9	91.4	76.1	114	91.4	137	108	161
		OVS	54.4	81.6	68.0	102	77.7	117	77.7	117
		SSLT	60.9	91.4	76.1	114	91.4	137	91.4	137
	SC Class B	STD	60.9	91.4	76.1	114	91.4	137	122	183
		OVS	54.4	81.6	68.0	102	81.6	122	109	163
		SSLT	60.9	91.4	76.1	114	91.4	137	122	183
A490	N	—	60.9	91.4	76.1	114	91.4	137	122	183
	X	—	60.9	91.4	76.1	114	91.4	137	122	183
	SC Class A	STD	60.9	91.4	76.1	114	91.4	137	122	183
		OVS	54.4	81.6	68.0	102	81.6	122	97.5	146
		SSLT	60.9	91.4	76.1	114	91.4	137	115	172
	SC Class B	STD	60.9	91.4	76.1	114	91.4	137	122	183
		OVS	54.4	81.6	68.0	102	81.6	122	109	163
		SSLT	60.9	91.4	76.1	114	91.4	137	122	183

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
	L_{eh}*	1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	145	218	154	230	130	194	138	207	141	212	150	224
	1 3/8	148	222	156	234	132	198	140	210	144	216	152	228
	1 1/2	150	225	158	238	134	202	143	214	146	219	154	232
	1 5/8	153	229	161	241	137	205	145	218	149	223	157	235
	2	160	240	168	252	144	216	152	229	156	234	164	246
	3	180	269	188	282	164	246	172	258	176	263	184	275
Coped at Both Flanges	1 1/4	137	205	137	205	122	183	122	183	137	205	137	205
	1 3/8	141	212	141	212	127	190	127	190	141	212	141	212
	1 1/2	146	219	146	219	132	197	132	197	146	219	146	219
	1 5/8	151	227	151	227	137	205	137	205	149	223	151	227
	2	160	240	166	249	144	216	151	227	156	234	164	246
	3	180	269	188	282	164	246	172	258	176	263	184	275
Uncoped		305	457	305	457	283	424	283	424	305	457	305	457

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	609	914
OVS	566	848

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

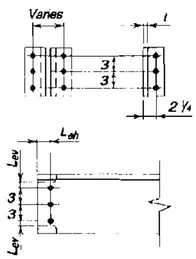
Beam F_y = 50 ksi, F_u = 65 ksi
Angle F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

Bolt and Angle Available Strength, kips

3 Rows
W18, 16, 14, 12, 10⁺
⁺Ltd. to W10x12, 15, 17, 19, 22, 26, 30



ASTM Desig.	Thread Cond.	Hole Type	1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
A325/F1852	N	—	44.6	66.9	55.7	83.6	66.9	100	89.2	134
	X	—	44.6	66.9	55.7	83.6	66.9	100	89.2	134
	SC Class A	STD	44.6	66.9	55.7	83.6	66.9	100	80.7	121
		OVS	39.7	59.5	49.6	74.4	58.3	87.4	58.3	87.4
		SSLT	44.6	66.9	55.7	83.6	66.9	100	68.6	103
	SC Class B	STD	44.6	66.9	55.7	83.6	66.9	100	89.2	134
		OVS	39.7	59.5	49.6	74.4	59.5	89.3	79.4	119
		SSLT	44.6	66.9	55.7	83.6	66.9	100	89.2	134
A490	N	—	44.6	66.9	55.7	83.6	66.9	100	89.2	134
	X	—	44.6	66.9	55.7	83.6	66.9	100	89.2	134
	SC Class A	STD	44.6	66.9	55.7	83.6	66.9	100	89.2	134
		OVS	39.7	59.5	49.6	74.4	59.5	89.3	73.2	110
		SSLT	44.6	66.9	55.7	83.6	66.9	100	86.1	129
	SC Class B	STD	44.6	66.9	55.7	83.6	66.9	100	89.2	134
		OVS	39.7	59.5	49.6	74.4	59.5	89.3	79.4	119
		SSLT	44.6	66.9	55.7	83.6	66.9	100	89.2	134

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
		L_{eh}*											
L_{ev}, in.		1½		1¾		1½		1¾		1½		1¾	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1¼	109	163	117	176	96.7	145	105	157	105	157	113	169
	1⅜	111	167	119	179	99.1	149	107	161	107	161	115	173
	1½	114	171	122	183	102	152	110	165	110	165	118	177
	1⅝	116	174	124	186	104	156	112	168	112	168	120	180
	2	124	185	132	197	111	167	119	179	119	179	128	191
	3	143	215	151	227	131	196	139	208	139	208	147	221
Coped at Both Flanges	1¼	99.9	150	99.9	150	89	133	89	133	99.9	150	99.9	150
	1⅜	105	157	105	157	93.8	141	93.8	141	105	157	105	157
	1½	110	165	110	165	98.7	148	98.7	148	110	165	110	165
	1⅝	115	172	115	172	104	155	104	155	112	168	115	172
	2	124	185	129	194	111	167	118	177	119	179	128	191
	3	143	215	151	227	131	196	139	208	139	208	147	221
Uncoped		229	344	229	344	215	322	215	322	229	344	229	344

Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/SSLT	458	687
OVS	429	644

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include ¼-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

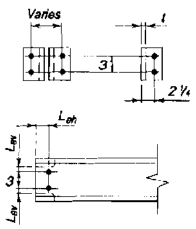
Beam F_y = 50 ksi, F_u = 65 ksi

Angle F_y = 36 ksi, F_u = 58 ksi

Table 10–1 (continued)
All-Bolted Double-Angle Connections

1-in. Bolts

Bolt and Angle Available Strength, kips



2 Rows W12, 10, 8	ASTM Desig.	Thread Cond.	Hole Type	Angle Thickness 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	1/2 ASD	1/2 LRFD
	A325/ F1852	N	—	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
		X	—	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
		SC Class A	STD	28.3	42.4	35.3	53.0	42.4	63.6	53.8	80.7
			OVS	25.0	37.5	31.3	46.9	37.5	56.3	38.9	58.3
			SSLT	28.3	42.4	35.3	53.0	42.4	63.6	45.7	68.6
		SC Class B	STD	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
			OVS	25.0	37.5	31.3	46.9	37.5	56.3	50.0	75.0
			SSLT	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
	A490	N	—	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
		X	—	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
		SC Class A	STD	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
			OVS	25.0	37.5	31.3	46.9	37.5	56.3	48.8	73.2
			SSLT	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
		SC Class B	STD	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8
			OVS	25.0	37.5	31.3	46.9	37.5	56.3	50.0	75.0
			SSLT	28.3	42.4	35.3	53.0	42.4	63.6	56.6	84.8

Beam Web Available Strength per Inch Thickness, kips/in.

Hole Type		STD				OVS				SSLT			
	L_{eh}*	1 1/2		1 3/4		1 1/2		1 3/4		1 1/2		1 3/4	
L_{ev}, in.		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Coped at Top Flange Only	1 1/4	72.3	108	80.4	121	63.8	95.7	71.9	108	68.3	102	76.4	115
	1 3/8	74.8	112	82.9	124	66.2	99.3	74.3	112	70.7	106	78.8	118
	1 1/2	77.2	116	85.3	128	68.7	103	76.8	115	73.1	110	81.3	122
	1 5/8	79.6	119	87.8	132	71.1	107	79.2	119	75.6	113	83.7	126
	2	86.9	130	95.1	143	78.4	118	86.5	130	82.9	124	91.0	137
	3	106	160	115	172	97.9	147	106	159	102	154	111	166
Coped at Both Flanges	1 1/4	63.4	95.1	63.4	95.1	56.1	84.1	56.1	84.1	63.4	95.1	63.4	95.1
	1 3/8	68.3	102	68.3	102	60.9	91.4	60.9	91.4	68.3	102	68.3	102
	1 1/2	73.1	110	73.1	110	65.8	98.7	65.8	98.7	73.1	110	73.1	110
	1 5/8	78.0	117	78.0	117	70.7	106	70.7	106	75.6	113	78.0	117
	2	86.9	130	92.6	139	78.4	118	85.3	128	82.9	124	91.0	137
	3	106	160	115	172	97.9	147	106	159	102	154	111	166
Uncoped		154	230	154	230	146	219	146	219	154	230	154	230

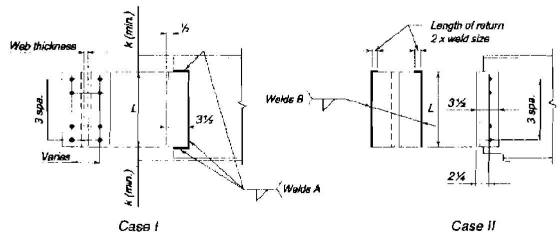
Support Available Strength per Inch Thickness, kips/in.

Hole Type	ASD	LRFD
STD/ SSLT	307	461
OVS	293	439

Notes:
STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

* Tabulated values include 1/4-in. reduction in end distance L_{eh} to account for possible underrun in beam length.

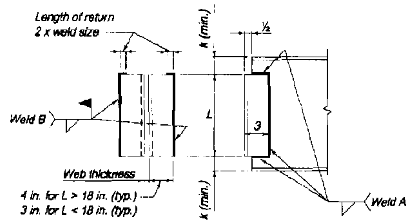
Table 10-2
Bolted/Welded Double-Angle Connections



n	L	Welds A (70 ksi)				Welds B (70 ksi)			
		Weld Size, in.	R_n/Ω kips ASD	ϕR_n kips LRFD	Minimum Web Thickness, in.	Weld Size, in.	R_n/Ω kips ASD	ϕR_n kips LRFD	Minimum Support Thickness, in.
12	35 1/2	5/16	391	586	0.476	3/8	366	550	0.286
		1/4	313	469	0.381	5/16	305	458	0.238
		3/16	234	352	0.286	1/4	244	366	0.190
11	32 1/2	5/16	366	548	0.476	3/8	331	496	0.286
		1/4	293	439	0.381	5/16	276	414	0.238
		3/16	219	329	0.286	1/4	221	331	0.190
10	29 1/2	5/16	337	506	0.476	3/8	295	443	0.286
		1/4	270	405	0.381	5/16	246	369	0.238
		3/16	202	303	0.286	1/4	197	295	0.190
9	26 1/2	5/16	309	464	0.476	3/8	259	389	0.286
		1/4	248	371	0.381	5/16	216	324	0.238
		3/16	186	278	0.286	1/4	173	259	0.190
8	23 1/2	5/16	282	422	0.476	3/8	223	335	0.286
		1/4	225	338	0.381	5/16	186	279	0.238
		3/16	169	253	0.286	1/4	149	223	0.190
7	20 1/2	5/16	253	379	0.476	3/8	187	280	0.286
		1/4	202	304	0.381	5/16	156	234	0.238
		3/16	152	228	0.286	1/4	125	187	0.190
6	17 1/2	5/16	223	334	0.476	3/8	150	226	0.286
		1/4	178	267	0.381	5/16	125	188	0.238
		3/16	134	200	0.286	1/4	100	150	0.190
5	14 1/2	5/16	191	287	0.476	3/8	115	172	0.286
		1/4	153	229	0.381	5/16	95.5	143	0.238
		3/16	115	172	0.286	1/4	76.4	115	0.190
4	11 1/2	5/16	158	237	0.476	3/8	79.9	120	0.286
		1/4	126	190	0.381	5/16	66.6	99.9	0.238
		3/16	94.9	142	0.286	1/4	53.3	79.9	0.190
3	8 1/2	5/16	122	184	0.476	3/8	48.1	72.2	0.286
		1/4	97.9	147	0.381	5/16	40.1	60.2	0.238
		3/16	73.4	110	0.286	1/4	32.1	48.1	0.190
2	5 1/2	5/16	83.6	125	0.476	3/8	21.9	32.8	0.286
		1/4	66.9	100	0.381	5/16	18.2	27.3	0.238
		3/16	50.2	75.3	0.286	1/4	14.6	21.9	0.190

ASD	LRFD	Beam	
$\Omega = 2.00$	$\phi = 0.75$	$F_y = 50$ ksi	$F_u = 65$ ksi

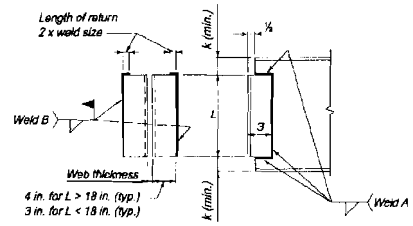
Table 10–3
All-Welded Double-Angle Connections



L	Welds A (70 ksi)				Welds B (70 ksi)			
	Weld Size, in.	R_n/Ω kips ASD	ϕR_n kips LRFD	Minimum Web Thickness, in.	Weld Size, in.	R_n/Ω kips ASD	ϕR_n kips LRFD	Minimum Web Thickness, in.
36	5/16	**395**	592	0.476	3/8	**372**	558	0.286
	1/4	**316**	474	0.381	5/16	**310**	465	0.238
	3/16	**237**	355	0.286	1/4	**248**	372	0.190
34	5/16	**378**	568	0.476	3/8	**349**	523	0.286
	1/4	**303**	454	0.381	5/16	**291**	436	0.238
	3/16	**227**	341	0.286	1/4	**232**	349	0.190
32	5/16	**361**	541	0.476	3/8	**325**	487	0.286
	1/4	**289**	433	0.381	5/16	**271**	406	0.238
	3/16	**217**	325	0.286	1/4	**217**	325	0.190
30	5/16	**342**	513	0.476	3/8	**301**	452	0.286
	1/4	**273**	410	0.381	5/16	**251**	377	0.238
	3/16	**205**	308	0.286	1/4	**201**	301	0.190
28	5/16	**323**	485	0.476	3/8	**277**	416	0.286
	1/4	**259**	388	0.381	5/16	**231**	347	0.238
	3/16	**194**	291	0.286	1/4	**185**	277	0.190
26	5/16	**305**	457	0.476	3/8	**253**	380	0.286
	1/4	**244**	366	0.381	5/16	**211**	317	0.238
	3/16	**183**	274	0.286	1/4	**169**	253	0.190
24	5/16	**286**	429	0.476	3/8	**229**	344	0.286
	1/4	**229**	343	0.381	5/16	**191**	286	0.238
	3/16	**172**	258	0.286	1/4	**153**	229	0.190
22	5/16	**267**	401	0.476	3/8	**205**	308	0.286
	1/4	**214**	321	0.381	5/16	**171**	256	0.238
	3/16	**160**	241	0.286	1/4	**137**	205	0.190
20	5/16	**248**	372	0.476	3/8	**181**	271	0.286
	1/4	**198**	298	0.381	5/16	**151**	226	0.238
	3/16	**149**	223	0.286	1/4	**121**	181	0.190
18	5/16	**228**	341	0.476	3/8	**157**	235	0.286
	1/4	**182**	273	0.381	5/16	**130**	196	0.238
	3/16	**137**	205	0.286	1/4	**104**	157	0.190
16	5/16	**207**	311	0.476	3/8	**148**	222	0.286
	1/4	**166**	249	0.381	5/16	**123**	185	0.238
	3/16	**124**	186	0.286	1/4	**98.5**	148	0.190

ASD	LRFD	Beam	
$\Omega = 2.00$	$\phi = 0.75$	$F_y = 50$ ksi	$F_u = 65$ ksi

Table 10–3 (continued)
All-Welded Double-Angle Connections



L	Welds A (70 ksi)				Welds B (70 ksi)			
	Weld Size, in.	R_n/Ω kips ASD	ϕR_n kips LRFD	Minimum Web Thickness, in.	Weld Size, in.	R_n/Ω kips ASD	ϕR_n kips LRFD	Minimum Web Thickness, in.
14	5/16	186	279	0.476	3/8	123	185	0.286
	1/4	149	223	0.381	5/16	103	154	0.238
	3/16	111	167	0.286	1/4	82.3	123	0.190
12	5/16	164	246	0.476	3/8	99.3	149	0.286
	1/4	131	197	0.381	5/16	82.8	124	0.238
	3/16	98.3	147	0.286	1/4	66.2	99.3	0.190
10	5/16	140	211	0.476	3/8	75.7	113	0.286
	1/4	112	169	0.381	5/16	63.1	94.6	0.238
	3/16	84.3	126	0.286	1/4	50.4	75.7	0.190
9	5/16	128	193	0.476	3/8	64.2	96.3	0.286
	1/4	103	154	0.381	5/16	53.5	80.2	0.238
	3/16	77.1	116	0.286	1/4	42.8	64.2	0.190
8	5/16	116	174	0.476	3/8	53.0	79.5	0.286
	1/4	92.9	139	0.381	5/16	44.2	66.3	0.238
	3/16	69.6	104	0.286	1/4	35.4	53.0	0.190
7	5/16	103	155	0.476	3/8	42.4	63.6	0.286
	1/4	82.5	124	0.381	5/16	35.3	53.0	0.238
	3/16	61.9	92.9	0.286	1/4	28.3	42.4	0.190
6	5/16	90.3	135	0.476	3/8	32.5	48.7	0.286
	1/4	72.3	108	0.381	5/16	27.0	40.6	0.238
	3/16	54.2	81.3	0.286	1/4	21.6	32.5	0.190
5	5/16	77.1	116	0.476	3/8	23.4	35.1	0.286
	1/4	61.7	92.6	0.381	5/16	19.5	29.2	0.238
	3/16	46.3	69.4	0.286	1/4	15.6	23.4	0.190
4	5/16	64.2	96.3	0.476	3/8	15.5	23.2	0.286
	1/4	51.3	77.0	0.381	5/16	12.9	19.3	0.238
	3/16	38.5	57.8	0.286	1/4	10.3	15.5	0.190

ASD	LRFD	Beam	
$\Omega = 2.00$	$\phi = 0.75$	$F_y = 50$ ksi	$F_u = 65$ ksi

SHEAR END-PLATE CONNECTIONS

A shear end-plate connection is made with a plate length less than the supported beam depth, as illustrated in Figure 10–6. The end plate is always shop-welded to the beam web with fillet welds on each side and usually field-bolted to the supporting member. Welds connecting the end plate to the beam web should not be returned across the thickness of the beam web at the top or bottom of the end plate because of the danger of creating a notch in the beam web.

If the end plate is field-welded to the support, adequate flexibility must be provided in the connection. Line welds are placed along the vertical edges of the plate with a return at the top per AISC Specification Section J2.2b. Note that welding across the entire top of the plate must be avoided as it would inhibit the flexibility and, therefore, the necessary end rotation of the connection. The performance of the resulting connection would not be as intended for simple shear connections.

Design Checks

The available strength of a shear end-plate connection is determined from the applicable limit states for bolts (see Part 7), welds (see Part 8), and connecting elements (see Part 9). Note that the limit-state of shear rupture of the beam web must be checked along the length of weld connecting the end plate to the beam web. In all cases, the available strength, ϕR_n or R_n/Ω, must equal or exceed the required strength, R_u or R_a.

Recommended End-Plate Dimensions and Thickness

To provide for stability during erection, it is recommended that the minimum end-plate length be one-half the T-dimension of the beam to be supported. The maximum length of the end plate must be compatible with the clear distance between the flanges of an uncoped beam and the remaining clear distance of a coped beam.

To provide for flexibility, the combination of plate thickness and gage should be consistent with the recommendations given previously for a double-angle connection of similar thickness and gage.

Shop and Field Practices

When framing to a column web, the associated constructability considerations should be addressed (see the preceding discussion under "Constructability Considerations").

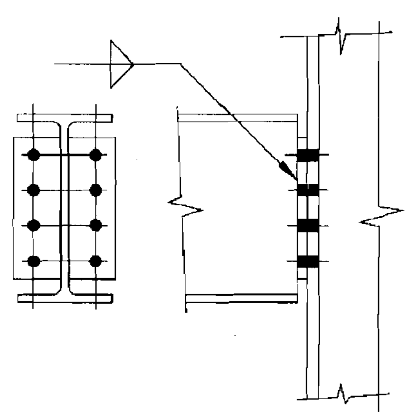


Figure 10–6. Shear end-plate connections.

When framing to a column flange, provision must be made for possible mill variation in the depth of the columns, particularly in fairly long runs (i.e., six or more bays of framing). The beam length can be shortened to provide for mill overrun with shims furnished at the appropriate intervals to fill the resulting gaps or to provide for mill underrun. Shear end-plate connections require close control in cutting the beam to the proper length and in squaring the beam ends such that both end plates are parallel, particularly when beams are cambered.

Table 10–4. Bolted/Welded Shear End-Plate Connections

Table 10–4 is a design aid for shear end-plate connections bolted to the supporting member and welded to the supported beam. Available strengths are tabulated for supported and supporting member material with $F_y = 50$ ksi and $F_u = 65$ ksi and end-plate material with $F_y = 36$ ksi and $F_u = 58$ ksi. Electrode strength is assumed to be 70 ksi. All values, including slip-critical bolt available strengths, are for comparison with the LRFD load combination for LRFD design and the ASD load combination for ASD design.

Tabulated bolt and end-plate available strengths consider the limit-states of bolt shear, bolt bearing on the end plate, shear yielding of the end plate, shear rupture of the end plate, and block shear rupture of the end plate. Values are included for 2 through 12 rows of $^{3}/_{4}$-in., $^{7}/_{8}$-in., and 1-in. diameter ASTM A325, F1852 and A490 bolts at 3-in. spacing. End-plate edge distances L_{ev} and L_{eh} are assumed to be $1^{1}/_{4}$ in.

Tabulated weld available strengths consider the limit-state of weld shear assuming an effective weld length equal to the end-plate length minus twice the weld size. The tabulated minimum beam web thickness matches the shear rupture strength of the web material to the strength of the weld metal. As derived in Part 9, the minimum supported beam web thickness for two lines of weld is

$$t_{min} = \frac{6.19D}{F_u}$$

where D is the number of sixteenths-of-an-inch in the weld size. When less than the minimum material thickness is present, the tabulated weld available strength must be reduced by the ratio of the thickness provided to the minimum thickness.

Tabulated supporting member available strengths, per in. of flange or web thickness, consider the limit-state of bolt bearing.

W44

Table 10–4
Bolted/Welded Shear End-Plate Connections

3/4-in. Bolts 12 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	197	295	246	369	254	382
	X	—	197	295	246	369	295	443
	SC Class A	STD	177	266	177	266	177	266
		OVS	128	192	128	192	128	192
		SSLT	151	226	151	226	151	226
	SC Class B	STD	197	295	246	369	253	380
		OVS	183	274	183	274	183	274
		SSLT	195	293	215	323	215	323
A490	N	—	197	295	246	369	295	443
	X	—	197	295	246	369	295	443
	SC Class A	STD	197	295	221	332	221	332
		OVS	160	240	160	240	160	240
		SSLT	188	282	188	282	188	282
	SC Class B	STD	197	295	246	369	295	443
		OVS	196	294	229	343	229	343
		SSLT	195	293	244	366	269	403

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips
		ASD	LRFD
3/16	0.286	196	293
1/4	0.381	260	390
5/16	0.476	324	486
3/8	0.571	387	581

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
1400	2110

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

3/4-in. Bolts 11 Rows

Table 10–4 (continued)
Bolted/Welded Shear End-Plate Connections

W44, 40

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD
A325/F1852	N	—	181	271	226	338	233	350
	X	—	181	271	226	338	271	406
	SC Class A	STD	162	244	162	244	162	244
		OVS	117	176	117	176	117	176
		SSLT	138	207	138	207	138	207
	SC Class B	STD	181	271	226	338	232	348
		OVS	168	251	168	251	168	251
		SSLT	179	269	197	296	197	296
A490	N	—	181	271	226	338	271	406
	X	—	181	271	226	338	271	406
	SC Class A	STD	181	271	203	305	203	305
		OVS	147	220	147	220	147	220
		SSLT	173	259	173	259	173	259
	SC Class B	STD	181	271	226	338	271	406
		OVS	180	269	210	314	210	314
		SSLT	179	269	224	336	247	370

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	179	268
1/4	0.381	238	356
5/16	0.476	296	444
3/8	0.571	354	530

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
1290	1930

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

W44, 40, 36

Table 10–4 (continued)
Bolted/Welded Shear End-Plate Connections

3/4-in. Bolts 10 Rows

Bolt and End-Plate Available Strength, kips									
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	164	246	205	308	212	318
	X	—	164	246	205	308	246	370
	SC Class A	STD	148	221	148	221	148	221
		OVS	107	160	107	160	107	160
		SSLT	126	188	126	188	126	188
	SC Class B	STD	164	246	205	308	211	316
		OVS	152	229	152	229	152	229
		SSLT	163	244	179	269	179	269
A490	N	—	164	246	205	308	246	370
	X	—	164	246	205	308	246	370
	SC Class A	STD	164	246	185	277	185	277
		OVS	133	200	133	200	133	200
		SSLT	157	235	157	235	157	235
	SC Class B	STD	164	246	205	308	246	370
		OVS	163	245	190	286	190	286
		SSLT	163	244	204	306	224	336

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	162	243	1170	1760
1/4	0.381	215	323		
5/16	0.476	268	402		
3/8	0.571	320	480		

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

3/4-in. Bolts 9 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W44, 40, 36, 33

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	148	222	185	278	191	286
	X	—	148	222	185	278	222	333
	SC Class A	STD	133	199	133	199	133	199
		OVS	96.0	144	96.0	144	96.0	144
		SSLT	113	169	113	169	113	169
	SC Class B	STD	148	222	185	278	190	285
		OVS	137	206	137	206	137	206
		SSLT	147	220	161	242	161	242
A490	N	—	148	222	185	278	222	333
	X	—	148	222	185	278	222	333
	SC Class A	STD	148	222	166	249	166	249
		OVS	120	180	120	180	120	180
		SSLT	141	212	141	212	141	212
	SC Class B	STD	148	222	185	278	222	333
		OVS	147	221	171	257	171	257
		SSLT	147	220	183	275	202	303

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	145	218
1/4	0.381	193	290
5/16	0.476	240	360
3/8	0.571	287	430

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
1050	1580

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

W44, 40, 36, 33, 30

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

3/4-in. Bolts 8 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD
A325/F1852	N	—	132	198	165	247	170	254
	X	—	132	198	165	247	198	297
	SC Class A	STD	118	177	118	177	118	177
		OVS	85.3	128	85.3	128	85.3	128
		SSLT	100	151	100	151	100	151
	SC Class B	STD	132	198	165	247	169	253
		OVS	122	183	122	183	122	183
		SSLT	131	196	143	215	143	215
A490	N	—	132	198	165	247	198	297
	X	—	132	198	165	247	198	297
	SC Class A	STD	132	198	148	221	148	221
		OVS	107	160	107	160	107	160
		SSLT	126	188	126	188	126	188
	SC Class B	STD	132	198	165	247	198	297
		OVS	131	197	152	229	152	229
		SSLT	131	196	163	245	179	269

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	129	193
1/4	0.381	171	256
5/16	0.476	212	318
3/8	0.571	253	380

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
936	1400

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

3/4-in. Bolts 7 Rows

Table 10–4 (continued)
Bolted/Welded Shear End-Plate Connections

W44, 40, 36, 33, 30, 27, 24

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	116	174	145	217	148	223
	X	—	116	174	145	217	174	260
	SC Class A	STD	103	155	103	155	103	155
		OVS	74.7	112	74.7	112	74.7	112
		SSLT	87.9	132	87.9	132	87.9	132
	SC Class B	STD	116	174	145	217	148	221
		OVS	107	160	107	160	107	160
		SSLT	114	172	126	188	126	188
A490	N	—	116	174	145	217	174	260
	X	—	116	174	145	217	174	260
	SC Class A	STD	116	174	129	194	129	194
		OVS	93.3	140	93.3	140	93.3	140
		SSLT	110	165	110	165	110	165
	SC Class B	STD	116	174	145	217	174	260
		OVS	115	172	133	200	133	200
		SSLT	114	172	143	214	157	235

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	112	168	819	1230
1/4	0.381	148	223		
5/16	0.476	184	277		
3/8	0.571	220	330		

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

W44, 40, 36, 33, 30, 27, 24, 21

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

3/4-in. Bolts 6 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	99.5	149	124	187	127	191
	X	—	99.5	149	124	187	149	224
	SC Class A	STD	88.6	133	88.6	133	88.6	133
		OVS	64.0	96.0	64.0	96.0	64.0	96.0
		SSLT	75.3	113	75.3	113	75.3	113
	SC Class B	STD	99.5	149	124	187	127	190
		OVS	91.4	137	91.4	137	91.4	137
		SSLT	98.2	147	108	161	108	161
A490	N	—	99.5	149	124	187	149	224
	X	—	99.5	149	124	187	149	224
	SC Class A	STD	99.5	149	111	166	111	166
		OVS	80.0	120	80.0	120	80.0	120
		SSLT	94.1	141	94.1	141	94.1	141
	SC Class B	STD	99.5	149	124	187	149	224
		OVS	98.6	148	114	171	114	171
		SSLT	98.2	147	123	184	134	202

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	95.4	143	702	1050
1/4	0.381	126	189		
5/16	0.476	157	235		
3/8	0.571	187	280		

Notes		End-Plate	Beam
STD = Standard holes OVS = Oversized holes SSLT = Short-slotted holes transverse to direction of load	N = Threads included X = Threads excluded SC = Slip critical	F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

3/4-in. Bolts 5 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W30, 27, 24, 21, 18

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	83.3	125	104	156	106	159
	X	—	83.3	125	104	156	125	187
	SC Class A	STD	73.8	111	73.8	111	73.8	111
		OVS	53.3	80.0	53.3	80.0	53.3	80.0
		SSLT	62.8	94.1	62.8	94.1	62.8	94.1
	SC Class B	STD	83.3	125	104	156	105	158
		OVS	76.2	114	76.2	114	76.2	114
		SSLT	82	123	89.6	134	89.6	134
A490	N	—	83.3	125	104	156	125	187
	X	—	83.3	125	104	156	125	187
	SC Class A	STD	83.3	125	92.3	138	92.3	138
		OVS	66.7	100	66.7	100	66.7	100
		SSLT	78.4	118	78.4	118	78.4	118
	SC Class B	STD	83.3	125	104	156	125	187
		OVS	82.4	124	95.2	143	95.2	143
		SSLT	82	123	102	154	112	168

Weld and Beam Web Available Strength, kips			
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips
		ASD	LRFD
3/16	0.286	78.7	118
1/4	0.381	104	156
5/16	0.476	129	193
3/8	0.571	153	230

Support Available Strength per Inch Thickness, kips/in.	
ASD	LRFD
585	878

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

W24, 21, 18, 16

Table 10–4 (continued)
Bolted/Welded Shear End-Plate Connections

3/4-in. Bolts 4 Rows

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	67.1	101	83.9	126	84.8	127
	X	—	67.1	101	83.9	126	101	151
	SC Class A	STD	59.1	88.6	59.1	88.6	59.1	88.6
		OVS	42.7	64.0	42.7	64.0	42.7	64.0
		SSLT	50.2	75.3	50.2	75.3	50.2	75.3
	SC Class B	STD	67.1	101	83.9	126	84.4	127
		OVS	61.0	91.4	61.0	91.4	61.0	91.4
		SSLT	65.8	98.7	71.7	108	71.7	108
A490	N	—	67.1	101	83.9	126	101	151
	X	—	67.1	101	83.9	126	101	151
	SC Class A	STD	67.1	101	73.8	111	73.8	111
		OVS	53.3	80.0	53.3	80.0	53.3	80.0
		SSLT	62.8	94.1	62.8	94.1	62.8	94.1
	SC Class B	STD	67.1	101	83.9	126	101	151
		OVS	65.3	97.9	76.2	114	76.2	114
		SSLT	65.8	98.7	82.2	123	89.6	134

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	61.9	92.9	468	702
1/4	0.381	81.7	123		
5/16	0.476	101	151		
3/8	0.571	120	180		
				End-Plate	Beam
				F_y = 36 ksi, F_u = 58 ksi	F_y = 50 ksi, F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

3/4-in. Bolts 3 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W18, 16, 14, 12, 10*

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	50.9	76.4	63.6	95.4	63.6	95.4
	X	—	50.9	76.4	63.7	95.5	76.4	115.0
	SC Class A	STD	44.3	66.4	44.3	66.4	44.3	66.4
		OVS	32.0	48.0	32.0	48.0	32.0	48.0
		SSLT	37.7	56.5	37.7	56.5	37.7	56.5
	SC Class B	STD	50.9	76.4	63.3	94.9	63.3	94.9
		OVS	45.7	68.6	45.7	68.6	45.7	68.6
		SSLT	49.6	74.4	53.8	80.7	53.8	80.7
A490	N	—	50.9	76.4	63.7	95.5	76.4	115.0
	X	—	50.9	76.4	63.7	95.5	76.4	115.0
	SC Class A	STD	50.9	76.4	55.4	83.1	55.4	83.1
		OVS	40.0	60.0	40.0	60.0	40.0	60.0
		SSLT	47.1	70.6	47.1	70.6	47.1	70.6
	SC Class B	STD	50.9	76.4	63.7	95.5	76.4	115.0
		OVS	47.9	71.8	57.1	85.7	57.1	85.7
		SSLT	49.8	74.4	62.0	92.9	67.2	101.0

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	45.2	67.9	351	526
1/4	0.381	59.4	89.1		
5/16	0.476	73.1	110		
3/8	0.571	88.3	129		
				End-Plate	Beam
				F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical
*Limited to W10×12, 15,17, 19, 22, 26, 30

W12, 10, 8

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

3/4-in. Bolts 2 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD
A325/F1852	N	—	32.6	48.9	40.8	61.2	42.4	63.6
	X	—	32.6	48.9	40.8	61.2	48.9	73.4
	SC Class A	STD	29.5	44.3	29.5	44.3	29.5	44.3
		OVS	21.3	32.0	21.3	32.0	21.3	32.0
		SSLT	25.1	37.7	25.1	37.7	25.1	37.7
	SC Class B	STD	32.6	48.9	40.8	61.2	42.2	63.3
		OVS	30.5	45.7	30.5	45.7	30.5	45.7
		SSLT	32.6	48.9	35.9	53.8	35.9	53.8
A490	N	—	32.6	48.9	40.8	61.2	48.9	73.4
	X	—	32.6	48.9	40.8	61.2	48.9	73.4
	SC Class A	STD	32.6	48.9	36.9	55.4	36.9	55.4
		OVS	26.7	40.0	26.7	40.0	26.7	40.0
		SSLT	31.4	47.1	31.4	47.1	31.4	47.1
	SC Class B	STD	32.6	48.9	40.8	61.2	48.9	73.4
		OVS	30.5	45.7	38.1	57.1	38.1	57.1
		SSLT	32.6	48.9	40.8	61.2	44.8	67.2

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	28.5	42.8
1/4	0.381	37.1	55.7
5/16	0.476	45.2	67.9
3/8	0.571	52.9	79.4

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
234	351

End-Plate	Beam
F_y = 36 ksi, F_u = 58 ksi	F_y = 50 ksi, F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

7/8-in. Bolts 12 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W44

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	196	294	245	367	294	441
	X	—	196	294	245	367	294	441
	SC Class A	STD	196	294	245	367	247	370
		OVS	178	267	178	267	178	267
		SSLT	194	292	210	315	210	315
	SC Class B	STD	196	294	245	367	294	441
		OVS	191	287	239	359	255	382
		SSLT	194	292	243	365	292	438
A490	N	—	196	294	245	367	294	441
	X	—	196	294	245	367	294	441
	SC Class A	STD	196	294	245	367	294	441
		OVS	191	287	224	336	224	336
		SSLT	194	292	243	365	264	395
	SC Class B	STD	196	294	245	367	294	441
		OVS	191	287	239	359	287	431
		SSLT	194	292	243	365	292	438

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips	Support Available Strength per Inch Thickness, kips/in.	
		ASD	LRFD	ASD	LRFD
3/16	0.286	196	293	1640	2460
1/4	0.381	260	390		
5/16	0.476	324	486		
3/8	0.571	387	581		

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

W44, 40

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

7/8-in. Bolts 11 Rows

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	180	269	225	337	269	404
	X	—	180	269	225	337	269	404
	SC Class A	STD	180	269	225	337	226	339
		OVS	163	245	163	245	163	245
		SSLT	178	267	192	288	192	288
	SC Class B	STD	180	269	225	337	269	404
		OVS	175	263	219	328	233	350
		SSLT	178	267	223	334	267	401
A490	N	—	180	269	225	337	269	404
	X	—	180	269	225	337	269	404
	SC Class A	STD	180	269	225	337	269	404
		OVS	175	263	205	308	205	308
		SSLT	178	267	223	334	242	362
	SC Class B	STD	180	269	225	337	269	404
		OVS	175	263	219	328	263	394
		SSLT	178	267	223	334	267	401

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	179	268	1500	2250
1/4	0.381	238	356		
5/16	0.476	296	444		
3/8	0.571	354	530		

		End-Plate	Beam
STD = Standard holes OVS = Oversized holes SSLT = Short-slotted holes transverse to direction of load	N = Threads included X = Threads excluded SC = Slip critical	F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

7/8-in. Bolts 10 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W44, 40, 36

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	163	245	204	306	245	368
	X	—	163	245	204	306	245	368
	SC Class A	STD	163	245	204	306	245	308
		OVS	149	223	149	223	149	223
		SSLT	162	243	175	262	175	262
	SC Class B	STD	163	245	204	306	245	368
		OVS	159	238	198	298	212	318
		SSLT	162	243	203	304	243	365
A490	N	—	163	245	204	306	245	368
	X	—	163	245	204	306	245	368
	SC Class A	STD	163	245	204	306	245	368
		OVS	159	238	187	280	187	280
		SSLT	162	243	203	304	220	329
	SC Class B	STD	163	245	204	306	245	368
		OVS	159	238	198	298	238	357
		SSLT	162	243	203	304	243	365

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	162	243	1370	2050
1/4	0.381	215	323		
5/16	0.476	268	402		
3/8	0.571	320	480		

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load

N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

W44, 40, 36, 33

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

7/8-in. Bolts 9 Rows

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	147	221	184	276	221	331
	X	—	147	221	184	276	221	331
	SC Class A	STD	147	221	184	276	185	278
		OVS	134	201	134	201	134	201
		SSLT	146	219	157	236	157	236
	SC Class B	STD	147	221	184	276	221	331
		OVS	142	214	178	267	191	287
		SSLT	146	219	182	273	219	328
A490	N	—	147	221	184	276	221	331
	X	—	147	221	184	276	221	331
	SC Class A	STD	147	221	184	276	221	331
		OVS	142	214	168	252	168	252
		SSLT	146	219	182	273	198	297
	SC Class B	STD	147	221	184	276	221	331
		OVS	142	214	178	267	214	321
		SSLT	146	219	182	273	219	328

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	145	218	1230	1840
1/4	0.381	193	290		
5/16	0.476	240	360		
3/8	0.571	287	430		

Notes	End-Plate	Beam
STD = Standard holes OVS = Oversized holes SSLT = Short-slotted holes transverse to direction of load N = Threads included X = Threads excluded SC = Slip critical	F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

7/8-in. Bolts 8 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W44, 40, 36, 33, 30

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	131	197	164	246	197	295
	X	—	131	197	164	246	197	295
	SC Class A	STD	131	197	164	246	165	247
		OVS	119	178	119	178	119	178
		SSLT	130	194	140	210	140	210
	SC Class B	STD	131	197	164	246	197	295
		OVS	126	189	158	237	170	255
		SSLT	130	194	162	243	194	292
A490	N	—	131	197	164	246	197	295
	X	—	131	197	164	246	197	295
	SC Class A	STD	131	197	164	246	197	295
		OVS	126	189	149	224	149	224
		SSLT	130	194	162	243	176	264
	SC Class B	STD	131	197	164	246	197	295
		OVS	126	189	158	237	189	284
		SSLT	130	194	162	243	194	292

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	129	193	1090	1640
1/4	0.381	171	256		
5/16	0.476	212	318		
3/8	0.571	253	380		

Notes	End-Plate	Beam
STD = Standard holes OVS = Oversized holes SSLT = Short-slotted holes transverse to direction of load N = Threads included X = Threads excluded SC = Slip critical	F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

W44, 40, 36, 33, 30, 27, 24

Table 10-4 (continued) Bolted/Welded Shear End-Plate Connections

7/8-in. Bolts 7 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD
A325/F1852	N	—	115	172	144	215	172	258
	X	—	115	172	144	215	172	258
	SC Class A	STD	115	172	144	215	144	216
		OVS	104	156	104	156	104	156
		SSLT	113	170	122	184	122	184
	SC Class B	STD	115	172	144	215	172	258
		OVS	110	165	137	206	149	223
		SSLT	113	170	142	213	170	255
A490	N	—	115	172	144	215	172	258
	X	—	115	172	144	215	172	258
	SC Class A	STD	115	172	144	215	172	258
		OVS	110	165	131	196	131	196
		SSLT	113	170	142	213	154	231
	SC Class B	STD	115	172	144	215	172	258
		OVS	110	165	137	206	165	247
		SSLT	113	170	142	213	170	255

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	112	168
1/4	0.381	148	223
5/16	0.476	184	277
3/8	0.571	220	330

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
956	1430

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

7/8-in. Bolts 6 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W40, 36, 33, 30, 27, 24, 21

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD
A325/F1852	N	—	98.6	148	123	185	148	222
	X	—	98.6	148	123	185	148	222
	SC Class A	STD	98.6	148	123	185	123	185
		OVS	89.2	134	89.2	134	89.2	134
		SSLT	97.3	146	105	157	105	157
	SC Class B	STD	98.6	148	123	185	148	222
		OVS	93.5	140	117	175	127	191
		SSLT	97.3	146	122	182	146	219
A490	N	—	98.6	148	123	185	148	222
	X	—	98.6	148	123	185	148	222
	SC Class A	STD	98.6	148	123	185	148	222
		OVS	93.5	140	112	168	112	168
		SSLT	97.3	146	122	182	132	198
	SC Class B	STD	98.6	148	123	185	148	222
		OVS	93.5	140	117	175	140	210
		SSLT	97.3	146	122	182	146	219

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	95.4	143
1/4	0.381	126	189
5/16	0.476	157	235
3/8	0.571	187	280

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
819	1230

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

W30, 27, 24, 21, 18

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

7/8-in. Bolts 5 Rows

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	82.4	124	103	155	124	185
	X	—	82.4	124	103	155	124	185
	SC Class A	STD	82.4	124	103	154	103	154
		OVS	74.3	111	74.3	111	74.3	111
		SSLT	81.1	122	87.4	131	87.4	131
	SC Class B	STD	82.4	124	103	155	124	185
		OVS	77.2	116	96.5	145	106	159
		SSLT	81.1	122	101	152	122	182
A490	N	—	82.4	124	103	155	124	185
	X	—	82.4	124	103	155	124	185
	SC Class A	STD	82.4	124	103	155	124	185
		OVS	77.2	116	93.3	140	93.3	140
		SSLT	81.1	122	101	152	110	165
	SC Class B	STD	82.4	124	103	155	124	185
		OVS	77.2	116	96.5	145	116	174
		SSLT	81.1	122	101	152	122	182

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	78.7	118	683	1020
1/4	0.381	104	156		
5/16	0.476	193	193		
3/8	0.571	153	230		

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

7/8-in. Bolts 4 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W24, 21, 18, 16

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	65.3	97.9	81.6	122	97.9	147
	X	—	65.3	97.9	81.6	122	97.9	147
	SC Class A	STD	65.3	97.9	81.6	122	82.3	123
		OVS	59.4	89.2	59.4	89.2	59.4	89.2
		SSLT	64.9	97.3	69.9	105	69.9	105
	SC Class B	STD	65.3	97.9	81.6	122	97.9	147
		OVS	60.9	91.4	76.1	114	84.9	127
		SSLT	64.9	97.3	81.1	122	97.3	146
A490	N	—	65.3	97.9	81.6	122	97.9	147
	X	—	65.3	97.9	81.6	122	97.9	147
	SC Class A	STD	65.3	97.9	81.6	122	97.9	147
		OVS	60.9	91.4	74.7	112	74.7	112
		SSLT	64.9	97.3	81.1	122	87.9	132
	SC Class B	STD	65.3	97.9	81.6	122	97.9	147
		OVS	60.9	91.4	76.1	114	91.4	137
		SSLT	64.9	97.3	81.1	122	97.3	146

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	61.9	92.9	546	819
1/4	0.381	81.7	123		
5/16	0.476	101	151		
3/8	0.571	120	180		

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

W18, 16, 14, 12, 10*

Table 10–4 (continued)
Bolted/Welded Shear End-Plate Connections

7/8-in. Bolts 3 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	47.9	71.8	59.8	89.7	71.8	108
	X	—	47.9	71.8	59.8	89.7	71.8	108
	SC Class A	STD	47.9	71.8	59.8	89.7	61.7	92.5
		OVS	44.6	66.9	44.6	66.9	44.6	66.9
		SSLT	47.9	71.8	52.4	78.7	52.4	78.7
	SC Class B	STD	47.9	71.8	59.8	89.7	71.8	108
		OVS	44.6	66.9	55.7	83.6	63.7	95.5
		SSLT	47.9	71.8	59.8	89.7	71.8	108
A490	N	—	47.9	71.8	59.8	89.7	71.8	108
	X	—	47.9	71.8	59.8	89.7	71.8	108
	SC Class A	STD	47.9	71.8	59.8	89.7	71.8	108
		OVS	44.6	66.9	55.7	83.6	56.0	84.0
		SSLT	47.9	71.8	59.8	89.7	65.9	98.8
	SC Class B	STD	47.9	71.8	59.8	89.7	71.8	108
		OVS	44.6	66.9	55.7	83.6	66.9	100
		SSLT	47.9	71.8	59.8	89.7	71.8	108

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	45.2	67.9
1/4	0.381	59.4	89.1
5/16	0.476	73.1	110
3/8	0.571	86.3	129

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
409	614

End-Plate	Beam
F_y = 36 ksi, F_u = 58 ksi	F_y = 50 ksi, F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical
*Limited to W10×12, 15, 17, 19, 22, 26, 30

7/8-in. Bolts 2 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W12, 10, 8

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	30.5	45.7	38.1	57.1	45.7	68.5
	X	—	30.5	45.7	38.1	57.1	45.7	68.5
	SC Class A	STD	30.5	45.7	38.1	57.1	41.1	61.7
		OVS	28.3	42.4	29.7	44.6	29.7	44.6
		SSLT	30.5	45.7	35.0	52.4	35.0	52.4
	SC Class B	STD	30.5	45.7	38.1	57.1	45.7	68.5
		OVS	28.3	42.4	35.3	53.0	42.4	63.6
		SSLT	30.5	45.7	38.1	57.1	45.7	68.5
A490	N	—	30.5	45.7	38.1	57.1	45.7	68.5
	X	—	30.5	45.7	38.1	57.1	45.7	68.5
	SC Class A	STD	30.5	45.7	38.1	57.1	45.7	68.5
		OVS	28.3	42.4	35.3	53.0	37.3	56.0
		SSLT	30.5	45.7	38.1	57.1	43.9	65.9
	SC Class B	STD	30.5	45.7	38.1	57.1	45.7	68.5
		OVS	28.3	42.4	35.3	53.0	42.4	63.6
		SSLT	30.5	45.7	38.1	57.1	45.7	68.5

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	28.5	42.8	273	409
1/4	0.381	37.1	55.7		
5/16	0.476	45.2	67.9		
3/8	0.571	52.9	79.4		

Notes		End-Plate	Beam
STD = Standard holes OVS = Oversized holes SSLT = Short-slotted holes transverse to direction of load	N = Threads included X = Threads excluded SC = Slip critical	F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

W44

Table 10-4 (continued)
Bolted/Welded Shear End-Plate Connections

1-in. Bolts 12 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	191	287	239	359	287	431
	X	—	191	287	239	359	287	431
	SC Class A	STD	191	287	239	359	287	431
		OVS	172	258	215	322	233	350
		SSLT	191	287	239	359	274	411
	SC Class B	STD	191	287	239	359	287	431
		OVS	172	258	215	322	258	387
		SSLT	191	287	239	359	287	431
A490	N	—	191	287	239	359	287	431
	X	—	191	287	239	359	287	431
	SC Class A	STD	191	287	239	359	287	431
		OVS	172	258	215	322	258	387
		SSLT	191	287	239	359	287	431
	SC Class B	STD	191	287	239	359	287	431
		OVS	172	258	215	322	258	387
		SSLT	191	287	239	359	287	431

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips
		ASD	LRFD
3/16	0.286	196	293
1/4	0.381	260	390
5/16	0.476	324	486
3/8	0.571	387	581

Support Available Strength per Inch Thickness, kips/in.

ASD		LRFD	
1820	STD/SSLT	2730	STD/SSLT
1660	OVS	2490	OVS

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

1-in. Bolts 11 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W44, 40

Bolt and End-Plate Available Strength, kips									
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.						
			1/4		5/16		3/8		
			ASD	LRFD	ASD	LRFD	ASD	LRFD	
A325/F1852	N	—	175	263	219	328	263	394	
	X	—	175	263	219	328	263	394	
	SC Class A	STD	175	263	219	328	263	394	
		OVS	157	236	196	295	214	321	
		SSLT	175	263	219	328	251	377	
	SC Class B	STD	175	263	219	328	263	394	
		OVS	157	236	196	295	236	354	
		SSLT	175	263	219	328	263	394	
A490	N	—	175	263	219	328	263	394	
	X	—	175	263	219	328	263	394	
	SC Class A	STD	175	263	219	328	263	394	
		OVS	157	236	196	295	236	354	
		SSLT	175	263	219	328	263	394	
	SC Class B	STD	175	263	219	328	263	394	
		OVS	157	236	196	295	236	354	
		SSLT	175	263	219	328	263	394	

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	179	268	1670 STD/SSLT	2500 STD/SSLT
1/4	0.381	238	356		
5/16	0.476	296	444	1520 OVS	2280 OVS
3/8	0.571	354	530		

		End-Plate	Beam
STD = Standard holes	N = Threads included	F_y = 36 ksi	F_y = 50 ksi
OVS = Oversized holes	X = Threads excluded	F_u = 58 ksi	F_u = 65 ksi
SSLT = Short-slotted holes transverse to direction of load	SC = Slip critical		

W44, 40, 36

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

1-in. Bolts 10 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	159	238	198	298	238	357
	X	—	159	238	198	298	238	357
	SC Class A	STD	159	238	198	298	238	357
		OVS	142	214	178	267	194	291
		SSLT	159	238	198	298	229	343
	SC Class B	STD	159	238	198	298	238	357
		OVS	142	214	178	267	214	321
		SSLT	159	238	198	298	238	357
A490	N	—	159	238	198	298	238	357
	X	—	159	238	198	298	238	357
	SC Class A	STD	159	238	198	298	238	357
		OVS	142	214	178	267	214	321
		SSLT	159	238	198	298	238	357
	SC Class B	STD	159	238	198	298	238	357
		OVS	142	214	178	267	214	321
		SSLT	159	238	198	298	238	357

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips
		ASD	LRFD
3/16	0.286	162	243
1/4	0.381	215	323
5/16	0.476	268	402
3/8	0.571	320	480

Support Available Strength per Inch Thickness, kips/in.

ASD		LRFD	
1520	STD/SSLT	2270	STD/SSLT
1380	OVS	2080	OVS

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

1-in. Bolts 9 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W44, 40, 36, 33

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in. $^1/_4$ ASD	$^1/_4$ LRFD	$^5/_{16}$ ASD	$^5/_{16}$ LRFD	$^3/_8$ ASD	$^3/_8$ LRFD
A325/F1852	N	—	142	214	178	267	214	321
	X	—	142	214	178	267	214	321
	SC Class A	STD	142	214	178	267	214	321
		OVS	128	192	160	240	175	262
		SSLT	142	214	178	267	206	309
	SC Class B	STD	142	214	178	267	214	321
		OVS	128	192	160	240	192	288
		SSLT	142	214	178	267	214	321
A490	N	—	142	214	178	267	214	321
	X	—	142	214	178	267	214	321
	SC Class A	STD	142	214	178	267	214	321
		OVS	128	192	160	240	192	288
		SSLT	142	214	178	267	214	321
	SC Class B	STD	142	214	178	267	214	321
		OVS	128	192	160	240	192	288
		SSLT	142	214	178	267	214	321

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
$^3/_{16}$	0.286	145	218
$^1/_4$	0.381	193	290
$^5/_{16}$	0.476	240	360
$^3/_8$	0.571	287	430

Support Available Strength per Inch Thickness, kips/in.

ASD	LRFD
1370 STD/SSLT	2050 STD/SSLT
1250 OVS	1870 OVS

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi, F_u = 58 ksi	F_y = 50 ksi, F_u = 65 ksi

W44, 40, 36, 33, 30

Table 10–4 (continued)
Bolted/Welded Shear End-Plate Connections

1-in. Bolts 8 Rows

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	126	189	158	237	189	284
	X	—	126	189	158	237	189	284
	SC Class A	STD	126	189	158	237	189	284
		OVS	113	170	141	212	155	233
		SSLT	126	189	158	237	183	274
	SC Class B	STD	126	189	158	237	189	284
		OVS	113	170	141	212	170	254
		SSLT	126	189	158	237	189	284
A490	N	—	126	189	158	237	189	284
	X	—	126	189	158	237	189	284
	SC Class A	STD	126	189	158	237	189	284
		OVS	113	170	141	212	170	254
		SSLT	126	189	158	237	189	284
	SC Class B	STD	126	189	158	237	189	284
		OVS	113	170	141	212	170	254
		SSLT	126	189	158	237	189	284

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	129	193	1210 STD/SSLT	1820 STD/SSLT
1/4	0.381	171	256		
5/16	0.476	212	318	1110 OVS	1670 OVS
3/8	0.571	253	380		
				End-Plate	Beam
				F_y = 36 ksi, F_u = 58 ksi	F_y = 50 ksi, F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

1-in. Bolts 7 Rows

Table 10-4 (continued) Bolted/Welded Shear End-Plate Connections

W44, 40, 36, 33, 30, 27, 24

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	110	165	137	206	165	247
	X	—	110	165	137	206	165	247
	SC Class A	STD	110	165	137	206	165	247
		OVS	98.4	148	123	185	136	204
		SSLT	110	165	137	206	160	240
	SC Class B	STD	110	165	137	206	165	247
		OVS	98.4	148	123	185	148	221
		SSLT	110	165	137	206	165	247
A490	N	—	110	165	137	206	165	247
	X	—	110	165	137	206	165	247
	SC Class A	STD	110	165	137	206	165	247
		OVS	98.4	148	123	185	148	221
		SSLT	110	165	137	206	165	247
	SC Class B	STD	110	165	137	206	165	247
		OVS	98.4	148	123	185	148	221
		SSLT	110	165	137	206	165	247

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	112	168	1060 STD/SSLT	1590 STD/SSLT
1/4	0.381	148	223		
5/16	0.476	184	277	975 OVS	1460 OVS
3/8	0.571	220	330		

	End-Plate	Beam
STD = Standard holes OVS = Oversized holes SSLT = Short-slotted holes transverse to direction of load N = Threads included X = Threads excluded SC = Slip critical	F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

W40, 36, 33, 30, 27, 24, 21

Table 10–4 (continued)
Bolted/Welded Shear End-Plate Connections

1-in. Bolts 6 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	93.5	140	117	175	140	210
	X	—	93.5	140	117	175	140	210
	SC Class A	STD	93.5	140	117	175	140	210
		OVS	83.7	126	105	157	117	175
		SSLT	93.5	140	117	175	137	206
	SC Class B	STD	93.5	140	117	175	140	210
		OVS	83.7	126	105	157	126	188
		SSLT	93.5	140	117	175	140	210
A490	N	—	93.5	140	117	175	140	210
	X	—	93.5	140	117	175	140	210
	SC Class A	STD	93.5	140	117	175	140	210
		OVS	83.7	126	105	157	126	188
		SSLT	93.5	140	117	175	140	210
	SC Class B	STD	93.5	140	117	175	140	210
		OVS	83.7	126	105	157	126	188
		SSLT	93.5	140	117	175	140	210

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	95.4	143
1/4	0.381	126	189
5/16	0.476	157	235
3/8	0.571	187	280

Support Available Strength per Inch Thickness, kips/in.

ASD		LRFD	
912	STD/SSLT	1370	STD/SSLT
839	OVS	1260	OVS

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

1-in. Bolts 5 Rows

Table 10-4 (continued) Bolted/Welded Shear End-Plate Connections

W30, 27, 24, 21, 18

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	77.2	116	96.5	145	116	174
	X	—	77.2	116	96.5	145	116	174
	SC Class A	STD	77.2	116	96.5	145	116	174
		OVS	69.1	104	86.3	129	97.2	146
		SSLT	77.2	116	96.5	145	114	171
	SC Class B	STD	77.2	116	96.5	145	116	174
		OVS	69.1	104	86.3	129	104	155
		SSLT	77.2	116	96.5	145	116	174
A490	N	—	77.2	116	96.5	145	116	174
	X	—	77.2	116	96.5	145	116	174
	SC Class A	STD	77.2	116	96.5	145	116	174
		OVS	69.1	104	86.3	129	104	155
		SSLT	77.2	116	96.5	145	116	174
	SC Class B	STD	77.2	116	96.5	145	116	174
		OVS	69.1	104	86.3	129	104	155
		SSLT	77.2	116	96.5	145	116	174

Weld and Beam Web Available Strength, kips			
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips
		ASD	LRFD
3/16	0.286	78.7	118
1/4	0.381	104	156
5/16	0.476	129	193
3/8	0.571	153	230

Support Available Strength per Inch Thickness, kips/in.	
ASD	LRFD
761 STD/SSLT	1140 STD/SSLT
702 OVS	1050 OVS

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

W24, 21, 18, 16

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

1-in. Bolts 4 Rows

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	60.9	91.4	76.1	114	91.4	137
	X	—	60.9	91.4	76.1	114	91.4	137
	SC Class A	STD	60.9	91.4	76.1	114	91.4	137
		OVS	54.4	81.6	68.0	102	77.7	117
		SSLT	60.9	91.4	76.1	114	91.4	137
	SC Class B	STD	60.9	91.4	76.1	114	91.4	137
		OVS	54.4	81.6	68.0	102	81.6	122
		SSLT	60.9	91.4	76.1	114	91.4	137
A490	N	—	60.9	91.4	76.1	114	91.4	137
	X	—	60.9	91.4	76.1	114	91.4	137
	SC Class A	STD	60.9	91.4	76.1	114	91.4	137
		OVS	54.4	81.6	68.0	102	81.6	122
		SSLT	60.9	91.4	76.1	114	91.4	137
	SC Class B	STD	60.9	91.4	76.1	114	91.4	137
		OVS	54.4	81.6	68.0	102	81.6	122
		SSLT	60.9	91.4	76.1	114	91.4	137

Weld and Beam Web Available Strength, kips			
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips
		ASD	LRFD
3/16	0.286	61.9	92.9
1/4	0.381	81.7	123
5/16	0.476	101	151
3/8	0.571	120	180

Support Available Strength per Inch Thickness, kips/in.			
ASD		LRFD	
609	STD/SSLT	914	STD/SSLT
566	OVS	848	OVS

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

1-in. Bolts 3 Rows

Table 10–4 (continued) Bolted/Welded Shear End-Plate Connections

W18, 16, 14, 12, 10*

Bolt and End-Plate Available Strength, kips								
ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	44.6	66.9	55.7	83.6	66.9	100
	X	—	44.6	66.9	55.7	83.6	66.9	100
	SC Class A	STD	44.6	66.9	55.7	83.6	66.9	100
		OVS	39.7	59.5	49.6	74.4	58.3	87.4
		SSLT	44.6	66.9	55.7	83.6	66.9	100
	SC Class B	STD	44.6	66.9	55.7	83.6	66.9	100
		OVS	39.7	59.5	49.6	74.4	59.5	89.3
		SSLT	44.6	66.9	55.7	83.6	66.9	100
A490	N	—	44.6	66.9	55.7	83.6	66.9	100
	X	—	44.6	66.9	55.7	83.6	66.9	100
	SC Class A	STD	44.6	66.9	55.7	83.6	66.9	100
		OVS	39.7	59.5	49.6	74.4	59.5	89.3
		SSLT	44.6	66.9	55.7	83.6	66.9	100
	SC Class B	STD	44.6	66.9	55.7	83.6	66.9	100
		OVS	39.7	59.5	49.6	74.4	59.5	89.3
		SSLT	44.6	66.9	55.7	83.6	66.9	100

Weld and Beam Web Available Strength, kips				Support Available Strength per Inch Thickness, kips/in.	
70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips	ϕR_n kips		
		ASD	LRFD	ASD	LRFD
3/16	0.286	45.2	67.9	458 STD/SSLT	687 STD/SSLT
1/4	0.381	59.4	89.1		
5/16	0.476	73.1	110	429 OVS	644 OVS
3/8	0.571	86.3	129		

Notes	End-Plate	Beam
STD = Standard holes; OVS = Oversized holes; SSLT = Short-slotted holes transverse to direction of load; N = Threads included; X = Threads excluded; SC = Slip critical; *Limited to W10×12, 15, 17, 19, 22, 26, 30	F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

W12, 10, 8

Table 10–4 (continued)
Bolted/Welded Shear End-Plate Connections

1-in. Bolts 2 Rows

Bolt and End-Plate Available Strength, kips

ASTM Desig.	Thread Cond.	Hole Type	End-Plate Thickness, in.					
			1/4		5/16		3/8	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
A325/F1852	N	—	28.3	42.4	35.3	53.0	42.4	63.6
	X	—	28.3	42.4	35.3	53.0	42.4	63.6
	SC Class A	STD	28.3	42.4	35.3	53.0	42.4	63.6
		OVS	25.0	37.5	31.3	46.9	37.5	56.3
		SSLT	28.3	42.4	35.3	53.0	42.4	63.6
	SC Class B	STD	28.3	42.4	35.3	53.0	42.4	63.6
		OVS	25.0	37.5	31.3	46.9	37.5	56.3
		SSLT	28.3	42.4	35.3	53.0	42.4	63.6
A490	N	—	28.3	42.4	35.3	53.0	42.4	63.6
	X	—	28.3	42.4	35.3	53.0	42.4	63.6
	SC Class A	STD	28.3	42.4	35.3	53.0	42.4	63.6
		OVS	25.3	37.5	31.3	46.9	37.5	56.3
		SSLT	28.3	42.4	35.3	53.0	42.4	63.6
	SC Class B	STD	28.3	42.4	35.3	53.0	42.4	63.6
		OVS	25.0	37.5	31.3	46.9	37.5	56.3
		SSLT	28.3	42.4	35.3	53.0	42.4	63.6

Weld and Beam Web Available Strength, kips

70 ksi Weld Size, in.	Minimum Beam Web Thickness, in.	R_n/Ω kips ASD	ϕR_n kips LRFD
3/16	0.286	28.5	42.8
1/4	0.381	37.1	55.7
5/16	0.476	45.2	67.9
3/8	0.571	52.9	79.4

Support Available Strength per Inch Thickness, kips/in.

ASD		LRFD	
307	STD/SSLT	461	STD/SSLT
293	OVS	439	OVS

End-Plate	Beam
F_y = 36 ksi F_u = 58 ksi	F_y = 50 ksi F_u = 65 ksi

STD = Standard holes
OVS = Oversized holes
SSLT = Short-slotted holes transverse to direction of load
N = Threads included
X = Threads excluded
SC = Slip critical

UNSTIFFENED SEATED CONNECTIONS

An unstiffened seated connection is made with a seat angle and a top angle, as illustrated in Figure 10–7. These angles may be bolted or welded to the supported beam as well as to the supporting member.

While the seat angle is assumed to carry the entire end reaction of the supported beam, the top angle must be placed as shown or in the optional side location for satisfactory performance and stability (Roeder and Dailey, 1989). The top angle and its connections are not usually sized for any calculated strength requirement. A $^1/_4$-in.-thick angle with a 4-in. vertical leg dimension will generally be adequate. It may be bolted with two bolts through each leg or welded with minimum-size welds to either the supported or the supporting members.

When the top angle is welded to the support and/or the supported beam, adequate flexibility must be provided in the connection. As illustrated in Figure 10–7b, line welds are placed along the toe of each angle leg. Note that welding along the sides of the vertical angle leg must be avoided as it would inhibit the flexibility and, therefore, the necessary end rotation of the connection. The performance of such a connection would not be as intended for unstiffened seated connections.

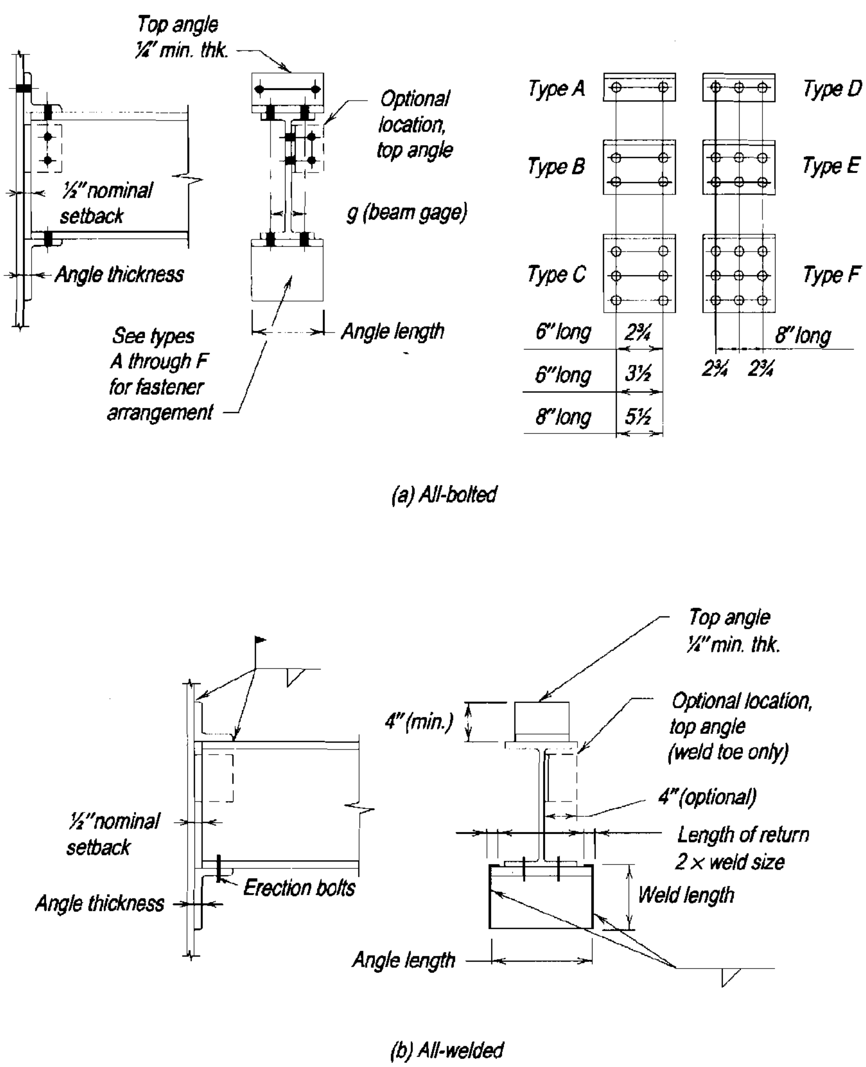


Figure 10–7. Unstiffened seated connections.

Design Checks

The available strength of an unstiffened seated connection is determined from the applicable limit states for bolts (see Part 7), welds (see Part 8), and connecting elements (see Part 9). Additionally, the strength of the supported beam web must be checked for the limit states of web local yielding and web local crippling. In all cases, the available strength, ϕR_n or R_n/Ω, must equal or exceed the required strength, R_u or R_a.

The available strength for web local yielding, ϕR_n or R_n/Ω, is determined per AISC Specification Section J10.2, which is simplified using the constants in Table 9-4. For further information, see Carter et al. (1997).

Shop and Field Practices

Unstiffened seated connections may be made to the webs and flanges of supporting columns. If adequate clearance exists, unstiffened seated connections may also be made to the webs of supporting girders.

To provide for overrun in beam length, the nominal setback for the beam end is 1/2 in. To provide for underrun in beam length, this setback is assumed to be 3/4 in. for calculation purposes.

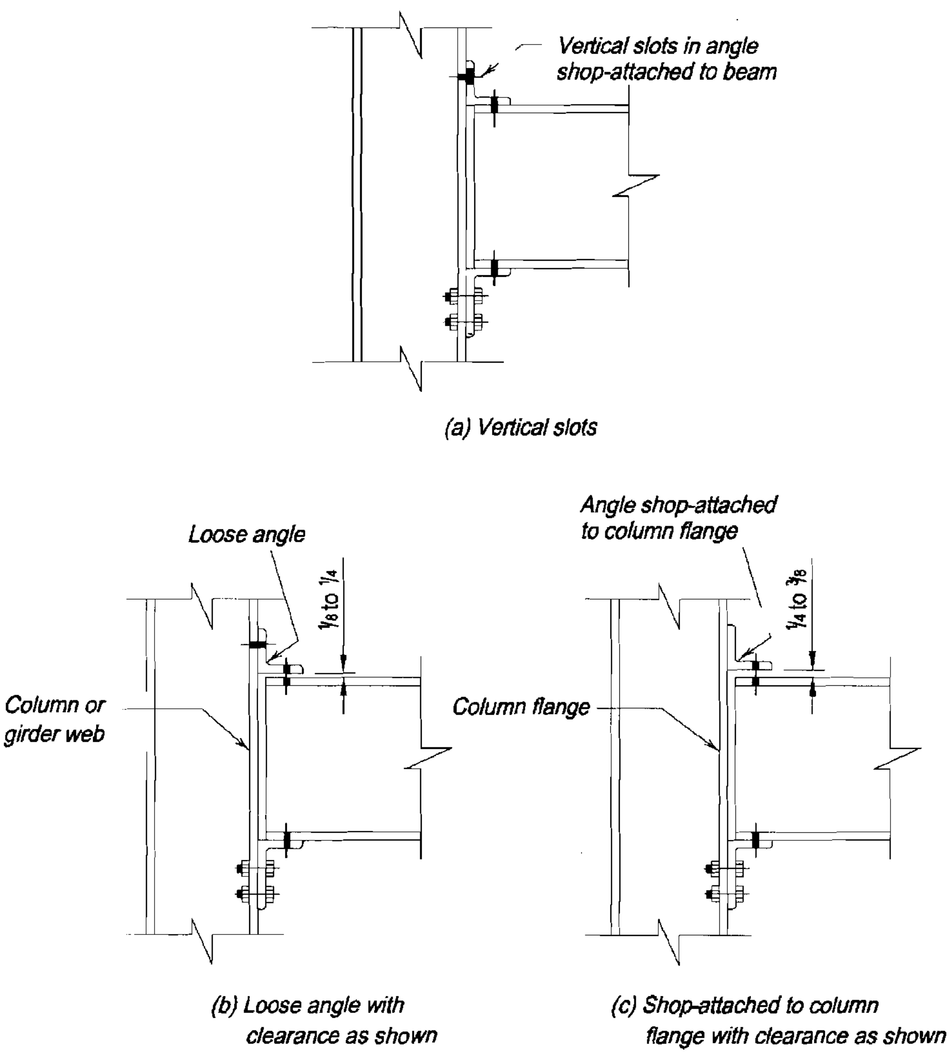


Figure 10–8. Providing for variation in beam depth with seated connections.

The seat angle is preferably shop-attached to the support. Since the bottom flange typically establishes the plane of reference for seated connections, mill variation in beam depth may result in variation in the elevation of the top flange. Such variation is usually of no consequence with concrete slab and metal deck floors, but may be a concern when a grating or steel-plate floor is used. Unless special care is required, the usual mill tolerances for member depth of 1/8 in. to 1/4 in. are ignored. However, when the top angle is shop-attached to the supported beam and field bolted to the support, mill variation in beam depth must be considered. Slotted holes, as illustrated in Figure 10–8a, will accommodate both overrun and underrun in the beam depth and are the preferred method for economy and convenience to both the fabricator and erector. Alternatively, the angle could be shipped loose with clearance provided, as shown in Figure 10–8b. When the top angle is to be field-welded to the support, no provision for mill variation in the beam depth is necessary.

When the top angle is shop-attached to the support, an appropriate erection clearance is provided, as illustrated in Figure 10–8c.

Table 10–5. All-Bolted Unstiffened Seated Connections

Table 10–5 is a design aid for all-bolted unstiffened seats. Seat available strengths are tabulated, assuming a 4-in. outstanding leg, for angle material with F_y = 36 ksi and F_u = 58 ksi and beam material with F_y = 50 ksi and F_u = 65 ksi. All values are for comparison with the LRFD load combination for LRFD design and the ASD load combination for ASD design.

Tabulated seat available strengths consider the limit states of shear yielding and flexural yielding of the outstanding angle leg, and local yielding and crippling of the beam web. A nominal beam setback of 1/2 in. is assumed in these tables. However, this setback is increased to 3/4 in. for calculation purposes in determining the tabulated values to account for the possibility of underrun in beam length.

Bolt available strengths are tabulated for the seat types illustrated in Figure 10–8a with 3/4-in., 7/8-in., and 1-in. diameter ASTM A325, F1852 and A490 bolts. Vertical spacing of bolts and gages in seat angles may be arranged to suit conditions, provided the edge distance and spacing requirements in AISC Specification Section J3 are met. Where thick angles are used, larger entering and tightening clearances may be required in the outstanding angle leg. The suitability of angle sizes and thicknesses for the seat types illustrated in Figure 10–8a is also listed in Table 10–5.

Bolted/Welded Unstiffened Seated Connections

Tables 10–5 and 10–6 may be used in combination to design unstiffened seated connections that are welded to the supporting member and bolted to the supported beam, or bolted to the supporting member and welded to the supported beam.

Table 10–6. All-Welded Unstiffened Seated Connections

Table 10–6 is a design aid for all-welded unstiffened seats (exception: the beam is bolted to the seat). Seat available strengths are tabulated, assuming either a 3 1/2-in. or 4-in. outstanding leg (as indicated in the table), for angle material with F_y = 36 ksi and F_u = 58 ksi and beam material with F_y = 50 ksi and F_u = 65 ksi. Electrode strength is assumed to be 70 ksi.

Tabulated seat available strengths consider the limit states of shear yielding and flexural yielding of the outstanding angle leg, and local yielding and crippling of the beam web. A nominal beam setback of 1/2 in. is assumed in these tables. However, this setback is increased to 3/4 in. for calculation purposes in determining the tabulated values to account for the possibility of underrun in beam length.

Weld available strengths are tabulated using the elastic method. The minimum and maximum angle thickness for each case is also tabulated. While these tabular values are based upon 70 ksi electrodes, they may be used for other electrodes, provided the tabular values are adjusted for the electrodes used (e.g., for 60 ksi electrodes, multiply the tabular values by 60/70 = 0.866, etc.) and the welds and base metal meet the required strength level provisions of AISC Specification Section J2. Should combinations of material thickness and weld size selected from Table 10–6 exceed the limits in AISC Specification Section J2.2, the weld size or material thickness should be increased as required.

As can be seen from the following, reduction of the tabulated weld strength is not normally required when unstiffened seats line up on opposite sides of the supporting web. From Salmon and Johnson (1996), the available strength, ϕR_n or R_n/Ω, of the welds to the support is

LRFD	ASD
$\phi R_n = 2 \times \dfrac{1.392DL}{\sqrt{1+\dfrac{20.25e^2}{L^2}}}$	$\dfrac{R_n}{\Omega} = 2 \times \dfrac{0.928DL}{\sqrt{1+\dfrac{20.25e^2}{L^2}}}$

where

D = number of sixteenths-of-an-inch in the weld size.

L = vertical leg dimension of the seat angle, in.

e = eccentricity of the beam end reaction with respect to the weld lines, in.

The term in the denominator that accounts for the eccentricity e increases the weld size far beyond what is required for shear alone, but with seats on both sides of the supporting member web, the forces due to eccentricity react against each other and have no effect on the web. Furthermore, as illustrated in Figure 10–9, there are actually two shear planes per weld, one at each weld toe and heel for a total of four shear planes. Thus, for an 8-in.-long 7×4×1 seat angle supporting a LRFD required strength of 70 kips or an equivalent ASD required strength of 46.67 kips, the minimum support thickness would be determined as follows

LRFD	ASD
$\dfrac{70\text{ kips}}{0.75 \times 0.6 \times 65\text{ ksi} \times 7\text{ in.} \times 4\text{ planes}} = 0.0855\text{ in.}$	$\dfrac{2.0 \times 46.67\text{ kips}}{0.6 \times 65\text{ ksi} \times 7\text{ in.} \times 4\text{ planes}} = 0.0855\text{ in.}$

For the identical connection on both sides of the support, the minimum support thickness would be less than 3/16 in. Thus, supporting web thickness is generally not a concern.

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Table 10–5
All-Bolted Unstiffened Seated Connections

Angle
F_y = 36 ksi

Outstanding Angle Leg Length Strength, kips

Required Bearing Length N_{req}, in.	Angle Length, in. 6 — Angle Thickness, in. 3/8		1/2		5/8		3/4		1		Min. Angle Leg
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	in.
1/2	18.2	27.3									
9/16	16.2	24.3									
5/8	14.6	21.9	43.1	64.8							
11/16	13.2	19.9	37.0	55.5							
3/4	12.1	18.2	32.3	48.6							
13/16	11.2	16.8	28.7	43.2							
7/8	10.4	15.6	25.9	38.9							
15/16	9.70	14.6	23.5	35.3	54.0	81.0					
1	9.09	13.7	21.6	32.4	50.5	75.9					
1 1/16	8.56	12.9	19.9	29.9	44.9	67.5					
1 1/8	8.08	12.2	18.5	27.8	40.4	60.8					
1 3/16	7.66	11.5	17.2	25.9	36.7	55.2					
1 1/4	7.28	10.9	16.2	24.3	33.7	50.6					
1 5/16	6.93	10.4	15.2	22.9	31.1	46.7	64.7	97.2			3 1/2
1 3/8	6.61	9.94	14.4	21.6	28.9	43.4	58.2	87.5			
1 7/16	6.33	9.51	13.6	20.5	26.9	40.5	52.9	79.5			
1 1/2	6.06	9.11	12.9	19.4	25.3	38.0	48.5	72.9			
1 5/8	5.60	8.41	11.8	17.7	22.5	33.8	41.6	62.5			
1 3/4	5.20	7.81	10.8	16.2	20.2	30.4	36.4	54.7			
1 7/8	4.85	7.29	10.0	15.0	18.4	27.6	32.3	48.6			
2	4.55	6.83	9.24	13.9	16.8	25.3	29.1	43.7	86.2	130	
2 1/8	4.28	6.43	8.62	13.0	15.5	23.4	26.5	39.8	73.9	111	
2 1/4	4.04	6.08	8.08	12.2	14.4	21.7	24.3	36.5	64.7	97.2	
2 3/8	3.83	5.76	7.61	11.4	13.5	20.3	22.4	33.6	57.5	86.4	
2 1/2	3.64	5.47	7.19	10.8	12.6	19.0	20.8	31.2	51.7	77.8	
2 5/8	3.46	5.21	6.81	10.2	11.9	17.9	19.4	29.2	47.0	70.7	
2 3/4	3.31	4.97	6.47	9.72	11.2	16.9	18.2	27.3	43.1	64.8	
2 7/8	3.16	4.75	6.16	9.26	10.6	16.0	17.1	25.7	39.8	59.8	
3	3.03	4.56	5.88	8.84	10.1	15.2	16.2	24.3	37.0	55.5	
3 1/8	2.91	4.37	5.62	8.45	9.62	14.5	15.3	23.0	34.5	51.8	4
3 1/4	2.80	4.21	5.39	8.10	9.19	13.8	14.6	21.9	32.3	48.6	

Bolt Available Strength, kips

Bolt Dia., in.	ASTM Desig.	Thread Cond.	Connection Type from Figure 10-7a: A ASD	A LRFD	B ASD	B LRFD	C ASD	C LRFD
3/4	A325/F1852	N	21.2	31.8	42.4	63.6	63.6	95.4
		X	26.5	39.8	53.0	79.5	79.5	119
	A490	N	26.5	39.8	53.0	79.5	79.5	119
		X	33.1	49.7	66.3	99.4	99.4	149
7/8	A325/F1852	N	28.9	43.3	57.7	86.6	86.6	130
		X	36.1	54.1	72.2	108	108	162
	A490	N	36.1	54.1	72.2	108	108	162
		X	45.1	67.6	90.2	135	135	203
1	A325/F1852	N	37.7	56.5	75.4	113	—	—
		X	47.1	70.7	94.2	141	—	—
	A490	N	47.1	70.7	94.2	141	—	—
		X	58.9	88.4	118	177	—	—

Available Angles

Connection Type	Angle Size	t, in.
A, D	4×3	3/8 – 1/2
	4×3 1/2	3/8 – 1/2
	4×4	3/8 – 3/4
B, E	6×4	3/8 – 3/4
	7×4	3/8 – 3/4
	8×4	1/2 – 1
C, F[b]	8×4	1/2 – 1

[b] Not suitable for use with 1-in. diameter bolts.

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$

For tabulated values above the heavy line, shear yielding of the angle leg controls the available strength.

Angle
F_y = 36 ksi

Table 10–5 (continued)
All-Bolted Unstiffened Seated Connections

L8

Outstanding Angle Leg Length Strength, kips

Required Bearing Length N_{req}, in.	Angle Length, in. 8 — Angle Thickness, in. 3/8		1/2		5/8		3/4		1		Min. Angle Leg
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	in.
1/2	24.3	36.5									
9/16	21.6	32.4									
5/8	19.4	29.2	57.5	86.4							
11/16	17.6	26.5	49.3	74.1							
3/4	16.2	24.3	43.1	64.8							
13/16	14.9	22.4	38.3	57.6							
7/8	13.9	20.8	34.5	51.8							
15/16	12.9	19.4	31.4	47.1	72.0	108					
1	12.1	18.2	28.7	43.2	67.4	101					
1 1/16	11.4	17.2	26.5	39.9	59.9	90.0					
1 1/8	10.8	16.2	24.6	37.0	53.9	81.0					
1 3/16	10.2	15.3	23.0	34.6	49.0	73.6					
1 1/4	9.7	14.6	21.6	32.4	44.9	67.5					
1 5/16	9.2	13.9	20.3	30.5	41.5	62.3	86.2	130			3 1/2
1 3/8	8.82	13.3	19.2	28.8	38.5	57.9	77.6	117			
1 7/16	8.44	12.7	18.2	27.3	35.9	54.0	70.5	106			
1 1/2	8.08	12.2	17.2	25.9	33.7	50.6	64.7	97.2			
1 5/8	7.46	11.2	15.7	23.6	29.9	45.0	55.4	83.3			
1 3/4	6.93	10.4	14.4	21.6	26.9	40.5	48.5	72.9			
1 7/8	6.47	9.72	13.3	19.9	24.5	36.8	43.1	64.8			
2	6.06	9.11	12.3	18.5	22.5	33.8	38.8	58.3	115	173	
2 1/8	5.71	8.58	11.5	17.3	20.7	31.2	35.3	53.0	98.5	148	
2 1/4	5.39	8.10	10.8	16.2	19.2	28.9	32.3	48.6	86.2	130	
2 3/8	5.11	7.67	10.1	15.2	18.0	27.0	29.8	44.9	76.6	115	
2 1/2	4.85	7.29	9.58	14.4	16.8	25.3	27.7	41.7	69.0	104	
2 5/8	4.62	6.94	9.08	13.6	15.9	23.8	25.9	38.9	62.7	94.3	
2 3/4	4.41	6.63	8.62	13.0	15.0	22.5	24.3	36.5	57.6	86.4	
2 7/8	4.22	6.34	8.21	12.3	14.2	21.3	22.8	34.3	53.1	79.8	4
3	4.04	6.08	7.84	11.8	13.5	20.3	21.6	32.4	49.3	74.1	
3 1/8	3.88	5.83	7.50	11.3	12.8	19.3	20.4	30.7	46.0	69.1	
3 1/4	3.73	5.61	7.19	10.8	12.2	18.4	19.4	29.2	43.1	64.8	

Bolt Available Strength, kips

Bolt Dia., in.	ASTM Desig.	Thread Cond.	Connection Type from Figure 10-7a: D		E		F	
			ASD	LRFD	ASD	LRFD	ASD	LRFD
3/4	A325/F1852	N	31.8	47.7	63.6	95.4	95.4	143
		X	39.8	59.6	79.5	119	119	179
	A490	N	39.8	59.6	79.5	119	119	179
		X	49.7	74.6	99.4	149	149	224
7/8	A325/F1852	N	43.3	64.9	86.6	130	130	195
		X	54.1	81.2	108	162	162	244
	A490	N	54.1	81.2	108	162	162	244
		X	67.6	101	135	203	203	304
1	A325/F1852	N	56.5	84.8	113	170	—	—
		X	70.7	106	141	212	—	—
	A490	N	70.7	106	141	212	—	—
		X	88.4	133	177	265	—	—

Available Angles

Connection Type	Angle Size	t, in.
A, D	4×3	3/8 – 1/2
	4×3 1/2	3/8 – 1/2
	4×4	3/8 – 3/4
B, E	6×4	3/8 – 3/4
	7×4	3/8 – 3/4
	8×4	1/2 – 1
C, F[b]	8×4	1/2 – 1

[b] Not suitable for use with 1-in. diameter bolts.

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$

For tabulated values above the heavy line, shear yielding of the angle leg controls the available strength.

L6

Table 10-6
All-Welded Unstiffened Seated Connections

Angle F_y = 36 ksi

Outstanding Angle Leg Length Strength, kips

Required Bearing Length N_{req}, in.	Angle Length, in. 6 — Angle Thickness, in. 3/8		1/2		5/8		3/4		1		Min. Angle Leg
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	in.
1/2	18.2	27.3									
9/16	16.2	24.3									
5/8	14.6	21.9	43.1	64.8							
11/16	13.2	19.9	37.0	55.5							
3/4	12.1	18.2	32.3	48.6							
13/16	11.2	16.8	28.7	43.2							
7/8	10.4	15.6	25.9	38.9							
15/16	9.70	14.6	23.5	35.3	54.0	81.0					
1	9.09	13.7	21.6	32.4	50.5	75.9					
1 1/16	8.56	12.9	19.9	29.9	44.9	67.5					
1 1/8	8.08	12.2	18.5	27.8	40.4	60.8					
1 3/16	7.66	11.5	17.2	25.9	36.7	55.2					
1 1/4	7.28	10.9	16.2	24.3	33.7	50.6					
1 5/16	6.93	10.4	15.2	22.9	31.1	46.7	64.7	97.2			3 1/2
1 3/8	6.61	9.94	14.4	21.6	28.9	43.4	58.2	87.5			
1 7/16	6.33	9.51	13.6	20.5	26.9	40.5	52.9	79.5			
1 1/2	6.06	9.11	12.9	19.4	25.3	38.0	48.5	72.9			
1 5/8	5.60	8.41	11.8	17.7	22.5	33.8	41.6	62.5			
1 3/4	5.20	7.81	10.8	16.2	20.2	30.4	36.4	54.7			
1 7/8	4.85	7.29	9.95	15.0	18.4	27.6	32.3	48.6			
2	4.55	6.83	9.24	13.9	16.8	25.3	29.1	43.7	86.2	130	
2 1/8	4.28	6.43	8.62	13.0	15.5	23.4	26.5	39.8	73.9	111	
2 1/4	4.04	6.08	8.08	12.2	14.4	21.7	24.3	36.5	64.7	97.2	
2 3/8	3.83	5.76	7.61	11.4	13.5	20.3	22.4	33.6	57.5	86.4	
2 1/2	3.64	5.47	7.19	10.8	12.6	19.0	20.8	31.2	51.7	77.8	
2 5/8	3.46	5.21	6.81	10.2	11.9	17.9	19.4	29.2	47.0	70.7	
2 3/4	3.31	4.97	6.47	9.72	11.2	16.9	18.2	27.3	43.1	64.8	
2 7/8	3.16	4.75	6.16	9.26	10.6	16.0	17.1	25.7	39.8	59.8	
3	3.03	4.56	5.88	8.84	10.1	15.2	16.2	24.3	37.0	55.5	4
3 1/8	2.91	4.37	5.62	8.45	9.62	14.5	15.3	23.0	34.5	51.8	
3 1/4	2.80	4.21	5.39	8.10	9.19	13.8	14.6	21.9	32.3	48.6	

Weld (70 ksi) Available Strength, kips

70 ksi Weld Size, in.	Seat Angle Size (long leg vertical) 4 × 3 1/2		5 × 3 1/2	
Design	ASD	LRFD	ASD	LRFD
1/4	11.5	17.2	17.2	25.8
5/16	14.3	21.5	21.5	32.2
3/8	17.2	25.8	25.8	38.7
7/16	20.1	30.1	30.1	45.2
1/2	—	—	34.4	51.6
9/16	—	—	38.7	58.1
5/8	—	—	43.0	64.5
11/16	—	—	47.3	71.0

Available Angle Thickness, in.

	4 × 3 1/2	5 × 3 1/2
Minimum	3/8	3/8
Maximum	1/2	3/4

ASD	LRFD	
Ω = 2.00	ϕ = 0.75	For tabulated values above the heavy line, shear yielding of the angle leg controls the available strength.

Table 10-6 (continued) All-Welded Unstiffened Seated Connections

Angle F_y = 36 ksi **L8**

Outstanding Angle Leg Length Strength, kips

Required Bearing Length N_{req}, in.	Angle Length, in. 8 — Angle Thickness, in. 3/8		1/2		5/8		3/4		1		Min. Angle Leg
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	in.
1/2	24.3	36.5									
9/16	21.6	32.4									
5/8	19.4	29.2	57.5	86.4							
11/16	17.6	26.5	49.3	74.1							
3/4	16.2	24.3	43.1	64.8							
13/16	14.9	22.4	38.3	57.6							
7/8	13.9	20.8	34.5	51.8							
15/16	12.9	19.4	31.4	47.1	72.0	108					
1	12.1	18.2	28.7	43.2	67.4	101					
1 1/16	11.4	17.2	26.5	39.9	59.9	90.0					
1 1/8	10.8	16.2	24.6	37.0	53.9	81.0					
1 3/16	10.2	15.3	23.0	34.6	49.0	73.6					
1 1/4	9.70	14.6	21.6	32.4	44.9	67.5					
1 5/16	9.24	13.9	20.3	30.5	41.5	62.3	86.2	130			3 1/2
1 3/8	8.82	13.3	19.2	28.8	38.5	57.9	77.6	117			
1 7/16	8.44	12.7	18.2	27.3	35.9	54.0	70.5	106			
1 1/2	8.08	12.2	17.2	25.9	33.7	50.6	64.7	97.2			
1 5/8	7.46	11.2	15.7	23.6	29.9	45.0	55.4	83.3			
1 3/4	6.93	10.4	14.4	21.6	26.9	40.5	48.5	72.9			
1 7/8	6.47	9.72	13.3	19.9	24.5	36.8	43.1	64.8			
2	6.06	9.11	12.3	18.5	22.5	33.8	38.8	58.3	115	173	
2 1/8	5.71	8.58	11.5	17.3	20.7	31.2	35.3	53.0	98.5	148	
2 1/4	5.39	8.10	10.8	16.2	19.2	28.9	32.3	48.6	86.2	130	
2 3/8	5.11	7.67	10.1	15.2	18.0	27.0	29.8	44.9	76.6	115	
2 1/2	4.85	7.29	9.58	14.4	16.8	25.3	27.7	41.7	69.0	104	
2 5/8	4.62	6.94	9.08	13.6	15.9	23.8	25.9	38.9	62.7	94.3	
2 3/4	4.41	6.63	8.62	13.0	15.0	22.5	24.3	36.5	57.5	86.4	
2 7/8	4.22	6.34	8.21	12.3	14.2	21.3	22.8	34.3	53.1	79.8	
3	4.04	6.08	7.84	11.8	13.5	20.3	21.6	32.4	49.3	74.1	4
3 1/8	3.88	5.83	7.50	11.3	12.8	19.3	20.4	30.7	46.0	69.1	
3 1/4	3.73	5.61	7.19	10.8	12.2	18.4	19.4	29.2	43.1	64.8	

Weld (70 ksi) Available Strength, kips

70 ksi Weld Size, in.	Seat Angle Size (long leg vertical) 6 × 4		7 × 4		8 × 4	
Design	ASD	LRFD	ASD	LRFD	ASD	LRFD
1/4	21.8	32.7	28.5	42.7	35.6	53.4
5/16	27.3	40.9	35.6	53.4	44.5	66.7
3/8	32.7	49.1	42.7	64.1	53.4	80.1
7/16	38.2	57.2	49.8	74.7	62.3	93.4
1/2	43.6	65.4	57.0	85.4	71.2	107
9/16	49.1	73.6	64.1	96.1	80.1	120
5/8	54.5	81.8	71.2	107	89.0	133
11/16	60.0	90.0	78.3	117	97.9	147

Available Angle Thickness, in.

	6 × 4	7 × 4	8 × 4
Minimum	3/8	3/8	1/2
Maximum	3/4	3/4	1

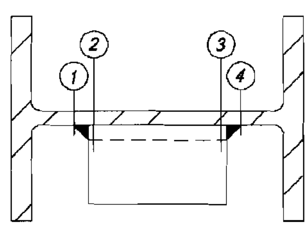
ASD	LRFD	
Ω = 2.00	ϕ = 0.75	For tabulated values above the heavy line, shear yielding of the angle leg controls the available strength.

STIFFENED SEATED CONNECTIONS

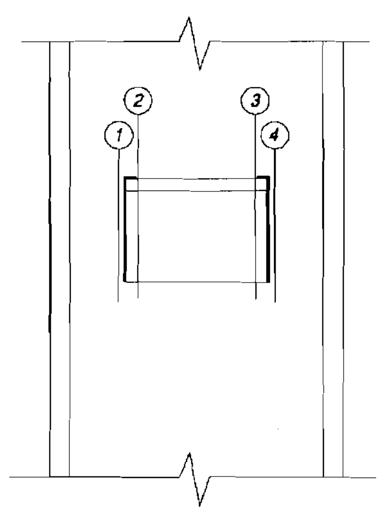
A stiffened seated connection is made with a seat plate and stiffening element (e.g., a plate, structural tee, or pair of angles) and a top angle, as illustrated in Figure 10–10. The top angle may be bolted or welded to the supported beam as well as to the supporting member and the stiffening element may be bolted or welded to the support. The seat plate should be bolted to the supported beam.

The stiffening element is assumed to carry the entire end reaction of the supported beam applied at a distance equal to $0.8W$. The top angle must be placed as shown or in the optional side location for satisfactory performance and stability (Roeder and Dailey, 1989). The top angle and its connections are not usually sized for any calculated strength requirement. A $^1/_4$-in.-thick angle with a 4-in. vertical leg dimension will generally be adequate. It may be bolted with two bolts through each leg or welded with minimum-size welds to either the supported or the supporting members.

When the top angle is welded to the support and/or the supported beam, adequate flexibility must be provided in the connection. As illustrated in Figure 10–10b, line welds are placed along the toe of each angle leg. Note that welding along the sides of the vertical angle leg must be avoided as it would inhibit the flexibility and, therefore, the necessary end rotation of the connection. The performance of such a connection would not be as intended for simple shear connections.

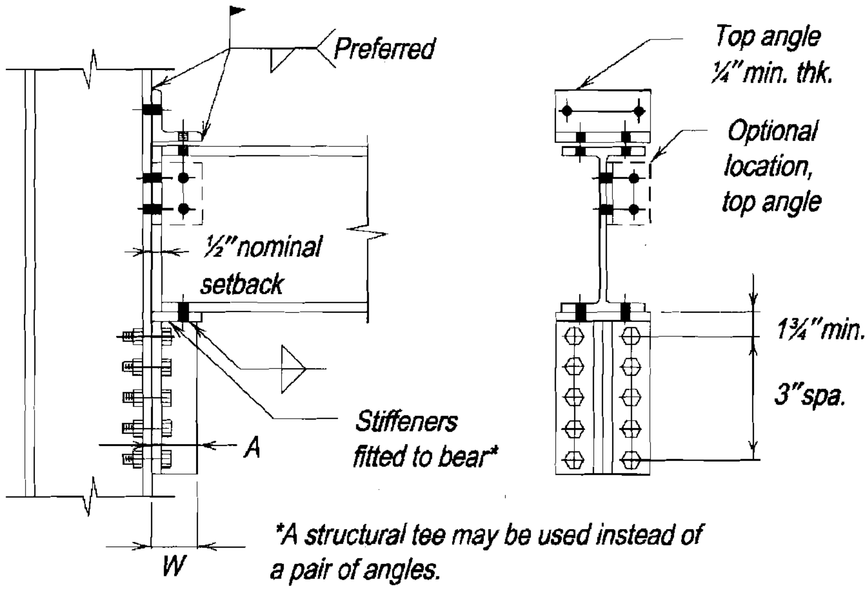


(a) Plan view

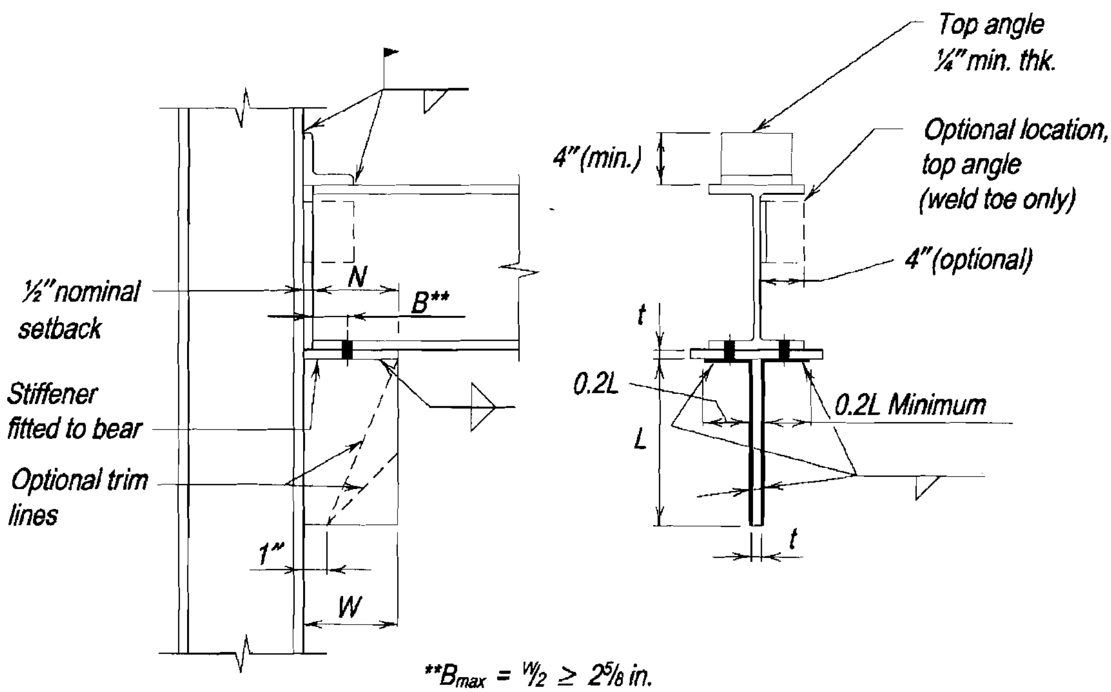


(b) Elevation

Figure 10–9. Shear planes in column web for unstiffened seated connections.



(a) All-bolted



(b) Bolted/welded

Figure 10–10. Stiffened seated connections.

Design Checks

The available strength of a stiffened seated connection is determined from the applicable limit states for the bolts (see Part 7), welds (see Part 8), and connecting elements (see Part 9). Additionally, the strength of the supported beam web must be checked for the limit states of local web yielding and web crippling. In all cases, the available strength, ϕR_n or R_n/Ω, must equal or exceed the required strength, R_u or R_a. The available strength for web local yielding, ϕR_n or R_n/Ω, is determined per AISC Specification Section J10.2, which is simplified using the constants in Table 9–4.

When stiffened seated connections such as the one shown in Figure 10–10b are made to one side of a supporting column web, the column web may also need to be investigated for resistance to punching shear. In lieu of a more detailed analysis, Sputo and Ellifritt (1991) showed that punching shear will not be critical if the design parameters below and those summarized graphically in Figure 10–10b are met.

1. This simplified approach is applicable to the following column sections:

W14×43-808	W12×40-336	W10×33-112
W8×24-67	W6×20-25	W5×16-19

2. The supported beam must be bolted to the seat plate with high-strength bolts to account for the prying action caused by rotation of the connection. Welding the beam to the seat plate is not recommended because welds may lack the required strength and ductility. The centerline of the bolts should be located no more than the greater of $W/2$ or $2^5/_8$ in. from the column web face.
3. For seated connections where $W = 8$ in. or $W = 9$ in. and $3^1/_2$ in. $< B \le W/2$, or where $W = 7$ in. and 3 in. $< B \le W/2$ for a W14×43 column, refer to Sputo and Ellifritt (1991). These limitations are summarized at the bottom of Table 10–8.
4. The top angle may be bolted or welded, but must have a minimum $^1/_4$-in. thickness.
5. The seat plate should not be welded to the beam flange.

See also Ellifritt and Sputo (1999).

Shop and Field Practices

The comments for unstiffened seated connections are equally applicable to stiffened seated connections.

Table 10–7. All-Bolted Stiffened Seated Connections

Table 10–7 is a design aid for all-bolted stiffened seats. Stiffener available strengths are tabulated for stiffener material with F_y = 36 ksi and F_u = 58 ksi and with F_y = 50 ksi and F_u = 65 ksi.

Tabulated values consider the limit-state of bearing on the stiffening material. The designer must independently check the available strength of the beam web based upon the limit states of local web yielding and local web crippling. A nominal beam setback of $^1/_2$ in. is assumed in these tables. However, this setback is increased to $^3/_4$ in. for calculation purposes in determining the tabulated values to account for the possibility of underrun in beam length.

Bolt available strengths are tabulated for two vertical rows of from three to seven $^3/_4$-in., $^7/_8$-in., and 1-in.-diameter ASTM A325, F1852 and A490 high-strength bolts based upon the limit-state of bolt shear. Vertical spacing of bolts and gages in seat angles may be arranged to suit conditions, provided the edge distance and spacing requirements in AISC Specification Section J3 are met.

Table 10–8. Bolted/Welded Stiffened Seated Connections

Table 10–8 is a design aid for stiffened seated connections welded to the support and bolted to the supported beam. Electrode strength is assumed to be 70 ksi.

Weld available strengths are tabulated using the elastic method. While these tabular values are based upon 70 ksi electrodes, they may be used for other electrodes, provided the tabular values are adjusted for the electrodes used (e.g., for 60 ksi electrodes, multiply the tabular values by 60/70 = 0.866, etc.) and the weld and base metal meet the provisions of AISC Specification Section J2.

The thickness of the horizontal seat plate or tee flange should not be less than $^3/_8$ in. If the seat and stiffener are built up from separate plates, the stiffener should be finished to bear under the seat. The welds connecting the two plates should have a strength equal to or greater than the horizontal welds to the support under the seat plate.

The designer must independently check the beam web for web local yielding and web local crippling. The nominal beam setback of $^1/_2$ in. should be assumed to be $^3/_4$ in. for calculation purposes to account for possible underrun in beam length.

The stiffener thickness may be conservatively determined as follows. The minimum stiffener plate thickness, t, for supported beams with unstiffened webs should be the supported beam web thickness, t_w, multiplied by the ratio of F_y of the beam material to F_y of the stiffener material (e.g., F_y beam = 50 ksi, F_y stiffener = 36 ksi, $t = t_w \times 50/36$ minimum). Additionally, the minimum stiffener thickness, t, should be at least $2w$ for stiffener material with F_y = 36 ksi or $1.5w$ for stiffener material with F_y = 50 ksi, where w is the weld size for 70 ksi electrodes.

For 70 ksi electrodes, the minimum column web thickness is

$$t_{min} = \frac{3.09D}{F_u}$$

where

D = the weld size in sixteenths of an inch.

When welds line up on opposite sides of the support, the minimum thickness is the sum of the thicknesses required for each weld. In either case, when less than the minimum material thickness is present, the weld available strength must be reduced by the ratio of the thickness provided to the minimum thickness. As with unstiffened seated connections, the contribution of eccentricity to the required shear yielding strength is negligible. Should combinations of material thickness and weld size selected from Table 10–8 exceed the limits of AISC Specification Section J2, increase the weld size or material thickness as required.

Table 10–7
All-Bolted Stiffened Seated Connections

Stiffener Material		Outstanding Angle Leg Available Strength, kips[a]											
Stiffener Outstanding Leg A, in.[b]		F_y = 36 ksi						F_y = 50 ksi					
		3 1/2		4		5		3 1/2		4		5	
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Thickness of Stiffener Outstanding Legs, in.	5/16	55.7	83.5	65.8	98.7	86.1	129	77.3	116	91.4	137	120	179
	3/8	66.8	100	79.0	118	103	155	92.8	139	110	165	143	215
	1/2	89.1	134	105	158	138	207	124	186	146	219	191	287
	5/8	111	167	132	197	172	258	155	232	183	274	239	359
	3/4	134	200	158	237	207	310	186	278	219	329	287	430

Use minimum 3/8-in. thick seat plate wide enough to extend beyond outstanding legs of stiffener.
a See AISC Specification Sect. J7.
b Beam bearing length assumed 3/4 in. less for calculation purposes.

Bolt Available Strength, kips

Bolt Diameter, in.	ATSM Desig.	Thread Cond.	Number of Bolts in One Vertical Row									
			3		4		5		6		7	
			ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
3/4	A325/F182	N	63.6	95.4	84.8	127	106	159	127	191	148	223
		X	79.5	119	106	159	133	199	159	239	186	278
	A490	N	79.5	119	106	159	133	199	159	239	186	278
		X	99.4	149	133	199	166	249	199	298	232	348
7/8	A325/F182	N	86.6	130	115	173	144	216	173	260	202	303
		X	108	162	144	216	180	271	216	325	253	379
	A490	N	108	162	144	216	180	271	216	325	253	379
		X	135	203	180	271	225	338	271	406	316	474
1	A325/F182	N	113	170	151	226	188	283	226	339	264	396
		X	141	212	188	283	236	353	283	424	330	495
	A490	N	141	212	188	283	236	353	283	424	330	495
		X	177	265	236	353	295	442	353	530	412	619

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$
$\frac{R_n}{\Omega} = \frac{1.8F_yA_{pb}}{2.00}$	$\phi R_n = 0.75 \times 1.8F_yA_{pb}$

Table 10-8
Bolted/Welded Stiffened Seated Connections

L, in.	Width of Seat *W*, in.											
	4								5			
	70 ksi Weld Size, in.								70 ksi Weld Size, in.			
	1/4		5/16		3/8		7/16		5/16		3/8	
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
6	**22.7**	34.0	**28.4**	42.5	**34.0**	51.1	**39.7**	59.6	**23.5**	35.2	**28.2**	42.2
7	**29.9**	44.9	**37.4**	56.1	**44.9**	67.3	**52.4**	78.6	**31.2**	46.9	**37.5**	56.2
8	**37.8**	56.7	**47.2**	70.8	**56.7**	85.0	**66.1**	99.2	**39.8**	59.8	**47.8**	71.7
9	**46.1**	69.2	**57.7**	86.5	**69.2**	104	**80.7**	121	**49.1**	73.7	**59.0**	88.5
10	**54.9**	82.3	**68.6**	103	**82.3**	123	**96.0**	144	**59.0**	88.5	**70.8**	106
11	**63.9**	95.8	**79.8**	120	**95.8**	144	**112**	168	**69.4**	104	**83.3**	125
12	**73.1**	110	**91.4**	137	**110**	165	**128**	192	**80.2**	120	**96.2**	144
13	**82.5**	124	**103**	155	**124**	186	**144**	217	**91.3**	137	**110**	164
14	**92.1**	138	**115**	173	**138**	207	**161**	242	**103**	154	**123**	185
15	**102**	152	**127**	191	**152**	229	**178**	267	**114**	171	**137**	206
16	**111**	167	**139**	209	**167**	250	**195**	292	**126**	189	**151**	227
17	**121**	181	**151**	227	**181**	272	**212**	318	**138**	207	**165**	248
18	**131**	196	**163**	245	**196**	294	**229**	343	**150**	225	**180**	270
19	**140**	211	**175**	263	**211**	316	**246**	369	**162**	243	**194**	291
20	**150**	225	**188**	281	**225**	338	**263**	394	**174**	261	**209**	313
21	**160**	240	**200**	300	**240**	359	**280**	419	**186**	279	**223**	335
22	**169**	254	**212**	318	**254**	381	**296**	445	**198**	297	**238**	357
23	**179**	269	**224**	336	**269**	403	**313**	470	**210**	315	**252**	378
24	**189**	283	**236**	354	**283**	425	**330**	495	**222**	334	**267**	400
25	**198**	297	**248**	372	**297**	446	**347**	520	**235**	352	**281**	422
26	**208**	312	**260**	390	**312**	468	**364**	546	**247**	370	**296**	444
27	**217**	326	**272**	408	**326**	489	**380**	571	**259**	388	**310**	466

Limitations for Connections to Column Webs

B = 2 5/8 in. max	B = 2 5/8 in. max
W12×40, W14×43 for L ≥ 9 in. limit weld ≤ 1/4 in.	None

Notes:

1. Values shown assume 70 ksi electrodes. For 60 ksi electrodes, multiply tabular values by 0.857, or enter table with 1.17 times the required strength, R_u or R_a. For 80 ksi electrodes, multiply tabular values by 1.14, or enter table with 0.875 times the required strength.
2. Tabulated values are valid for stiffeners with minimum thickness of

$$t_{min} = \frac{F_{y\ beam}}{F_{y\ stiffener}} \times t_w$$

but not less than $2w$ for stiffeners with $F_y = 36$ ksi nor $1.5w$ for stiffeners with $F_y = 50$ ksi. In the above, t_w is the thickness of the unstiffened supported beam web and w is the nominal weld size.

3. Tabulated values may be limited by shear yielding of or bearing on the stiffener; refer to LRFD Specification Sections F2.2 and J8, respectively.

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$

Table 10–8 (continued)
Bolted/Welded Stiffened Seated Connections

L, in.	Width of Seat W, in.											
	5				6							
	70 ksi Weld Size, in.				70 ksi Weld Size, in.							
	7/16		1/2		5/16		3/8		7/16		1/2	
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
6	32.8	49.3	37.5	56.3	19.9	29.9	23.9	35.9	27.9	41.9	31.9	47.8
7	43.7	65.6	50.0	75.0	26.7	40.1	32.0	48.1	37.4	56.1	42.7	64.1
8	55.8	83.7	63.8	95.6	34.3	51.4	41.1	61.7	48.0	72.0	54.8	82.2
9	68.8	103	78.6	118	42.5	63.8	51.1	76.6	59.6	89.3	68.1	102
10	82.6	124	94.4	142	51.4	77.2	61.7	92.6	72.0	108	82.3	123
11	97.2	146	111	167	60.9	91.3	73.1	110	85.3	128	97.4	146
12	112	168	128	192	70.8	106	85.0	127	99.2	149	113	170
13	128	192	146	219	81.2	122	97.4	146	114	170	130	195
14	144	216	164	246	91.9	138	110	165	129	193	147	220
15	160	240	183	274	103	154	123	185	144	216	165	247
16	176	265	202	302	114	171	137	205	160	240	183	274
17	193	290	221	331	126	188	151	226	176	264	201	301
18	210	315	240	360	137	206	165	247	192	288	219	329
19	227	340	259	388	149	223	179	268	208	313	238	357
20	244	365	278	417	161	241	193	289	225	337	257	386
21	260	391	298	446	173	259	207	311	242	362	276	414
22	277	416	317	476	185	277	222	332	258	388	295	443
23	294	442	336	505	197	295	236	354	275	413	315	472
24	311	467	356	534	209	313	250	376	292	438	334	501
25	328	492	375	563	221	331	265	397	309	464	353	530
26	345	518	395	592	233	349	280	419	326	489	373	559
27	362	543	414	621	245	368	294	441	343	515	392	588

Limitations for Connections to Column Webs

B = 2⁵/₈ in. max	B = 3 in. max
None	None

Notes:
1. Values shown assume 70 ksi electrodes. For 60 ksi electrodes, multiply tabular values by 0.857, or enter table with 1.17 times the required strength, R_u or R_a. For 80 ksi electrodes, multiply tabular values by 1.14, or enter table with 0.875 times the required strength.
2. Tabulated values are valid for stiffeners with minimum thickness of

$$t_{min} = \frac{F_{y\ beam}}{F_{y\ stiffener}} \times t_w$$

but not less than $2w$ for stiffeners with $F_y = 36$ ksi nor $1.5w$ for stiffeners with $F_y = 50$ ksi. In the above, t_w is the thickness of the unstiffened supported beam web and w is the nominal weld size.

3. Tabulated values may be limited by shear yielding of or bearing on the stiffener; refer to LRFD Specification Sections F2.2 and J8, respectively.

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$

Table 10–8 (continued)
Bolted/Welded Stiffened Seated Connections

L, in.	Width of Seat *W*, in.											
	7								8			
	70 ksi Weld Size, in.								70 ksi Weld Size, in.			
	5/16		3/8		7/16		1/2		5/16		3/8	
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
11	54.0	81.0	64.8	97.2	75.6	113	86.4	130	48.4	72.5	58.0	87.1
12	63.1	94.7	75.7	114	88.4	133	101	151	56.7	85.1	68.1	102
13	72.7	109	87.2	131	102	153	116	174	65.6	98.3	78.7	118
14	82.6	124	99.2	149	116	174	132	198	74.8	112	89.8	135
15	93.0	139	112	167	130	195	149	223	84.5	127	101	152
16	104	155	124	186	145	217	166	249	94.4	142	113	170
17	114	172	137	206	160	240	183	275	105	157	126	189
18	126	188	151	226	176	264	201	301	115	173	138	208
19	137	205	164	246	192	287	219	329	126	189	151	227
20	148	223	178	267	208	312	237	356	137	206	165	247
21	160	240	192	288	224	336	256	384	148	222	178	267
22	172	258	206	309	240	361	275	412	160	240	192	287
23	184	275	220	330	257	385	294	440	171	257	205	308
24	195	293	234	352	274	410	313	469	183	274	219	329
25	207	311	249	373	290	435	332	498	195	292	233	350
26	219	329	263	395	307	461	351	526	206	309	248	371
27	231	347	278	417	324	486	370	555	218	327	262	393
28	244	365	292	438	341	511	390	584	230	345	276	414
29	256	383	307	460	358	537	409	613	242	363	291	436
30	268	402	321	482	375	562	428	643	254	381	305	457
31	280	420	336	504	392	588	448	672	266	399	319	479
32	292	438	350	526	409	613	467	701	278	417	334	501

Limitations for Connections to Column Webs

B = 3 1/2 in. max	B = 3 1/2 in. max
W14 × 43, limit B ≤ 3 in. See item 3 in preceding discussion "Design Checks"	See item 3 in preceding discussion "Design Checks"

Notes:

1. Values shown assume 70 ksi electrodes. For 60 ksi electrodes, multiply tabular values by 0.857, or enter table with 1.17 times the required strength, R_u or R_a. For 80 ksi electrodes, multiply tabular values by 1.14, or enter table with 0.875 times the required strength.
2. Tabulated values are valid for stiffeners with minimum thickness of

$$t_{min} = \frac{F_{y\ beam}}{F_{y\ stiffener}} \times t_w$$

but not less than $2w$ for stiffeners with $F_y = 36$ ksi nor $1.5w$ for stiffeners with $F_y = 50$ ksi. In the above, t_w is the thickness of the unstiffened supported beam web and w is the nominal weld size.

3. Tabulated values may be limited by shear yielding of or bearing on the stiffener; refer to LRFD Specification Sections F2.2 and J8, respectively.

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$

Table 10-8 (continued)
Bolted/Welded Stiffened Seated Connections

L, in.	Width of Seat *W*, in.											
	8				9							
	70 ksi Weld Size, in.				70 ksi Weld Size, in.							
	1/2		5/8		5/16		3/8		1/2		5/8	
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
11	77.4	116	96.7	145	43.7	65.6	52.5	78.7	69.9	105	87.4	131
12	90.8	136	113	170	51.4	77.1	61.7	92.5	82.2	123	103	154
13	105	157	131	197	59.6	89.3	71.5	107	95.3	143	119	179
14	120	180	150	224	68.2	102	81.8	123	109	164	136	204
15	135	203	169	253	77.2	116	92.6	139	123	185	154	232
16	151	227	189	283	86.5	130	104	156	138	208	173	260
17	168	251	209	314	96.2	144	115	173	154	231	192	289
18	184	277	231	346	106	159	127	191	170	255	212	319
19	202	303	252	378	117	175	140	210	186	280	233	350
20	219	329	274	411	127	191	152	229	203	305	254	381
21	237	356	297	445	138	207	165	248	220	331	276	413
22	256	383	319	479	149	223	178	268	238	357	297	446
23	274	411	342	514	160	240	192	288	256	384	320	480
24	292	439	366	548	171	257	205	308	274	411	342	513
25	311	467	389	584	183	274	219	329	292	438	365	548
26	330	495	413	619	194	291	233	349	310	466	388	582
27	349	524	436	655	206	308	247	370	329	494	411	617
28	368	552	460	690	217	326	261	391	348	522	435	652
29	387	581	484	726	229	344	275	412	367	550	458	687
30	407	610	508	762	241	362	289	434	386	578	482	723
31	426	639	532	799	253	379	304	455	405	607	506	759
32	445	668	557	835	265	397	318	477	424	636	530	795

Limitations for Connections to Column Webs	
B = 3 1/2 in. max	B = 3 1/2 in. max
See item 3 in preceding discussion "Design Checks"	See item 3 in preceeding discussion "Design Checks"

Notes:
1. Values shown assume 70 ksi electrodes. For 60 ksi electrodes, multiply tabular values by 0.857, or enter table with 1.17 times the required strength, R_u or R_a. For 80 ksi electrodes, multiply tabular values by 1.14, or enter table with 0.875 times the required strength.
2. Tabulated values are valid for stiffeners with minimum thickness of

$$t_{min} = \frac{F_{y\ beam}}{F_{y\ stiffener}} \times t_w$$

but not less than $2w$ for stiffeners with F_y = 36 ksi nor $1.5w$ for stiffeners with F_y = 50 ksi. In the above, t_w is the thickness of the unstiffened supported beam web and w is the nominal weld size.
3. Tabulated values may be limited by shear yielding of or bearing on the stiffener; refer to LRFD Specification Sections F2.2 and J8, respectively.

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$

SINGLE-PLATE CONNECTIONS

A single-plate connection is made with a plate, as illustrated in Figure 10–11. The plate is always welded to the support on both sides of the plate and bolted to the supported member.

Design Checks

The available strength of a single-plate connection is determined from the applicable limit states for the bolts (see Part 7), welds (see Part 8), and connecting elements (see Part 9). In all cases, the available strength, ϕR_n or R_n/Ω, must equal or exceed the required strength, R_u or R_a, respectively.

Single-plate shear connections that satisfy the corresponding dimensional limitations can be designed using the simplified design procedure for the "conventional" configuration. Other single-plate shear connections can be designed using the procedure for the "extended" configuration, which is applicable to any configuration of single-plate shear connections, regardless of connection geometry.

Both the conventional and extended configurations permit the use of ASTM A325, F1852, or A490 bolts. The procedure is valid for bolts that are snug-tightened, pretensioned, or slip-critical. In both the conventional and extended configuration, the design recommendations are equally applicable to plate and beam web material with F_y = 36 ksi or 50 ksi. In both cases, the weld between the single plate and the support should be sized as $^5/_8 t_p$, which will develop the strength of either a 36 ksi or 50 ksi plate.

Conventional Configuration

The following method may be used when the dimensional and other limitations upon which it is based are satisfied.

Dimensional Limitations

1. Only a single vertical row of bolts is permitted. The number of bolts in the connection, n, is limited to 2 to 12.
2. The distance from the bolt line to the weld line, a, must be equal to or less than $3^1/_2$ in.

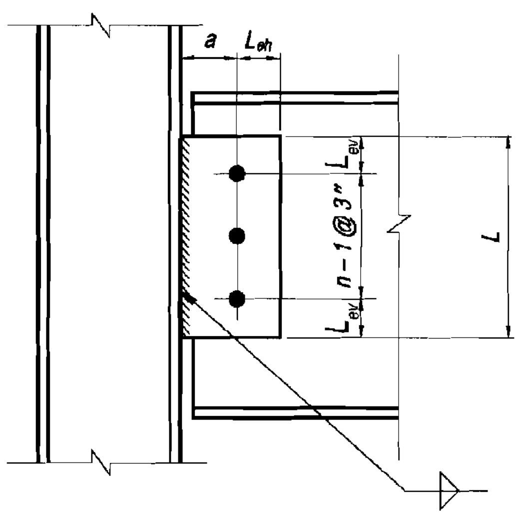


Figure 10–11. Single-plate connection.

3. STD or SSL holes are permitted to be used.
4. The horizontal edge distance, L_{eh}, must be equal to or greater than $2d_b$ for both the plate and the beam web. Note that L_{eh} is measured to the center of the hole or slot.
5. The vertical edge distance, L_{ev}, must satisfy AISC Specification Table J3.4 requirements.
6. Either the plate or the beam web must satisfy $t \le d_b/2 + {}^1/_{16}$ in.

Design Checks

1. The connection must be checked for bolt shear, block shear rupture, and bolt bearing. For STD holes, eccentricity can be ignored when the number of bolts, n, is less than or equal to 9. For connections with 10 to 12 bolts, use $e = n - 4$ and a 1.25 multiplier on the calculated eccentricity coefficient C. For SSL holes, eccentricity can be ignored up to $n = 12$.
2. Check the plate for shear yielding and shear rupture. Plate buckling will not control for the conventional configuration.

Extended Configuration

The following method is useful when the dimensional and other limitations of the conventional method cannot be satisfied. This procedure can be used to determine the strength of single plate shear connections with multiple vertical rows or in the extended configuration, as shown in Figure 10–12.

Dimensional Limitations

1. The number of bolts, n, is not limited.
2. The distance from the bolt line to the weld line, a, is not limited.
3. The use of holes must satisfy AISC Specification Section J3.2 requirements.
4. The horizontal and vertical edge distances, L_{eh} and L_{ev}, must satisfy AISC Specification Table J3.4 requirements.

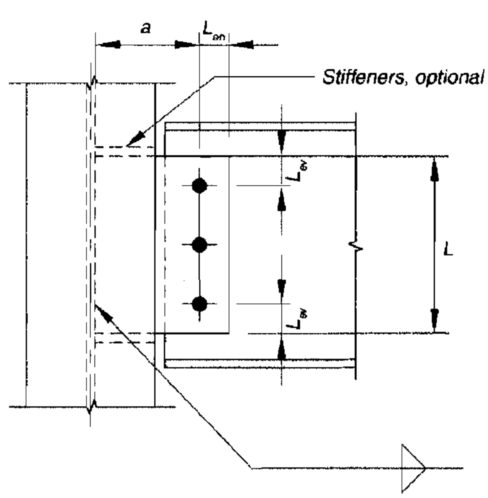


Figure 10–12. Extended single-plate connection.

Design Checks

1. Determine the bolt group required for bolt shear and bolt bearing with eccentricity $e = a$, where a is defined as the distance from the support to the first row of bolts. Exception: alternative considerations of the design eccentricity are acceptable when justified by rational analysis. For example, see Sherman and Ghorbanpoor (2002).
2. Determine the maximum plate thickness permitted such that the plate moment strength does not exceed the moment strength of the bolt group in shear, as follows:

$$t_{max} = \frac{6M_{max}}{F_y d^2}$$

where

$M_{max} = 1.25F_v A_b C'$

$1.25F_v$ = shear strength of an individual bolt from AISC Specification Table J3.2, ksi, multiplied by a factor of 1.25 to remove the 20 percent reduction for uneven for distribution in end-loaded bolt groups (Kulak, 2002). The joint in question is not end-loaded.

A_b = area of an individual bolt, in.^{2}

C' = coefficient from Part 7 for the moment-only case (instantaneous center of rotation at the centroid of the bolt group)

F_y = plate specified yield stress, ksi

d = plate depth, in.

The foregoing check is made at the nominal strength level, since the check is to ensure ductility, not strength.

Exceptions:

a. For a single vertical row of bolts only, the foregoing criterion need not be satisfied if either the beam web or the plate satisfies $t \le d_b/2 + {}^1/_{16}$ and both satisfy $L_{eh} \ge 2d_b$.

b. For a double vertical row of bolts only, the foregoing criterion need not be satisfied if both the beam web and the plate satisfy $t \le d_b/2 + {}^1/_{16}$ and $L_{eh} \ge 2d_b$.

3. Check the plate for shear yielding, shear rupture, and block shear rupture.
4. Check the plate for flexure with the von-Mises shear reduction. That is, check the available flexural yielding strength of the plate, ϕM_n or M_n/Ω, based upon a critical stress, F_{cr}, as follows:

$$F_{cr} = \sqrt{F_y^2 - 3f_v^2}$$

$$M_n = F_{cr} Z$$

$$\phi = 0.90 \qquad \Omega = 1.67$$

5. Check the plate for buckling using the double-coped beam procedure given in Part 9.
6. Ensure that the supported beam is braced at points of support.

The design procedure for extended single-plate shear connections permits the column to be designed for an axial force without eccentricity. In some cases, economy may be gained by considering alternative design procedures that allow the transfer of some moment into the support, for example, 5 percent of the beam fixed-end moment, provided that this moment is also considered in the design of the supporting member.

Recommended Plate Length

To provide for stability during erection, it is recommended that the minimum plate length be one-half the T-dimension of the beam to be supported. The maximum length of the plate must be compatible with the T-dimension of an uncoped beam and the remaining web depth, exclusive of fillets, of a coped beam. Note that the plate may encroach upon the fillet(s) as given in Figure 10–3.

Shop and Field Practices

Conventional and extended single-plate connections may be made to the webs of supporting girders and to the flanges of supporting columns. Extended single-plate connections are suitable for connections to the webs of supporting columns when the bolt line is located a sufficient distance beyond the column flanges.

With the plate shop-attached to the support, side erection of the beam is permitted. Play in the open holes usually compensates for mill variation in column flange supports and other field adjustments.

Table 10–9. Single-Plate Connections

Table 10–9 is a design aid for single-plate connections welded to the support and bolted to the supported beam. Available strengths are tabulated for plate material with $F_y = 36$ ksi and $F_u = 58$ ksi.

Tabulated bolt and plate available strengths consider the limit-states of bolt shear, bolt bearing on the plate, shear yielding of the plate, shear rupture of the plate, block shear rupture of the plate, and weld shear. Values are tabulated for two through twelve rows of $^3/_4$-in., $^7/_8$-in., 1-in. and $1^1/_8$-in. diameter ASTM A325, F1852, and A490 bolts at 3-in. spacing. For calculation purposes, plate edge distance, L_{ev}, is in accordance with AISC Specification Section J3.10 and Table J3.4. End distance, L_{eh}, is provided as 2 times the diameter of the bolt, to match tested connections. Weld sizes are tabulated equal to $^5/_8 t_p$.

While the tabular values are based on $a = 3$ in., they may conservatively be used when the distance from the support to the bolt line, a, is between $2^1/_2$ in. and 3 in. The tabulated values are valid for laterally supported beams in steel and composite construction, all types of loading, snug-tightened or pretensioned bolts, and for supported and supporting members of all grades of steel.

Table 10-9a
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 36 ksi

3/4-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	7/16 ASD	7/16 LRFD	1/2 ASD	1/2 LRFD	9/16 ASD	9/16 LRFD
12 ($L = 35^1/_2$)	A325 F1852	N	STD	100	150	118	178	118	178	118	178	—	—	—	—
			SSLT	99.5	149	124	187	127	191	127	191	—	—	—	—
		X	STD	100	150	125	188	148	222	148	222	—	—	—	—
			SSLT	99.5	149	124	187	149	224	159	239	—	—	—	—
	A490	N	STD	100	150	125	188	148	222	148	222	—	—	—	—
			SSLT	99.5	149	124	187	149	224	159	239	—	—	—	—
		X	STD	100	150	125	188	150	225	175	263	—	—	—	—
			SSLT	99.5	149	124	187	149	224	174	261	—	—	—	—
11 ($L = 32^1/_2$)	A325 F1852	N	STD	92.1	138	111	166	111	166	111	166	—	—	—	—
			SSLT	91.4	137	114	171	117	175	117	175	—	—	—	—
		X	STD	92.1	138	115	173	138	207	139	208	—	—	—	—
			SSLT	91.4	137	114	171	137	206	146	219	—	—	—	—
	A490	N	STD	92.1	138	115	173	138	207	139	208	—	—	—	—
			SSLT	91.4	137	114	171	137	206	146	219	—	—	—	—
		X	STD	92.1	138	115	173	138	207	161	242	—	—	—	—
			SSLT	91.4	137	114	171	137	206	160	240	—	—	—	—
10 ($L = 29^1/_2$)	A325 F1852	N	STD	84.0	126	103	155	103	155	103	155	—	—	—	—
			SSLT	83.3	125	104	156	106	159	106	159	—	—	—	—
		X	STD	84.0	126	105	157	126	189	129	194	—	—	—	—
			SSLT	83.3	125	104	156	125	187	133	199	—	—	—	—
	A490	N	STD	84.0	126	105	157	126	189	129	194	—	—	—	—
			SSLT	83.3	125	104	156	125	187	133	199	—	—	—	—
		X	STD	84.0	126	105	157	126	189	147	220	—	—	—	—
			SSLT	83.3	125	104	156	125	187	146	219	—	—	—	—
9 ($L = 26^1/_2$)	A325 F1852	N	STD	75.9	114	94.8	142	95.4	143	95.4	143	—	—	—	—
			SSLT	75.2	113	94.0	141	95.4	143	95.4	143	—	—	—	—
		X	STD	75.9	114	94.8	142	114	171	119	179	—	—	—	—
			SSLT	75.2	113	94.0	141	113	169	119	179	—	—	—	—
	A490	N	STD	75.9	114	94.8	142	114	171	119	179	—	—	—	—
			SSLT	75.2	113	94.0	141	113	169	119	179	—	—	—	—
		X	STD	75.9	114	94.8	142	114	171	133	199	—	—	—	—
			SSLT	75.2	113	94.0	141	113	169	132	197	—	—	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

3/4-in. diameter bolts

Table 10–9a (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 36 ksi

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	7/16 ASD	7/16 LRFD	1/2 ASD	1/2 LRFD	9/16 ASD	9/16 LRFD
8 (L = 23 1/2)	A325 F1852	N	STD	67.8	102	84.7	127	84.8	127	84.8	127	—	—	—	—
			SSLT	67.1	101	83.9	126	84.8	127	84.8	127	—	—	—	—
		X	STD	67.8	102	84.7	127	102	153	106	159	—	—	—	—
			SSLT	67.1	101	83.9	126	101	151	106	159	—	—	—	—
	A490	N	STD	67.8	102	84.7	127	102	153	106	159	—	—	—	—
			SSLT	67.1	101	83.9	126	101	151	106	159	—	—	—	—
		X	STD	67.8	102	84.7	127	102	153	119	178	—	—	—	—
			SSLT	67.1	101	83.9	126	101	151	117	176	—	—	—	—
7 (L = 20 1/2)	A325 F1852	N	STD	59.7	89.5	74.2	111	74.2	111	74.2	111	—	—	—	—
			SSLT	59.0	88.5	73.7	111	74.2	111	74.2	111	—	—	—	—
		X	STD	59.7	89.5	74.6	112	89.5	134	92.8	139	—	—	—	—
			SSLT	59.0	88.5	73.7	111	88.5	133	92.8	139	—	—	—	—
	A490	N	STD	59.7	89.5	74.6	112	89.5	134	92.8	139	—	—	—	—
			SSLT	59.0	88.5	73.7	111	88.5	133	92.8	139	—	—	—	—
		X	STD	59.7	89.5	74.6	112	89.5	134	104	157	—	—	—	—
			SSLT	59.0	88.5	73.7	111	88.5	133	103	155	—	—	—	—
6 (L = 17 1/2)	A325 F1852	N	STD	51.6	77.4	63.6	95.4	63.6	95.4	63.6	95.4	—	—	—	—
			SSLT	50.9	76.3	63.6	95.4	63.6	95.4	63.6	95.4	—	—	—	—
		X	STD	51.6	77.4	64.5	96.7	77.4	116	79.5	119	—	—	—	—
			SSLT	50.9	76.3	63.6	95.4	76.3	115	79.5	119	—	—	—	—
	A490	N	STD	51.6	77.4	64.5	96.7	77.4	116	79.5	119	—	—	—	—
			SSLT	50.9	76.3	63.6	95.4	76.3	115	79.5	119	—	—	—	—
		X	STD	51.6	77.4	64.5	96.7	77.4	116	90.3	135	—	—	—	—
			SSLT	50.9	76.3	63.6	95.4	76.3	115	89.1	134	—	—	—	—
5 (L = 14 1/2)	A325 F1852	N	STD	43.5	65.2	53.0	79.5	53.0	79.5	53.0	79.5	—	—	—	—
			SSLT	42.8	64.2	53.0	79.5	53.0	79.5	53.0	79.5	—	—	—	—
		X	STD	43.5	65.2	54.3	81.5	65.2	97.8	66.3	99.4	—	—	—	—
			SSLT	42.8	64.2	53.5	80.2	64.2	96.3	66.3	99.4	—	—	—	—
	A490	N	STD	43.5	65.2	54.3	81.5	65.2	97.8	66.3	99.4	—	—	—	—
			SSLT	42.8	64.2	53.5	80.2	64.2	96.3	66.3	99.4	—	—	—	—
		X	STD	43.5	65.2	54.3	81.5	65.2	97.8	76.1	114	—	—	—	—
			SSLT	42.8	64.2	53.5	80.2	64.2	96.3	74.9	112	—	—	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

Plate
F_y = 36 ksi

Table 10-9a (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

3/4-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	7/16 ASD	7/16 LRFD	1/2 ASD	1/2 LRFD	9/16 ASD	9/16 LRFD
4 (L = 11 1/2)	A325 F1852	N	STD	34.8	52.2	42.4	63.6	42.4	63.6	42.4	63.6	—	—	—	—
			SSLT	34.7	52.0	42.4	63.6	42.4	63.6	42.4	63.6	—	—	—	—
		X	STD	34.8	52.2	43.5	65.3	52.2	78.3	53.0	79.5	—	—	—	—
			SSLT	34.7	52.0	43.4	65.1	52.0	78.1	53.0	79.5	—	—	—	—
	A490	N	STD	34.8	52.2	43.5	65.3	52.2	78.3	53.0	79.5	—	—	—	—
			SSLT	34.7	52.0	43.4	65.1	52.0	78.1	53.0	79.5	—	—	—	—
		X	STD	34.8	52.2	43.5	65.3	52.2	78.3	60.9	91.4	—	—	—	—
			SSLT	34.7	52.0	43.4	65.1	52.0	78.1	60.7	91.1	—	—	—	—
3 (L = 8 1/2)	A325 F1852	N	STD	25.6	38.3	31.8	47.7	31.8	47.7	31.8	47.7	—	—	—	—
			SSLT	25.6	38.3	31.8	47.7	31.8	47.7	31.8	47.7	—	—	—	—
		X	STD	25.6	38.3	31.9	47.9	38.3	57.5	39.8	59.6	—	—	—	—
			SSLT	25.6	38.3	31.9	47.9	38.3	57.5	39.8	59.6	—	—	—	—
	A490	N	STD	25.6	38.3	31.9	47.9	38.3	57.5	39.8	59.6	—	—	—	—
			SSLT	25.6	38.3	31.9	47.9	38.3	57.5	39.8	59.6	—	—	—	—
		X	STD	25.6	38.3	31.9	47.9	38.3	57.5	44.7	67.1	—	—	—	—
			SSLT	25.6	38.3	31.9	47.9	38.3	57.5	44.7	67.1	—	—	—	—
2 (L = 5 1/2)	A325 F1852	N	STD	16.3	24.5	20.4	30.6	21.2	31.8	21.2	31.8	—	—	—	—
			SSLT	16.3	24.5	20.4	30.6	21.2	31.8	21.2	31.8	—	—	—	—
		X	STD	16.3	24.5	20.4	30.6	24.5	36.7	26.5	39.8	—	—	—	—
			SSLT	16.3	24.5	20.4	30.6	24.5	36.7	26.5	39.8	—	—	—	—
	A490	N	STD	16.3	24.5	20.4	30.6	24.5	36.7	26.5	39.8	—	—	—	—
			SSLT	16.3	24.5	20.4	30.6	24.5	36.7	26.5	39.8	—	—	—	—
		X	STD	16.3	24.5	20.4	30.6	24.5	36.7	28.5	42.8	—	—	—	—
			SSLT	16.3	24.5	20.4	30.6	24.5	36.7	28.5	42.8	—	—	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

7/8-in. diameter bolts

Table 10–9a (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 36 ksi

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				1/4		5/16		3/8		7/16		1/2		9/16	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
12 (*L* = 36)	A325 F1852	N	STD	102	153	128	192	153	230	161	242	161	242	—	—
			SSLT	102	152	127	190	152	228	173	260	173	260	—	—
		X	STD	102	153	128	192	153	230	179	268	201	302	—	—
			SSLT	102	152	127	190	152	228	178	267	203	305	—	—
	A490	N	STD	102	153	128	192	153	230	179	268	201	302	—	—
			SSLT	102	152	127	190	152	228	178	267	203	305	—	—
		X	STD	102	153	128	192	153	230	179	268	204	307	—	—
			SSLT	102	152	127	190	152	228	178	267	203	305	—	—
11 (*L* = 33)	A325 F1852	N	STD	94.1	141	118	176	141	212	151	226	151	226	—	—
			SSLT	93.4	140	117	175	140	210	159	238	159	238	—	—
		X	STD	94.1	141	118	176	141	212	165	247	188	282	—	—
			SSLT	93.4	140	117	175	140	210	164	245	187	280	—	—
	A490	N	STD	94.1	141	118	176	141	212	165	247	188	282	—	—
			SSLT	93.4	140	117	175	140	210	164	245	187	280	—	—
		X	STD	94.1	141	118	176	141	212	165	247	188	282	—	—
			SSLT	93.4	140	117	175	140	210	164	245	187	280	—	—
10 (*L* = 30)	A325 F1852	N	STD	86.0	129	108	161	129	194	141	211	141	211	—	—
			SSLT	85.3	128	107	160	128	192	144	216	144	216	—	—
		X	STD	86.0	129	108	161	129	194	151	226	172	258	—	—
			SSLT	85.3	128	107	160	128	192	149	224	171	256	—	—
	A490	N	STD	86.0	129	108	161	129	194	151	226	172	258	—	—
			SSLT	85.3	128	107	160	128	192	149	224	171	256	—	—
		X	STD	86.0	129	108	161	129	194	151	226	172	258	—	—
			SSLT	85.3	128	107	160	128	192	149	224	171	256	—	—
9 (*L* = 27)	A325 F1852	N	STD	77.9	117	97.4	146	117	175	130	195	130	195	—	—
			SSLT	77.2	116	96.5	145	116	174	130	195	130	195	—	—
		X	STD	77.9	117	97.4	146	117	175	136	205	156	234	—	—
			SSLT	77.2	116	96.5	145	116	174	135	203	154	232	—	—
	A490	N	STD	77.9	117	97.4	146	117	175	136	205	156	234	—	—
			SSLT	77.2	116	96.5	145	116	174	135	203	154	232	—	—
		X	STD	77.9	117	97.4	146	117	175	136	205	156	234	—	—
			SSLT	77.2	116	96.5	145	116	174	135	203	154	232	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

Table 10–9a (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 36 ksi

7/8-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	7/16 ASD	7/16 LRFD	1/2 ASD	1/2 LRFD	9/16 ASD	9/16 LRFD
8 (*L* = 24)	A325 F1852	N	STD	69.6	104	87.0	131	104	157	115	173	115	173	—	—
			SSLT	69.1	104	86.4	130	104	156	115	173	115	173	—	—
		X	STD	69.6	104	87.0	131	104	157	122	183	139	209	—	—
			SSLT	69.1	104	86.4	130	104	156	121	181	138	207	—	—
	A490	N	STD	69.6	104	87.0	131	104	157	122	183	139	209	—	—
			SSLT	69.1	104	86.4	130	104	156	121	181	138	207	—	—
		X	STD	69.6	104	87.0	131	104	157	122	183	139	209	—	—
			SSLT	69.1	104	86.4	130	104	156	121	181	138	207	—	—
7 (*L* = 21)	A325 F1852	N	STD/SSLT	60.9	91.4	76.1	114	91.4	137	101	152	101	152	—	—
		X		60.9	91.4	76.1	114	91.4	137	107	160	122	183	—	—
	A490	N		60.9	91.4	76.1	114	91.4	137	107	160	122	183	—	—
		X		60.9	91.4	76.1	114	91.4	137	107	160	122	183	—	—
6 (*L* = 18)	A325 F1852	N	STD/SSLT	52.2	78.3	65.3	97.9	78.3	117	86.6	130	86.6	130	—	—
		X		52.2	78.3	65.3	97.9	78.3	117	91.4	137	104	157	—	—
	A490	N		52.2	78.3	65.3	97.9	78.3	117	91.4	137	104	157	—	—
		X		52.2	78.3	65.3	97.9	78.3	117	91.4	137	104	157	—	—
5 (*L* = 15)	A325 F1852	N	STD/SSLT	43.5	65.3	54.4	81.6	65.3	97.9	72.2	108	72.2	108	—	—
		X		43.5	65.3	54.4	81.6	65.3	97.9	76.1	114	87.0	131	—	—
	A490	N		43.5	65.3	54.4	81.6	65.3	97.9	76.1	114	87.0	131	—	—
		X		43.5	65.3	54.4	81.6	65.3	97.9	76.1	114	87.0	131	—	—
4 (*L* = 12)	A325 F1852	N	STD/SSLT	34.8	52.2	43.5	65.3	52.2	78.3	57.7	86.6	57.7	86.6	—	—
		X		34.8	52.2	43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	—	—
	A490	N		34.8	52.2	43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	—	—
		X		34.8	52.2	43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	—	—
3 (*L* = 9)	A325 F1852	N	STD/SSLT	26.1	39.1	32.6	48.9	39.1	58.7	43.3	64.9	43.3	64.9	—	—
		X		26.1	39.1	32.6	48.9	39.1	58.7	45.7	68.5	52.2	78.3	—	—
	A490	N		26.1	39.1	32.6	48.9	39.1	58.7	45.7	68.5	52.2	78.3	—	—
		X		26.1	39.1	32.6	48.9	39.1	58.7	45.7	68.5	52.2	78.3	—	—
2 (*L* = 6)	A325 F1852	N	STD/SSLT	17.4	26.1	21.8	32.6	26.1	39.1	28.9	43.3	28.9	43.3	—	—
		X		17.4	26.1	21.8	32.6	26.1	39.1	30.4	45.7	34.8	52.2	—	—
	A490	N		17.4	26.1	21.8	32.6	26.1	39.1	30.4	45.7	34.8	52.2	—	—
		X		17.4	26.1	21.8	32.6	26.1	39.1	30.4	45.7	34.8	52.2	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes

SSLT = Short-slotted holes transverse to direction of load

STD/SSLT = Standard holes or short-slotted holes transverse to direction of load

– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.

Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included

X = Threads Excluded

1-in. diameter bolts

Table 10–9a (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 36 ksi

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				1/4		5/16		3/8		7/16		1/2		9/16	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
12 (L = 36 1/2)	A325 F1852	N	STD	100	150	125	188	150	225	175	263	200	300	210	316
			SSLT	100	150	125	188	150	225	175	263	200	300	225	338
		X	STD	100	150	125	188	150	225	175	263	200	300	225	338
			SSLT	100	150	125	188	150	225	175	263	200	300	225	338
	A490	N	STD	100	150	125	188	150	225	175	263	200	300	225	338
			SSLT	100	150	125	188	150	225	175	263	200	300	225	338
		X	STD	100	150	125	188	150	225	175	263	200	300	225	338
			SSLT	100	150	125	188	150	225	175	263	200	300	225	338
11 (L = 33 1/2)	A325 F1852	N	STD	91.9	138	115	172	138	207	161	241	184	276	197	295
			SSLT	91.9	138	115	172	138	207	161	241	184	276	207	310
		X	STD	91.9	138	115	172	138	207	161	241	184	276	207	310
			SSLT	91.9	138	115	172	138	207	161	241	184	276	207	310
	A490	N	STD	91.9	138	115	172	138	207	161	241	184	276	207	310
			SSLT	91.9	138	115	172	138	207	161	241	184	276	207	310
		X	STD	91.9	138	115	172	138	207	161	241	184	276	207	310
			SSLT	91.9	138	115	172	138	207	161	241	184	276	207	310
10 (L = 30 1/2)	A325 F1852	N	STD	83.7	126	105	157	126	188	147	220	167	251	184	275
			SSLT	83.7	126	105	157	126	188	147	220	167	251	188	283
		X	STD	83.7	126	105	157	126	188	147	220	167	251	188	283
			SSLT	83.7	126	105	157	126	188	147	220	167	251	188	283
	A490	N	STD	83.7	126	105	157	126	188	147	220	167	251	188	283
			SSLT	83.7	126	105	157	126	188	147	220	167	251	188	283
		X	STD	83.7	126	105	157	126	188	147	220	167	251	188	283
			SSLT	83.7	126	105	157	126	188	147	220	167	251	188	283
9 (L = 27 1/2)	A325 F1852	N	STD/SSLT	75.6	113	94.5	142	113	170	132	198	151	227	170	254
		X		75.6	113	94.5	142	113	170	132	198	151	227	170	255
	A490	N		75.6	113	94.5	142	113	170	132	198	151	227	170	255
		X		75.6	113	94.5	142	113	170	132	198	151	227	170	255
8 (L = 24 1/2)	A325 F1852	N	STD/SSLT	67.4	101	84.3	126	101	152	118	177	135	202	151	226
		X		67.4	101	84.3	126	101	152	118	177	135	202	152	228
	A490	N		67.4	101	84.3	126	101	152	118	177	135	202	152	228
		X		67.4	101	84.3	126	101	152	118	177	135	202	152	228
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes

SSLT = Short-slotted holes transverse to direction of load

STD/SSLT = Standard holes or short-slotted holes transverse to direction of load

Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included

X = Threads Excluded

Table 10–9a (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 36 ksi

1-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				1/4		5/16		3/8		7/16		1/2		9/16	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
7 ($L = 21^1/_2$)	A325	N	STD/SSLT	59.3	88.9	74.1	111	88.9	133	104	156	119	178	132	198
	F1852	X		59.3	88.9	74.1	111	88.9	133	104	156	119	178	133	200
	A490	N		59.3	88.9	74.1	111	88.9	133	104	156	119	178	133	200
		X		59.3	88.9	74.1	111	88.9	133	104	156	119	178	133	200
6 ($L = 18^1/_2$)	A325	N	STD/SSLT	51.1	76.7	63.9	95.8	76.7	115	89.4	134	102	153	113	170
	F1852	X		51.1	76.7	63.9	95.8	76.7	115	89.4	134	102	153	115	173
	A490	N		51.1	76.7	63.9	95.8	76.7	115	89.4	134	102	153	115	173
		X		51.1	76.7	63.9	95.8	76.7	115	89.4	134	102	153	115	173
5 ($L = 15^1/_2$)	A325	N	STD/SSLT	43.0	64.4	53.7	80.5	64.4	96.7	75.2	113	85.9	129	94.2	141
	F1852	X		43.0	64.4	53.7	80.5	64.4	96.7	75.2	113	85.9	129	96.7	145
	A490	N		43.0	64.4	53.7	80.5	64.4	96.7	75.2	113	85.9	129	96.7	145
		X		43.0	64.4	53.7	80.5	64.4	96.7	75.2	113	85.9	129	96.7	145
4 ($L = 12^1/_2$)	A325	N	STD/SSLT	34.8	52.2	43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	75.4	113
	F1852	X		34.8	52.2	43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	78.3	117
	A490	N		34.8	52.2	43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	78.3	117
		X		34.8	52.2	43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	78.3	117
3 ($L = 9^1/_2$)	A325	N	STD/SSLT	26.6	40.0	33.3	50.0	40.0	59.9	46.6	69.9	53.3	79.9	56.5	84.8
	F1852	X		26.6	40.0	33.3	50.0	40.0	59.9	46.6	69.9	53.3	79.9	59.9	89.9
	A490	N		26.6	40.0	33.3	50.0	40.0	59.9	46.6	69.9	53.3	79.9	59.9	89.9
		X		26.6	40.0	33.3	50.0	40.0	59.9	46.6	69.9	53.3	79.9	59.9	89.9
2 ($L = 6^1/_2$)	A325	N	STD/SSLT	18.5	27.7	23.1	34.7	27.7	41.6	32.4	48.5	37.0	55.5	37.7	56.5
	F1852	X		18.5	27.7	23.1	34.7	27.7	41.6	32.4	48.5	37.0	55.5	41.6	62.4
	A490	N		18.5	27.7	23.1	34.7	27.7	41.6	32.4	48.5	37.0	55.5	41.6	62.4
		X		18.5	27.7	23.1	34.7	27.7	41.6	32.4	48.5	37.0	55.5	41.6	62.4
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

$1\frac{1}{8}$-in. diameter bolts

Table 10–9a (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 36 ksi

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				5/16		3/8		7/16		1/2		9/16		5/8	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
12 (*L* = 37)	A325 F1852	N	STD	120	179	144	215	167	251	191	287	215	323	239	359
			SSLT	120	179	144	215	167	251	191	287	215	323	239	359
		X	STD	120	179	144	215	167	251	191	287	215	323	239	359
			SSLT	120	179	144	215	167	251	191	287	215	323	239	359
	A490	N	STD	120	179	144	215	167	251	191	287	215	323	239	359
			SSLT	120	179	144	215	167	251	191	287	215	323	239	359
		X	STD	120	179	144	215	167	251	191	287	215	323	239	359
			SSLT	120	179	144	215	167	251	191	287	215	323	239	359
11 (*L* = 34)	A325 F1852	N	STD	110	165	132	198	154	231	176	264	198	297	220	330
			SSLT	110	165	132	198	154	231	176	264	198	297	220	330
		X	STD	110	165	132	198	154	231	176	264	198	297	220	330
			SSLT	110	165	132	198	154	231	176	264	198	297	220	330
	A490	N	STD	110	165	132	198	154	231	176	264	198	297	220	330
			SSLT	110	165	132	198	154	231	176	264	198	297	220	330
		X	STD	110	165	132	198	154	231	176	264	198	297	220	330
			SSLT	110	165	132	198	154	231	176	264	198	297	220	330
10 (*L* = 31)	A325 F1852	N	STD	101	151	121	181	141	211	161	241	181	272	201	302
			SSLT	101	151	121	181	141	211	161	241	181	272	201	302
		X	STD	101	151	121	181	141	211	161	241	181	272	201	302
			SSLT	101	151	121	181	141	211	161	241	181	272	201	302
	A490	N	STD	101	151	121	181	141	211	161	241	181	272	201	302
			SSLT	101	151	121	181	141	211	161	241	181	272	201	302
		X	STD	101	151	121	181	141	211	161	241	181	272	201	302
			SSLT	101	151	121	181	141	211	161	241	181	272	201	302
9 (*L* = 28)	A325 F1852	N	STD/ SSLT	91.1	137	109	164	128	191	146	219	164	246	182	273
		X		91.1	137	109	164	128	191	146	219	164	246	182	273
	A490	N		91.1	137	109	164	128	191	146	219	164	246	182	273
		X		91.1	137	109	164	128	191	146	219	164	246	182	273
8 (*L* = 25)	A325 F1852	N	STD/ SSLT	81.6	122	97.9	147	114	171	131	196	147	220	163	245
		X		81.6	122	97.9	147	114	171	131	196	147	220	163	245
	A490	N		81.6	122	97.9	147	114	171	131	196	147	220	163	245
		X		81.6	122	97.9	147	114	171	131	196	147	220	163	245
Weld Size				1/4		1/4		5/16		5/16		3/8		7/16	

STD = Standard Holes

SSLT = Short-slotted holes transverse to direction of load

STD/SSLT = Standard holes or short-slotted holes transverse to direction of load

Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included

X = Threads Excluded

Plate
F_y = 36 ksi

Table 10–9a (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

1⅛-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				5/16		3/8		7/16		1/2		9/16		5/8	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
7 (*L* = 22)	A325	N	STD/ SSLT	72.0	108	86.5	130	101	151	115	173	130	195	144	216
	F1852	X		72.0	108	86.5	130	101	151	115	173	130	195	144	216
	A490	N		72.0	108	86.5	130	101	151	115	173	130	195	144	216
		X		72.0	108	86.5	130	101	151	115	173	130	195	144	216
6 (*L* = 19)	A325	N	STD/ SSLT	62.5	93.8	75.0	113	87.5	131	100	150	113	169	125	188
	F1852	X		62.5	93.8	75.0	113	87.5	131	100	150	113	169	125	188
	A490	N		62.5	93.8	75.0	113	87.5	131	100	150	113	169	125	188
		X		62.5	93.8	75.0	113	87.5	131	100	150	113	169	125	188
5 (*L* = 16)	A325	N	STD/ SSLT	53.0	79.5	63.6	95.4	74.2	111	84.8	127	95.4	143	106	159
	F1852	X		53.0	79.5	63.6	95.4	74.2	111	84.8	127	95.4	143	106	159
	A490	N		53.0	79.5	63.6	95.4	74.2	111	84.8	127	95.4	143	106	159
		X		53.0	79.5	63.6	95.4	74.2	111	84.8	127	95.4	143	106	159
4 (*L* = 13)	A325	N	STD/ SSLT	43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	78.3	117	87.0	131
	F1852	X		43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	78.3	117	87.0	131
	A490	N		43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	78.3	117	87.0	131
		X		43.5	65.3	52.2	78.3	60.9	91.4	69.6	104	78.3	117	87.0	131
3 (*L* = 10)	A325	N	STD/ SSLT	34.0	51.0	40.8	61.2	47.6	71.4	54.4	81.6	61.2	91.8	68.0	102
	F1852	X		34.0	51.0	40.8	61.2	47.6	71.4	54.4	81.6	61.2	91.8	68.0	102
	A490	N		34.0	51.0	40.8	61.2	47.6	71.4	54.4	81.6	61.2	91.8	68.0	102
		X		34.0	51.0	40.8	61.2	47.6	71.4	54.4	81.6	61.2	91.8	68.0	102
2 (*L* = 7)	A325	N	STD/ SSLT	24.5	36.7	29.4	44.0	34.3	51.4	39.1	58.7	44.0	66.1	47.7	71.6
	F1852	X		24.5	36.7	29.4	44.0	34.3	51.4	39.1	58.7	44.0	66.1	48.9	73.4
	A490	N		24.5	36.7	29.4	44.0	34.3	51.4	39.1	58.7	44.0	66.1	48.9	73.4
		X		24.5	36.7	29.4	44.0	34.3	51.4	39.1	58.7	44.0	66.1	48.9	73.4
Weld Size				1/4		1/4		5/16		5/16		3/8		7/16	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

3/4-in. diameter bolts

Table 10–9b
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 50 ksi

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				1/4		5/16		3/8		7/16		1/2		9/16	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
12 (L = 35 1/2)	A325 F1852	N	STD	118	178	118	178	118	178	118	178	—	—	—	—
			SSLT	122	183	127	191	127	191	127	191	—	—	—	—
		X	STD	122	183	148	222	148	222	148	222	—	—	—	—
			SSLT	122	183	152	229	159	239	159	239	—	—	—	—
	A490	N	STD	122	183	148	222	148	222	148	222	—	—	—	—
			SSLT	122	183	152	229	159	239	159	239	—	—	—	—
		X	STD	122	183	152	229	183	274	185	277	—	—	—	—
			SSLT	122	183	152	229	183	274	199	298	—	—	—	—
11 (L = 32 1/2)	A325 F1852	N	STD	111	166	111	166	111	166	111	166	—	—	—	—
			SSLT	112	167	117	175	117	175	117	175	—	—	—	—
		X	STD	112	167	139	208	139	208	139	208	—	—	—	—
			SSLT	112	167	139	209	146	219	146	219	—	—	—	—
	A490	N	STD	112	167	139	208	139	208	139	208	—	—	—	—
			SSLT	112	167	139	209	146	219	146	219	—	—	—	—
		X	STD	112	167	139	209	167	251	173	260	—	—	—	—
			SSLT	112	167	139	209	167	251	182	273	—	—	—	—
10 (L = 29 1/2)	A325 F1852	N	STD	101	152	103	155	103	155	103	155	—	—	—	—
			SSLT	101	152	106	159	106	159	106	159	—	—	—	—
		X	STD	101	152	126	190	129	194	129	194	—	—	—	—
			SSLT	101	152	126	190	133	199	133	199	—	—	—	—
	A490	N	STD	101	152	126	190	129	194	129	194	—	—	—	—
			SSLT	101	152	126	190	133	199	133	199	—	—	—	—
		X	STD	101	152	126	190	152	228	161	242	—	—	—	—
			SSLT	101	152	126	190	152	228	166	249	—	—	—	—
9 (L = 26 1/2)	A325 F1852	N	STD/SSLT	90.8	136	95.4	143	95.4	143	95.4	143	—	—	—	—
		X		90.8	136	113	170	119	179	119	179	—	—	—	—
	A490	N		90.8	136	113	170	119	179	119	179	—	—	—	—
		X		90.8	136	113	170	136	204	149	224	—	—	—	—
8 (L = 23 1/2)	A325 F1852	N	STD/SSLT	80.4	121	84.8	127	84.8	127	84.8	127	—	—	—	—
		X		80.4	121	101	151	106	159	106	159	—	—	—	—
	A490	N		80.4	121	101	151	106	159	106	159	—	—	—	—
		X		80.4	121	101	151	121	181	133	199	—	—	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

Plate
F_y = 50 ksi

Table 10–9b (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

3/4-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	7/16 ASD	7/16 LRFD	1/2 ASD	1/2 LRFD	9/16 ASD	9/16 LRFD
7 (L = 20 1/2)	A325	N	STD/SSLT	70.1	105	74.2	111	74.2	111	74.2	111	—	—	—	—
	F1852	X		70.1	105	87.6	131	92.8	139	92.8	139	—	—	—	—
	A490	N		70.1	105	87.6	131	92.8	139	92.8	139	—	—	—	—
		X		70.1	105	87.6	131	105	158	116	174	—	—	—	—
6 (L = 17 1/2)	A325	N	STD/SSLT	59.7	89.6	63.6	95.4	63.6	95.4	63.6	95.4	—	—	—	—
	F1852	X		59.7	89.6	74.6	112	79.5	119	79.5	119	—	—	—	—
	A490	N		59.7	89.6	74.6	112	79.5	119	79.5	119	—	—	—	—
		X		59.7	89.6	74.6	112	89.6	134	99.4	149	—	—	—	—
5 (L = 14 1/2)	A325	N	STD/SSLT	49.4	74.0	53.0	79.5	53.0	79.5	53.0	79.5	—	—	—	—
	F1852	X		49.4	74.0	61.7	92.5	66.3	99.4	66.3	99.4	—	—	—	—
	A490	N		49.4	74.0	61.7	92.5	66.3	99.4	66.3	99.4	—	—	—	—
		X		49.4	74.0	61.7	92.5	74.0	111	82.8	124	—	—	—	—
4 (L = 11 1/2)	A325	N	STD/SSLT	39.0	58.5	42.4	63.6	42.4	63.6	42.4	63.6	—	—	—	—
	F1852	X		39.0	58.5	48.8	73.1	53.0	79.5	53.0	79.5	—	—	—	—
	A490	N		39.0	58.5	48.8	73.1	53.0	79.5	53.0	79.5	—	—	—	—
		X		39.0	58.5	48.8	73.1	58.5	87.8	66.3	99.4	—	—	—	—
3 (L = 8 1/2)	A325	N	STD/SSLT	28.6	43.0	31.8	47.7	31.8	47.7	31.8	47.7	—	—	—	—
	F1852	X		28.6	43.0	35.8	53.7	39.8	59.6	39.8	59.6	—	—	—	—
	A490	N		28.6	43.0	35.8	53.7	39.8	59.6	39.8	59.6	—	—	—	—
		X		28.6	43.0	35.8	53.7	43.0	64.4	49.7	74.6	—	—	—	—
2 (L = 5 1/2)	A325	N	STD/SSLT	18.3	27.4	21.2	31.8	21.2	31.8	21.2	31.8	—	—	—	—
	F1852	X		18.3	27.4	22.9	34.3	26.5	39.8	26.5	39.8	—	—	—	—
	A490	N		18.3	27.4	22.9	34.3	26.5	39.8	26.5	39.8	—	—	—	—
		X		18.3	27.4	22.9	34.3	27.4	41.1	32.0	48.0	—	—	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

7/8-in. diameter bolts

Table 10–9b (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 50 ksi

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				1/4		5/16		3/8		7/16		1/2		9/16	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
12 (L = 36)	A325 F1852	N	STD	117	176	146	219	161	242	161	242	161	242	—	—
			SSLT	117	176	146	219	173	260	173	260	173	260	—	—
		X	STD	117	176	146	219	176	263	201	302	201	302	—	—
			SSLT	117	176	146	219	176	263	205	307	216	325	—	—
	A490	N	STD	117	176	146	219	176	263	201	302	201	302	—	—
			SSLT	117	176	146	219	176	263	205	307	216	325	—	—
		X	STD	117	176	146	219	176	263	205	307	234	351	—	—
			SSLT	117	176	146	219	176	263	205	307	234	351	—	—
11 (L = 33)	A325 F1852	N	STD	107	161	134	201	151	226	151	226	151	226	—	—
			SSLT	107	161	134	201	159	238	159	238	159	238	—	—
		X	STD	107	161	134	201	161	241	188	282	189	283	—	—
			SSLT	107	161	134	201	161	241	188	282	198	298	—	—
	A490	N	STD	107	161	134	201	161	241	188	282	189	283	—	—
			SSLT	107	161	134	201	161	241	188	282	198	298	—	—
		X	STD	107	161	134	201	161	241	188	282	215	322	—	—
			SSLT	107	161	134	201	161	241	188	282	215	322	—	—
10 (L = 30)	A325 F1852	N	STD	97.5	146	122	183	141	211	141	211	141	211	—	—
			SSLT	97.5	146	122	183	144	216	144	216	144	216	—	—
		X	STD	97.5	146	122	183	146	219	171	256	176	263	—	—
			SSLT	97.5	146	122	183	146	219	171	256	180	271	—	—
	A490	N	STD	97.5	146	122	183	146	219	171	256	176	263	—	—
			SSLT	97.5	146	122	183	146	219	171	256	180	271	—	—
		X	STD	97.5	146	122	183	146	219	171	256	195	293	—	—
			SSLT	97.5	146	122	183	146	219	171	256	195	293	—	—
9 (L = 27)	A325 F1852	N	STD/SSLT	87.8	132	110	165	130	195	130	195	130	195	—	—
		X		87.8	132	110	165	132	197	154	230	162	244	—	—
	A490	N		87.8	132	110	165	132	197	154	230	162	244	—	—
		X		87.8	132	110	165	132	197	154	230	176	263	—	—
8 (L = 24)	A325 F1852	N	STD/SSLT	78.0	117	97.5	146	115	173	115	173	115	173	—	—
		X		78.0	117	97.5	146	117	176	137	205	144	216	—	—
	A490	N		78.0	117	97.5	146	117	176	137	205	144	216	—	—
		X		78.0	117	97.5	146	117	176	137	205	156	234	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

Plate
F_y = 50 ksi

Table 10–9b (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

7/8-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	7/16 ASD	7/16 LRFD	1/2 ASD	1/2 LRFD	9/16 ASD	9/16 LRFD
7 (*L* = 21)	A325	N	STD/SSLT	68.3	102	85.3	128	101	152	101	152	101	152	—	—
	F1852	X		68.3	102	85.3	128	102	154	119	179	126	189	—	—
	A490	N		68.3	102	85.3	128	102	154	119	179	126	189	—	—
		X		68.3	102	85.3	128	102	154	119	179	137	205	—	—
6 (*L* = 18)	A325	N	STD/SSLT	58.5	87.8	73.1	110	86.6	130	86.6	130	86.6	130	—	—
	F1852	X		58.5	87.8	73.1	110	87.8	132	102	154	108	162	—	—
	A490	N		58.5	87.8	73.1	110	87.8	132	102	154	108	162	—	—
		X		58.5	87.8	73.1	110	87.8	132	102	154	117	176	—	—
5 (*L* = 15)	A325	N	STD/SSLT	48.8	73.1	60.9	91.4	72.2	108	72.2	108	72.2	108	—	—
	F1852	X		48.8	73.1	60.9	91.4	73.1	110	85.3	128	90.2	135	—	—
	A490	N		48.8	73.1	60.9	91.4	73.1	110	85.3	128	90.2	135	—	—
		X		48.8	73.1	60.9	91.4	73.1	110	85.3	128	97.5	146	—	—
4 (*L* = 12)	A325	N	STD/SSLT	39.0	58.5	48.8	73.1	57.7	86.6	57.7	86.6	57.7	86.6	—	—
	F1852	X		39.0	58.5	48.8	73.1	58.5	87.8	68.3	102	72.2	108	—	—
	A490	N		39.0	58.5	48.8	73.1	58.5	87.8	68.3	102	72.2	108	—	—
		X		39.0	58.5	48.8	73.1	58.5	87.8	68.3	102	78.0	117	—	—
3 (*L* = 9)	A325	N	STD/SSLT	29.3	43.9	36.6	54.8	43.3	64.9	43.3	64.9	43.3	64.9	—	—
	F1852	X		29.3	43.9	36.6	54.8	43.9	65.8	51.2	76.8	54.1	81.2	—	—
	A490	N		29.3	43.9	36.6	54.8	43.9	65.8	51.2	76.8	54.1	81.2	—	—
		X		29.3	43.9	36.6	54.8	43.9	65.8	51.2	76.8	58.5	87.8	—	—
2 (*L* = 6)	A325	N	STD/SSLT	19.5	29.3	24.4	36.6	28.9	43.3	28.9	43.3	28.9	43.3	—	—
	F1852	X		19.5	29.3	24.4	36.6	29.3	43.9	34.1	51.2	36.1	54.1	—	—
	A490	N		19.5	29.3	24.4	36.6	29.3	43.9	34.1	51.2	36.1	54.1	—	—
		X		19.5	29.3	24.4	36.6	29.3	43.9	34.1	51.2	39.0	58.5	—	—
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
– indicates that the plate thickness is greater than $d_b/2 + 1/16$ in.
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

1-in. diameter bolts

Table 10–9b (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 50 ksi

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in. 1/4 ASD	1/4 LRFD	5/16 ASD	5/16 LRFD	3/8 ASD	3/8 LRFD	7/16 ASD	7/16 LRFD	1/2 ASD	1/2 LRFD	9/16 ASD	9/16 LRFD
12 (L = 36 1/2)	A325 F1852	N	STD	112	168	140	210	168	252	196	294	210	316	210	316
			SSLT	112	168	140	210	168	252	196	294	224	336	226	339
		X	STD	112	168	140	210	168	252	196	294	224	336	252	378
			SSLT	112	168	140	210	168	252	196	294	224	336	252	378
	A490	N	STD	112	168	140	210	168	252	196	294	224	336	252	378
			SSLT	112	168	140	210	168	252	196	294	224	336	252	378
		X	STD	112	168	140	210	168	252	196	294	224	336	252	378
			SSLT	112	168	140	210	168	252	196	294	224	336	252	378
11 (L = 33 1/2)	A325 F1852	N	STD	103	154	129	193	154	232	180	270	197	295	197	295
			SSLT	103	154	129	193	154	232	180	270	206	309	207	311
		X	STD	103	154	129	193	154	232	180	270	206	309	232	348
			SSLT	103	154	129	193	154	232	180	270	206	309	232	348
	A490	N	STD	103	154	129	193	154	232	180	270	206	309	232	348
			SSLT	103	154	129	193	154	232	180	270	206	309	232	348
		X	STD	103	154	129	193	154	232	180	270	206	309	232	348
			SSLT	103	154	129	193	154	232	180	270	206	309	232	348
10 (L = 30 1/2)	A325 F1852	N	STD	93.8	141	117	176	141	211	164	246	184	275	184	275
			SSLT	93.8	141	117	176	141	211	164	246	188	282	188	283
		X	STD	93.8	141	117	176	141	211	164	246	188	282	211	317
			SSLT	93.8	141	117	176	141	211	164	246	188	282	211	317
	A490	N	STD	93.8	141	117	176	141	211	164	246	188	282	211	317
			SSLT	93.8	141	117	176	141	211	164	246	188	282	211	317
		X	STD	93.8	141	117	176	141	211	164	246	188	282	211	317
			SSLT	93.8	141	117	176	141	211	164	246	188	282	211	317
9 (L = 27 1/2)	A325 F1852	N	STD/ SSLT	84.7	127	106	159	127	191	148	222	169	254	170	254
		X		84.7	127	106	159	127	191	148	222	169	254	191	286
	A490	N		84.7	127	106	159	127	191	148	222	169	254	191	286
		X		84.7	127	106	159	127	191	148	222	169	254	191	286
8 (L = 24 1/2)	A325 F1852	N	STD/ SSLT	75.6	113	94.5	142	113	170	132	198	151	226	151	226
		X		75.6	113	94.5	142	113	170	132	198	151	227	170	255
	A490	N		75.6	113	94.5	142	113	170	132	198	151	227	170	255
		X		75.6	113	94.5	142	113	170	132	198	151	227	170	255
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

Table 10–9b (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 50 ksi

1-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				1/4		5/16		3/8		7/16		1/2		9/16	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
7 (L = 21 1/2)	A325	N	STD/SSLT	66.4	99.6	83.0	125	99.6	149	116	174	132	198	132	198
	F1852	X		66.4	99.6	83.0	125	99.6	149	116	174	133	199	149	224
	A490	N		66.4	99.6	83.0	125	99.6	149	116	174	133	199	149	224
		X		66.4	99.6	83.0	125	99.6	149	116	174	133	199	149	224
6 (L = 18 1/2)	A325	N	STD/SSLT	57.3	85.9	71.6	107	85.9	129	100	150	113	170	113	170
	F1852	X		57.3	85.9	71.6	107	85.9	129	100	150	115	172	129	193
	A490	N		57.3	85.9	71.6	107	85.9	129	100	150	115	172	129	193
		X		57.3	85.9	71.6	107	85.9	129	100	150	115	172	129	193
5 (L = 15 1/2)	A325	N	STD/SSLT	48.1	72.2	60.2	90.3	72.2	108	84.2	126	94.2	141	94.2	141
	F1852	X		48.1	72.2	60.2	90.3	72.2	108	84.2	126	96.3	144	108	162
	A490	N		48.1	72.2	60.2	90.3	72.2	108	84.2	126	96.3	144	108	162
		X		48.1	72.2	60.2	90.3	72.2	108	84.2	126	96.3	144	108	162
4 (L = 12 1/2)	A325	N	STD/SSLT	39.0	58.5	48.8	73.1	58.5	87.8	68.3	102	75.4	113	75.4	113
	F1852	X		39.0	58.5	48.8	73.1	58.5	87.8	68.3	102	78.0	117	87.8	132
	A490	N		39.0	58.5	48.8	73.1	58.5	87.8	68.3	102	78.0	117	87.8	132
		X		39.0	58.5	48.8	73.1	58.5	87.8	68.3	102	78.0	117	87.8	132
3 (L = 9 1/2)	A325	N	STD/SSLT	29.9	44.8	37.3	56.0	44.8	67.2	52.3	78.4	56.5	84.8	56.5	84.8
	F1852	X		29.9	44.8	37.3	56.0	44.8	67.2	52.3	78.4	59.7	89.6	67.2	101
	A490	N		29.9	44.8	37.3	56.0	44.8	67.2	52.3	78.4	59.7	89.6	67.2	101
		X		29.9	44.8	37.3	56.0	44.8	67.2	52.3	78.4	59.7	89.6	67.2	101
2 (L = 6 1/2)	A325	N	STD/SSLT	20.7	31.1	25.9	38.8	31.1	46.6	36.3	54.4	37.7	56.5	37.7	56.5
	F1852	X		20.7	31.1	25.9	38.8	31.1	46.6	36.3	54.4	41.4	62.2	46.6	69.9
	A490	N		20.7	31.1	25.9	38.8	31.1	46.6	36.3	54.4	41.4	62.2	46.6	69.9
		X		20.7	31.1	25.9	38.8	31.1	46.6	36.3	54.4	41.4	62.2	46.6	69.9
Weld Size				3/16		1/4		1/4		5/16		5/16		3/8	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

Table 10–9b (continued)
Single-Plate Connections
Bolt, Weld, and Single-Plate Available Strengths, kips

1 1/8-in. diameter bolts

Plate F_y = 50 ksi

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				5/16		3/8		7/16		1/2		9/16		5/8	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
12 (*L* = 37)	A325 F1852	N	STD	134	201	161	241	188	282	215	322	241	362	266	399
			SSLT	134	201	161	241	188	282	215	322	241	362	268	402
		X	STD	134	201	161	241	188	282	215	322	241	362	268	402
			SSLT	134	201	161	241	188	282	215	322	241	362	268	402
	A490	N	STD	134	201	161	241	188	282	215	322	241	362	268	402
			SSLT	134	201	161	241	188	282	215	322	241	362	268	402
		X	STD	134	201	161	241	188	282	215	322	241	362	268	402
			SSLT	134	201	161	241	188	282	215	322	241	362	268	402
11 (*L* = 34)	A325 F1852	N	STD	123	185	148	222	173	259	197	296	222	333	247	370
			SSLT	123	185	148	222	173	259	197	296	222	333	247	370
		X	STD	123	185	148	222	173	259	197	296	222	333	247	370
			SSLT	123	185	148	222	173	259	197	296	222	333	247	370
	A490	N	STD	123	185	148	222	173	259	197	296	222	333	247	370
			SSLT	123	185	148	222	173	259	197	296	222	333	247	370
		X	STD	123	185	148	222	173	259	197	296	222	333	247	370
			SSLT	123	185	148	222	173	259	197	296	222	333	247	370
10 (*L* = 31)	A325 F1852	N	STD	113	169	135	203	158	237	180	271	203	304	225	338
			SSLT	113	169	135	203	158	237	180	271	203	304	225	338
		X	STD	113	169	135	203	158	237	180	271	203	304	225	338
			SSLT	113	169	135	203	158	237	180	271	203	304	225	338
	A490	N	STD	113	169	135	203	158	237	180	271	203	304	225	338
			SSLT	113	169	135	203	158	237	180	271	203	304	225	338
		X	STD	113	169	135	203	158	237	180	271	203	304	225	338
			SSLT	113	169	135	203	158	237	180	271	203	304	225	338
9 (*L* = 28)	A325 F1852	N	STD/ SSLT	102	153	122	184	143	214	163	245	184	276	204	306
		X		102	153	122	184	143	214	163	245	184	276	204	306
	A490	N		102	153	122	184	143	214	163	245	184	276	204	306
		X		102	153	122	184	143	214	163	245	184	276	204	306
8 (*L* = 25)	A325 F1852	N	STD/ SSLT	91.4	137	110	165	128	192	146	219	165	247	183	274
		X		91.4	137	110	165	128	192	146	219	165	247	183	274
	A490	N		91.4	137	110	165	128	192	146	219	165	247	183	274
		X		91.4	137	110	165	128	192	146	219	165	247	183	274
Weld Size				1/4		1/4		5/16		5/16		3/8		7/16	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

Table 10–9b (continued)

Single-Plate Connections

Bolt, Weld, and Single-Plate Available Strengths, kips

Plate F_y = 50 ksi

1 1/8-in. diameter bolts

n	ASTM Desig.	Thread Cond.	Hole Type	Plate Thickness, in.											
				5/16		3/8		7/16		1/2		9/16		5/8	
				ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
7 (*L* = 22)	A325	N	STD/ SSLT	80.7	121	96.9	145	113	170	129	194	145	218	161	242
	F1852	X		80.7	121	96.9	145	113	170	129	194	145	218	161	242
	A490	N		80.7	121	96.9	145	113	170	129	194	145	218	161	242
		X		80.7	121	96.9	145	113	170	129	194	145	218	161	242
6 (*L* = 19)	A325	N	STD/ SSLT	70.1	105	84.1	126	98.1	147	112	168	126	189	140	210
	F1852	X		70.1	105	84.1	126	98.1	147	112	168	126	189	140	210
	A490	N		70.1	105	84.1	126	98.1	147	112	168	126	189	140	210
		X		70.1	105	84.1	126	98.1	147	112	168	126	189	140	210
5 (*L* = 16)	A325	N	STD/ SSLT	59.4	89.1	71.3	107	83.2	125	95.1	143	107	160	119	178
	F1852	X		59.4	89.1	71.3	107	83.2	125	95.1	143	107	160	119	178
	A490	N		59.4	89.1	71.3	107	83.2	125	95.1	143	107	160	119	178
		X		59.4	89.1	71.3	107	83.2	125	95.1	143	107	160	119	178
4 (*L* = 13)	A325	N	STD/ SSLT	48.8	73.1	58.5	87.8	68.3	102	78.0	117	87.8	132	95.4	143
	F1852	X		48.8	73.1	58.5	87.8	68.3	102	78.0	117	87.8	132	97.5	146
	A490	N		48.8	73.1	58.5	87.8	68.3	102	78.0	117	87.8	132	97.5	146
		X		48.8	73.1	58.5	87.8	68.3	102	78.0	117	87.8	132	97.5	146
3 (*L* = 10)	A325	N	STD/ SSLT	38.1	57.1	45.7	68.6	53.3	80.0	60.9	91.4	68.6	103	71.6	107
	F1852	X		38.1	57.1	45.7	68.6	53.3	80.0	60.9	91.4	68.6	103	76.2	114
	A490	N		38.1	57.1	45.7	68.6	53.3	80.0	60.9	91.4	68.6	103	76.2	114
		X		38.1	57.1	45.7	68.6	53.3	80.0	60.9	91.4	68.6	103	76.2	114
2 (*L* = 7)	A325	N	STD/ SSLT	27.4	41.1	32.9	49.4	38.4	57.6	43.9	65.8	47.7	71.6	47.7	71.6
	F1852	X		27.4	41.1	32.9	49.4	38.4	57.6	43.9	65.8	49.4	74.0	54.8	82.3
	A490	N		27.4	41.1	32.9	49.4	38.4	57.6	43.9	65.8	49.4	74.0	54.8	82.3
		X		27.4	41.1	32.9	49.4	38.4	57.6	43.9	65.8	49.4	74.0	54.8	82.3
Weld Size				1/4		1/4		5/16		5/16		3/8		7/16	

STD = Standard Holes
SSLT = Short-slotted holes transverse to direction of load
STD/SSLT = Standard holes or short-slotted holes transverse to direction of load
Tabulated values are grouped when available strength is independent of hole type.

N = Threads Included
X = Threads Excluded

SINGLE-ANGLE CONNECTIONS

A single-angle connection is made with an angle on one side of the web of the beam to be supported, as illustrated in Figure 10–13. This angle is preferably shop-bolted or welded to the supporting member and field-bolted to the supported beam.

When the angle is welded to the support, adequate flexibility must be provided in the connection. As illustrated in Figure 10–13c, the weld is placed along the toe and across the bottom of the angle with a return at the top per AISC Specification Section J2.2b. Note that welding across the entire top of the angle must be avoided as it would inhibit the flexibility and, therefore, the necessary end rotation of the connection. The performance of the resulting connection would not be as intended for simple shear connections.

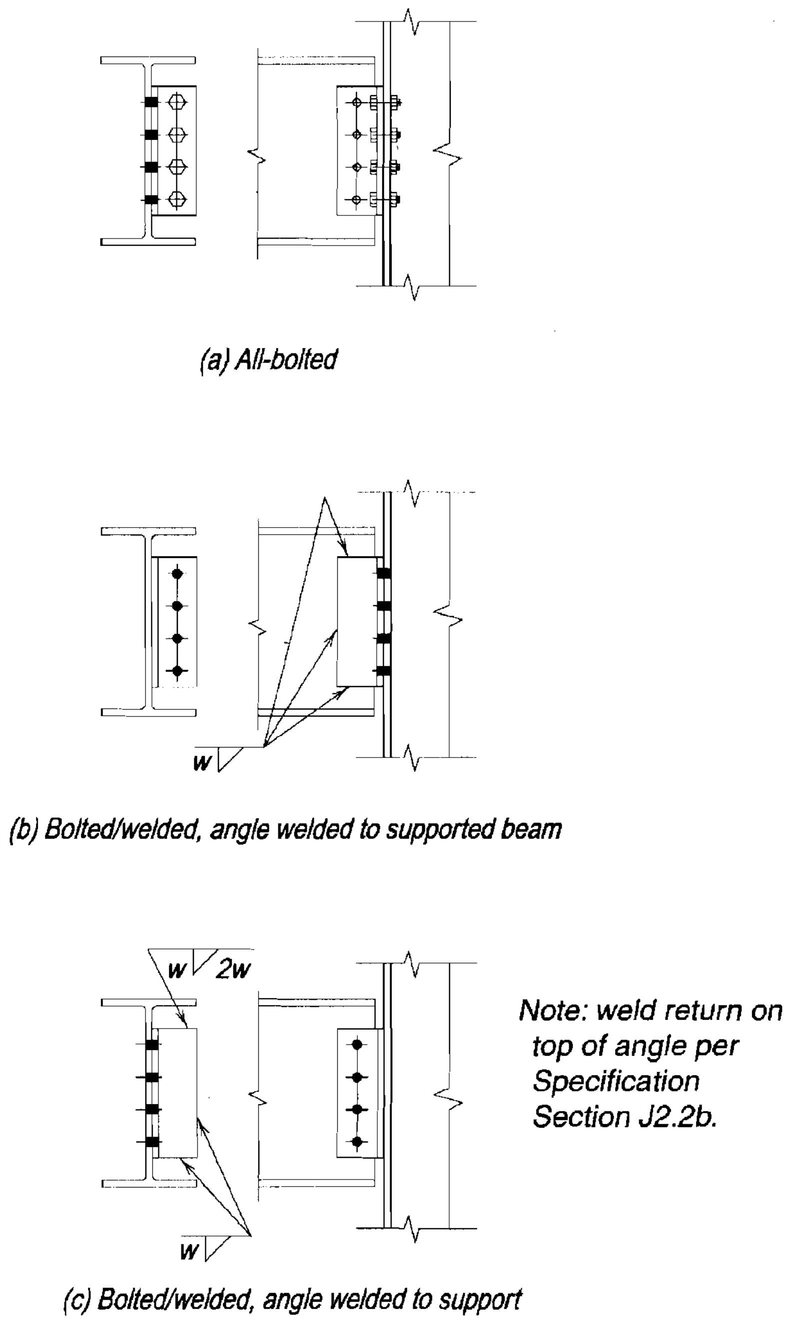


Figure 10–13. Single-angle connections.

Design Checks

The available strength of a single-angle connection is determined from the applicable limit states for bolts (see Part 7), welds (see Part 8), and connecting elements (see Part 9). In all cases, the available strength, ϕR_n or R_n/Ω, must equal or exceed the required strength, R_u or R_a.

As illustrated in Figure 10–14, the effect of eccentricity should always be considered in the angle leg attached to the support. Additionally, eccentricity should be considered in the case of a double vertical row of bolts through the web of the supported beam or if the eccentricity exceeds 3 in. (2³/₄-in. gage plus ¹/₄-in. half web). Eccentricity should always be considered in the design of welds for single-angle connections.

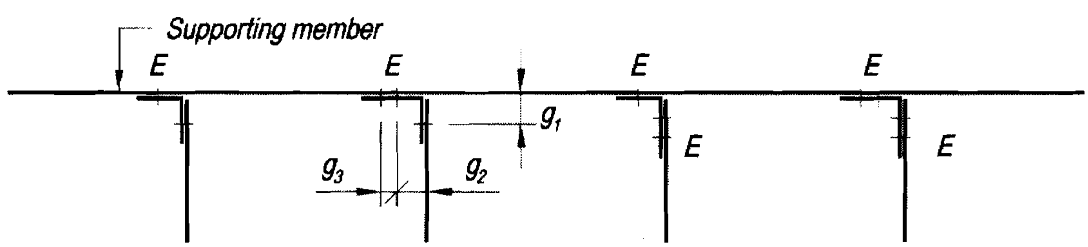
Recommended Angle Length and Thickness

To provide for stability during erection, it is recommended that the mimimum angle length be one-half the *T*-dimension of the beam to be supported. The maximum length of the connection angles must be compatible with the *T*-dimension of an uncoped beam and the remaining web depth, exclusive of fillets, of a coped beam. Note that the angle may encroach upon the fillet(s) as given in Figure 10–3.

A minimum angle thickness of ³/₈-in. for ³/₄-in. and ⁷/₈-in. diameter bolts, and ¹/₂-in. for 1-in. diameter bolts should be used. A 4×3 angle is normally selected for a single angle welded to the support with the 3-in. leg being the welded leg.

Shop and Field Practices

Single-angle connections may be readily made to the webs of supporting girders and to the flanges of supporting columns. When framing to a column flange, provision must be made for possible mill variation in the depth of the columns. Since the angle is usually shop-attached to the column flange, play in the open holes or horizontal slots in the angle leg may be used to provide the necessary adjustment to compensate for the mill variation. Attaching the angle to the column flange offers the advantage of side erection of the beam. The same is true for a girder web or truss support. Additionally, proper bay dimensions may be maintained without the need for shims. This advantage is lost in the case that the angle is shop-attached to the supported beam web.



E indicates that eccentricity must be considered in this leg. Gages g_1, g_2, and g_3 are workable gages as shown in Table 1-7

Figure 10–14. Eccentricity in angles.

Table 10–10. All-Bolted Single-Angle Connections

Table 10–10 is a design aid for all-bolted single-angle connections. The tabulated eccentrically loaded bolt group coefficients, C, are useful in determining the available strength, ϕR_n or R_n/Ω, where

$$R_n = C \times r_n$$

$$\phi = 0.75 \qquad \Omega = 2.0$$

In the above equation,

C = coefficient from Table 10–10
r_n = the nominal strength of one bolt in shear or bearing, kips

Table 10–11. Bolted/Welded Single-Angle Connections

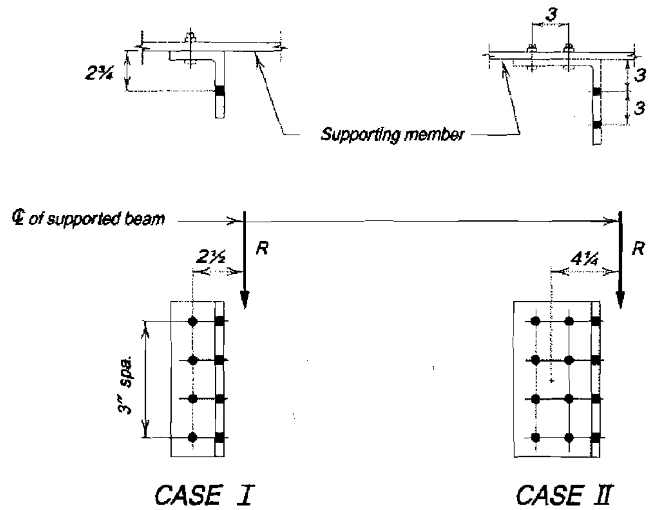
Table 10–11 is a design aid for bolted/welded single-angle connections. Electrode strength is assumed to be 70 ksi. In the rare case where a single-angle connection must be field-welded, erection bolts may be placed in the leg to be field-welded.

Weld available strengths are determined by the instantaneous center of rotation method using Table 8-11 with $\theta = 0°$. The tabulated values assume a half-web thickness of $^1/_4$ in. and may be used conservatively for lesser half-web thicknesses. For half-web thicknesses greater than $^1/_4$ in., the tabulated values should be reduced proportionally to eight percent at a half-web thickness of $^1/_2$ in. The tabulated minimum supporting flange or web thickness is the thickness that matches the strength of the support material to the strength of the weld material. In a manner similar to that illustrated previously for Table 10–2, the minimum material thickness (for one line of weld) may be calculated as:

$$t_{min} = \frac{3.09D}{F_u}$$

where D is the number of sixteenths in the weld size. When welds line up on opposite sides of the support, the minimum thickness is the sum of the thicknesses required for each weld. In either case, when less than the minimum material thickness is present, the tabulated weld available strength should be multiplied by the ratio of the thickness provided to the minimum thickness.

Table 10–10
All-Bolted Single-Angle Connections



Note: standard holes in support leg of angle

Eccentrically Loaded Bolt Group Coefficients, *C*		
Number of Bolts in One Vertical Row, *n*	**Case I**	**Case II**
12	11.4	21.5
11	10.4	19.4
10	9.37	17.3
9	8.34	15.2
8	7.31	13.0
7	6.27	10.9
6	5.22	8.70
5	4.15	6.63
4	3.07	4.70
3	1.99	2.94
2	1.03	1.61
1	—	0.518

$\phi R_n = C \times \phi r_n$ or $R_n/\Omega = C \times r_n/\Omega$

where

C = coefficient from Table above

ϕr_n = design strength of one bolt in shear or bearing, kips/bolt

r_n/Ω = allowable strength of one bolt in shear or bearing, kips/bolt

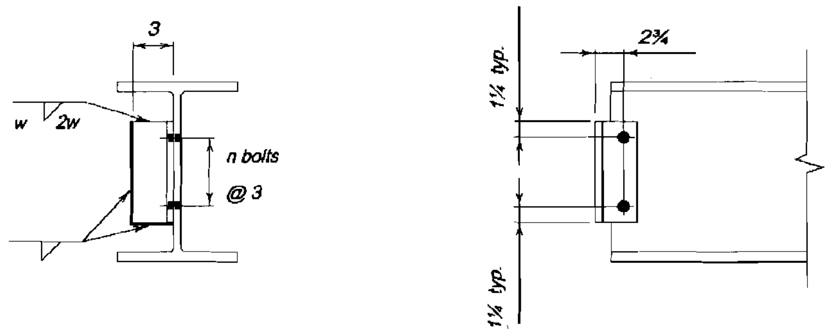
Notes:

For eccentricities less than or equal to those shown above, tabulated values may be used.

For greater eccentricities, coefficient C should be recalculated from Part 7.

Connection may be bearing-type or slip-critical.

Table 10–11
Bolted/Welded Single-Angle Connections



Number of Bolts in One Vertical Row	Bolt and Angle Strength, kips				Angle Size (F_y = 36 ksi)	Angle Length, in.	Weld (70 ksi)			Minimum t_w of Supporting Member with Angles Both Sides of Web, in.
	3/4 in.		7/8 in.				Size, w, in.	Available Strength, kips		
	ASD	LRFD	ASD	LRFD				ASD	LRFD	
12	127	191	147	220	L4×3×3/8	35 1/2	5/16	176	265	0.476
							1/4	141	212	0.381
							3/16	106	159	0.286
11	117	175	135	202		32 1/2	5/16	164	246	0.476
							1/4	131	197	0.381
							3/16	98.6	148	0.286
10	106	159	123	184		29 1/2	5/16	151	227	0.476
							1/4	121	181	0.381
							3/16	90.6	136	0.286
9	95.4	143	110	166		26 1/2	5/16	137	206	0.476
							1/4	110	165	0.381
							3/16	82.3	123	0.286
8	84.8	127	98.3	147		23 1/2	5/16	123	185	0.476
							1/4	98.7	148	0.381
							3/16	74	111	0.286
7	74.2	111	86.1	129		20 1/2	5/16	109	164	0.476
							1/4	87.5	131	0.381
							3/16	65.6	98.4	0.286

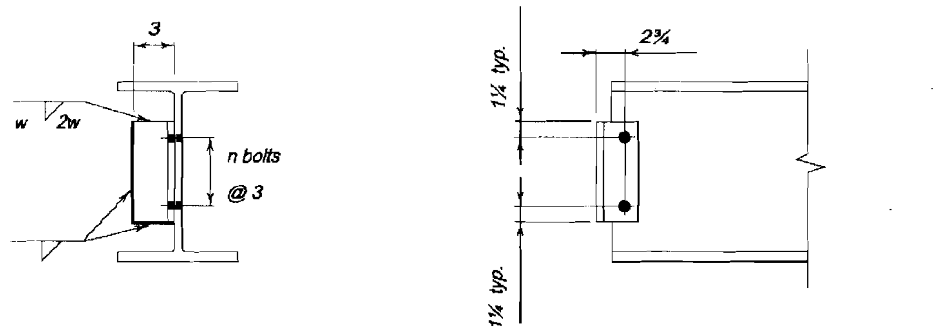
Notes:

Gage in angle leg attached to beam web as well as leg width may be decreased. 3-in. welded leg may not be increased or decreased.

Tabulated weld available strengths are based on a 1/4-in. half web for the supported member. Smaller half webs will result in these values being conservative. For half webs over 1/4 in., weld values must be reduced proportionally to 8% for a 1/2-in. half web or recalculated.

When the beam web thickness of the supporting member is less than the minimum and single-angle connections are back to back, either stagger the angles, or multiply the weld design strength by the ratio of the actual web thickness to the tabulated minimum thickness to determine the reduced weld design strength.

Table 10–11 (continued)
Bolted/Welded Single-Angle Connections



Number of Bolts in One Vertical Row	Bolt and Angle Strength, kips: 3/4 in. ASD	3/4 in. LRFD	7/8 in. ASD	7/8 in. LRFD	Angle Size (F_y = 36 ksi)	Angle Length, in.	Weld (70 ksi) Size, w, in.	Weld Available Strength, kips ASD	LRFD	Minimum t_w of Supporting Member with Angles Both Sides of Web, in.
6	63.6	95.4	74	111	L4×3×3/8	17 1/2	5/16	94.3	142	0.476
							1/4	75.5	113	0.381
							3/16	56.6	84.9	0.286
5	53	79.5	61.8	92.7		14 1/2	5/16	79	119	0.476
							1/4	63.2	94.8	0.381
							3/16	47.4	71.1	0.286
4	42.4	63.6	48.9	73.4		11 1/2	5/16	62.8	94.3	0.476
							1/4	50.3	75.4	0.381
							3/16	37.7	56.6	0.286
3	31.8	47.7	35.9	53.8		8 1/2	5/16	45.7	68.5	0.476
							1/4	36.5	54.8	0.381
							3/16	27.4	41.1	0.286
2	21.2	31.8	22.8	34.3		5 1/2	5/16	28.1	42.2	0.476
							1/4	22.5	33.7	0.381
							3/16	16.9	25.3	0.286

Notes:

Gage in angle leg attached to beam web as well as leg width may be decreased. 3-in. welded leg may not be increased or decreased.

Tabulated weld available strengths are based on a 1/4-in. half web for the supported member. Smaller half webs will result in these values being conservative. For half webs over 1/4 in., weld values must be reduced proportionally to 8% for a 1/2-in. half web or recalculated.

When the beam web thickness of the supporting member is less than the minimum and single-angle connections are back to back, either stagger the angles, or multiply the weld design strength by the ratio of the actual web thickness to the tabulated minimum thickness to determine the reduced weld design strength.

TEE CONNECTIONS

A tee connection is made with a structural tee, as illustrated in Figure 10–15. The tee is preferably shop-bolted or welded to the supporting member and field-bolted to the supported beam.

When the tee is welded to the support, adequate flexibility must be provided in the connection. As illustrated in Figure 10–15b, line welds are placed along the toes of the tee flange with a return at the top per AISC Specification Section J2.2b. Note that welding across the entire top of the tee must be avoided as it would inhibit the flexibility and, therefore, the necessary end rotation of the connection. The performance of the resulting connection would not be as intended for simple shear connections.

Design Checks

The available strength of a tee connection is determined from the applicable limit-states for bolts (see Part 7), welds (see Part 8), and connecting elements (see Part 9). In all cases, the available strength, ϕR_n or R_n/Ω, must equal or exceed the required strength, R_u or R_a.

Eccentricity must be considered when determining the available strength of tee connections. For a flexible support, the bolts or welds attaching the tee flange to the support must be designed for the shear, R_u or R_a. Also, the bolts through the tee stem must be designed for the shear and the eccentric moment, $R_u a$ or $R_a a$, where a is the distance from the face of the support to the centroid of the bolt group through the tee stem.

For a rigid support, the bolts or welds attaching the tee flange to the support must be designed for the shear and the eccentric moment; the bolts through the tee stem must be designed for the shear.

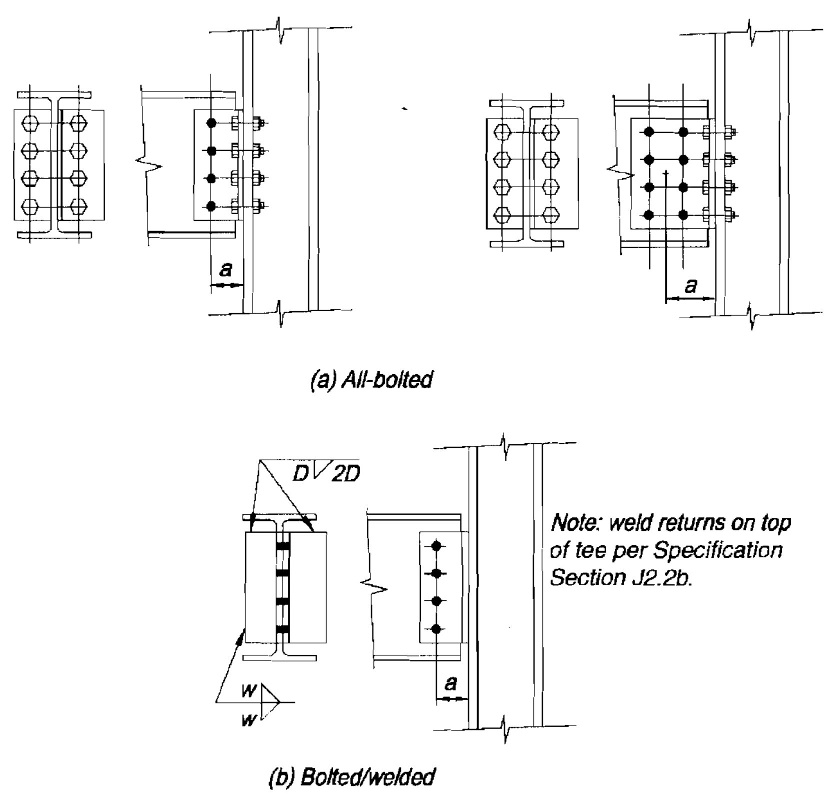


Figure 10–15. Tee connections.

Recommended Tee Length and Flange and Web Thicknesses

To provide for stability during erection, it is recommended that the mimimum tee length be one-half the T-dimension of the beam to be supported. The maximum length of the tee must be compatible with the T-dimension of an uncoped beam and the remaining web depth, exclusive of fillets, of a coped beam. Note that the tee may encroach upon the fillet(s) as given in Figure 10–3.

To provide for flexibility, the tee selected should meet the ductility checks illustrated in Part 9. The flange thickness of tees used in simple shear connections should be held to a minimum to permit the flexure necessary to accommodate the end rotation of the beam, unless the tee connection is proportioned to meet the geometric requirements for single-plate connections.

Shop and Field Practices

When framing to a column flange, provision must be made for possible mill variation in the depth of the columns. If the tee is shop-attached to the column flange, play in the open holes usually furnishes the necessary adjustment to compensate for the mill variation. This approach offers the advantage of side erection of the beam. Alternatively, if the tee is shop-attached to the supported beam web, the beam length could be shortened to provide for mill overrun and shims could be furnished at the appropriate intervals to fill the resulting gaps or to provide for mill underrun.

When a single vertical row of bolts is used in a tee stem, a 4-in. or 5-in. stem is required to accommodate the end distance of the supported beam and possible overrun/underrun in beam length. A double vertical row of bolts will require a 7-in. or 8-in. tee stem. There is no maximum limit on L_{eh} for the tee stem.

SHEAR SPLICES

Shear splices are usually made with a single plate, as shown in Figure 10–16a, or two plates, as shown in Figures 10–16b and 10–16c. Although the rotational flexibility required at a shear splice is usually much less than that required at the end of a simple-span beam, when a highly flexible splice is desired, the splice utilizing four framing angles, shown in Figure 10–17, is especially useful. These shear splices may be bolted and/or welded.

The available strength of a shear splice is determined from the applicable limit-states for the bolts (see Part 7), welds (see Part 8), and connecting elements (see Part 9). In all cases, the available strength, ϕR_n or R_n/Ω, must equal or exceed the required strength, R_u or R_a.

Eccentricity must be considered in the design of shear splices, with the exception of all-bolted shear splices utilizing four framing angles, as illustrated in Figure 10–17. When the splice is symmetrical, as shown for the bolted splice in Figure 10–16a, each side of the splice is equally restrained regardless of the relative flexibility of the spliced members. Accordingly, as illustrated in Figure 10–18, the eccentricity of the shear to the center of gravity of either bolt group is equal to half the distance between the centroids of the bolt groups. Therefore, each bolt group can be designed for the shear, R_u or R_a, and one-half the eccentric moment, $R_u e$ or $R_a e$ (Kulak and Green, 1990). This approach is also applicable to symmetrical welded splices.

When the splice is not symmetrical, as shown in Figures 10–16b and 10–16c, one side of the splice will possess a higher degree of rigidity. For the splice shown in Figure 10–16b, the right side is more rigid because the stiffness of the weld group exceeds the stiffness of the bolt group, even if the bolts are pretensioned or slip-critical. Also, for the splice shown in Figure 10–16c, the right side is more rigid since there are two vertical rows of bolts while the left side has only one. In these cases, it is conservative to design the side with the higher rigidity for the shear, R_u or R_a, and the full eccentric moment R_ue or R_ae. The side with the lower rigidity can then be designed for the shear only. This approach is applicable regardless of the relative flexibility of the spliced members.

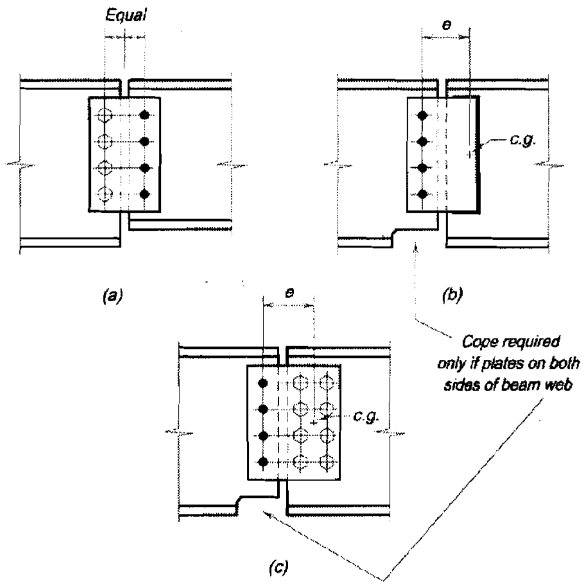


Figure 10–16. Plate-type shear splices.

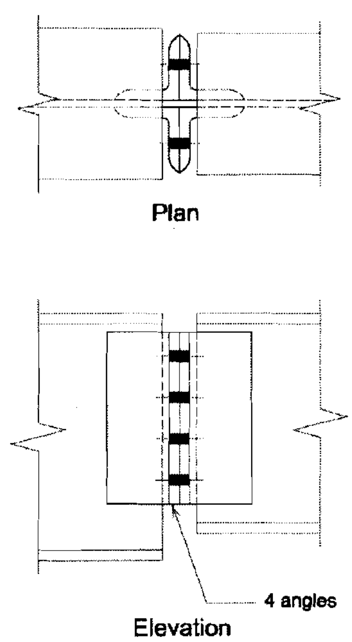


Figure 10–17. Angle-type shear splice.

Some splices, such as those that occur at expansion joints, require special attention and are beyond the scope of this Manual.

SPECIAL CONSIDERATIONS FOR SIMPLE SHEAR CONNECTIONS

Simple Shear Connections Subject to Axial Forces

When simple shear connections are subjected to axial load in addition to the shear, the important limit-states are angle leg bending and prying action. These tend to require that the angle, plate, or flange thickness increase or the gage decrease, or both, and these requirements may compromise the connection's ability to remain flexible enough to accommodate the simple beam end rotation. The shear connection ductility checks derived in Part 9 can be used to ensure that adequate ductility exists.

Simple Shear Connections at Stiffened Column-Web Locations

Stiffeners are obstacles to direct connections to the column web. Figure 10–19a illustrates a seat angle-welded to the toes of the column flanges; Figure 10–19d shows a vertical plate extended beyond the column flanges. Figures 10–19b and 10–19c offer two additional options for framing at locations of diagonal stiffeners; these should be examined carefully as they may create erection problems. Additionally, the deep cope of Figure 10–19c may significantly reduce the available strength of the beam at the end connection. Alternatively, the bottom transverse stiffener could be extended to serve as a seat plate with a bearing stiffener provided to distribute the beam reaction.

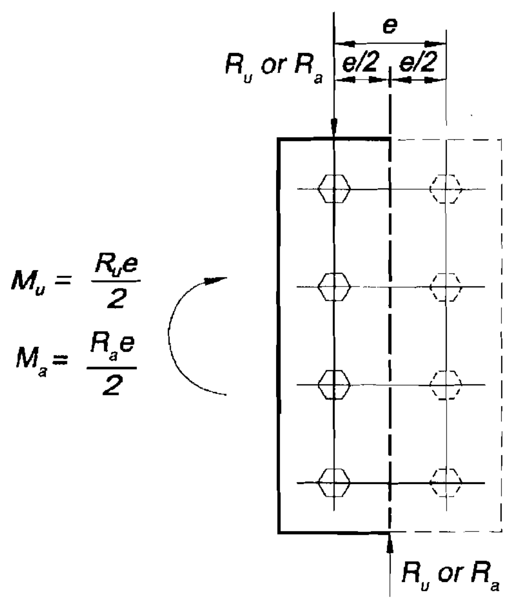


Figure 10–18. Eccentricity in a symmetrical shear splice.

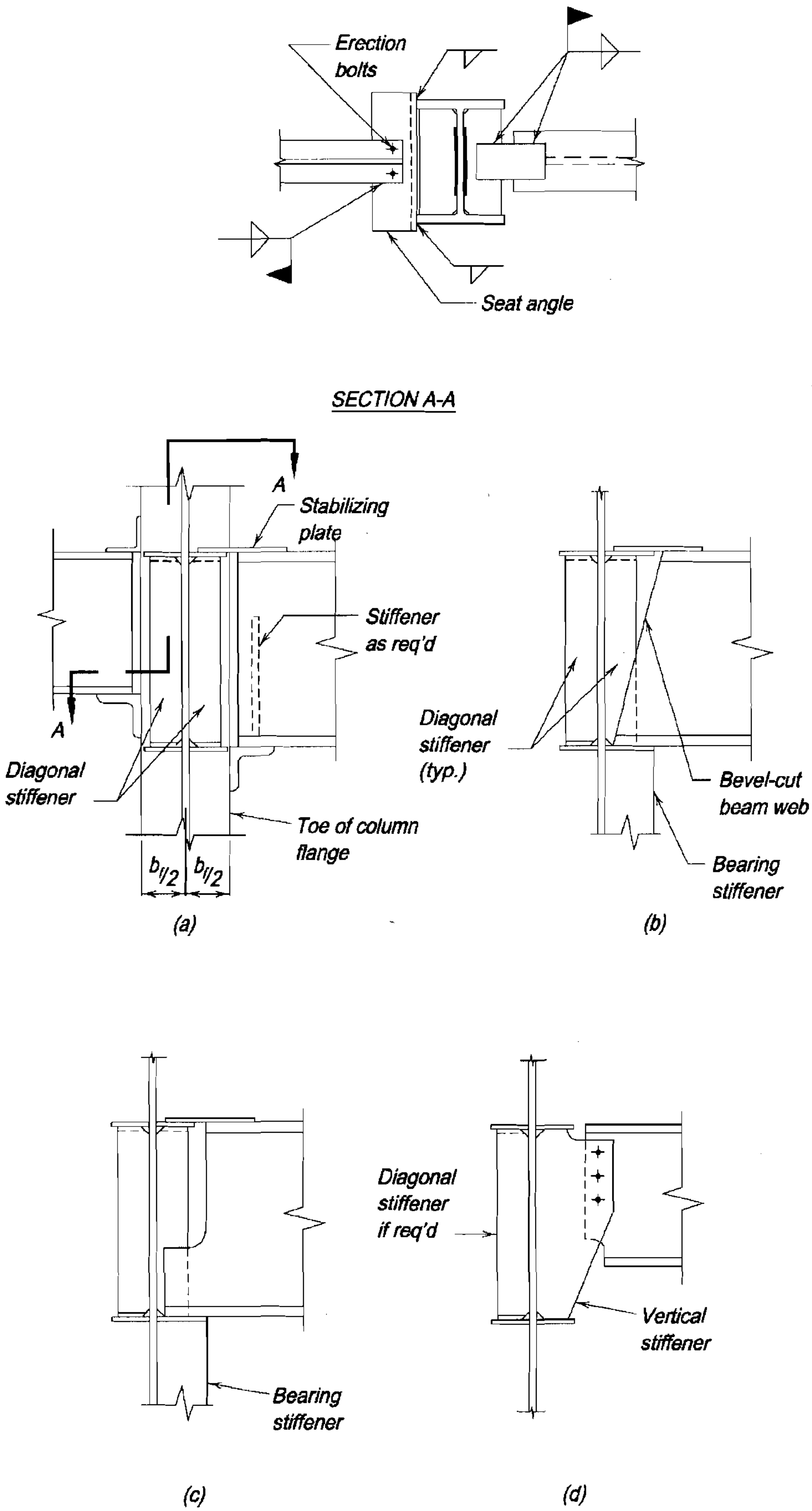


Figure 10–19. Simple shear connections at stiffened column-web locations.

Eccentric Effect of Extended Gages

Consider a simple shear connection to the web of a column that requires transverse stiffeners for two concurrent beam-to-column-flange moment connections. If it were not possible to eliminate the stiffeners by selection of a heavier column section, the field connection would have to be located clear of the column flanges, as shown in Figure 10–20, to provide for access and erectability.

The extension of the connection beyond normal gage lines results in an eccentric moment. While this eccentric moment is usually neglected in a connection framing to a column flange, the resistance of the column to weak-axis bending is typically only 20 to 50 percent of that in the strong axis. Thus the eccentric moment should be considered in this column-web connection, especially if the eccentricity, e, is large. Similarly, eccentricities larger than normal gages may also be a concern in connections to girder webs.

Column-Web Supports

There are two components contributing to the total eccentric moment: (1) the eccentricity of the beam end reaction, Re; and (2) M_{pr}, the partial restraint of the connection. To determine what eccentric moment must be considered in the design, first assume that the column is part of a braced frame for weak-axis bending, is pinned-ended with $K = 1$, and will be concentrically loaded, as illustrated in Figure 10–21. The beam is loaded before the column and will deflect under load as shown in Figure 10–22. Because of the partial restraint of the connection, a couple, M_{pr}, develops between the beam and column and adds to the eccentric couple, Re. Thus, $M_{con} = Re + M_{pr}$.

As the loading of the column begins, the assembly will deflect further in the same direction under load, as indicated in Figure 10–23, until the column load reaches some magnitude P_{sbr} when the rotation of the column will equal the simply supported beam end rotation. At this load, the rotation of the column negates M_{pr} since it also relieves the partial restraint effect of the connection, and $M_{con} = Re$. As the column load is increased above P_{sbr}, the column rotation exceeds the simply supported beam end rotation and a moment M'_{pr} results such that $M_{con} = Re - M'_{pr}$.

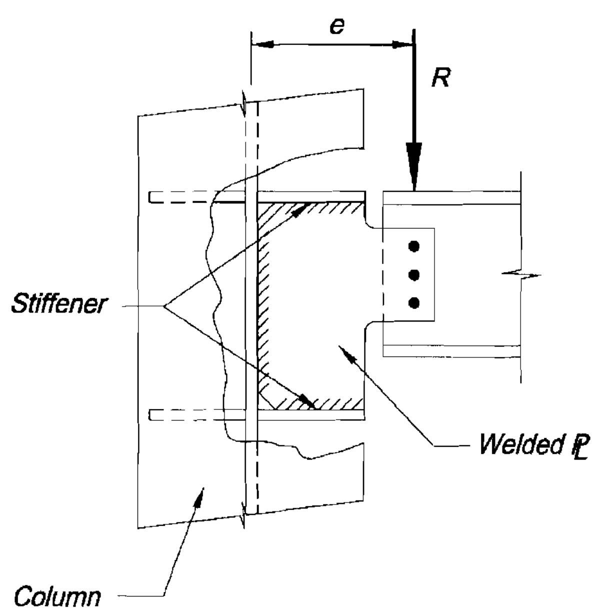


Figure 10–20. Eccentric effect of extended gages.

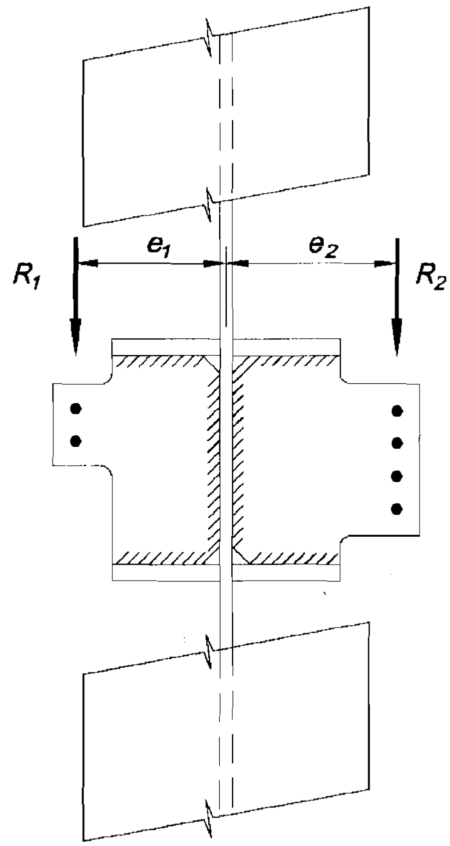


Figure 10–21. Column subject to dual eccentric moments.

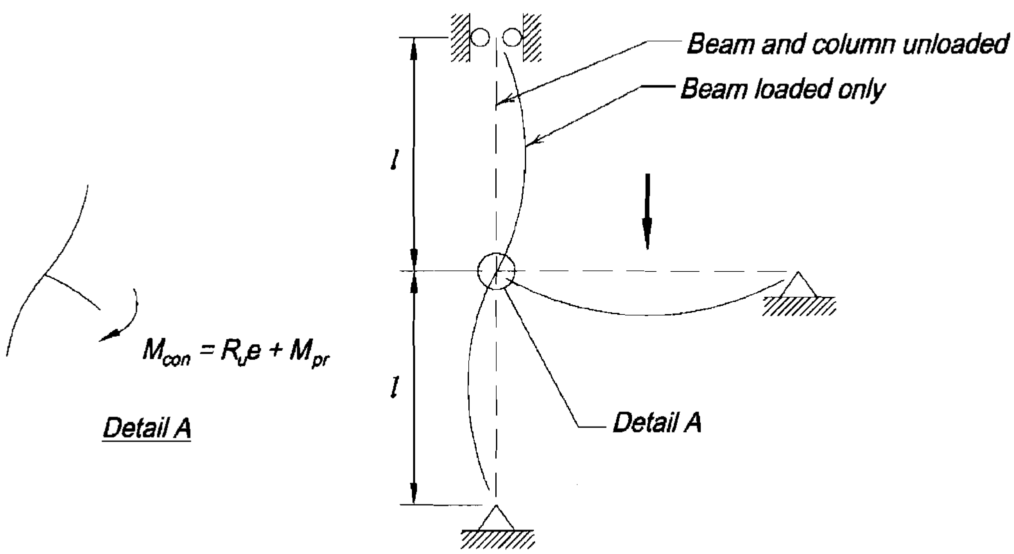


Figure 10–22. Illustration of beam, column, and connection behavior under loading of beam only.

Note that the partial restraint of the connection now actually stabilizes the column and reduces its effective length factor K below the originally assumed value of 1. Thus, since M'_{pr} must be greater than zero, it must also be true that $Re > M_{con}$. It is therefore conservative to design the connection for the shear, R and the eccentric moment, Re.

The welds connecting the plate to the supporting column web should be designed to resist the full shear, R only; the top and bottom plate-to-stiffener welds have minimal strength normal to their length, are not assumed to carry any calculated force, and may be of minimum size in accordance with AISC Specification Section J2.

If simple shear connections frame to both sides of the column web, as illustrated in Figure 10–21, each connection should be designed for its respective shear, R_1, and R_2 and the eccentric moment $|R_2e_2 - R_1e_1|$ may be apportioned between the two simple shear connections as the designer sees fit; the total eccentric moment may be assumed to act on the larger connection, the moment may be divided proportionally among the connections according to the polar moments of inertia of the bolt groups (relative stiffness), or the moment may be divided proportionally between the connections according to the section moduli of the bolt groups (relative moment strength). If provision is made for ductility and stability, it follows from the lower bound theorem of limit states analysis that the distribution which yields the greatest strength is closest to the true strength. Note that the possibility exists that one of the beams may be devoid of live load at the same time that the opposite beam is fully loaded. This condition must be considered by the designer when apportioning the moment.

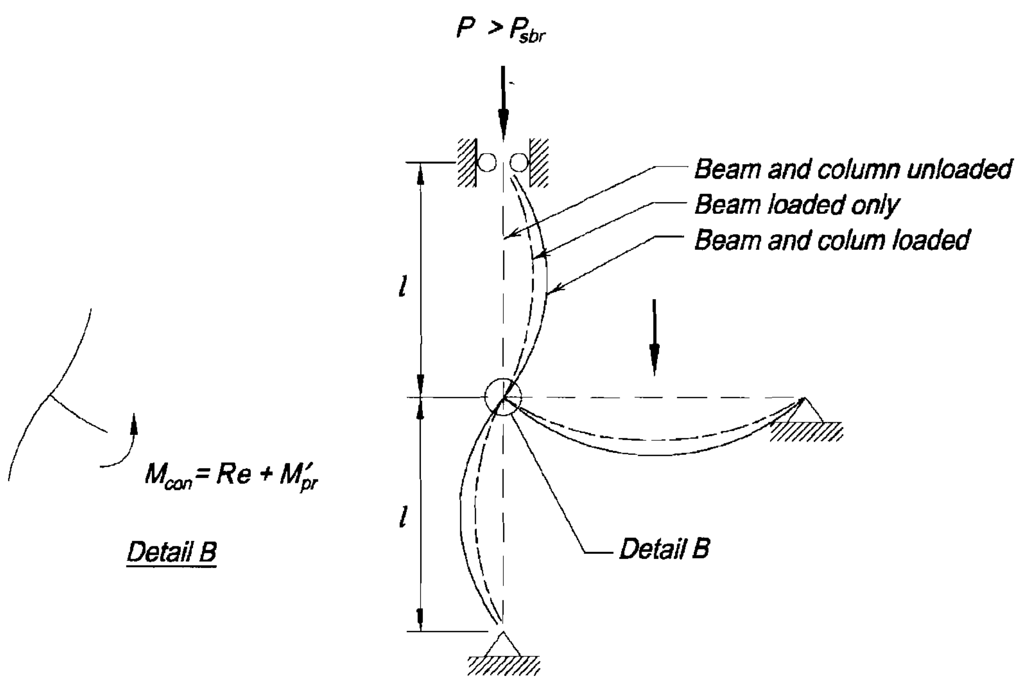


Figure 10–23. Illustration of beam, column, and connection behavior under loading of beam and column.

Girder-Web Supports

The girder-web support of Figure 10–24 usually provides only minimal torsional stiffness or strength. When larger-than-normal gages are used, the end rotation of the supported beam will usually be accommodated through rotation of the girder support. It follows that the bolt group should be designed to resist both the shear, R, and the eccentric moment, Re. The beam end reaction will then be carried through to the center of the supporting girder web.

The welds connecting the plate to the supporting girder web should be designed to resist the shear, R, only; the top and bottom plate-to-girder-flange welds have minimal strength normal to their length, are not assumed to carry any calculated force, and may be of minimum size in accordance with AISC Specification Section J2.

Similarly, for the girder illustrated in Figure 10–25 supporting two eccentric reactions, each connection should be designed for its respective shear R_1 and R_2, and the eccentric moment, $|R_2e_2 - R_1e_1|$, may be apportioned between the two simple shear connections as the designer sees fit.

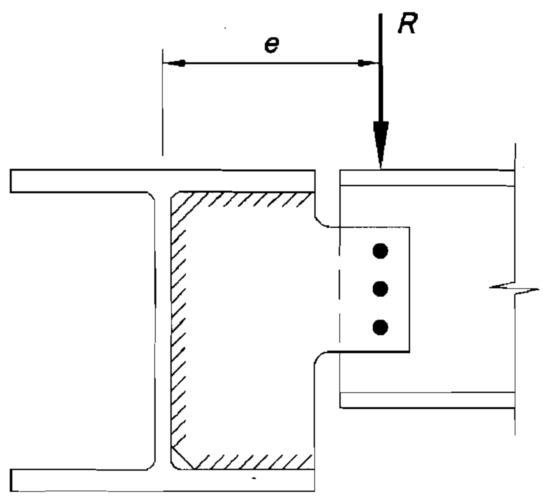


Figure 10–24. Eccentric moment on girder-web support.

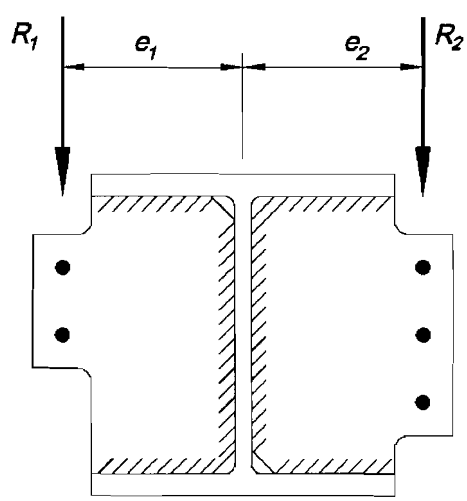


Figure 10–25. Girder-web support subject to dual eccentric moments.

Alternative Treatment of Eccentric Moment

In the foregoing treatment of eccentric moments with column- and girder-web supports, it is possible to design the support (instead of the connection) for the eccentric moment Re. Additionally, when metal deck is used with puddle welds or self-tapping screws, the metal deck tends to reduce relative movement between the two members and thus will tend to carry all or some of the eccentric moment. In these cases, the connection may be designed for the shear, R, only or the shear and a reduced eccentric moment.

Double Connections

When beams frame opposite each other and are welded to the web of the supporting girder or column, there are usually no dimensional constraints imposed on one connection by the presence of the other connection unless erection bolts are common to each connection. When the connections are bolted to the web of the supporting column or girder, however, the close proximity of the connections requires that some or all fasteners be common to both connections. This is known as a double connection. See also the discussion under Erectability Considerations.

Supported Beams of Different Nominal Depths

When beams of different nominal depths frame into a double connection, care must be taken to avoid interference from the bottom flange of the shallower beam with the entering and tightening clearances for the bolts of the connection for the deeper beam. Access to the bolts that will support the deeper beam may be provided by coping or blocking the bottom flange of the shallower beam. Alternatively, stagger may be used to favorably position the bolts around the bottom flange of the shallower beam.

Supported Beams Offset Laterally

Frequently, beams do not frame exactly opposite each other, but are offset slightly, as illustrated in Figure 10–26. Several connection configurations are possible, depending on the offset dimension.

If the offset were equal to the gage on the support, the connection could be designed with all bolts on the same gage lines, as shown in Figure 10–26b, and the angles arranged, as shown in Figure 10–26d. If the offset were less than the gage on the support, staggering the bolts, as shown in Figure 10–26c, would reduce the required gage and the angles could be arranged, as shown in Figure 10–26c. In any case, each bolt transmits an equal share of its beam reaction(s) to the supporting member, with the bolts that are loaded in double shear ultimately carrying twice as much force as those loaded in single shear. Once the geometry of the connection has been determined, the distribution of the forces is patterned after that in the design of a typical connection. For normal gages, eccentricity may be ignored in this type of connection.

Beams Offset From Column Centerline

Framing to the Column Flange from the Strong Axis

As illustrated in Figure 10–27, beam-to-column-flange connections offset from the column centerline may be supported on a typical welded seat, stiffened or unstiffened, provided the welds for the seat can be spaced approximately equally on either side of the beam centerline.

Two such seats offset from the W12×65 column centerline by 2¼ in. and 3½ in. are shown in Figures 10–27a and 10–27b, respectively. While not shown, top angles should be used with this connection.

Since the entire seat fits within the flange width of the column, the connection of Figure 10–27a is readily selected from the design aids presented previously. However, the larger

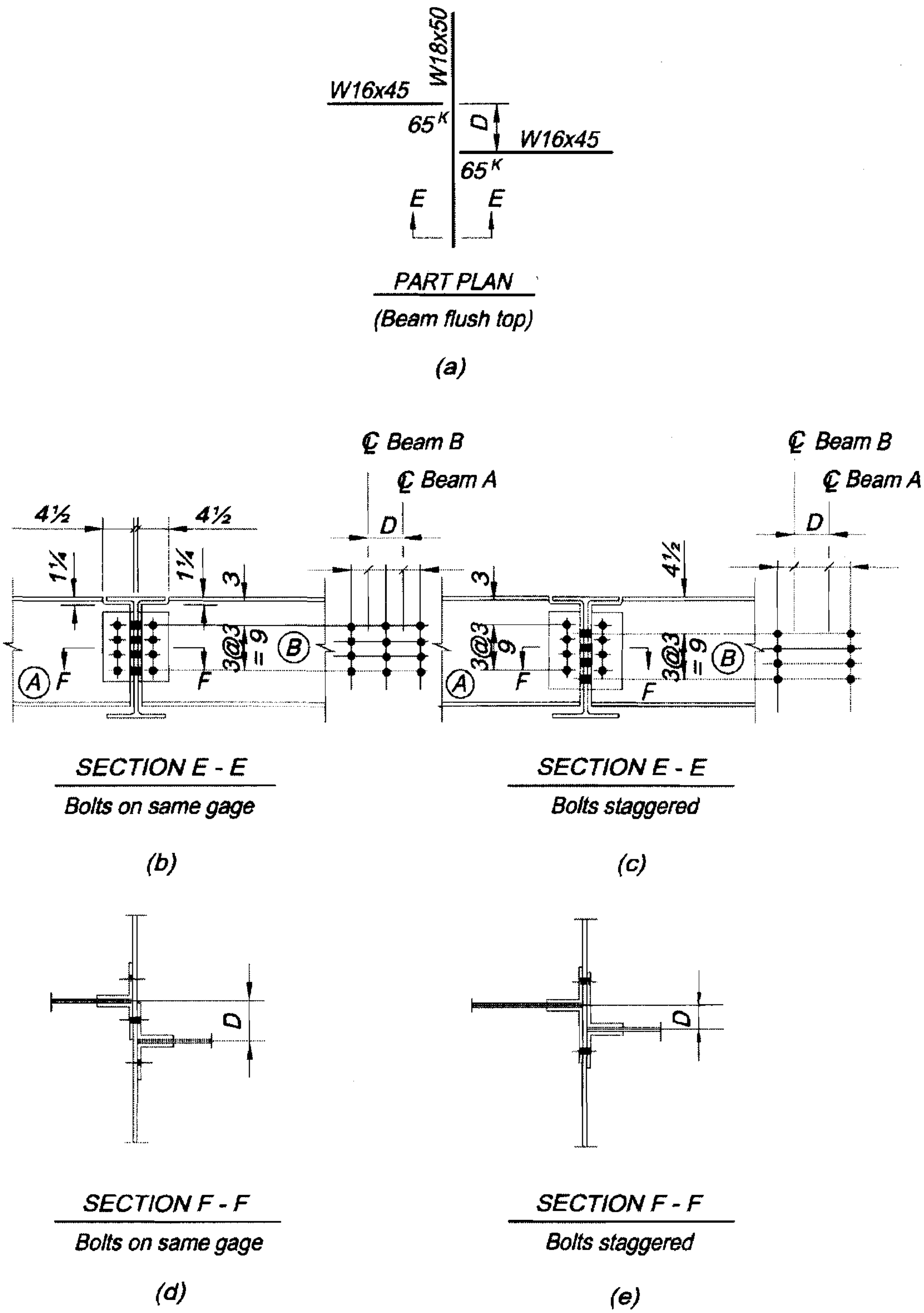
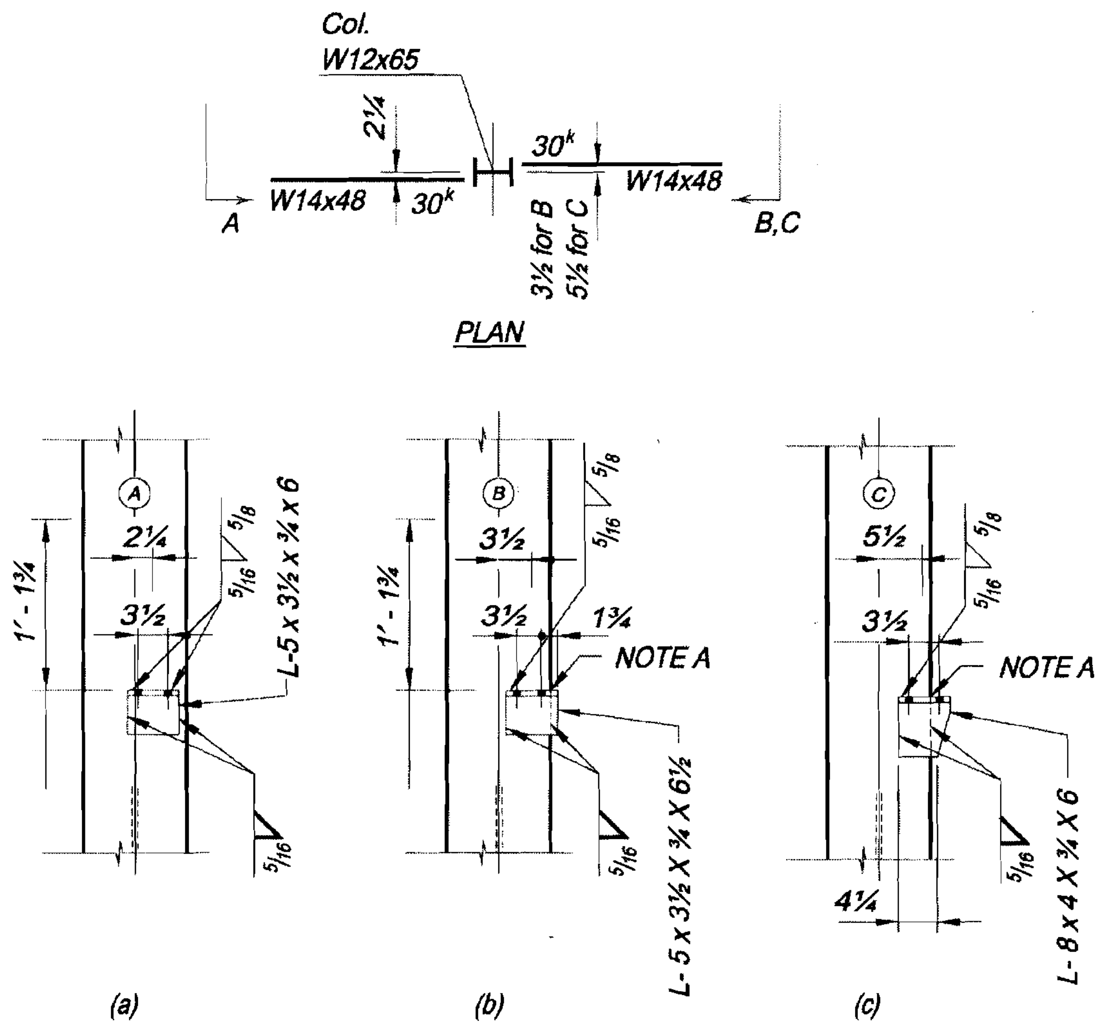


Figure 10–26. Offset beams connected to girder.



NOTE A

End return is omitted because the AWS Code does not permit weld returns to be carried around the corner formed by the column flange toe and seat angle heel.

NOTE B

Beam and top angle not shown for clarity.

Figure 10–27. Offset beams connected column flanges.

beam offsets in Figures 10–27b and 10–27c require that one of the welds be made along the edge of the column flange against the back side of the seat angle. Note that the end return is omitted because weld returns should not be carried around such a corner.

For the beam offset of $5^1/_2$ in. shown in Figure 10–27c, the seat angle overhangs the edge of the beam and the horizontal distance between the vertical welds is reduced to $3^1/_2$ in.; the center of gravity of the weld group is located $1^1/_4$ in. to the left of the beam centerline. The force on each weld may be determined by statics. In this case, the larger force is in the righthand weld and may be determined by summing moments about the lefthand weld. Once the larger force has been determined, the seat should conservatively be designed to carry twice the force in the more highly loaded weld.

Framing to the Column Flange from the Weak Axis

Spandrel beams X and Y in the partial plan shown in Figure 10–28 are offset $4^1/_8$ in. from the centerline of column C1, permitting the beam web to be connected directly to the column flange. At column B2, spandrel beam X is offset five inches and requires a $^7/_8$-in. filler between the beam web and the column flange. Beams X and Y are both plain-punched beams, with flange cuts on one side, as noted in Figure 10–28a, Section F-F.

In establishing gages, the requirements of other connections to the column at adjacent locations must be considered. While the workable flange gage is $3^1/_2$ in. for the W8×28 columns supporting the spandrel beams, for beams Z, the combination of a 4-in. column gage and $1^1/_2$-in. stagger of fasteners is used to provide entering and tightening clearance for the field bolts and sufficient edge distance on the column flange, as illustrated in Figure 10–28b. The 4-in. column gage also permits a $1^1/_2$-in. edge distance at the ends of the spandrel beams, which will accommodate the normal length tolerance of $\pm^1/_4$ in. as specified in "Standard Mill Practice" in Part 1.

The spandrel beams are shown with the notation "Cut and Grind Flush FS" in Sections E-E and F-F. This cut permits the beam web to lie flush against the column flange. The uncut flange on the near side of the spandrel beam contributes to the stiffness of the connection. The $2^1/_2$×$^7/_8$-in. filler is required between the spandrel beam web and the flange of the column B2 because of the $^7/_8$-in. offset. Since the filler in Section E-E, Figure 10–28a, is thicker than $^3/_4$ in., it must be fully developed.

In the part plan in Figure 10–29a, the W16×40 beam is offset $6^1/_4$ in. from the centerline of column D1. This prevents the web of the W16×40 from being placed flush against the side of the column flange. A plate and filler are used to connect the beam to the column flange, as shown in Figure 10–29b. Such a connection is eccentric and one group of fasteners must be designed for the eccentricity. Lack of space on the inner flange face of the column requires development of the moment induced by the eccentricity in the beam web fasteners.

To minimize the number of field fasteners, the plate in this case is shop-bolted to the beam and field-bolted to the column. A careful check must be made to ensure that the beam can be erected without interference from fittings on the column web. Some fabricators would elect to shop-attach the plate to the column to eliminate possible interference and permit use of plain-punched beams. Additionally, if the column were a heavy section, the fabricator may elect to shop-weld the plate to the column to avoid drilling the thick flanges. The welding of this plate to the column creates a much stiffer connection and the design should be modified to recognize the increased rigidity.

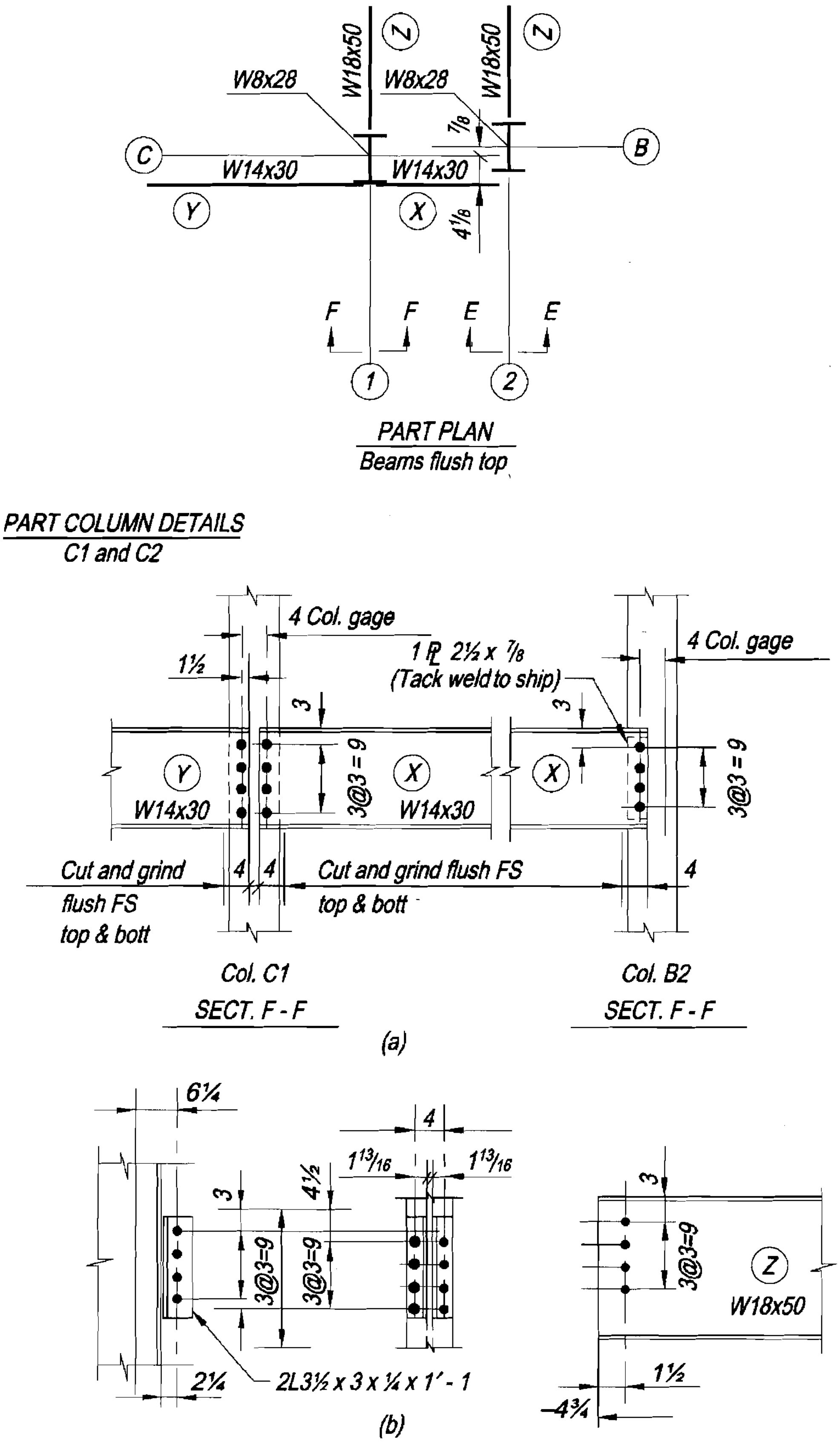
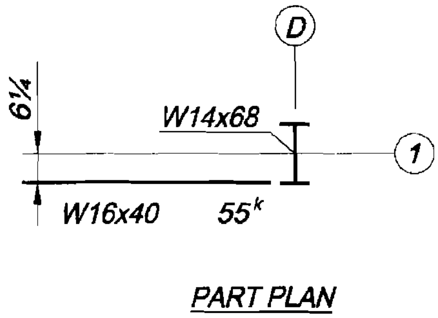


Figure 10–28. Offset beams connected to column.



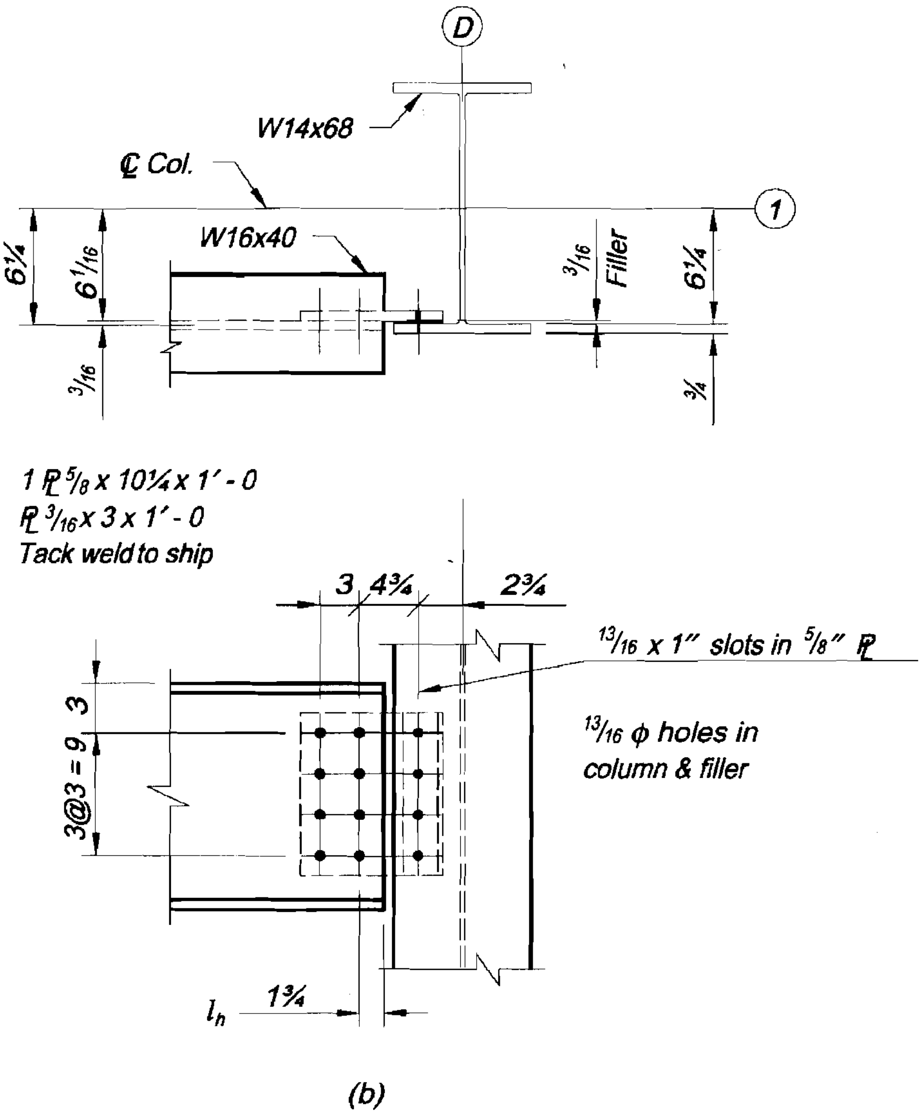


Figure 10–29. Offset beam connected to column.

If the centerline of the W16 were offset $6^1/_{16}$ in. from line 1, it would be possible to cope or cut the flanges flush top and bottom and frame the web directly to the column flange with details similar to those shown in Figure 10–29. This type of framing also provides a connection with more rigidity than normally contemplated in simple construction. A coped connection of this type would create a bending moment at the root of the cope that might require reinforcement of the beam web.

One method frequently adopted to avoid moment transfer to the column because of beam connection rigidity is to use slotted holes and a bearing connection to provide some flexibility. The slotted holes would be provided in the connection plate only and would be in the field connection only. These slotted connections also would accommodate fabrication and erection tolerances.

The type of connection detailed in Figure 10–29 is similar to a coped beam and should be checked for buckling, as illustrated in Part 9. The following differences are apparent and should be recognized in the analysis:

1. The effective length of equivalent "cope" is longer by the amount of end distance to the first bolt gage line.
2. There is an inherent eccentricity due to the beam web and plate thickness. The ordinary web and plate thicknesses normally will not require an analysis for this condition, since the inelastic rotation allowed by the AISC Specification will relieve this secondary moment effect. Two plates may sometimes be required to counter this eccentricity when dimensions are significant.
3. The connection plate can be made of sufficient thickness as required for bending or buckling stresses with a minimum thickness of $^3/_8$ in.

Framing to the Column Web

If the offset of the beam from the centerline of the column web is small enough that the connection may still be centered on or under the supported beam, no special considerations need be made. However, when the offset of the beam is too large to permit the centering of the connection under the beam, as in Figure 10–30, it may be necessary to consider the effect of eccentricity in the fastener group.

The offset of the beam in Figure 10–30 requires that the top and bottom flanges be blocked to provide erection clearance at the column flange. Since only half of each flange, then, remains in which to punch holes, a 6-in. outstanding leg is used for both the seat and top angles of these connections; this permits the use of two field bolts to each of the seat and top angles, which are required by OSHA.

Connections for Raised Beams

When raised beams are connected to column flanges or webs, there is usually no special consideration required. However, when the support is a girder, the differing tops of steel may preclude the use of typical connections. Figure 10–31 shows several typical details commonly used for such cases in bolted construction. Figure 10–32 shows several typical details commonly used in welded construction.

In Figure 10–31a, since the top of the W12×35 is located somewhat less than 12 in. above the top of the W18 supporting beam, a double-angle connection is used. This connection would be designed for the beam reaction and the shop bolts would be governed by double shear or bearing, just as if they were located in a vertical position. However, the field bolts are not required to carry any calculated force under gravity loading.

The maximum permissible distance *m* depends on the beam reaction, since the web remaining after the bottom cope must provide sufficient area to resist the vertical shear as well as the bending moment which would be critical at the end of the cope. The beam can be reinforced by extending the angles beyond the cope and adding additional shop bolts for development. The angle size and/or thickness can be increased to gain shear area or section modulus, if required. The effect of any eccentricity would be a matter of judgment, but could be neglected for small dimensions.

When this connection is used for flexure or for dynamic or cyclical loading, the web is subjected to high stress concentrations at the end of the cope, and it is good practice to extend the angles, as shown in Figure 10–31a by the dashed lines, to add at least two additional web fasteners.

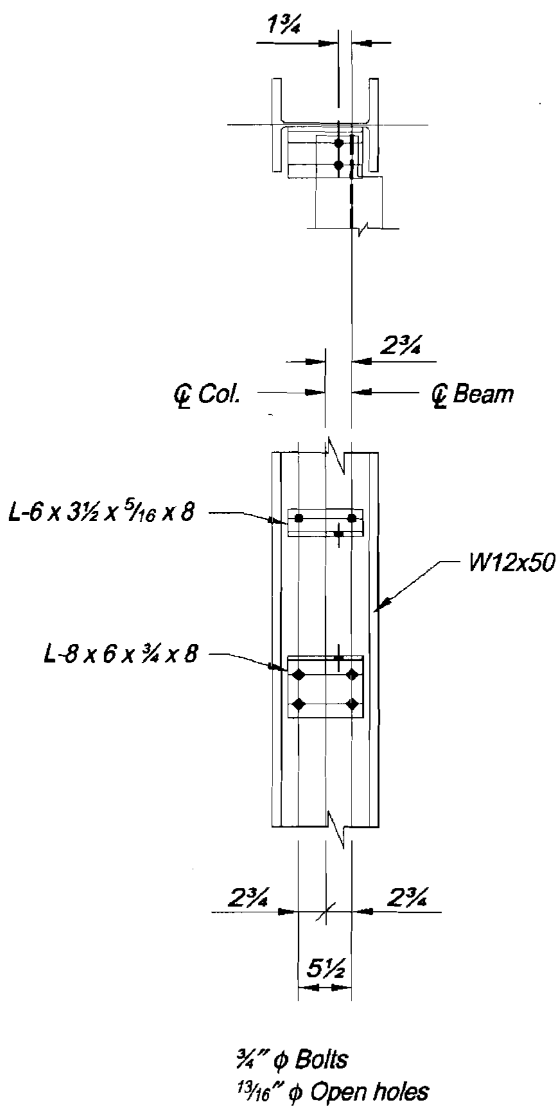


Figure 10–30. Offset beam connected to column web.

Figure 10–31b covers the case where the bottom flange of the W12×35 is located a few inches above the top of the W18. The beam bears directly upon fillers and is connected to the W18 by four field bolts which are not required to transmit a calculated gravity load. If the distance *m* exceeds the thickest plate which can be punched, two or more plates may be used. Even though the fillers in this case need only be 6½-in. square, the amount of material required increases rapidly as *m* increases. If *m* exceeds 2 or 3 in., another type of detail may be more economical.

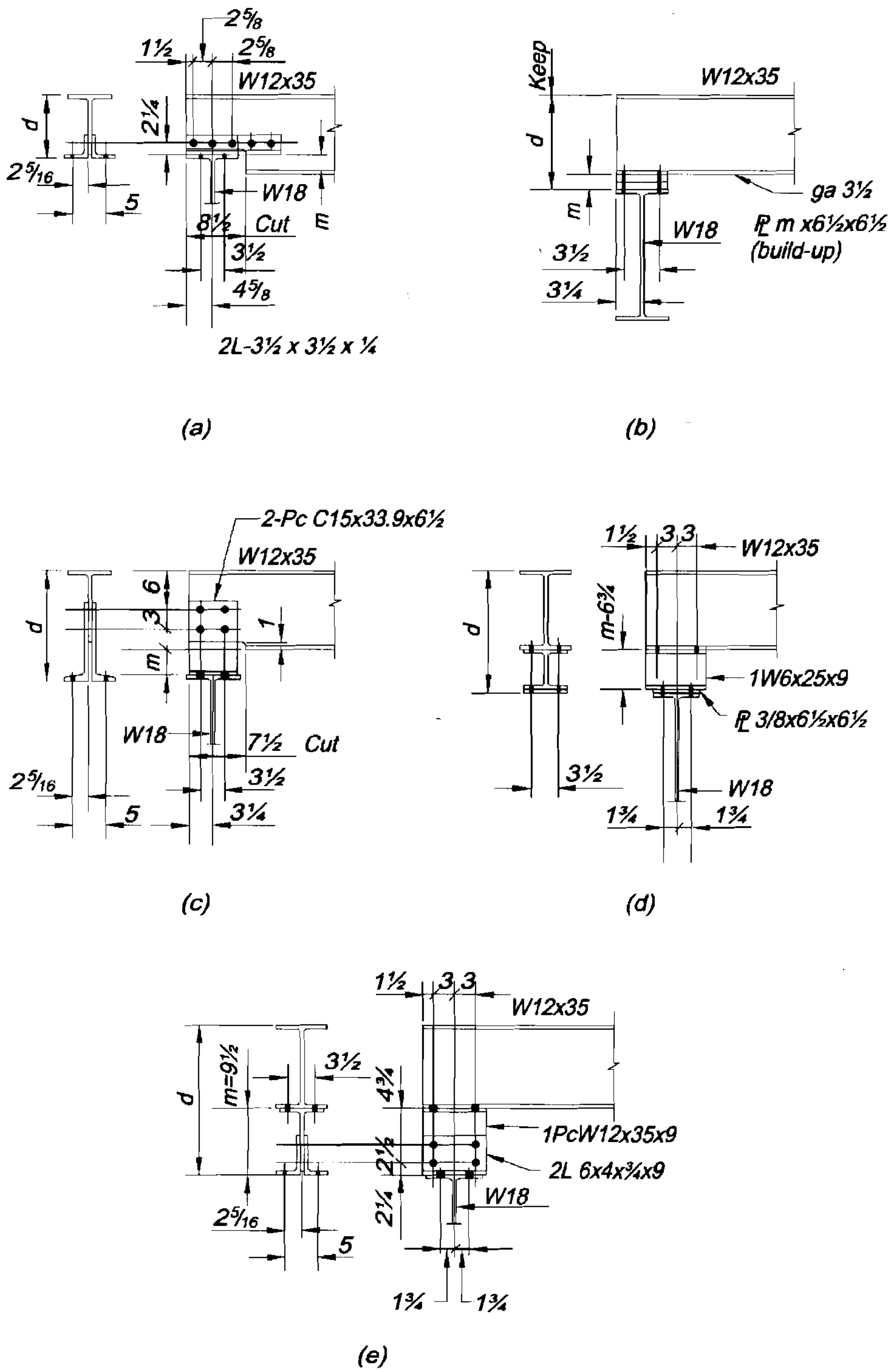


Figure 10–31. Bolted raised-beam connections.

The detail shown in Figure 10–31c is used frequently when *m* is up to 6 or 7 in. The load on the shop bolts in this case is no greater than that in Figure 10–31a. However, to provide more lateral stiffness, the fittings are cut from a 15-in. channel and are detailed to overlap the beam web sufficiently to permit four shop bolts on two gage lines.

A stool or pedestal, cut from a rolled shape, can be used with or without fillers to provide for the necessary *m* distance, as in Figure 10–31d. A pair of connection angles and a tee will also serve a similar purpose, as shown in Figure 10–31e. To provide adequate strength to

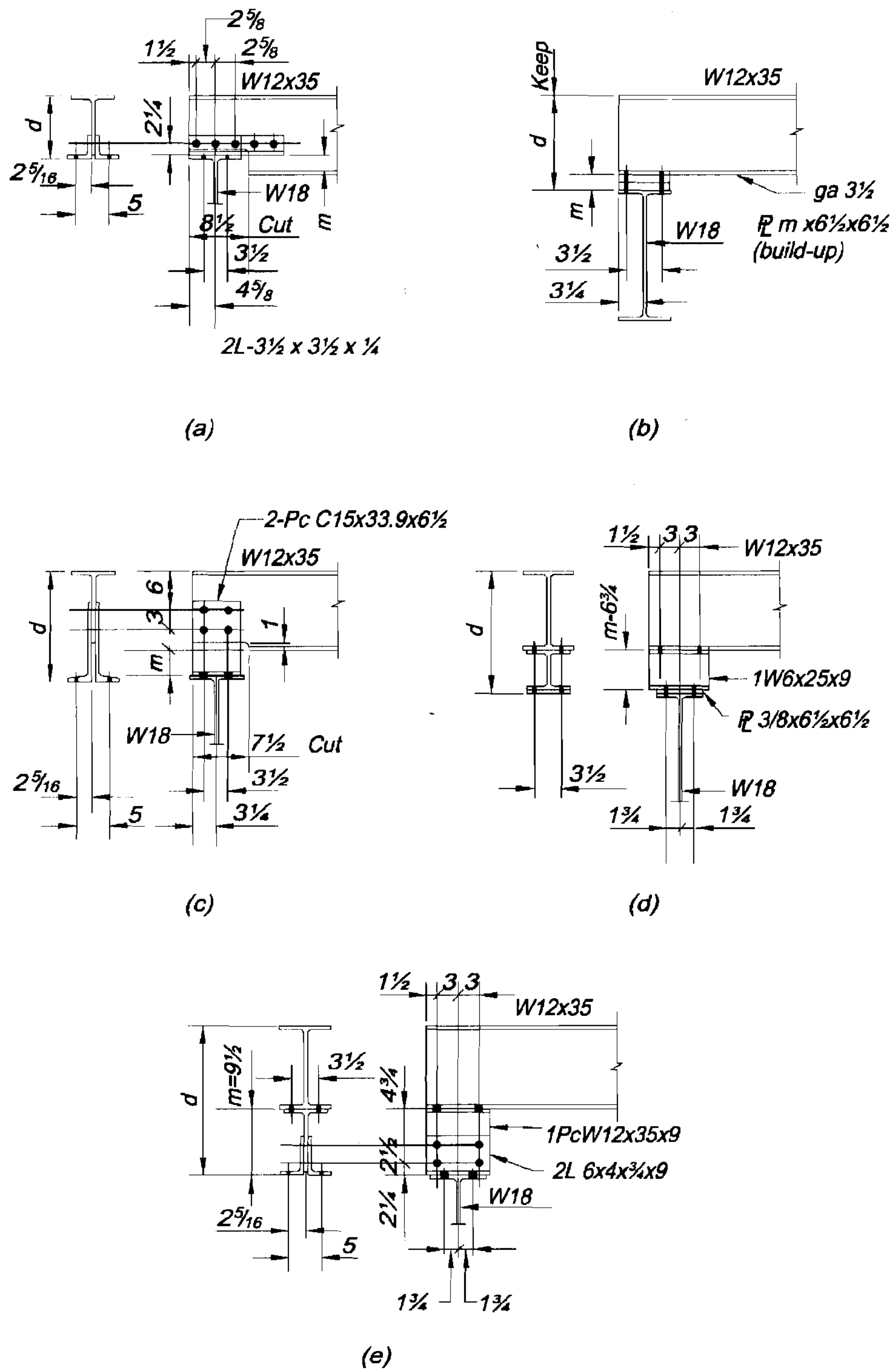


Figure 10–32. Welded raised-beam connections.

carry the beam end reaction and to provide lateral stiffness, the web thickness of the pedestal in each of these cases should be at least as thick as the member being supported.

In Figure 10–32a, welded framing angles are substituted for the bolted angles of Figure 10–32a. In Figure 10–32b, a single horizontal plate is shown replacing the pair of framing angles; this results in a savings in material and the amount of shop-welding. In this case, particular care must be taken in cutting the beam web and positioning the plate at right angles to the beam web. For this reason, if only a few connections of this type are to be made, some fabricators prefer to use the angles, as in Figure 10–32a. If sufficient duplication were available to warrant making a simple jig to position the plate during welding, the solution of Figure 10–32b may be economical.

Figure 10–32c shows a tee centered on the beam web and welded to the bottom flange of the beam. The tee stem thickness should not be less than the beam web thickness. The welded solutions shown in Figures 10–32d and 10–32e are capable of providing good lateral stiffness. The latter two types also permit end rotation as the beam deflects under load. However, if the m distance exceeds 3 or 4 in., it is advisable to shop-weld a triangular bracket plate at one end of the beam, as indicated by the dashed lines, to prevent the beam from deflecting along its longitudinal axis.

Other equally satisfactory details may be devised to meet the needs of connections for raised beams. They will vary depending on the size of the supported beam and the distance m. When using this type of connection where the load is transmitted through bearing, the provisions of AISC Specification Sections J10.2 and J10.3 must be satisfied for both the supported and supporting members. For the detail of Figure 10–32b, since the rolled fillet has been removed by the cut, the value of k would be taken as the thickness of the plate plus the fillet weld size.

AISC Specification Appendix 6 requires stability and restraint against rotation about the beam's longitudinal axis. This provision is most easily accomplished with a floor on top of the supported beam. In the absence of a floor, the top flange may be supported by a strut or bracket attached to the supporting member. When the beam is encased in a wall, this stability may also be provided with wall anchors; refer to "Wall Anchors" in Part 15.

This discussion has considered that the field bolts which attach the beam to the pedestal or support beam are subject to no calculated load. It is important, however, to recognize that when the beam deflects about its neutral axis, a tensile force can be exerted on the outside bolts. The intensity of this tensile force is a function of the dimension d, indicated in Figure 10–31, the span length of the supported member, and the beam stiffness. If these forces are large, high-strength bolts should be used and the connection analyzed for the effects of prying action.

Raised-beam connections such as these are used frequently as equipment or machinery supports where it is important to maintain a true and level surface or elevation. When this tolerance becomes important, the dimension d should be noted "keep" to advise the fabricator of this importance, as shown in Figure 10–31b. Since the supporting beam is subject to certain camber/deflection tolerances, it also may be appropriate to furnish shim packs between the connection and the supporting member.

Non-Rectangular Simple Shear Connections

It is often necessary to design connections for beams that do not frame into a support orthogonally. Such a beam may be inclined with respect to the supporting member in various directions. Depending upon the relative angular position which a beam assumes, the connection may be classified among three categories: skewed, sloped, or canted. These conditions are illustrated in Figure 10–33 for beam-to-girder web connections; the same descriptions apply to beam-to-column-flange and web connections. Additionally, beams may be oriented in a combination of any or all of these conditions. For any condition of skewed, sloped, or canted framing, the single-plate connection is generally the simplest and most economical of those illustrated in this text.

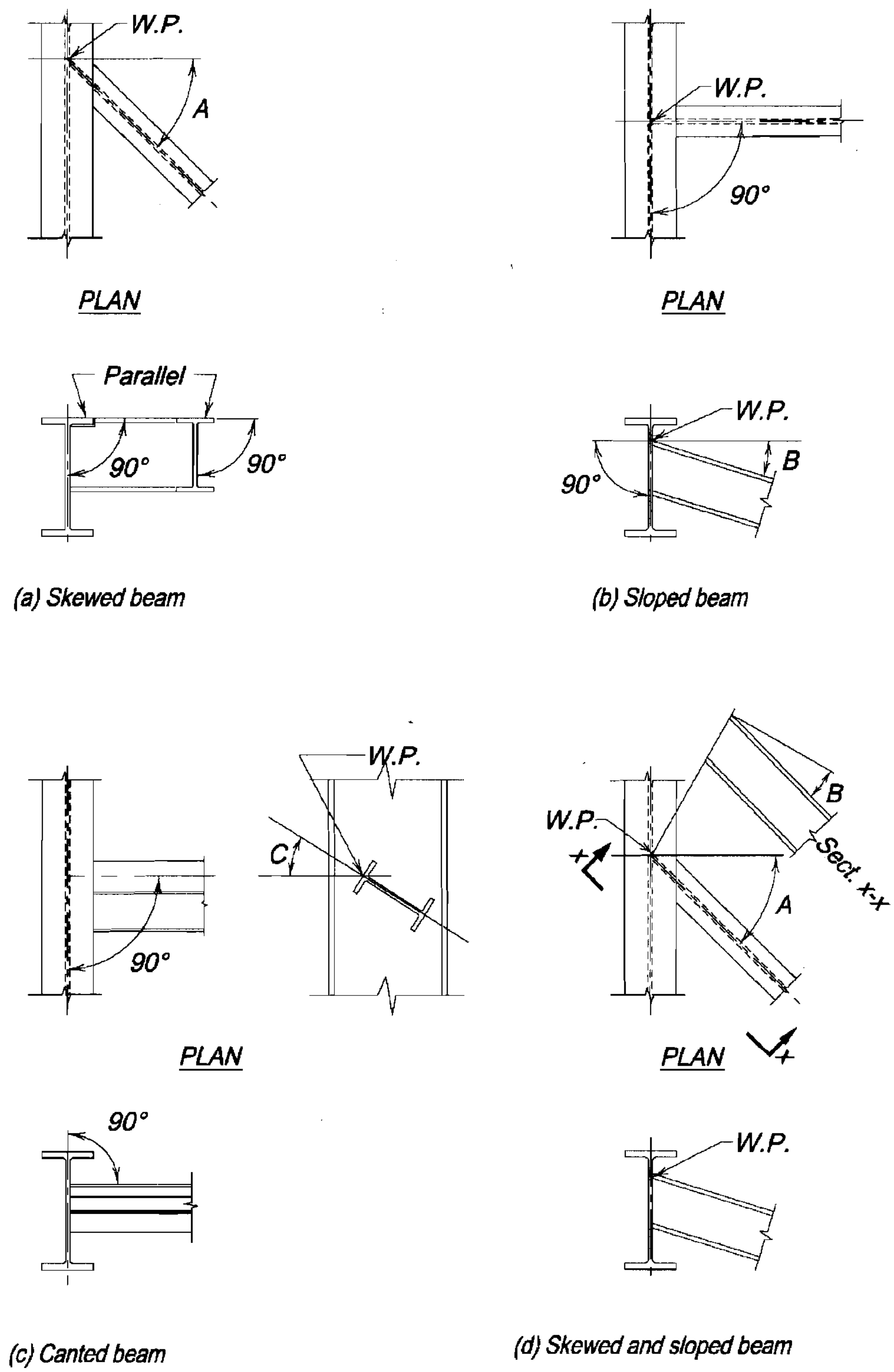


Figure 10–33. Non-rectangular connections.

Skewed Connections

A beam is said to be skewed when its flanges lie in a plane perpendicular to the plane of the face of the supporting member, but its web inclined to the face of the supporting member. The angle of skew A appears in Figure 10–33a and represents the horizontal bevel to which the fittings must be bent or set, or the direction of gage lines on a seated connection.

When the skew angle is less than 5° (1-in-12 slope), a pair of double angles can be bent inward or outward to make the connection, as shown in Figure 10–34. While bent angle sections are usually drawn as bending in a straight line from the heel, rolled angles will tend to bend about the root of the fillet (dimension *k* in Manual Part 1). This produces a significant jog in the leg alignment, which is magnified by the amount of bend. Above this angle of skew, it becomes impractical to bend rolled angles.

For skews approximately greater than 5° (1-in-12 slope), a pair of bent plates, shown in Figure 10–35, may be a more practical solution. Bent plates are not subject to the deformation problem described for bent angles, but the radius and direction of the bend must be considered to avoid cracking during the cold-bending operation.

Bent plates exhibit better ductility when bent perpendicular to the rolling direction and are, therefore, less likely to crack. Whenever possible, bent connection plates should be

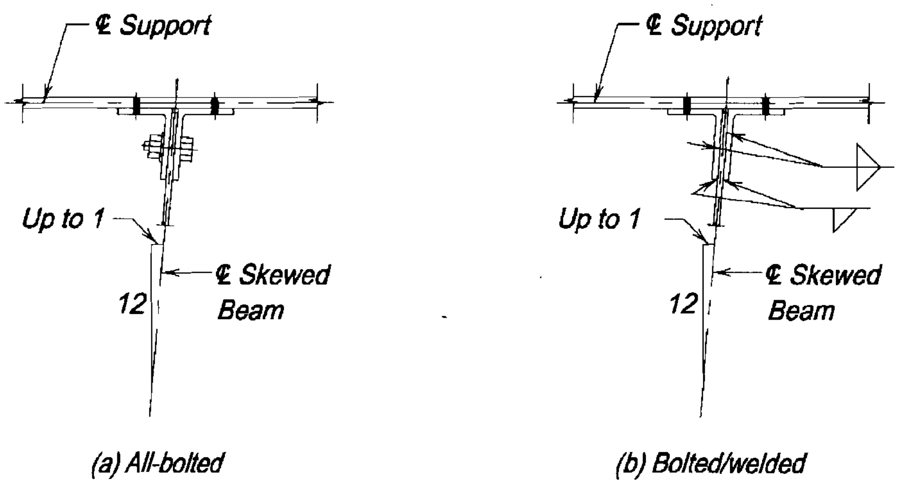


Figure 10–34. Skewed beam connections with bent double angles.

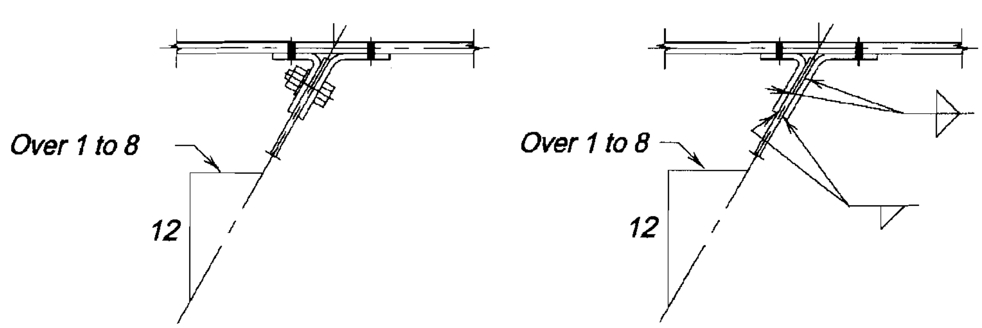


Figure 10–35. Skewed beam connections with double bent plates.

billed with the width dimension parallel to the bend line. The length of the plate is measured on its mid-thickness, without regard to the radius of the bend. While this will provide a plate that is slightly longer than necessary, this will be corrected when the bend is laid out to the proper radius prior to fabrication.

Table 10–12 gives the generally accepted minimum inside-bending radius for plate thickness, t, for various grades of steel. Values are for bend lines transverse to the direction of final rolling (Brockenbrough, 1998). When bend lines are parallel to the direction of final rolling, the tabular values may have to be approximately doubled. When bend lines are longer than 36 inches, all radii may have to be increased if problems in bending are encountered.

Before bending, special attention should be given to the condition of plate edges transverse to the bend lines. Flame-cut edges of hardenable steels should be machined or softened by heat treatment. Nicks should be ground out and sharp corners should be rounded.

The strength of bent angles and bent plate connections may be calculated in the same manner as for square framed beams, making due allowances for eccentricity. The load is assumed to be applied at the point where the skewed beam center line intersects the face of the supporting member.

As the angle of skew increases, entering and tightening clearances on the acutely angled side of the connection will require a larger gage on the support. If the gage were to become objectionable, a single bent plate, illustrated in Figure 10–36, may provide a better solution. Note that the single-bent plate may be of the conventional type, or a more compact connection may be developed by "wrapping" the single bent plate, as illustrated in Figure 10–36c.

In all-bolted construction, both the shop and field bolts should be designed for shear and the eccentric moment. A C-shaped weld is preferable to avoid turning the beam during shop fabrication. Single bent plates should be checked for flexural strength.

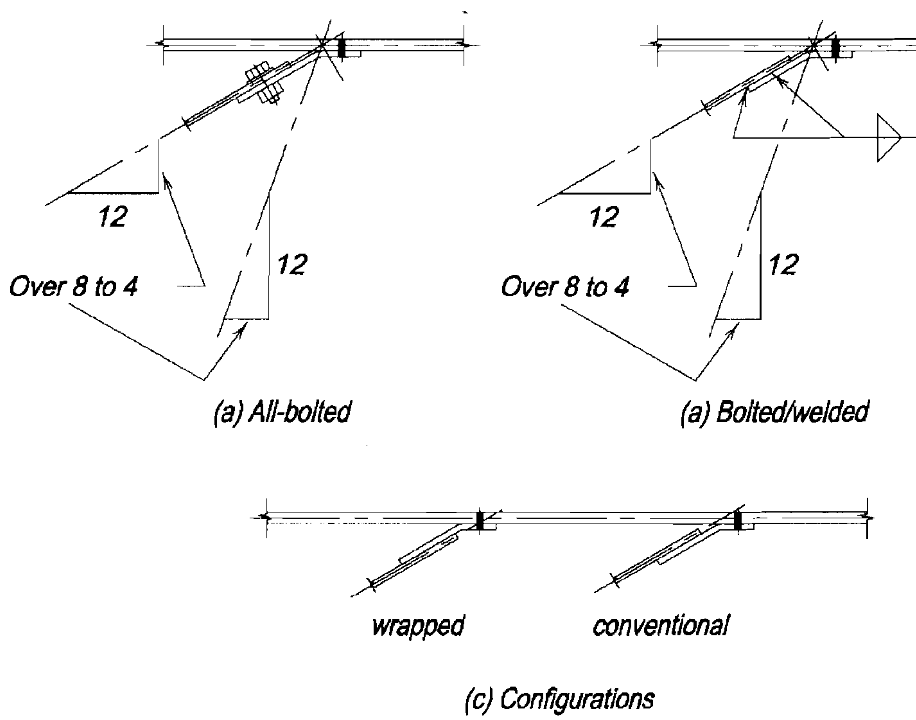


Figure 10–36. Skewed-beam connections with single-bent plates.

Table 10–13 gives clearance dimensions for bent double-angle connections and double- and single-bent plate connections, and specifies beam set-backs and gages. Since these dimensions are based on the maximum material thicknesses and fastener sizes indicated, it is suggested that in cases where many duplicate connections with less than maximum material or fasteners are required, savings can be effected if these dimensions are developed from specific bevels, beam sizes, and fitting thicknesses.

Skewed single-plate and skewed end-plate connections, shown in Figures 10–37 and 10–40, provide a simple, direct connection with a minimum of fittings and multiple punching requirements. When fillet-welded, these connections may be used for skews up to 30° (or a slope of 6⁵/₁₆-in-12) provided the root opening formed does not exceed ³/₁₆ in. For skew angles greater than 30°, see AWS D1.1, Section 2.2.5.2.

The maximum beam-web thickness which may be supported is a function of the maximum root opening and the angle of skew. If the thickness of the beam web were such that a larger root opening were encountered, the skewed single plate or the web connecting to the skewed end plate may be beveled, as shown in Figures 10–37b and 10–38b. Since no root opening occurs with the bevel, there is no limitation on the thickness of the beam web. However, beveling, especially of the beam web, requires careful finishing and is an expensive procedure which may outweigh its advantages.

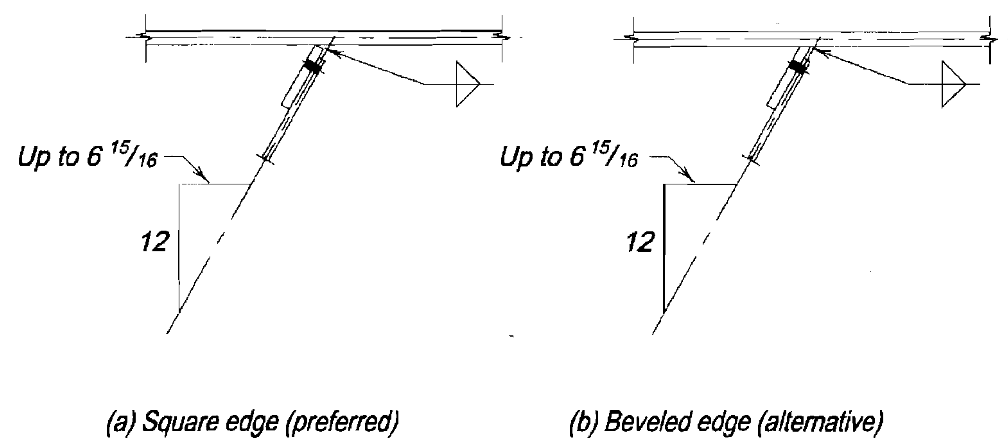


Figure 10–37. Skewed single-plate connections.

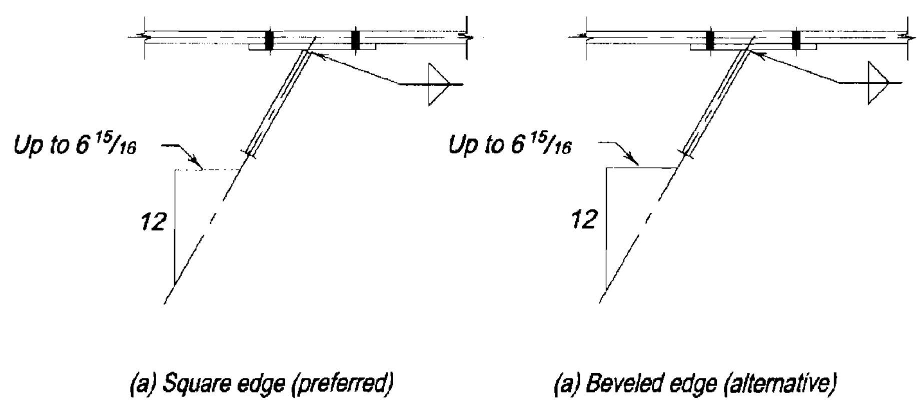


Figure 10–38. Skewed shear end-plate connections.

The design of skewed end-plate connections is similar to that discussed previously in "Shear End-Plate Connections" in this Part. However, when the gage of the bolts is not centered on the beam web, this eccentric loading should be considered. The design of skewed single-plate connections is similar to that discussed previously in "Single-Plate Connections" in this Part.

Table 10–13 specifies gages and the dimension A which is added to the fillet weld size to compensate for the root opening for skewed end-plate connections. This table is based conservatively on a gap of $^1/_8$ in. For beam webs beveled to the appropriate skew, $A = 0$ and the tabulated values do not apply. Table 10–13 also provides similar information for skewed single-plate connections. Additionally, this table provides clearances and dimensions for groove-welded single-plate connections with backing bars for skews greater than 30°; refer to AWS D1.1 for prequalified welds for both types of joints.

When skewed, stiffened seated connections are used, the stiffening element should be located so as to cross the skewed beam centerline well out on the seat. This can be accomplished by shifting the stiffener to the left or right of center to support beams which skew to the left or to the right, respectively. Alternatively, it may be possible to skew the stiffening element.

Sloped Connections

A beam is said to be sloped if the plane of its web is perpendicular to the plane of the face of the supporting member, but its flanges are not perpendicular to this face. The angle of slope B is shown in Figure 10–33b and represents the vertical angle to which the fittings must be set to the web of the sloped beam, or the amount that seat and top angles must be bent.

The design of sloped connections usually can be adapted directly from the rectangular connections covered earlier in this part, with consideration of the geometry of the connection to establish the location of fittings and fasteners. Note that sloped beams often require copes to clear supporting girders, as illustrated in Figure 10–39.

Figure 10–40 shows a sloped beam with double-angle connections, welded to the beam and bolted to the support. The design of this connection is essentially similar to that for rectangular double-angle connections. Alternatively, shear end-plate, tee, single-angle, single-plate, or seated connections could be used. Selection of a particular connection type may be influenced by fabrication economy, erectability, and/or by the types of connections used elsewhere in the structure.

Sloped seated beam connections may utilize either bent angles or plates, depending on the angle of slope. Dimensioning and entering and clearance requirements for sloped seated connections are generally similar to those for skewed connections. The bent seat and top plate shown in Figure 10–41 may be used for smaller bevels.

When the angle of slope is small, it is economical to place transverse holes in the beam web on lines perpendicular to the beam flange; this requires only one stroke of a multiple punch per line. Since non-standard hole arrangements, then, usually occur in the connecting materials (which are single-punched), this requires that sufficient dimensions be provided for the connecting material to contain fasteners with adequate edges and gages, and at the same time fit the angle to the web without encroaching on the flange fillets of the beam. For the end connection of the beam, this was accomplished by using a 6-in. angle leg; a 4-in. or even a 5-in. leg would not have furnished sufficient edge distance at the extreme fastener.

As the angle of slope increases, however, bolts for the end connections cannot conveniently be lined up to permit simultaneous punching of all holes in a transverse row. In this case, the fabricator may choose to disregard beam gage lines and arrange the hole-punching so that ordinary square-framed connection material can be used throughout, as shown in Figure 10–42.

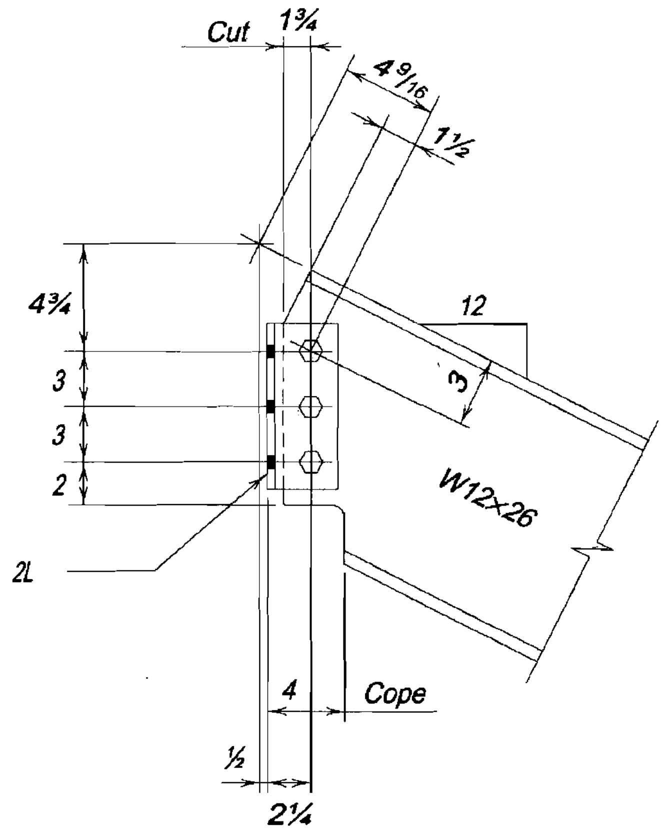


Figure 10–39. Sloped double-angle connection.

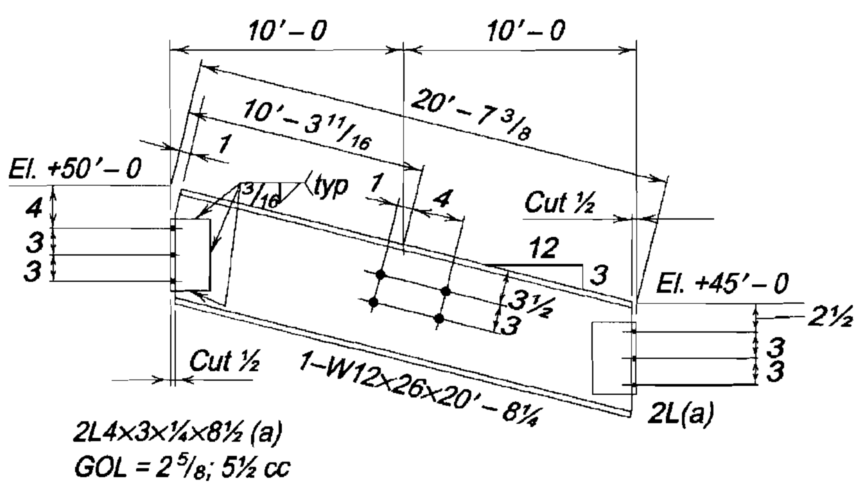


Figure 10–40. Sloped double-angle connection.

Canted Connections

A beam perpendicular to the face of a supporting member, but rotated so that its flanges are tilted with respect to those of the support, is said to be canted. The angle of cant C is shown in Figure 10–33c.

The design of canted connections usually can be adapted directly from the rectangular connections covered earlier in this part. In Figure 10–43, a double-angle connection is used.

Alternatively, shear end-plate, seated, single-angle, single-plate, and tee connections may also be used.

For channel B2, which is supported by a sloping member B1 (not shown), to match the hole pattern in supporting member B1, the holes in the connecting materials must be canted.

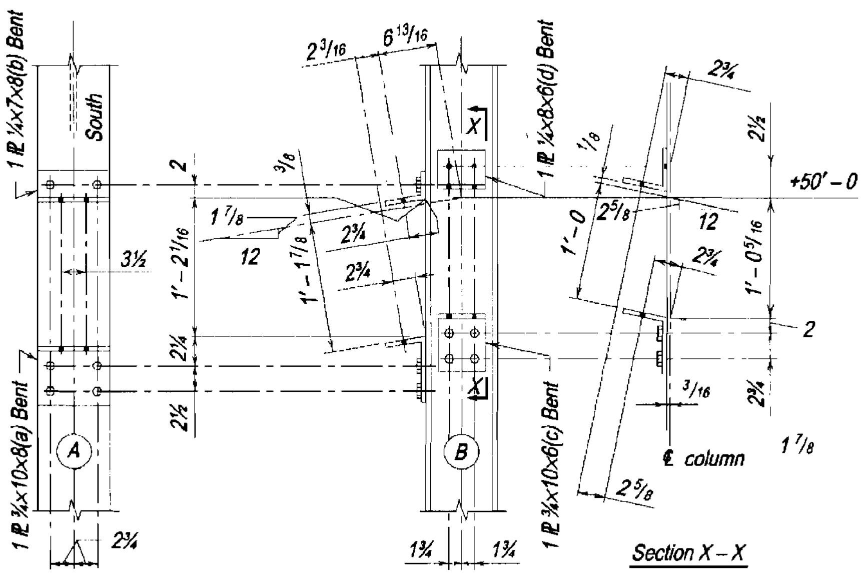


Figure 10–41. Sloped seated connections.

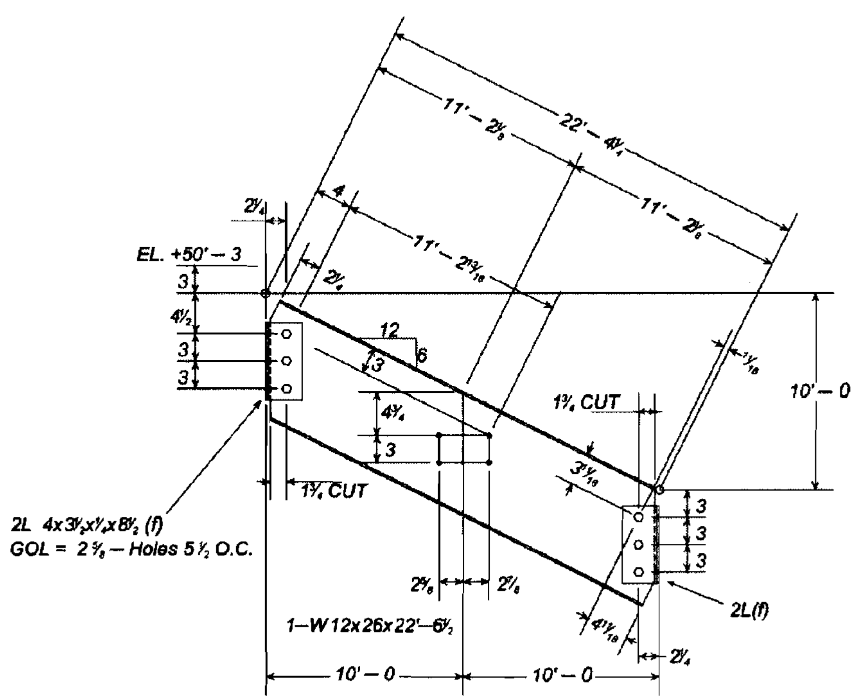


Figure 10–42. Sloped beam with rectangular connections.

As shown in Figure 10–44, the top flange of the channel and the connection angles d^R and d^L are cut to clear the flanges of beam B1. In this detail, with a 3-in-12 angle of cant, 4-in. legs were wide enough to contain the pattern of hole-punching.

Since the multiple punching or drilling of column flanges requires strict adherence to column gage lines, punching is generally skewed in the fittings. When, for some reason, this is not possible, as in Figure 10–45, skewed reference lines are shown on the column to aid in matching connections.

When canted connecting materials are assembled on the beam, particular care must be used in determining the direction of skew for punching the connection angles. An error reversing this skew may permit matching of holes in both members, but the beam will be canted opposite to the intended direction.

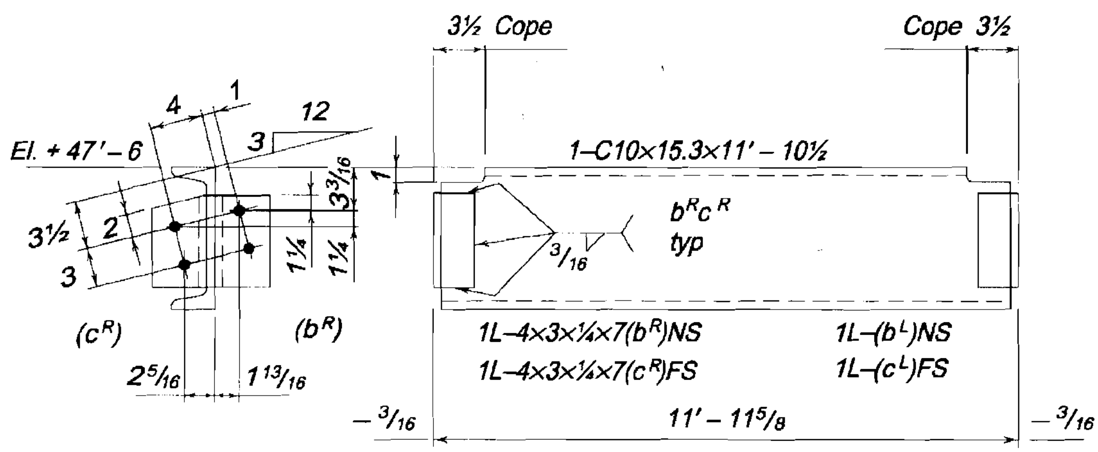


Figure 10–43. Canted double-angle connections.

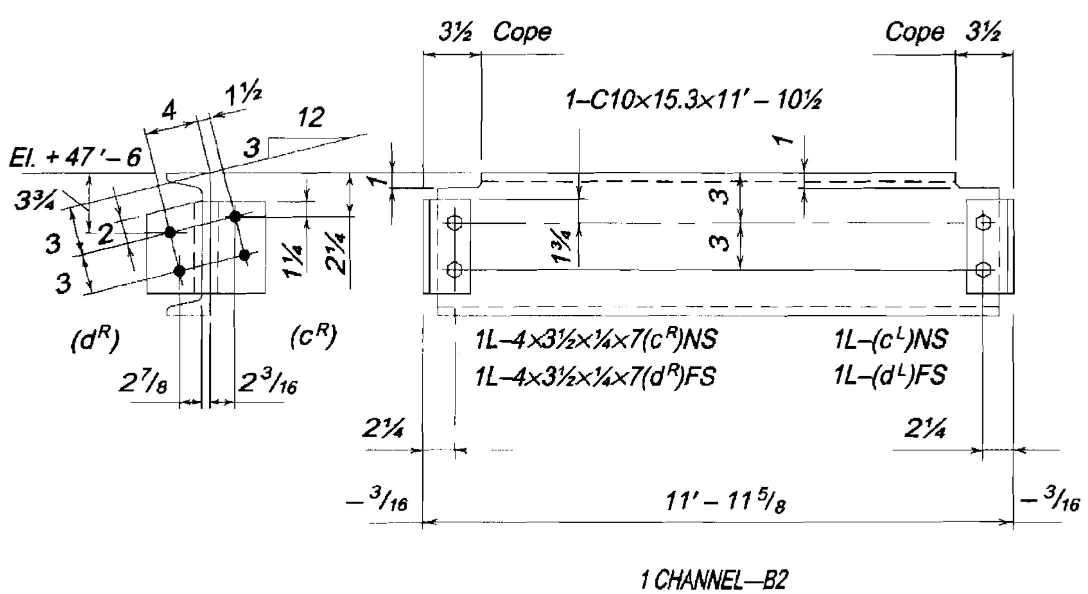


Figure 10–44. Canted connections to a sloping support.

Note the connection angles in Figure 10–45 are shown shop-welded to the beam. This was done to provide tightening clearance for ¾-in. high-strength field bolts in the opposite leg. Had the shop fasteners been bolts, it would have been necessary to stagger the field and shop fasteners and provide longer angles for the increased spacing.

Canted seated beams, shown in Figure 10–46, present few problems other than those in ordinary square-end seated beams. Sufficient width and length of angle leg must be provided to contain the gage line punching or drilling in the column face, as well as the off-center location of the holes matching the punching in the beam flange. The elevation of the top flange centerline and the bevel of the beam flange may be given for reference on the beam detail, although the bevel shown will not affect the fabrication.

Inclines in Two or More Directions (Hip and Valley Framing)

When a beam inclines in two or more directions with respect to the axis of its supporting member, it can be classified as a combination of those inclination directions. For example, the beam of Figure 10–33d is both skewed and sloped. Angle A shows the skew and angle B shows the slope. Note that, since the inclined beam is foreshortened in the elevation, the true angle B appears only in the auxiliary projection, Section X-X. The development of these details is quite complicated and graphical solutions to this compound angle work can be found in any textbook on descriptive geometry. Accurate dimensions may then be determined with basic trigonometry.

DESIGN CONSIDERATIONS FOR SIMPLE SHEAR CONNECTIONS TO HSS COLUMNS

Many of the familiar simple shear connections that are used to connect to wide-flange columns can be used with HSS columns. These include double and single angles, unstiffened and stiffened seats, single plates, and tee connections. One additional connection that is unique for HSS columns is the through-plate; note that this alternative is seldom required structurally and presents a significant economic penalty when a single plate connection would otherwise suffice. Variations in attachments are more limited with HSS columns since the connecting element will typically be shop-welded to the HSS and bolted

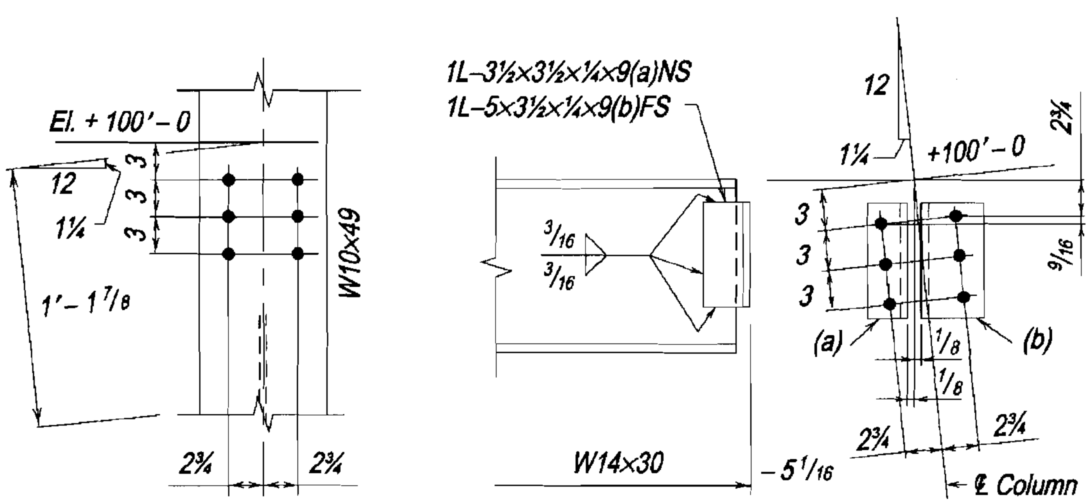


Figure 10–45. Canted connection to column flange.

to the supported beam. Except for seated connections, the bolting will be to the web of a wide-flange or other open profile section. Coping is not required except for bottom-flange copes that facilitate knifed erection with double-angle connections.

Double-Angle Connections to HSS

Table 10–1 is a design aid for double-angle connections. The table shows the compatible sizes of W-beams for the various connection configurations. Based on maximum beam web thickness, maximum weld size, maximum HSS corner radius and 4-in. outstanding angle legs, double-angle connections may be used with any HSS having a width greater than or equal to 12 in. If 3-in. outstanding angle legs are used for connections with six bolts or less, HSS with widths of 10 in. are acceptable for obtaining welds on the flat of the side. For smaller web thicknesses, welds and corner radii, it may be possible to fit the connection on widths of 10 in. if the outstanding angle legs are 4 in. and on widths of 8 in. for outstanding angle legs of 3 in. However, these dimensions must be verified for a particular case. See the tabulated workable flat dimensions for HSS in Part 1.

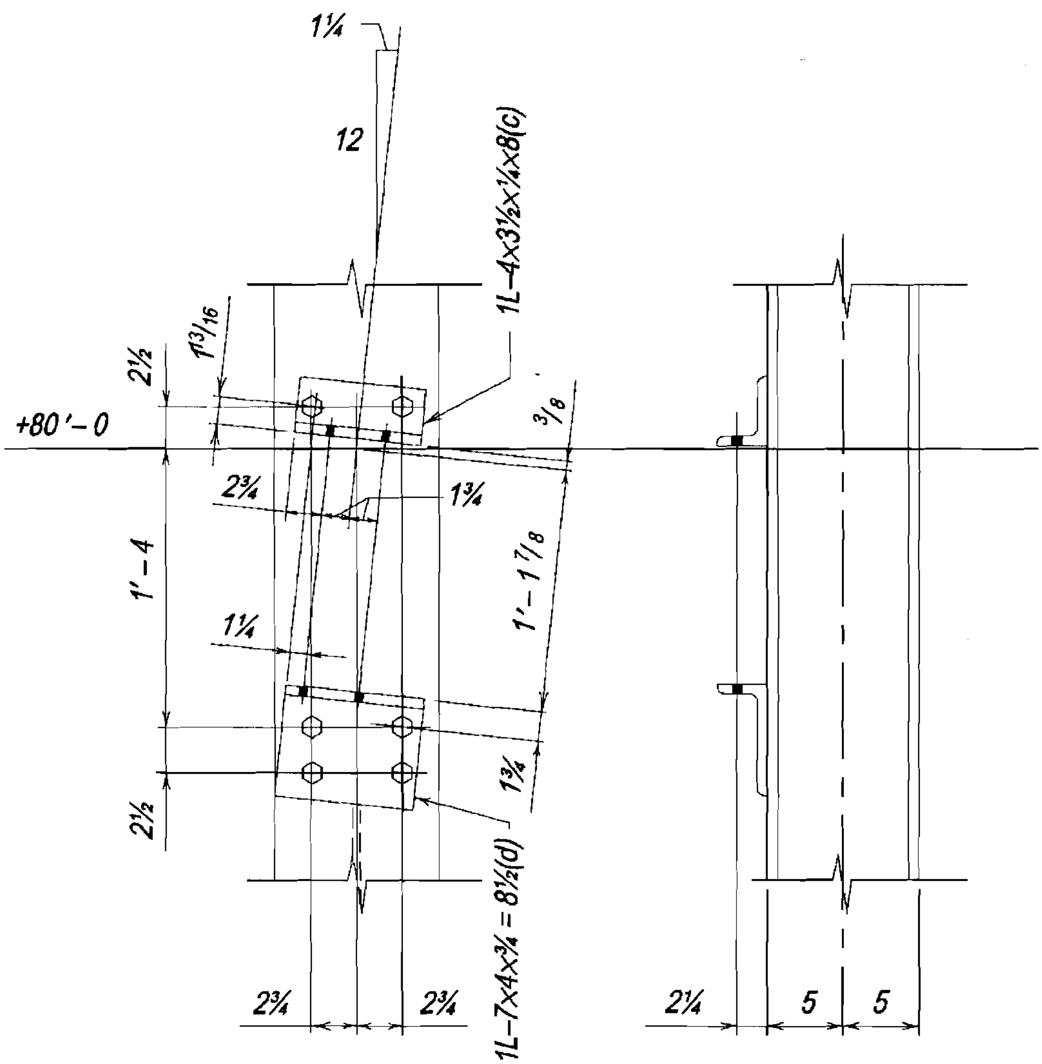


Figure 10–46. Canted seated connections.

Single-Plate Connections to HSS

As long as the HSS wall is not classified as a slender element, the local distortion caused by the single-plate connection will be insignificant in reducing the column strength of the HSS (Sherman, 1996). Therefore, single-plate connections may be used with HSS when $b/t \le 1.40(E/F_y)^{0.5}$ or 35.1 for $F_y = 46$ ksi. Single-plate connections may also be used with round HSS as long as they are non-slender under axial load ($D/t \le 0.11E/F_y$).

Unstiffened Seated Connections to HSS

In order to properly attach seat angles to the flat of the HSS, the workable flat must be large enough to accommodate both the width of the seat angle and the welds. Seat widths are usually 6 in. or 8 in., but other widths may also be used. See the tabulated workable flat dimensions for HSS in Part 1.

Table 10–6 may be used for unstiffened seated connections to HSS. The minimum HSS thicknesses are established based on the weld strength. If the HSS thickness is less than the minimum value, the weld strength must be reduced proportionally.

Stiffened Seated Connections to HSS

Tables 10–8 and 10–14 are design aids for stiffened seated connections. Table 10–8 is applicable to all member types, and Table 10–14 presents specific limits for HSS, based on the yield-line mechanism limit state for HSS. Some values for small connection lengths L and large HSS widths B have been reduced to meet the limit-state for a line load with a width of $0.4L$ across the HSS, per AISC Specification Section K1. The strength of the connection is obtained by multiplying the tabulated value for a particular HSS width and stiffener length by the square of the HSS thickness and dividing by the width of the seat. For combinations of B and L that are not listed in Table 10–14, the HSS does not have sufficient flat width to accommodate a weld to the seat that is $0.2L$ on each side of the stiffener. Since the required width also depends on the stiffener thickness and the HSS corner-radius, the HSS width must be checked even when the values are tabulated. See the tabulated workable flat dimensions for HSS in Part 1.

The minimum HSS thicknesses associated with the weld strengths of Table 10–8 are given in Table 10–14. If the HSS thickness is less than the minimum tabulated value, the weld strength must be reduced proportionally.

Through-Plate Connections

In the through-plate connection shown in Figure 10–47, the front and rear faces of the HSS are slotted so that the plate can be passed completely through the HSS and welded to both faces. Through-plate connections should be used when the HSS wall is classified as a slender element ($b/t > 1.40(E/F_y)^{0.5}$ or 35.1 for $F_y = 46$ ksi for rectangular HSS; $D/t > 0.11E/F_y$ for round HSS and Pipe) or does not satisfy the punching shear limit-state. A single-plate connection is more economical and should be used if the HSS is neither slender nor inadequate for the punching shear rupture limit-state.

Through-plate connections have the same limit-states as single-plate connections and Table 10–9 may be used to determine the size and number of bolts and the plate thickness. The welds, however, are subject to direct shear and may not have to be as large as those for single-plate connections. For equilibrium of the forces in Figure 10–47, the shear in the welds on the front face should not exceed the strength of the pair of welds. The HSS wall strength can be matched to the weld shear strength to determine the minimum thickness, as illustrated in Part 9. If the thickness of the HSS is less than the minimum, the weld strength must be reduced proportionally. Conservatively, the welds on the rear face may be the same size.

When a connection is made on both sides of the HSS with an extended through-plate, the portion of the plate inside the HSS is subject to a uniform bending moment. For long connections, this portion of the plate may buckle in a lateral-torsional mode prior to yielding, unless H is very small. Using a thicker plate to prevent lateral-torsional buckling would restrict the rotational flexibility of the connection. Therefore, it must be recognized that the plate may buckle and that the moment will be shared with the HSS wall in a complex manner. However, if the HSS would be satisfactory for a single-plate connection, the lateral-torsional buckling limit-state is not a critical concern involving loss of strength.

Single-Angle Connections

For fillet welding on the flat of the HSS side, while keeping the center of the beam web in line with the center of the HSS, single-angle connections must be compatible with one-half the workable flat dimension provided in Part 1. Generally, the following HSS widths and thicknesses will work:

$b = 8$ in. and $t \leq {}^1\!/_4$ in.
$b = 9$ in. and $t \leq {}^3\!/_8$ in.
$b \geq 10$ in. and any nominal thickness

Alternatively, single angles can be welded to narrow HSS with a flare-bevel weld.

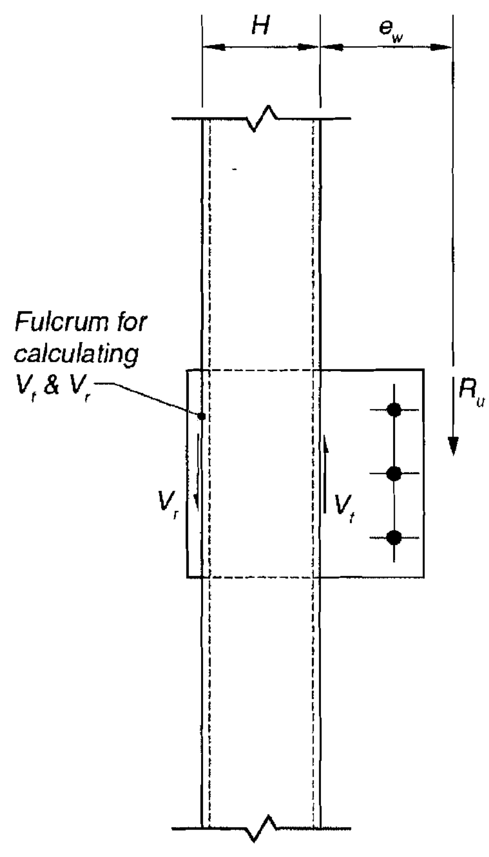


Figure 10–47. Shear forces in a through-plate connection.

Table 10–12
Minimum Inside Radius for Cold-Bending[1]

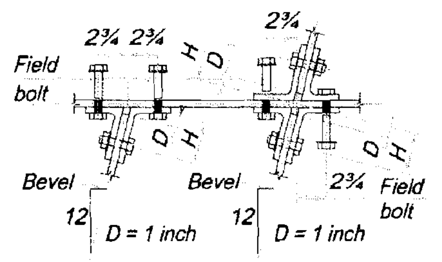
ASTM Designation[2]	Thickness *t*, in.			
	Up to $^3/_4$	Over $^3/_4$ to 1	Over 1 to 2	Over 2
A36, A572-42	$1^1/_2\,t$	$1^1/_2\,t$	$1^1/_2\,t$	$2t$
A242, A529-50, A529-55, A572-50, A588, A992	$1^1/_2\,t$	$1^1/_2\,t$	$2\,t$	$2^1/_2\,t$
A572-55, A852	$1^1/_2\,t$	$1^1/_2\,t$	$2^1/_2\,t$	$3\,t$
A572-60, A572-65	$1^1/_2\,t$	$1^1/_2\,t$	$3\,t$	$1^1/_2\,t$
A514	$1^3/_4\,t$	$2^1/_4\,t$	$4^1/_2\,t$	$5^1/_2\,t$

[1] Values are for bend lines perpendicular to direction of final rolling. If bend lines are parallel to final rolling direction, multiply values by 1.5.

[2] The grade designation follows the dash; where no grade is shown, all grades and/or classes are included.

Table 10–13
Clearances for All-Bolted Skewed Connections

Values given are for webs up to ¾-in. thick, angles up to ⅝-in. thick, and bent plates up to ½-in. thick. Bolts are either ⅞-in. diameter or 1 in. diameter, as noted. Values will be conservative for material thinner than the maximums listed, or for work with smaller bolts, and may be reduced to suit conditions by calculation or layout. For thicker material or larger bolts, check entering, driving, and tightening clearances and increase D and bolt gages as necessary. All dimensions are in inches. Enter bolts as shown.



Bent angles

Values of *H* for Various Fastener Combinations

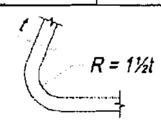
Field Bolts		⅞	1
Shop Bolts		⅞	1
Bevel	Up to 1	4*	4¼*
	Over 1 to 2	4⅛	4⅜
	Over 2 to 3	4⅜	4¾

*For back to back connections, stagger shop and field bolts or increase the 2¾-in. field bolt dimension to 3¼.

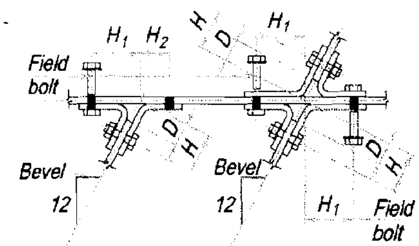
Values of H, H_1, H_2, and D for Various Bolt Combinations

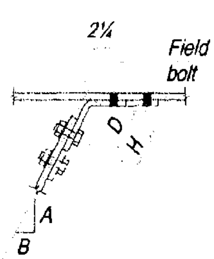
Field Fastener		⅞			1			
Shop Fastener		⅞			1			
Dimension		H	H_1	H_2	H	H_1	H_2	D
Bevel	Over 3 to 4	3¾	3¼	2½	4¼	3¼	2¾	1¼
	Over 4 to 5	3¾	3½	2¼	4½	3½	2½	1¼
	Over 5 to 6	4	3¾	2¼	4¾	3¾	2¼	1½
	Over 6 to 7	4½	4	2¼	5	4	2¼	1½
	Over 7 to 8	4¾	4¼	2¼	5¼	4¼	2¼	1½

Double bent plates



Min. radius of cold bend for A 36 steel up to ½ in. thick. For other bends see Table10-12





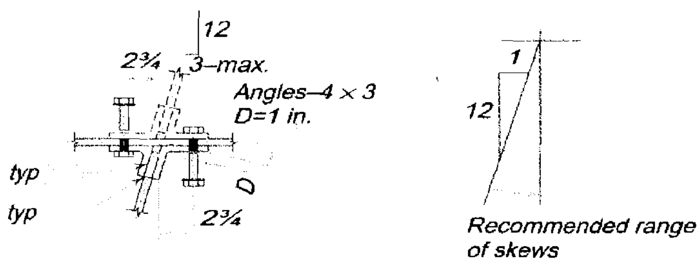
Field bolts—1 in. dia. max.
Shop bolts—1 in. dia. max.

Single bent plates

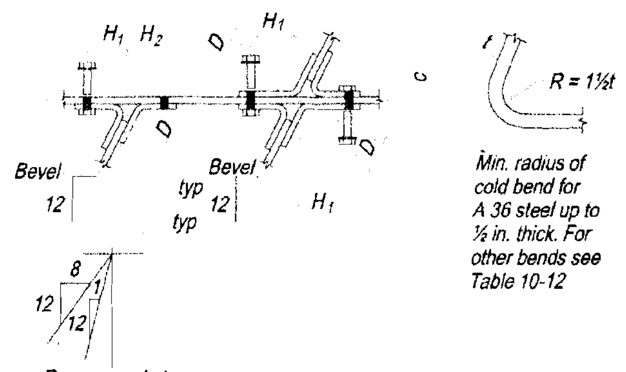
		Shop Bolts	
A	*B*	*D*	*H*
12	Over 8 to 9	1½	3
12	Over 9 to 10	1⅝	3⅛
12	Over 10 to 11	1¾	3¼
12	Over 11 to 12	1⅞	3⅜
Under 12 to 11	12	2⅛	3⅝
Under 11 to 10	12	2¼	3¾
Under 10 to 9	12	2½	4
Under 9 to 8	12	2¾	4¼
Under 8 to 7	12	3¼	4¾
Under 7 to 6	12	3¾	5¼
Under 6 to 5	12	4½	6
Under 5 to 4	12	5⅝	7⅛

Table 10–13 (continued)
Clearances for Bolted/Welded Skewed Connections

Values given are for webs up to ¾-in. thick, angles up to ⅝-in. thick, and bent plates up to ½-in. thick, with bolts 1 in. diameter maximum. Values will be conservative for thinner material and for work with smaller bolts, and may be reduced to suit conditions by calculation or layout. For thicker material or larger bolts check entering and tightening clearances and increase beam set-back *D* and bolt gages as necessary. Enter bolts as shown. All dimensions are in inches.



Bent angles

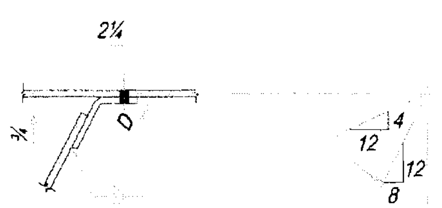


Recommended range of skews

Double bent plates

Bevel	D	H_1	H_2
Over 3 to 4	c + ⅝	3¼	2¾
Over 4 to 5	c + 11⁄16	3½	2½
Over 5 to 6	c + ¾	3¾	2¼
Over 6 to 7	c + 13⁄16	4	2¼
Over 7 to 8	c + ⅞	4¼	2¼

$$C = \frac{t_w}{2} + 1/16''$$



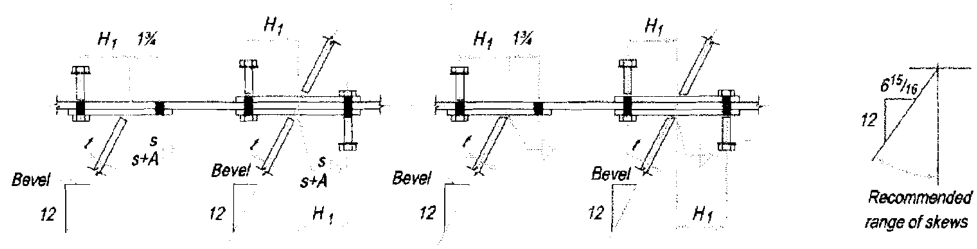
Determine value of D by calculation or layout

Recommended range of skews

Single bent plates

Table 10-13 (continued)
Clearances for Bolted/Welded Skewed Connections

Values given are for material and bolt sizes noted below. See "Shear End-Plate Connections" in Part 9 for proportioning these connections. *S* indicates weld size required for strength, or a size suitable to the thickness of material. When the beam web is cut square, only that portion of the table above the heavy lines is applicable. Dimension *A* is added to the weld size to compensate for the root opening caused by the skew. When the beam web is beveled to the required skew, values of H_1 for the entire table are valid, and A = 0. In either case, where weld strength is critical, increase the weld size to obtain the required throat dimension. Enter bolts as shown. All dimensions are in inches.



Square ends *Beveled ends*

End plates

Bevel	t = 1/4		t = 5/16		t = 3/8		t = 7/16		t = 1/2		t = 5/8		t = 3/4	
	H_1	A	H_1	A	H_1	A	H_1	A	H_1	A	H_1	A	H_1	A
Up to 1 5/8	1 3/4	0	1 3/4	0	1 3/4	1/16	1 3/4	1/16	1 3/4	1/16	1 7/8	1/8	1 7/8	1/8
Over 1 5/8 to 2 1/8	1 3/4	0	1 3/4	1/16	1 7/8	1/16	1 7/8	1/16	1 7/8	1/8	2	1/8	2	1/8
Over 2 1/8 to 3 1/4	1 7/8	1/16	1 7/8	1/8	2	1/8	2	1/8	2	1/8	2 1/8	0	2 1/8	0
Over 3 1/4 to 4 3/8	2 1/8	1/8	2 1/8	1/8	2 1/8	1/8	2 1/8	0	2 1/4	0	2 1/4	0	2 3/8	0
Over 4 3/8 to 5 5/8	2 1/4	1/8	2 1/4	1/8	2 3/8	0	2 3/8	0	2 3/8	0	2 1/2	0	2 1/2	0
Over 5 5/8 to 6 15/16	2 1/2	1/8	2 1/2	0	2 1/2	0	2 1/2	0	2 5/8	0	2 5/8	0	2 3/4	0

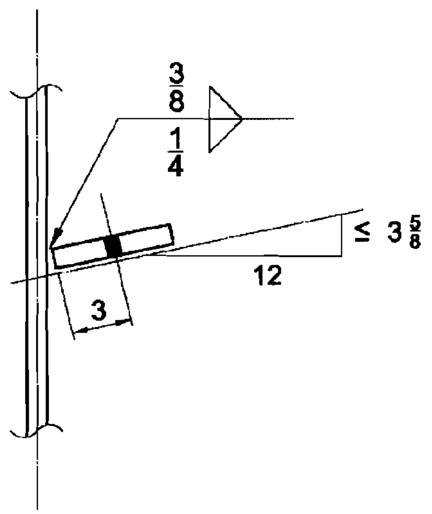
Bolts: 7/8-in. diameter maximum
End Plate thickness: 3/8-in. maximum
Supporting web thickness: 3/4-in. maximum

Use of fillet welds is limited to connections with bevels of 6 15/16 in 12 and less.
For greater bevels consider use of double or single bent plates.

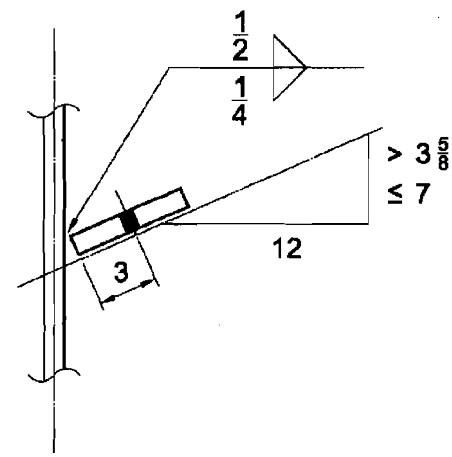
Table 10–13 (continued)
Clearances for Bolted/Welded Skewed Connections

$^5/_{16}$- and $^3/_8$-in. Plate Thickness

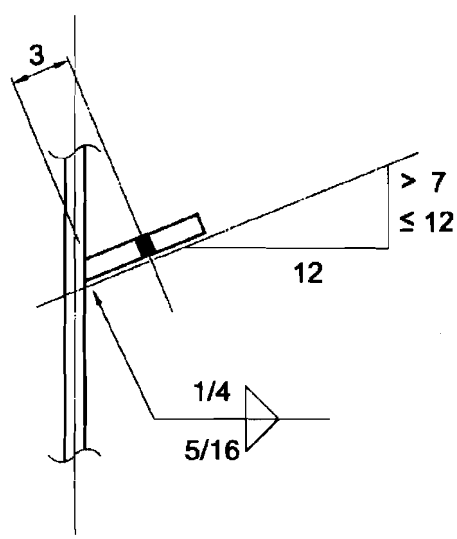
For θ ≤ 17° from Perpendicular



For 17°< θ ≤ 30° from Perpendicular



For 30°< θ ≤ 45° from Perpendicular



For θ = 45° from Perpendicular

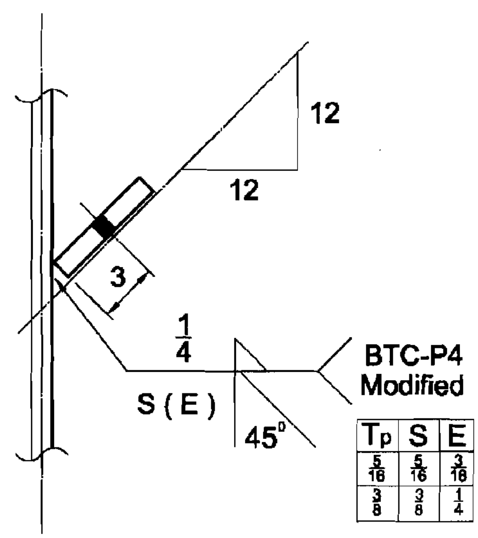
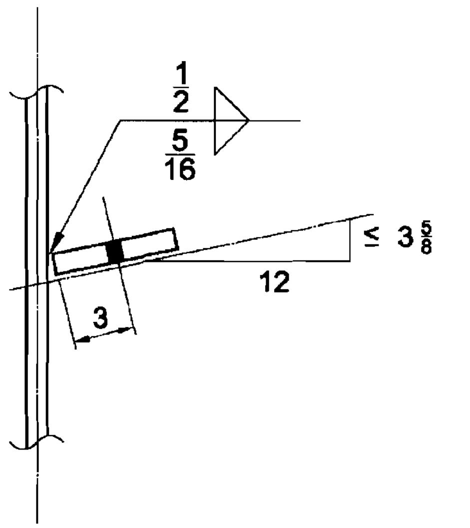


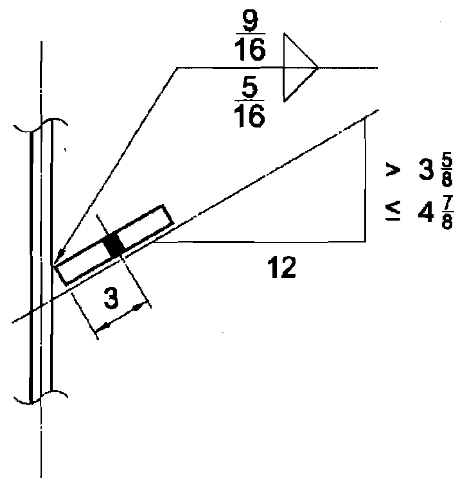
Table 10–13 (continued)
Clearances for Bolted/Welded Skewed Connections

1/2-in. Plate Thickness

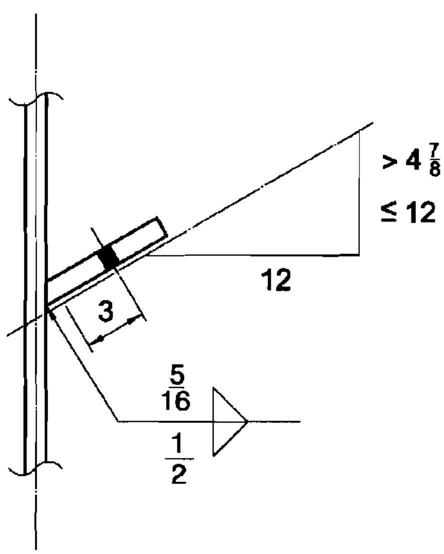
For θ ≤ 17° from Perpendicular



For 17°< θ ≤ 22° from Perpendicular



For 22°< θ ≤ 45° from Perpendicular



For θ = 45° from Perpendicular

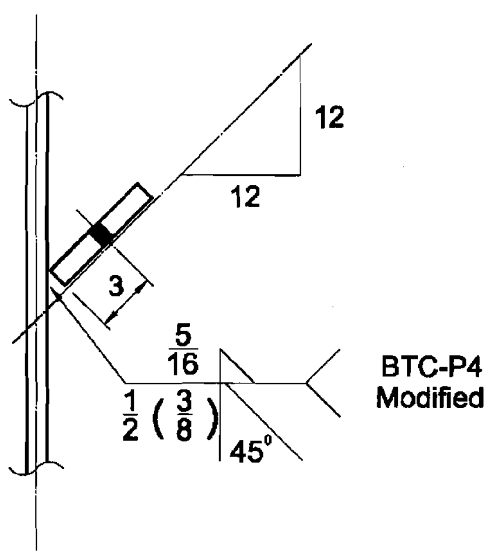


Table 10–14
Required Length and Thickness for Stiffened Seated Connections to HSS

	HSS Wall Strength Factor, R_uW/t^2 or R_aW/t^2, kips/in.											
	HSS Width B, in.											
L, in.	5		5.5		6		7		8		9	
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
6	558	839	545	819	536	805	526	791	525	789	528	793
7	687	1030	664	997	646	971	625	940	615	925	612	920
8			798	1200	771	1160	735	1100	714	1070	704	1060
9					911	1370	856	1290	823	1240	804	1210
10					1070	1600	990	1490	942	1420	912	1370
11							1140	1710	1070	1610	1030	1550
12							1300	1960	1210	1820	1160	1740
13									1370	2060	1290	1940
14									1540	2310	1440	2170
15									1720	2580	1600	2410
16											1700	2660
17											1960	2940

Required HSS Thickness

Weld Size, in.	Min. HSS Thickness, in.
1/4	0.224
5/16	0.280
3/8	0.336
7/16	0.392
1/2	0.448
5/8	0.560

Table 10–14 (continued)
Required Length and Thickness for Stiffened Seated Connections to HSS

HSS Wall Strength Factor, $R_u W/t^2$ or $R_a W/t^2$, kips/in.

	HSS Width *B*, in.											
	10		12		14		16		18		20	
L, in.	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
6	534	802	552	830	561	843	491	737	437	656	393	590
7	614	922	625	940	644	968	667	1000	594	892	535	803
8	700	1050	704	1060	717	1080	736	1110	759	1140	699	1050
9	793	1190	787	1180	794	1190	809	1220	828	1240	851	1280
10	893	1340	876	1320	876	1320	885	1330	901	1350	920	1380
11	1000	1500	971	1460	962	1450	965	1450	976	1470	993	1490
12	1120	1680	1070	1610	1050	1580	1050	1580	1060	1590	1070	1600
13	1240	1870	1180	1770	1150	1730	1140	1710	1140	1710	1150	1720
14	1370	2070	1290	1940	1250	1880	1230	1850	1220	1840	1230	1840
15	1520	2280	1410	2120	1360	2040	1330	1990	1310	1980	1310	1970
16	1670	2510	1540	2320	1470	2210	1430	2150	1410	2120	1400	2100
17	1830	2760	1680	2520	1590	2390	1540	2310	1510	2260	1490	2240
18	2010	3020	1820	2740	1710	2570	1650	2470	1610	2420	1590	2380
19	2190	3300	1970	2970	1840	2770	1760	2650	1710	2580	1680	2530
20	2390	3600	2130	3210	1980	2980	1880	2830	1820	2740	1790	2680
21			2300	3460	2120	3190	2010	3020	1940	2910	1890	2840
22			2480	3730	2280	3420	2140	3220	2060	3090	2000	3010
23			2670	4020	2440	3660	2280	3430	2180	3280	2120	3180
24			2870	4310	2600	3910	2430	3650	2310	3480	2230	3360
25			3080	4630	2780	4170	2580	3880	2450	3680	2360	3540
26					2960	4450	2740	4110	2590	3890	2480	3730
27					3150	4730	2900	4360	2730	4110	2610	3930
28					3350	5030	3070	4620	2880	4330	2750	4130
29					3560	5340	3250	4890	3040	4570	2890	4340
30					3770	5660	3440	5160	3200	4810	3040	4560
31							3630	5450	3370	5070	3190	4790
32							3830	5750	3540	5330	3340	5020

Required HSS Thickness

Weld Size, in.	Min. HSS Thickness, in.
1/4	0.224
5/16	0.280
3/8	0.336
7/16	0.392
1/2	0.448
5/8	0.560

Table 10–14 (continued)
Required Length and Thickness for Stiffened Seated Connections to HSS

HSS Wall Strength Factor, R_uW/t^2 or R_aW/t^2, kips/in.

L, in.	HSS Width *B*, in. 22		24		26		28		30		32	
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
6	357	536	328	492	302	454	281	421	262	393	246	369
7	486	730	446	669	412	618	382	574	357	535	334	502
8	635	953	582	874	537	807	499	749	466	699	437	656
9	804	1210	737	1110	680	1020	632	948	590	885	553	830
10	943	1420	910	1370	840	1260	780	1170	728	1090	682	1020
11	1010	1520	1030	1560	1020	1530	944	1420	881	1320	826	1240
12	1080	1630	1100	1660	1130	1690	1120	1690	1050	1570	983	1470
13	1160	1740	1180	1770	1200	1800	1220	1830	1230	1850	1150	1730
14	1240	1860	1250	1880	1270	1910	1290	1940	1310	1970	1330	2010
15	1320	1980	1330	2000	1340	2020	1360	2040	1380	2070	1400	2110
16	1400	2100	1410	2120	1420	2130	1430	2160	1450	2180	1470	2210
17	1490	2230	1490	2240	1500	2250	1510	2270	1530	2290	1540	2320
18	1580	2370	1570	2370	1580	2370	1590	2390	1600	2410	1620	2430
19	1670	2510	1660	2500	1660	2500	1670	2510	1680	2520	1690	2540
20	1760	2650	1750	2630	1750	2630	1750	2630	1760	2640	1770	2660
21	1860	2800	1850	2770	1840	2760	1840	2760	1840	2770	1850	2780
22	1960	2950	1940	2920	1930	2900	1920	2890	1920	2890	1930	2900
23	2070	3110	2040	3070	2020	3040	2010	3030	2010	3020	2010	3030
24	2180	3280	2140	3220	2120	3190	2110	3170	2100	3160	2100	3150
25	2290	3450	2250	3380	2220	3340	2200	3310	2190	3290	2190	3290
26	2410	3620	2360	3540	2320	3490	2300	3450	2280	3430	2280	3420
27	2530	3800	2470	3710	2430	3650	2400	3600	2380	3570	2370	3560
28	2650	3990	2590	3890	2540	3810	2500	3760	2480	3720	2460	3700
29	2780	4180	2700	4060	2650	3980	2610	3920	2580	3870	2560	3840
30	2920	4380	2830	4250	2760	4150	2710	4080	2680	4030	2650	3990
31	3050	4590	2950	4440	2880	4330	2820	4250	2780	4180	2760	4140
32	3190	4800	3080	4630	3000	4510	2940	4420	2890	4350	2860	4300

Required HSS Thickness

Weld Size, in.	Min. HSS Thickness, in.
1/4	0.224
5/16	0.280
3/8	0.336
7/16	0.392
1/2	0.448
5/8	0.560

PART 10 REFERENCES

Astaneh, A., S.M. Call, and K.M. McMullin, 1989, "Design of Single-Plate Shear Connections," *Engineering Journal*, Vol. 26, No. 1, (1st Qtr.), pp. 21-32, AISC, Chicago, IL.

Brockenbrough, R.L., 1998, *Fabrication Guidelines for Cold Bending*, R.L. Brockenbrough and Associates, Pittsburgh, PA.

Carter, C.J., W.A. Thornton, and T.M. Murray, 1997, "Discussion – The Behavior and Load-Carrying Capacity of Unstiffened Seated Beam Connections," *Engineering Journal*, Vol. 34, No. 4, (4th Qtr.), pp. 151-156, AISC, Chicago, IL.

Roeder, C.W., and R.H. Dailey, 1989, "The Results of Experiments on Seated Beam Connections," *Engineering Journal*, Vol. 26, No. 3, (3rd Qtr.), pp. 90-95, AISC, Chicago, IL.

Ellifritt, D.S., and T. Sputo, 1999, "Design Criteria for Stiffened Seated Connections to Column Webs," *Engineering Journal*, Vol. 36, No. 4, (4th Qtr.), pp. 160-167, AISC, Chicago, IL.

Kulak, G.L., 2002, AISC Design Guide No. 17 *High Strength Bolts – A Primer For Structural Engineers*, AISC, Chicago, IL.

Kulak, G.L., and D.L. Green, 1990, "Design of Connectors in Web-Flange Beam or Girder Splices," *Engineering Journal*, Vol. 27, No. 2, (2nd Qtr.), pp. 41-48, AISC, Chicago, IL.

Salmon, C.G. and J.E. Johnson, 1996, *Steel Structures: Design and Behavior*, 4th Edition, Harper Collins, New York, NY.

Sputo, T., and D.S. Ellifritt, 1991, "Proposed Design Criteria for Stiffened Seated Connections to Column Webs," *Proceedings of the 1991 National Steel Construction Conference*, pp. 8.1-8.26, AISC, Chicago, IL.

Sherman, D.R., 1996, "Designing With Structural Tubing," *Engineering Journal*, AISC, Vol. 33, No. 3, pp. 101-109, AISC, Chicago, IL.

Sherman, D.R., and A. Ghorbanpoor, 2002, "Design of Extended Shear Tabs," *Final Report to the American Institute of Steel Construction*, AISC, Chicago, IL.

Sumner, E.A., 2003, "North Carolina State Research Report on Single Plate Shear Connections" *Report to the American Institute of Steel Construction*, AISC, Chicago, IL.