ENCE 455
Design of Steel Structures

VII. Fasteners/Welding

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Introduction

Following subjects are covered:

- Introduction of Fasteners
- Failure modes of bolted shear connections
- LRFD - Fasteners
- LRFD of slip-critical connections
- High-strength bolts in tension
- Fasteners in combined shear and tension
- Basics of welding
- Fillet weld
- LRFD of welded connections

Reading:

- Chapter 7 of Segui
- AISC Steel Manual Specifications, Chapter J

Importance of Connections

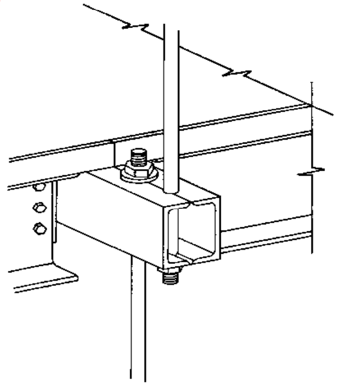
- Beams and columns rarely fail
- Many catastrophic failure resulted from inadequate connection strength

What can go wrong?

- Hyatt Regency
- Kansas City, 1981
- 114 Dead
- 200+ Injured

http://www.sgh.com

The Culprit



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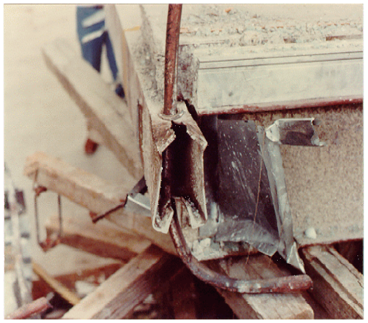

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Problem and Solution

Problem -

- Lack of Understanding
- AISC Addresses "Typical" Details Only
- Failure Modes may be neglected

Solution -

- Develop Consistent Methodology
- Systematically Identify All Failure Modes
- Illustrate Applicable Failure Planes

Introduction of Fasteners

- Types of Fasteners: rivets (obsolete) and bolts (high-strength bolts: most common)
- Properties of bolts

ASTM designation	Bolt diameter in. (mm)	Proof load,[a] length measurement[b] method, ksi (MPa)	Proof load,[a] yield strength[c] method, ksi (MPa)	Minimum tensile strength, ksi (MPa)
A307 [2.4], low-carbon steel Grades A and B	$\frac{1}{4}$ to 4 (6.35 to 104)	—	—	60
A325 [2.5], high-strength steel Types 1, 2, and 3	$\frac{1}{2}$ to 1 (12.7 to 25.4)	85 (585)	92 (635)	120 (825)
Types 1, 2, and 3	$1\frac{1}{8}$ to $1\frac{1}{2}$ (28.6 to 38.1)	74 (510)	81 (560)	105 (725)
A449 [2.7], quenched and tempered steel	$\frac{1}{4}$ to 1 (6.35 to 25.4)	85 (585)	92 (635)	120 (825)
(*Note:* AISC[d] permits use only for bolts	$1\frac{1}{8}$ to $1\frac{1}{2}$ (28.6 to 38.1)	74 (510)	81 (560)	105 (725)
larger than $1\frac{1}{2}$ in. and for threaded rods and anchor bolts)	$1\frac{3}{4}$ to 3 (6.35 to 76.2)	55 (380)	58 (400)	90 (620)
A490 [2.8], quenched and tempered alloy steel	$\frac{1}{2}$ to $1\frac{1}{2}$ (12.7 to 38.1)	120 (825)	130 (895)	150 (1035)

[a] Actual proof load and tensile load obtained by multiplying given stress value by the tensile stress area A_s; $A_s = 0.785\,[d_b - (0.9743/n)]^2$, where A_s = stress area in square inches, d_b = nominal diameter of bolt in inches, and n = number of threads per inch.

[b] 0.5% extension under load.

[c] 0.2% offset value.

[d] LRFD and ASD-A3.3 and J3.

Introduction of Fasteners

- Two conditions of bolt installation are used with high-strength bolts
  - Snug-tight (producing a bearing connection)
    - Few impacts of an impact wrench
    - Full effort of a worker with an ordinary spud wrench
  - Tensioned (producing a slip-critical connection)
    - Turn-of-nut method: specified number of rotations of the nut from snug tight (nut rotations correlated to bolt elongation)
    - Calibrated wrench tightening
    - Alternate design bolts: specially design bolts whose tops twist off when the proper tension has been achieved
    - Direct tension indicators: compress washer (under bolt head or nut) with protrusions to a gap that is correlated to bolt tension

Ref: AISC LRFD p.16.4-46 thru -52

Introduction of Fasteners

- When high-strength bolts are to be tensioned, minimum limits are set on the bolt tension. See AISC Table J3.1
- Tension equal to 70% of the minimum tensile strength of the bolt
- Purpose of tensioning is to achieve the clamping force between connected parts.

TABLE J3.1
Minimum Bolt Pretension, kips*

Bolt Size, in.	A325 Bolts	A490 Bolts
½	12	15
⅝	19	24
¾	28	35
⅞	39	49
1	51	64
1⅛	56	80
1¼	71	102
1⅜	85	121
1½	103	148

*Equal to 0.70 of minimum tensile strength of bolts, rounded off to nearest kip, as specified in ASTM specifications for A325 and A490 bolts with UNC threads.

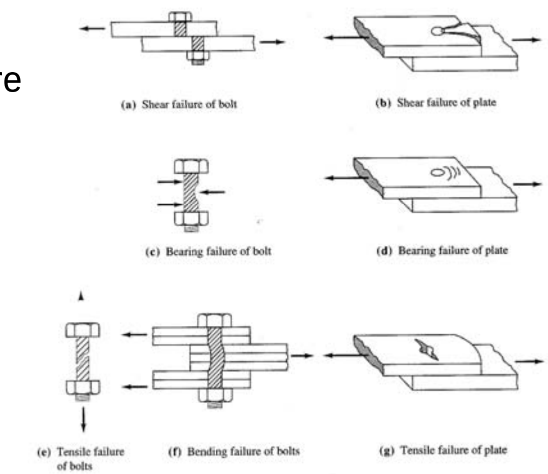
LRFD - Fasteners

- $\Phi R_n \geq \Sigma \gamma_i Q_i$ general
  - where Φ = resistance factor (strength reduction factor)
  - R_n = nominal resistance (strength)
  - γ_i = overload factors (LRFD-A4.1)
  - Q_i = loads (such as dead load, live load, wind load, earthquake load) of load effects (such as bending moment, shear, axial force, and torsional moment resulting from the various loads)
- $\Phi R_n \geq P_u$ fasteners
  - where Φ = resistance factor, 0.75 for fracture in tension, shear on high-strength bolts, and bearing of bolt against side of hole
  - R_n = nominal strength of one fastener
  - P_u = factored load on one fastener

Failure Mode of Bolted Shear Connections

Two types of bolted connector failure are considered in this section

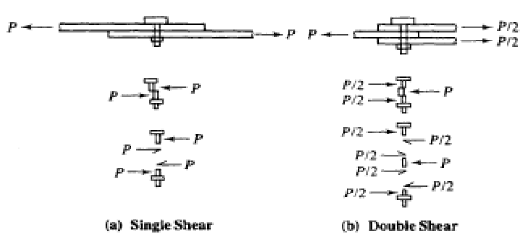
- Failure of the connector
- Failure of the connected parts



Failure Mode of Bolted Shear Connections (cont.)

Connector failure

- Single shear connection – Single shear plane. P = $f_v A$, where f_v is the average shearing stress and A is the connector's cross-sectional area.
- Double shear connection – Double shear plane. P = $2 f_v A$



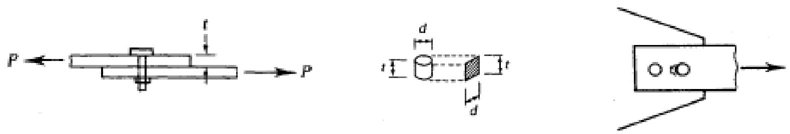
Failure Mode of Bolted Shear Connections (cont.)

Failure of the connected parts , separated into two categories.

1. Failure resulting from excessive tension, shear, or bending in the parts being connected
   - For a tension member must consider tension on the net area, tension on the gross area, and block shear
   - For beam-beam or beam-column connections, must consider block shear
   - Gusset plates and framing angles must be checked for P, M, and V

Failure Mode of Bolted Shear Connections (cont.)

2. Failure of the connected part because of bearing exerted by the fastener (average bearing stress is $f_p = P/dt$)
   - If the hole is slightly larger than the fastener and the fastener is assumed to be placed loosely in the hole (rarely the case), contact between the fastener and the connected part will exist over approximately 50% of the circumference of the fastener.
   - The bearing problem is affected by the edge distance and bolt spacing



LRFD – Fasteners (cont)

Design bearing strength

1. *Usual conditions* based on the deformation limit state, according to LRFD-Formula (J3-1a). This applies for all holes except long-slotted holes perpendicular to the line of force, where end distance is at least 1.5*d*, the center-to-center spacing *s* is at least 3*d*, and there are two or more bolts in the line of force.

$$\Phi R_n = \Phi(1.2 L_e t F_u) < \Phi(2.4 d t F_u)$$

- where Φ = 0.75
- d = nominal diameter of bolt at unthreaded area
- t = thickness of part against which bolt bears
- F_u = tensile strength of connected part against which bolt bears
- L_e = distance along line of force from the edge of the connected part to the center of a standard hole or the center of a short- and long-slotted hole perpendicular to the line of force.

LRFD – Fasteners (cont)

Design shear strength – no threads in shear planes

- $\Phi R_n = 0.75(0.50 F_u^b) m A_b$
  - where Φ = 0.75, the standard value for shear
  - F_u^b = tensile strength of the bolt material (120 ksi for A325 bolts; 150 ksi for A490 bolts)
  - m = the number of shear planes participating [usually one (*single shear*) or two (*double shear*)]
  - A_b = gross cross-sectional area across the unthreaded shank of the bolt

Design shear strength – threads in shear planes

- $\Phi R_n = 0.75(0.40 F_u^b) m A_b$

Sequi Examples 7.1 & 7.2

LRFD – Fasteners (cont)

Ref: AISC LRFD p. 16.1-61

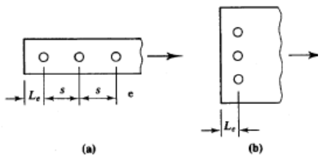
TABLE J3.2
Design Strength of Fasteners

Description of Fasteners	Tensile Strength: Resistance Factor ϕ	Tensile Strength: Nominal Strength, ksi (MPa)	Shear Strength in Bearing-type Connections: Resistance Factor ϕ	Shear Strength in Bearing-type Connections: Nominal Strength, ksi (MPa)
A307 bolts	0.75	45 (310) [a]	0.75	24 (165) [b,e]
A325 or A325M bolts, when threads are not excluded from shear planes		90 (620) [d]		48 (330) [e]
A325 or A325M bolts, when threads are excluded from shear planes		90 (620) [d]		60 (414) [e]
A490 or A490M bolts, when threads are not excluded from shear planes		113 (780) [d]		60 (414) [e]
A490 or A490M bolts, when threads are excluded from shear planes		113 (780) [d]		75 (520) [e]
Threaded parts meeting the requirements of Section A3, when threads are not excluded from shear planes		$0.75F_u$ [a,c]		$0.40F_u$
Threaded parts meeting the requirements of Section A3, when threads are excluded from shear planes		$0.75F_u$ [a,c]		$0.50F_u$ [a,c]
A502, Gr. 1, hot-driven Rivets		45 (310) [a]		25 (172) [e]
A502, Gr. 2 & 3, hot-driven Rivets		60 (414) [a]		33 (228) [e]

[a] Static loading only.
[b] Threads permitted in shear planes.
[c] The nominal tensile strength of the threaded portion of an upset rod, based upon the cross-sectional area at its major thread diameter, A_D shall be larger than the nominal body area of the rod before upsetting times F_y.
[d] For A325 or A325M and A490 or A490M bolts subject to tensile fatigue loading, see Appendix K3.
[e] When bearing-type connections used to splice tension members have a fastener pattern whose length, measured parallel to the line of force, exceeds 50 in. (1 270 mm), tabulated values shall be reduced by 20 percent.

LRFD – Fasteners (cont)

- Minimum edge distance requirement (AISC J3.4)



Ref: AISC LRFD p. 16.1-63

TABLE J3.4
Minimum Edge Distance,[a] in., From Center of Standard Hole[b] to Edge of Connected Part

Nominal Rivet or Bolt Diameter (in.)	At Sheared Edges	At Rolled Edges of Plates, Shapes or Bars, or Gas Cut Edges [c]
1/2	7/8	3/4
5/8	1 1/8	7/8
3/4	1 1/4	1
7/8	1 1/2 [d]	1 1/8
1	1 3/4 [d]	1 1/4
1 1/8	2	1 1/2
1 1/4	2 1/4	1 5/8
Over 1 1/4	1 3/4 × Diameter	1 1/4 × Diameter

[a] Lesser edge distances are permitted to be used provided Equations from Section J3.10, as appropriate, are satisfied.
[b] For oversized or slotted holes, see Table J3.6.
[c] All edge distances in this column are permitted to be reduced 1/8-in. when the hole is at a point where stress does not exceed 25 percent of the maximum design strength in the element.
[d] These are permitted to be 1 1/4-in. at the ends of beam connection angles and shear end plates.

LRFD – Fasteners (cont)

Maximum edge distance – $\leq 12\ t \leq 6''$, where t is the thickness of the connected part.

Maximum spacing of connectors

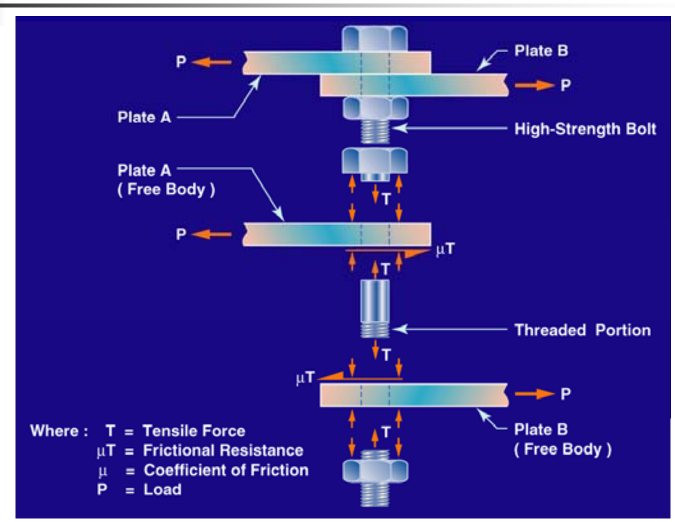
(a) For painted members or unpainted members not subject to corrosion, $\leq 24t \leq 12''$

(b) For unpainted members of weathering steel subject to atmospheric corrosion, $\leq 14t \leq 7''$

LRFD Slip-critical Connections

- A connection with high-strength bolts is classified as either a bearing or slip-critical connection.
- Bearing connections - the bolt is brought to a snug-tight condition so that the surfaces of the connected parts are in firm contact.
  - Slippage is acceptable
  - Shear and bearing on the connector
- Slip-critical connections - no slippage is permitted and the friction force described earlier must not be exceeded.
  - Slippage is not acceptable (Proper installation and tensioning is key)
  - Must have sufficient shear an d bearing strength in the event of overload that causes slip. AISC J3.8 for details.

Overview of Theory for Design



LRFD Slip-critical Connections(cont)

- $\Phi R_{str} = \Phi 1.13 \mu T_i m$ (4.9.1)
  - Where R_{str} = nominal slip resistance per bolt at factored loads
  - m = number of slip (shear) planes
  - T_i = minimum fastener initial tension given in AISC Table J3.1
  - = mean slip coefficient, as applicable, or as established by tests
  - μ = 0.35 for Class A surface condition
  - = 0.50 for Class B surface condition
  - = 0.40 for Class C surface condition
  - = 1.0 for standard holes
  - Φ = 0.85 for oversize and short-slotted holes
  - = 0.70 for long-slotted holes transverse to load
  - = 0.60 for long-slotted holes parallel to load

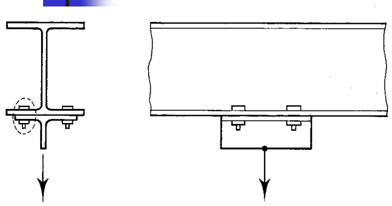
Sequi Example 7.4

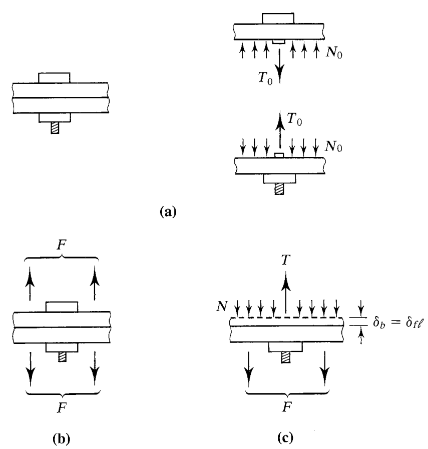
LRFD – Fasteners (cont)

Design tensile strength

- $\Phi R_n = 0.75(0.75 F_u^b) A_b$
  - where Φ = 0.75, a value for the tensile fracture mode
  - F_u^b = tensile strength of the bolt material (120 ksi for A325 bolts; 150 si for A490 bolts)
  - A_b = gross cross-sectional area across the unthreaded shank of the bolt

High-Strength Bolts in Tension





$T_0 + \Delta T = F$

$$\Delta T = \frac{A_b E_b}{L_0}\delta_b = \frac{A_b E_b}{L_0}\delta_{fl} = \left(\frac{\Delta T}{\Delta N}\right) T_0 = 0.1 T_0$$

$$where..\delta_{fl} = \frac{N_0 L_{fl}}{A_{fl} E_{fl}}$$

Figures 7-24 & 7-25

Prying Action

- Bolt tension $B_0 \rightarrow B$
- Prying force Q
- The corresponding bolt force, including the effects of prying, is B_c

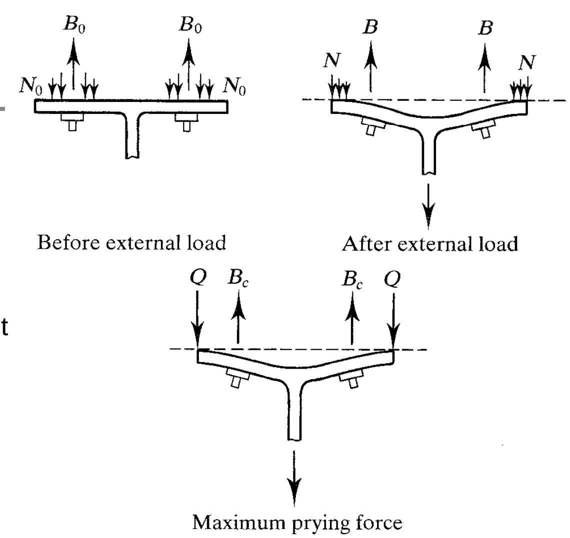
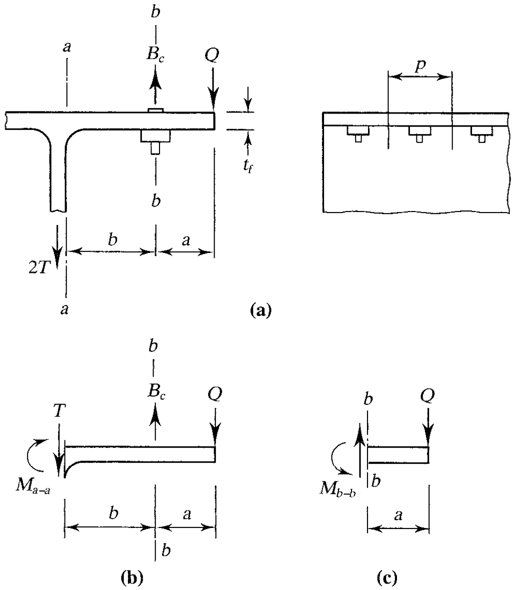


Figure 7.27

Prying Action



$$Tb - M_{a-a} = Qa$$

$$M_{b-b} = Qa$$

$$B_c = T + Q$$

Figure 7.28

Prying Action

$$M_{a-a} = design \cdot strength = \phi_b M_b = \phi_b \left(\frac{pt_f^2 F_u}{4} \right)$$

$$B_c = T + Q \quad \longrightarrow \quad B_c = T\left[1 + \frac{\delta\alpha}{(1+\delta\alpha)}\frac{b}{a}\right]$$

$$\alpha = \frac{M_{b-b}}{\delta M_{a-a}}$$

$$\delta = 1 - \frac{d'}{p} = \frac{net \cdot area \cdot at \cdot bolt \cdot line}{gross \cdot area \cdot at \cdot stem \cdot face}$$

Prying Action

$$\phi_b \left(\frac{pt_f^2 F_u}{4} \right) = \frac{Tb'}{(1+\delta\alpha)} \quad \longrightarrow \quad t_f = \sqrt{\frac{4Tb'}{\phi_b pF_u (1+\delta\alpha)}}$$

$$\longrightarrow \quad \text{Re}\,quired \cdot t_f = \sqrt{\frac{4.44Tb'}{pF_u (1+\delta\alpha)}}$$

LRFD Solution

For Evaluation:

$$\alpha = \frac{\left[\left(B/T\right) - 1\right]\left(a'/b'\right)}{\delta\left[1 - \left[\left(B/T\right) - 1\right]\left(a'/b'\right)\right]}$$

For back checking:

$$\alpha = \frac{1}{\delta}\left[\frac{4.44Tb'}{pt_f^2 F_b} - 1\right]$$

Sequi Example 7.8

Combined Shear and Tension

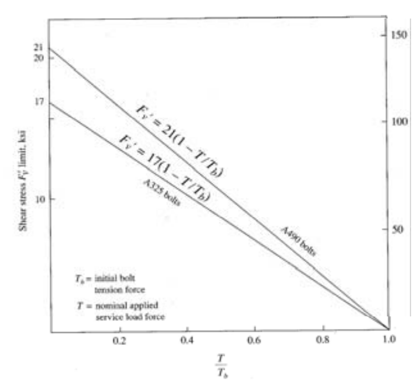
Bearing-type connections

Fastener	$\phi F'_{ut}$ (ksi)	$\phi F'_{ut}$ (MPa)
A307 bolts	$\phi(59 - 1.9 f_{uv}) \le \phi(45)$	$\phi(407 - 1.9 f_{uv}) \le \phi(310)$
A325-N bolts (threads *not* excluded)	$\phi(117 - 1.9 f_{uv}) \le \phi(90)$	$\phi(807 - 1.9 f_{uv}) \le \phi(621)$
A325-X bolts (threads excluded)	$\phi(117 - 1.5 f_{uv}) \le \phi(90)$	$\phi(807 - 1.5 f_{uv}) \le \phi(621)$
A490-N bolts (threads *not* excluded)	$\phi(147 - 1.9 f_{uv}) \le \phi(113)$	$\phi(1010 - 1.9 f_{uv}) \le \phi(779)$
A490-X bolts (threads excluded)	$\phi(147 - 1.5 f_{uv}) \le \phi(113)$	$\phi(1010 - 1.5 f_{uv}) \le \phi(779)$

* Note that $\phi = 0.75$

‡ Nominal stress due to factored load acting on gross bolt cross-sectional area, $f_{ut} = R_{ut}/A_b$

Slip-critical connections



Sequi Example 7.9

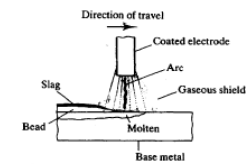
Basic of welding

- Structural welding is a process whereby the parts to be connected are heated and fused with a molten filler metal.
- Upon cooling, the structural steel (parent metal) and weld or filler metal will act as one continuous part. The filler metal is deposited from a special electrode. A number of welding processes are used, depending on the application
  - Field welds
  - Shop welds

Basic of welding (cont)

Basic process:

1. Shielded Metal Arc Welding (SMAW):
   - Normally done manually and is widely used for field welding
   - Current arcs across the gap between the electrode and the base metal
   - Connected parts are heated and part of the filler metal is deposited into the molten base metal
   - Coating on the electrode vaporizes and forms a protective gaseous shield, preventing the molten metal from oxidizing before it solidifies
   - The electrode is moved across the joint and a weld bead is deposited. Size of the weld bead depends on the rate of travel
   - As the weld cools, impurities rise to the surface and form a coating called slag. Slag must be removed before the next pass or the weld is painted.

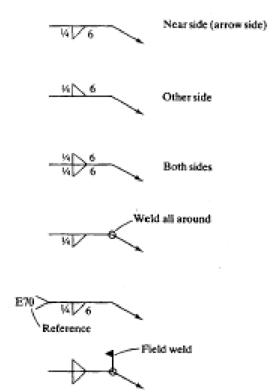


Basic of welding (cont)

Basic process (cont. used for shop welding):

2. Submerged Arc Welding (SAW)
3. Gas Metal Arc Welding (GMAW)
   - End of the electrode and the arc are submerged in a granular flux that melts and forms a gaseous shield.
4. Flux Cored Arc Welding (FCAW)
5. Electro Gas Welding (FGW)
6. Electroslag Welding (ESW)

Basic of welding (cont)



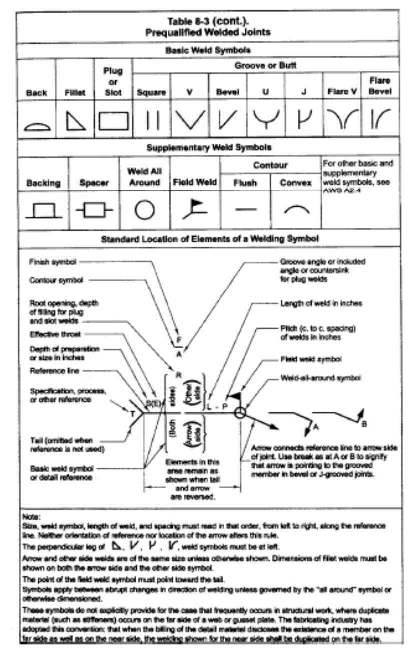


Table 8-3 (cont.).
Prequalified Welded Joints

Basic Weld Symbols

Back	Fillet	Plug or Slot	Groove or Butt: Square	V	Bevel	U	J	Flare V	Flare Bevel

Supplementary Weld Symbols

Backing	Spacer	Weld All Around	Field Weld	Contour: Flush	Contour: Convex	For other basic and supplementary weld symbols, see AWS A2.4

Standard Location of Elements of a Welding Symbol

Note:
Size, weld symbol, length of weld, and spacing must read in that order, from left to right, along the reference line. Neither orientation of reference nor location of the arrow alters this rule.
The perpendicular leg of ◺, V, ⊬, V, weld symbols must be at left.
Arrow and other side welds are of the same size unless otherwise shown. Dimensions of fillet welds must be shown on both the arrow side and the other side symbol.
The point of the field weld symbol must point toward the tail.
Symbols apply between abrupt changes in direction of welding unless governed by the "all around" symbol or otherwise dimensioned.
These symbols do not explicitly provide for the case that frequently occurs in structural work, where duplicate material (such as stiffeners) occurs on the far side of a web or gusset plate. The fabricating industry has adopted this convention: that when the billing of the detail material discloses the existence of a member on the far side as well as on the near side, the welding shown for the near side shall be duplicated on the far side.

Basic of welding (cont)

Minimum weld size, maximum weld size, and minimum length:

- The minimum size of a fillet weld is a function of the thickness of the thicker connected part. See AISC Table J2.4 for details.
- The maximum size of a fillet weld is as follows:
  - Along the edge of a connected part less than ¼-inch thick, the maximum fillet weld size (w) equals the plate thickness
  - For other values of plate thickness, t, the maximum weld size is t - 1/16 in.

TABLE J2.4
Minimum Size of Fillet Welds

Material Thickness of Thicker Part Joined, in. (mm)	Minimum Size of Fillet Weld[a] in. (mm)
To $^1/_4$ (6) inclusive	$^1/_8$ (3)
Over $^1/_4$ (6) to $^1/_2$ (13)	$^3/_{16}$ (5)
Over $^1/_2$ (13) to $^3/_4$ (19)	$^1/_4$ (6)
Over $^3/_4$ (19)	$^5/_{16}$ (8)

[a] Leg dimension of fillet welds. Single pass welds must be used.
[b] See Section J2.2b for maximum size of fillet welds.

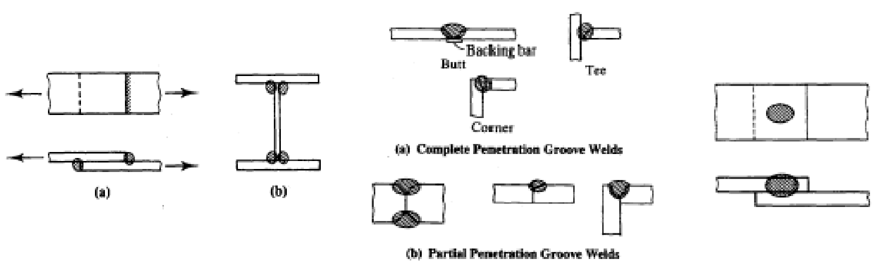
Basic of welding (cont)

- The minimum permissible length of a fillet weld is 4 times its size. If only a shorter length is available, w = L/4. For the welds in the connection shown below, L ≥ W to address shear lag in such connections.
- When a weld extends to the corner of a member, it must be continued around the corner (an end return)
  - Prevent stress concentrations at the corner of the weld
  - Minimum length of return is 2w

Basic of welding (cont)

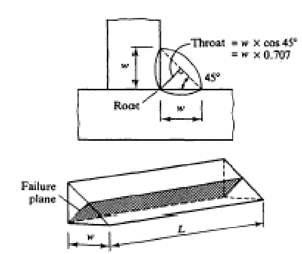
Common types of welds are

- Fillet welds - Welds placed in a corner formed by two parts in contact
- Groove welds - Welds deposited in a gap between two parts
- Plug welds - Circular or slotted hole that is filled with weld metal. Used sometimes when more we ld length is needed than is available



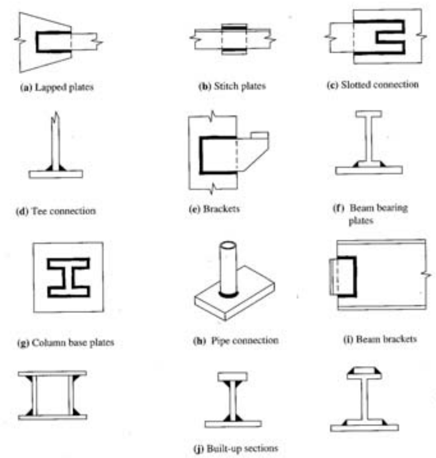
Fillet Weld

- The design and analysis of fillet welds is based on the assumption that the geometry of the weld is a 45-degree right triangle
- Standard weld sizes are expressed in sixteenths of an inch.
- Failure of fillet welds is assumed to occur in shear on the throat.



Fillet Weld (cont)

▪ The strength of a fillet weld depends on the strength of the filler or electrode metal used. The strength of an electrode is given in terms of its tensile strength in ksi. Strengths of 60, 70, 80, 90, 100, 110, and 120 ksi are available.



Fillet Weld (cont)

- The standard notation for an electrode is E**XX where ** indicate the tensile strength in ksi and XX denotes the type of coating used.
  - Usually XX is the focus of design
  - E70XX is an electrode with a tensile strength of 70 ksi
  - Electrodes should be chosen to match the base metal.
    - Use E70XX electrodes for use with steels that have a yield stress less than 60 ksi
    - Use E80XX electrodes that have a yield stress of 60 ksi or 65 ksi

Fillet Weld (cont)

- The critical shearing stress on a weld of length L is given by
  $f = P/(0.707wL)$
- If the ultimate shearing stress in the weld is termed F_W, the nominal design strength of the weld can be written as
  $\varphi R_n = 0.707wL(\varphi F_w) = 0.707wL(0.75[0.6F_{EXX}]) = 0.32wLF_{EXX}$
- For E70XX and E80XX electrodes, the design stresses are φF_w, or 31.5 ksi and 36 ksi, respectively.
- In addition, the factored load shear on the base metal shall not produce a stress in excess of φF_{BM}, where F_{BM} is the nominal shear strength of the connected material. The factored load on the connection is thus subjected to the limit of
  $\varphi R_n = \varphi F_{BM}A_g = 0.90(0.6F_y)A_g = 0.54F_yA_g$

LRFD of Welded Connections

TABLE J2.5
Design Strength of Welds

Types of Weld and Stress [a]	Material	Resistance Factor φ	Nominal Strength F_{BM} or F_w	Filler Metal Requirements [b, c]
Complete-Joint-Penetration Groove Weld				
Tension normal to effective area	Base	0.90	F_y	Matching filler metal shall be used. For CVN requirements see footnote [d].
Compression normal to effective area	Base	0.90	F_y	Filler metal with a strength level equal to or less than matching filler metal is permitted to be used.
Tension or compression parallel to axis of weld				
Shear on effective area	Base Weld	0.90 0.80	$0.60F_y$ $0.60F_{EXX}$	
Partial-Joint-Penetration Groove Weld				
Compression normal to effective area	Base	0.90	F_y	Filler metal with a strength level equal to or less than matching filler metal is permitted to be used.
Tension or compression parallel to axis of weld [e]				
Shear parallel to axis of weld	Base Weld	[f] 0.75	[f] $0.60F_{EXX}$	
Tension normal to effective area	Base Weld	0.90 0.80	F_y $0.60F_{EXX}$	
Fillet Welds				
Shear on effective area	Base Weld	[f] 0.75	[f] $0.60F_{EXX}$[g]	Filler metal with a strength level equal to or less than matching filler metal is permitted to be used.
Tension or compression parallel to axis of weld [e]	Base	0.90	F_y	
Plug or Slot Welds				
Shear parallel to faying surfaces (on effective area)	Base Weld	[f] 0.75	[f] $0.60F_{EXX}$	Filler metal with a strength level equal to or less than matching filler metal is permitted to be used.

[a] For definition of effective area, see Section J2.
[b] For matching filler metal, see Table 3.1, AWS D1.1.
[c] Filler metal one strength level stronger than matching filler metal is permitted.
[d] For T and corner joints with the backing bar left in place during service, filler metal with a classification requiring a minimum Charpy V-notch (CVN) toughness of 20 ft-lbs. (27 J) @ +40°F (4°C) shall be used. If filler metal without the required toughness is used and the backing bar is left in place, the joint shall be sized using the resistance factor and nominal strength for a partial-joint-penetration weld.
[e] Fillet welds and partial-joint-penetration groove welds joining component elements of built-up members, such as flange-to-web connections, are not required to be designed with regard to the tensile or compressive stress in these elements parallel to the axis of the welds.
[f] The design of connected material is governed by Sections J4 and J5.
[g] For alternative design strength, see Appendix J2.4.

Sequi Examples 7.11 & 7.15