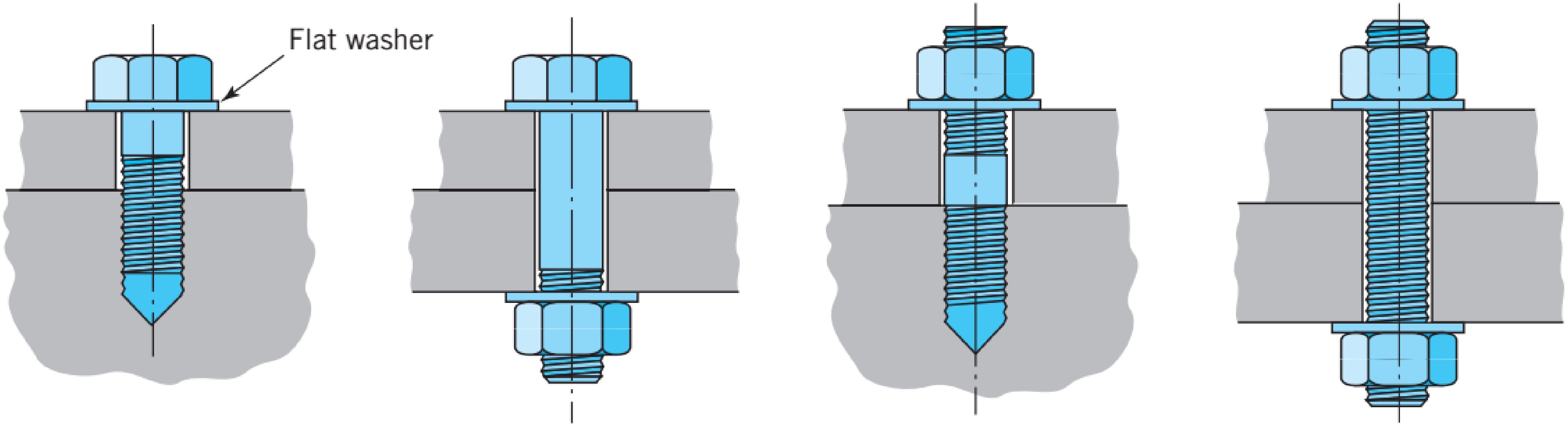
Mechanical Joints

1. **Non-Permanent Joints** – Bolts, Screws, Circlips
2. **Permanent Joints** – Welding, Brazing, Soldering

Basic Types of Non-Permanent Joints



(*a*) Screw (*b*) Bolt and nut (*c*) Stud and nut (*d*) Threaded rod and nuts

Head Type of Bolts

- Hexagon head bolt
  - Usually uses nut
  - Heavy duty
- Hexagon head cap screw
  - Thinner head
  - Often used as screw (in threaded hole, without nut)
- Socket head cap screw
  - Usually more precision applications
  - Access from the top
- Machine screws
  - Usually smaller sizes
  - Slot or philips head common
  - Threaded all the way

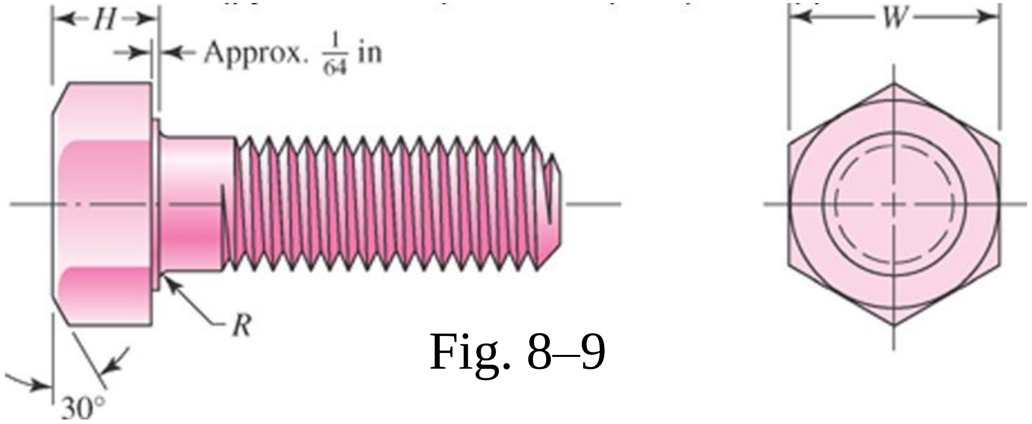


Fig. 8–9

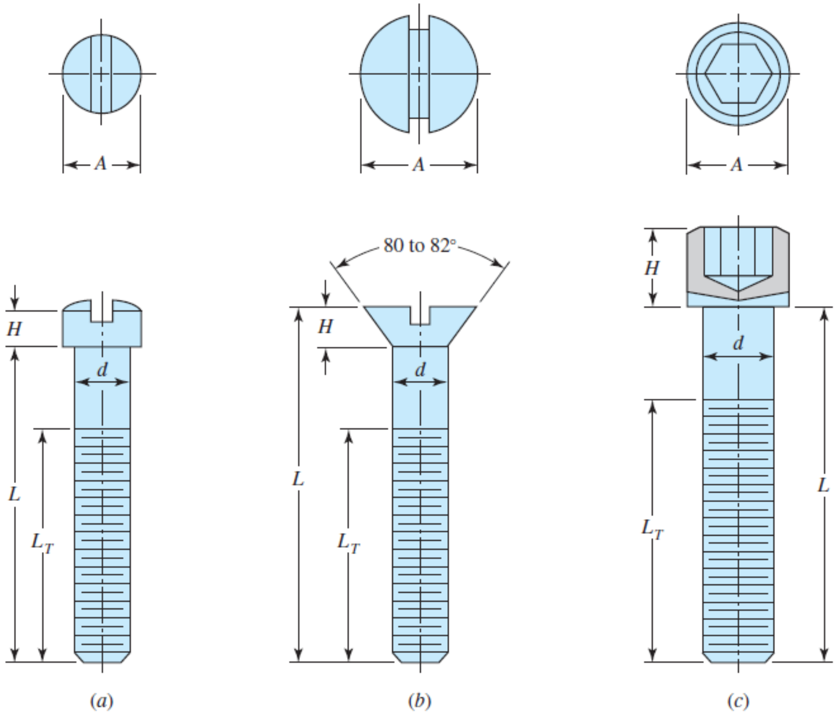


Fig. 8–10

Machine Screws

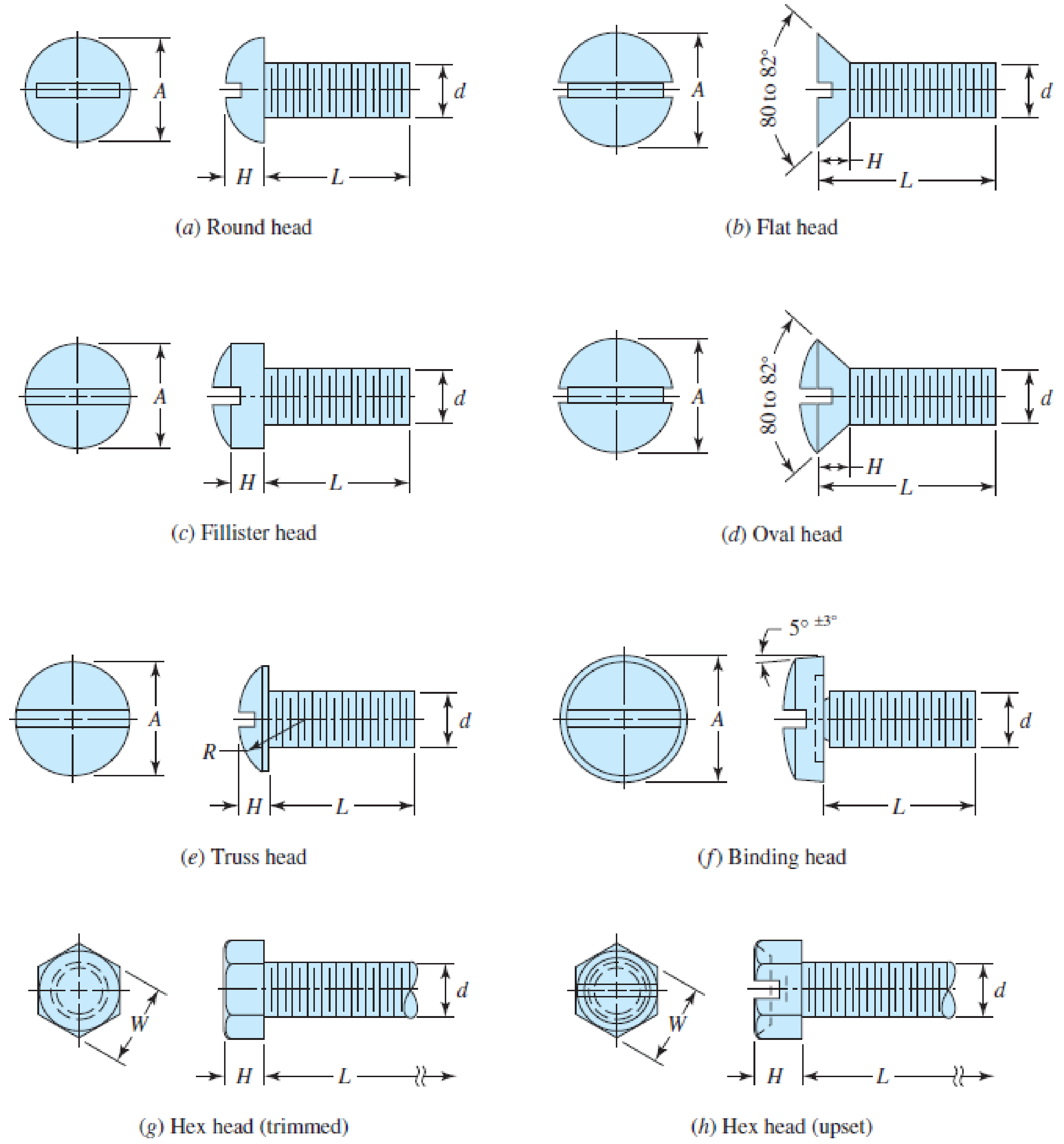
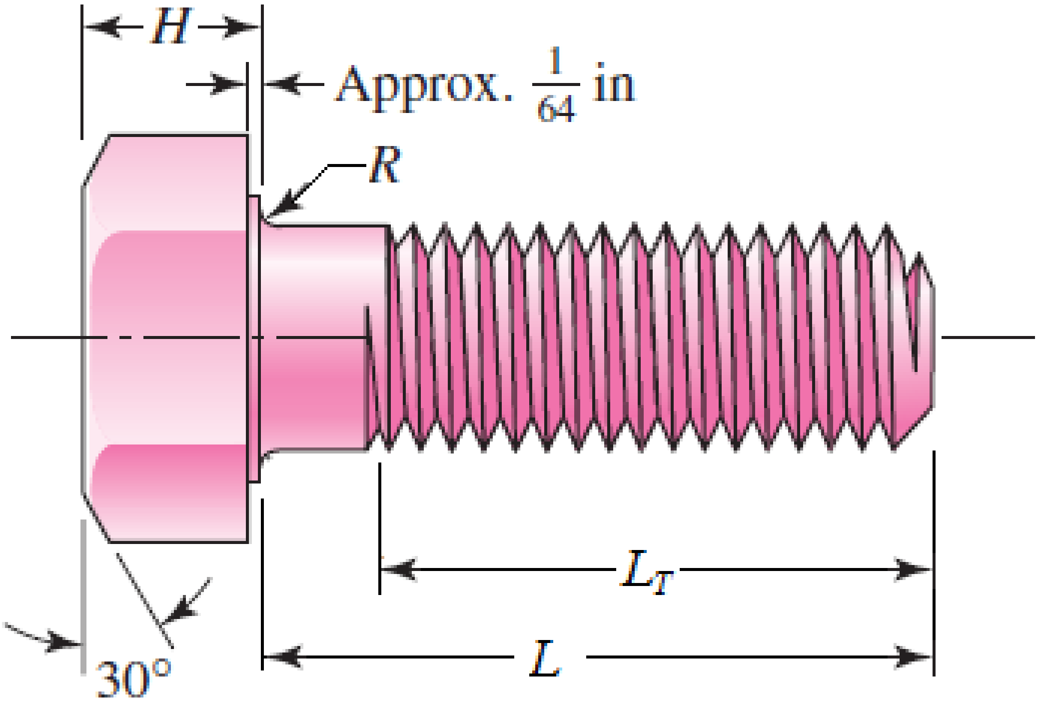
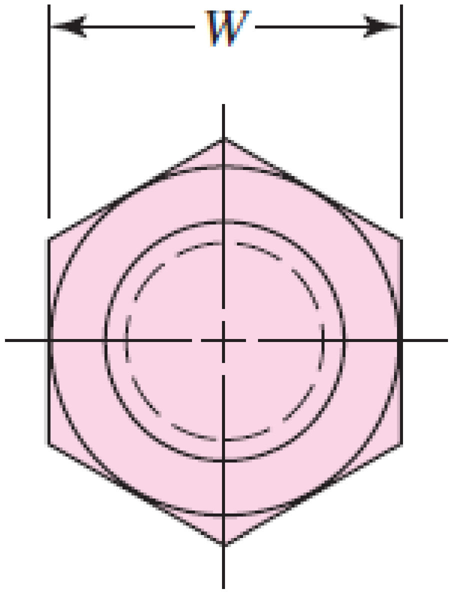


Fig. 8–11

Hexagon-Head Bolt

- Hexagon-head bolts are one of the most common for engineering applications
- Standard dimensions are included in Table A–29
- *W* is usually about 1.5 times nominal diameter
- Bolt length *L* is measured from below the head

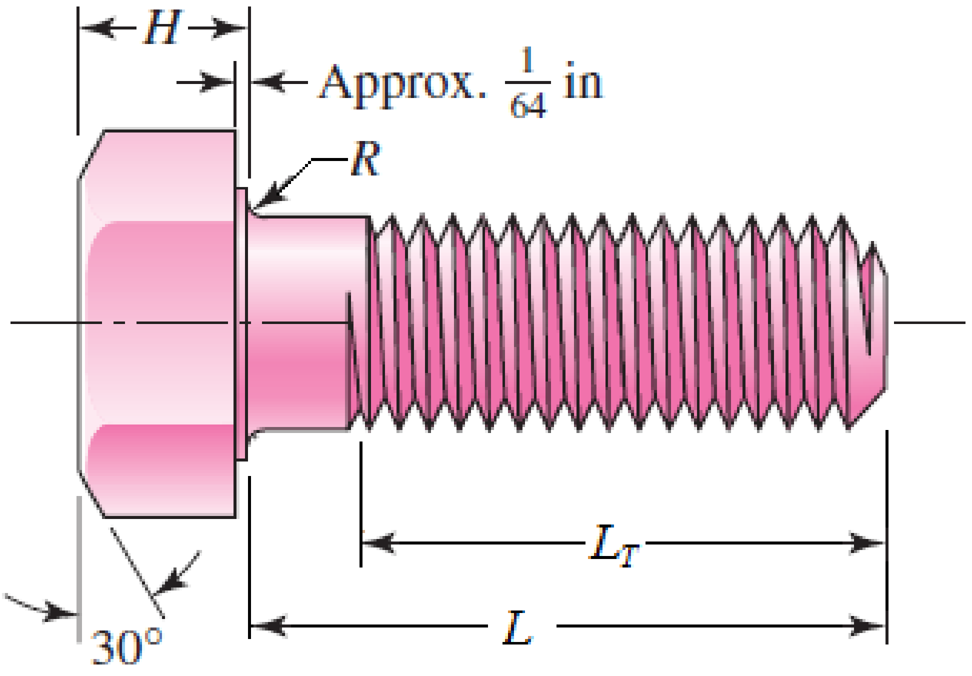




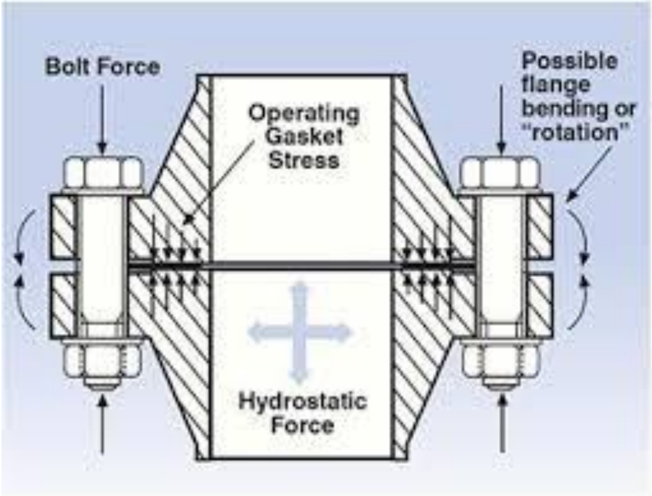
Threaded Lengths

English
$$L_T = \begin{cases} 2d + \frac{1}{4}\text{ in} & L \le 6\text{ in} \\ 2d + \frac{1}{2}\text{ in} & L > 6\text{ in} \end{cases} \qquad (8\text{–}13)$$

Metric
$$L_T = \begin{cases} 2d + 6 & L \le 125 \quad d \le 48 \\ 2d + 12 & 125 < L \le 200 \\ 2d + 25 & L > 200 \end{cases} \qquad (8\text{–}14)$$



Application of Bolted Joints



ISO Metric Screw Threads

Table 10.2 Basic Dimensions of ISO Metric Screw Threads

	Coarse Threads			Fine Threads		
Nominal Diameter d (mm)	Pitch p (mm)	Minor Diameter d_r (mm)	Stress Area A_t (mm^2)	Pitch p (mm)	Minor Diameter d_r (mm)	Stress Area A_t (mm^2)
3	0.5	2.39	5.03			
3.5	0.6	2.76	6.78			
4	0.7	3.14	8.78			
5	0.8	4.02	14.2			
6	1	4.77	20.1			
7	1	5.77	28.9			
8	1.25	6.47	36.6	1	6.77	39.2
10	1.5	8.16	58.0	1.25	8.47	61.2
12	1.75	9.85	84.3	1.25	10.5	92.1
14	2	11.6	115	1.5	12.2	125
16	2	13.6	157	1.5	14.2	167
18	2.5	14.9	192	1.5	16.2	216
20	2.5	16.9	245	1.5	18.2	272
22	2.5	18.9	303	1.5	20.2	333
24	3	20.3	353	2	21.6	384
27	3	23.3	459	2	24.6	496
30	3.5	25.7	561	2	27.6	621
33	3.5	28.7	694	2	30.6	761
36	4	31.1	817	3	32.3	865
39	4	34.1	976	3	35.3	1030

Note: Metric threads are identified by diameter and pitch as "M8 × 1.25."

Bolt Materials

- ***Proof load*** **(F_p)** is the maximum load that a bolt can withstand without acquiring a permanent set
- ***Proof strength*** **(S_p)** is the quotient ***(proportion)*** of proof load and tensile-stress area **(A_t)**
  - Corresponds to proportional limit
  - Slightly lower than yield strength
  - Typically used for static strength of bolt
- Good bolt materials have stress-strain curve that continues to rise to fracture

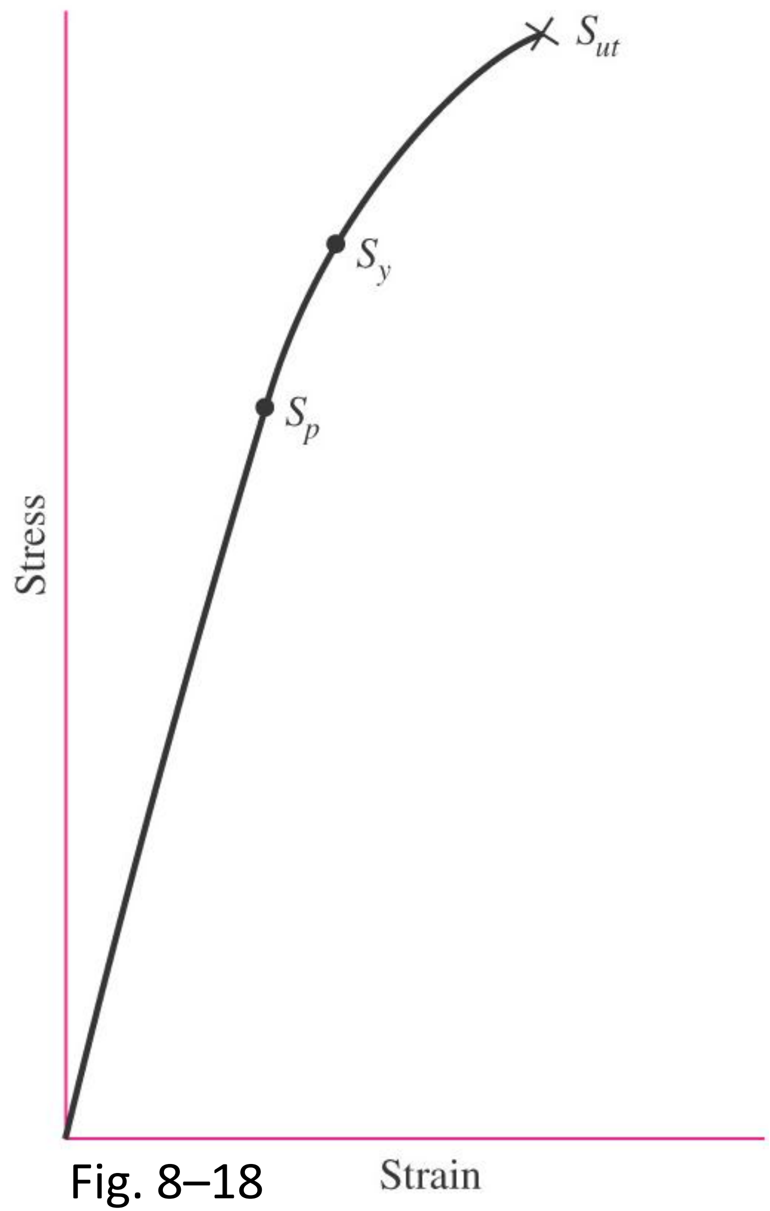


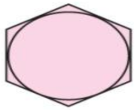
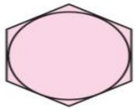
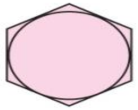
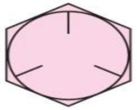
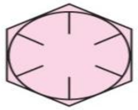
Fig. 8–18

Bolt Standardization and Materials

- **Grades specify material, heat treatment, strengths**
  - Table 8–9 for SAE grades
  - Table 8–10 for ASTM designations
  - Table 8–11 for metric property class
- **Grades should be marked on head of bolt**

SAE Specifications for Steel Bolts

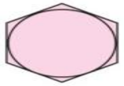
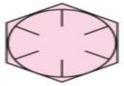
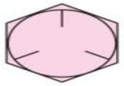
Table 8–9

SAE Grade No.	Size Range Inclusive, in	Minimum Proof Strength,* kpsi	Minimum Tensile Strength,* kpsi	Minimum Yield Strength,* kpsi	Material	Head Marking
1	$\frac{1}{4}$–$1\frac{1}{2}$	33	60	36	Low or medium carbon	
2	$\frac{1}{4}$–$\frac{3}{4}$	55	74	57	Low or medium carbon	
	$\frac{7}{8}$–$1\frac{1}{2}$	33	60	36		
4	$\frac{1}{4}$–$1\frac{1}{2}$	65	115	100	Medium carbon, cold-drawn	
5	$\frac{1}{4}$–1	85	120	92	Medium carbon, Q&T	
	$1\frac{1}{8}$–$1\frac{1}{2}$	74	105	81		
5.2	$\frac{1}{4}$–1	85	120	92	Low-carbon martensite, Q&T	
7	$\frac{1}{4}$–$1\frac{1}{2}$	105	133	115	Medium-carbon alloy, Q&T	
8	$\frac{1}{4}$–$1\frac{1}{2}$	120	150	130	Medium-carbon alloy, Q&T	
8.2	$\frac{1}{4}$–1	120	150	130	Low-carbon martensite, Q&T	

*Minimum strengths are strengths exceeded by 99 percent of fasteners.

ASTM Specification for Steel Bolts

Table 8–10

ASTM Desig-nation No.	Size Range, Inclusive, in	Minimum Proof Strength,* kpsi	Minimum Tensile Strength,* kpsi	Minimum Yield Strength,* kpsi	Material	Head Marking
A307	$\frac{1}{4}$–$1\frac{1}{2}$	33	60	36	Low carbon	
A325, type 1	$\frac{1}{2}$–1	85	120	92	Medium carbon, Q&T	
	$1\frac{1}{8}$–$1\frac{1}{2}$	74	105	81		
A325, type 2	$\frac{1}{2}$–1	85	120	92	Low-carbon, martensite, Q&T	
	$1\frac{1}{8}$–$1\frac{1}{2}$	74	105	81		
A325, type 3	$\frac{1}{2}$–1	85	120	92	Weathering steel, Q&T	
	$1\frac{1}{8}$–$1\frac{1}{2}$	74	105	81		
A354, grade BC	$\frac{1}{4}$–$2\frac{1}{2}$	105	125	109	Alloy steel, Q&T	
	$2\frac{3}{4}$–4	95	115	99		
A354, grade BD	$\frac{1}{4}$–4	120	150	130	Alloy steel, Q&T	
A449	$\frac{1}{4}$–1	85	120	92	Medium-carbon, Q&T	
	$1\frac{1}{8}$–$1\frac{1}{2}$	74	105	81		
	$1\frac{3}{4}$–3	55	90	58		
A490, type 1	$\frac{1}{2}$–$1\frac{1}{2}$	120	150	130	Alloy steel, Q&T	
A490, type 3	$\frac{1}{2}$–$1\frac{1}{2}$	120	150	130	Weathering steel, Q&T	

*Minimum strengths are strengths exceeded by 99 percent of fasteners.

Metric Mechanical-Property Classes for Steel Bolts

Table 8–11

Property Class	Size Range, Inclusive	Minimum Proof Strength,† MPa	Minimum Tensile Strength,† MPa	Minimum Yield Strength,† MPa	Material	Head Marking
4.6	M5–M36	225	400	240	Low or medium carbon	4.6
4.8	M1.6–M16	310	420	340	Low or medium carbon	4.8
5.8	M5–M24	380	520	420	Low or medium carbon	5.8
8.8	M16–M36	600	830	660	Medium carbon, Q&T	8.8
9.8	M1.6–M16	650	900	720	Medium carbon, Q&T	9.8
10.9	M5–M36	830	1040	940	Low-carbon martensite, Q&T	10.9
12.9	M1.6–M36	970	1220	1100	Alloy, Q&T	12.9

*The thread length for bolts and cap screws is

Table 10.5 Specifications for Steel Used in Millimeter Series Screws and Bolts

SAE Class	Diameter d (mm)	Proof Load (Strength)[a] S_p (MPa)	Yield Strength[b] S_y (MPa)	Tensile Strength S_u (MPa)	Elongation, Minimum (%)	Reduction of Area, Minimum (%)	Core Hardness, Rockwell	
							Min	Max
4.6	5 thru 36	225	240	400	22	35	B67	B87
4.8	1.6 thru 16	310	—	420	—	—	B71	B87
5.8	5 thru 24	380	—	520	—	—	B82	B95
8.8	17 thru 36	600	660	830	12	35	C23	C34
9.8	1.6 thru 16	650	—	900	—	—	C27	C36
10.9	6 thru 36	830	940	1040	9	35	C33	C39
12.9	1.6 thru 36	970	1100	1220	8	35	C38	C44

[a] Proof load (strength) corresponds to the axially applied load that the screw or bolt must withstand without permanent set.

[b] Yield strength corresponds to 0.2 percent offset measured on machine test specimens.

Source: Society of Automotive Engineers standard J1199 (1979).

Bolt Specification

Threads per inch

Thread series

Material grade

¼-20 x ¾ in UNC-2 Grade 5 Hex head bolt

Nominal diameter

length

Class fit

Head type

Metric

Pitch

M12 x 1.75 ISO 4.8 Hex head bolt

Nominal diameter

Material class

Tension in Loaded Bolted Joints

$$F_i = \text{preload}$$

$$P_{\text{total}} = \text{Total external tensile load applied to the joint}$$

$$P = \text{external tensile load per bolt}$$

$$P_b = \text{portion of } P \text{ taken by bolt}$$

$$P_m = \text{portion of } P \text{ taken by members}$$

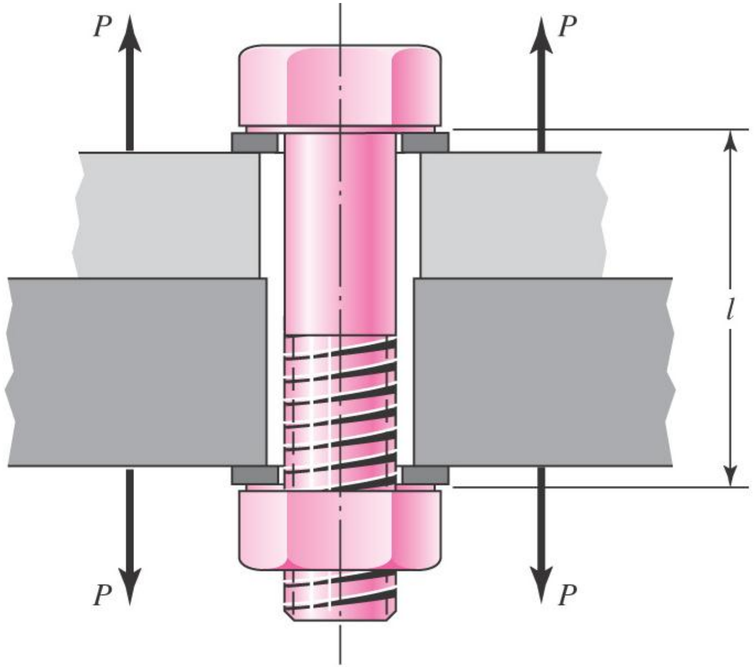
$$F_b = P_b + F_i = \text{resultant bolt load}$$

$$F_m = P_m - F_i = \text{resultant load on members}$$

$$C = \text{fraction of external load } P \text{ carried by bolt}$$

$$1 - C = \text{fraction of external load } P \text{ carried by members}$$

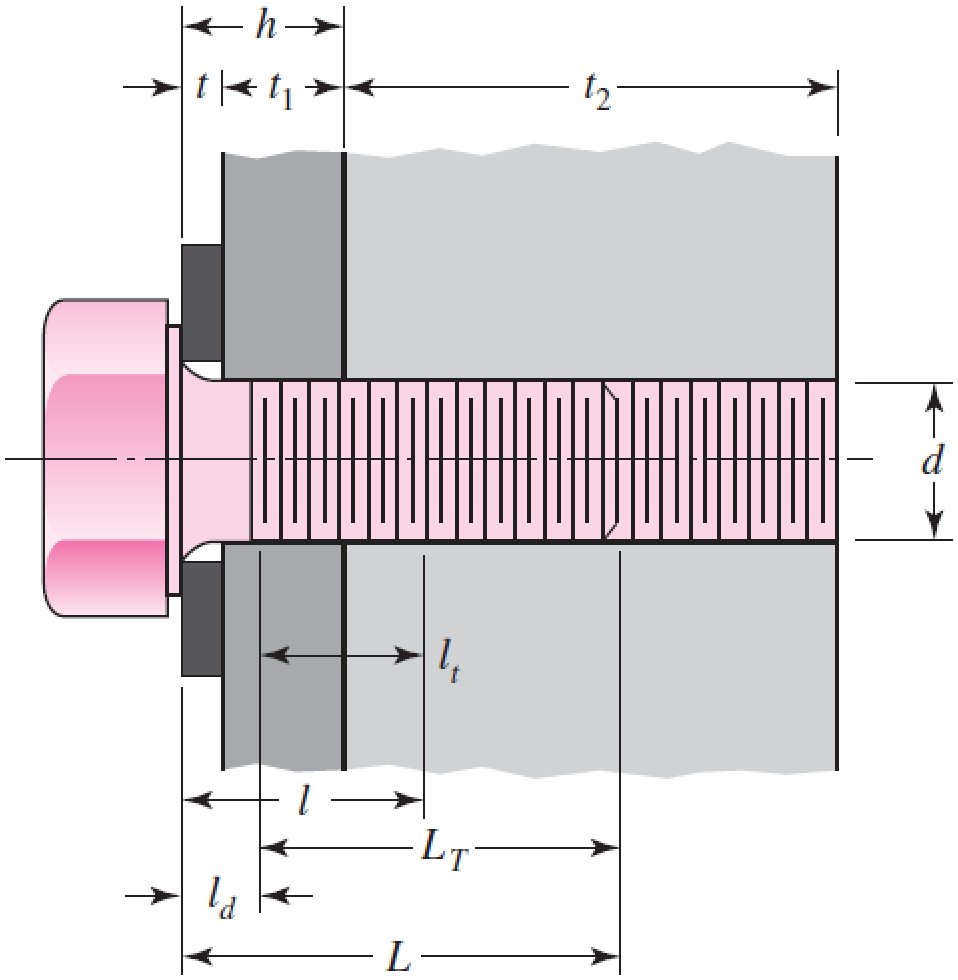
$$N = \text{Number of bolts in the joint}$$



Effective Grip Length for Tapped Holes

- For screw in tapped hole, effective grip length is

$$l = \begin{cases} h + t_2/2, & t_2 < d \\ h + d/2, & t_2 \geq d \end{cases}$$



Bolted Joint Stiffnesses

- During bolt preload
  - bolt is stretched
  - members in grip are compressed
- When external load *P* is applied
  - Bolt stretches further
  - Members in grip uncompress some
- Joint can be modeled as a soft bolt spring in parallel with a stiff member spring

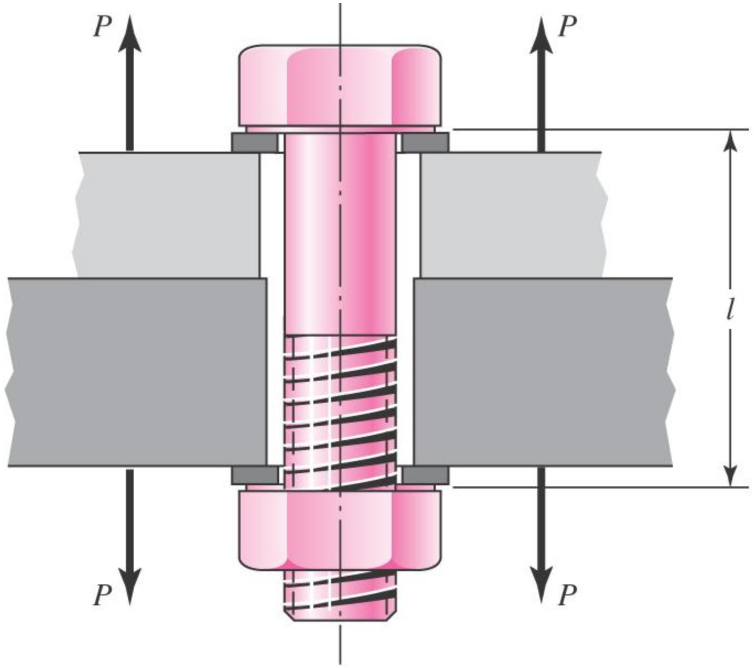
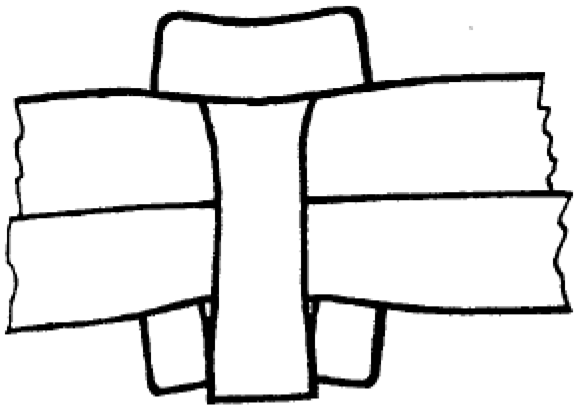


Fig. 8–13



Tension in Loaded Bolted Joints

- **During bolt preload**
  - bolt is stretched
  - members in grip are compressed
- **When external load *P* is applied**
  - Bolt stretches an additional amount δ
  - Members in grip uncompress same amount δ

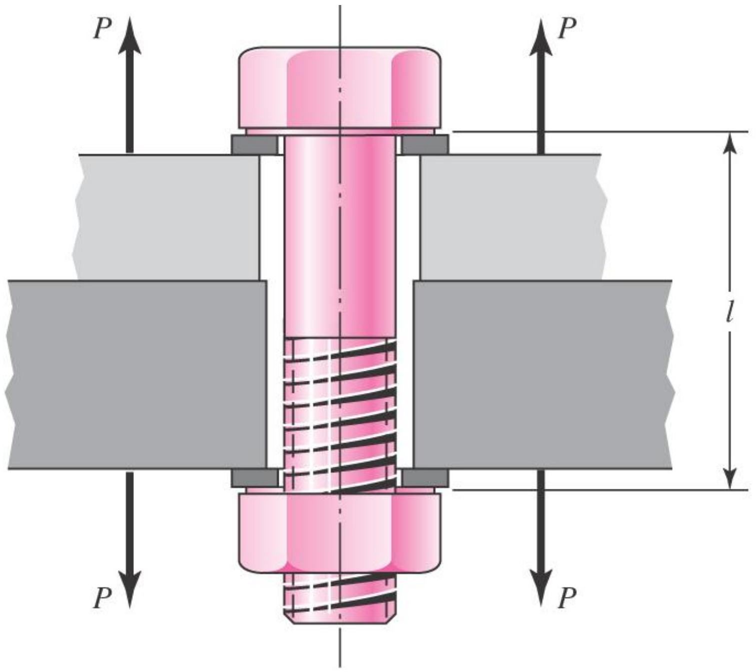


Fig. 8–13

$$\delta = \frac{P_b}{k_b} \qquad \text{and} \qquad \delta = \frac{P_m}{k_m} \qquad (b)$$

$$P_m = P_b \frac{k_m}{k_b} \qquad (c)$$

Stiffness Constant

- Since $P = P_b + P_m$,

$$P_b = \frac{k_b P}{k_b + k_m} = CP \qquad (d)$$

$$P_m = P - P_b = (1 - C)P \qquad (e)$$

- C is defined as the *stiffness constant* of the joint

$$C = \frac{k_b}{k_b + k_m} \qquad (f)$$

- C indicates the proportion of external load P that the bolt will carry. A good design target is around 0.2.

Table 8–12

Computation of Bolt and Member Stiffnesses. Steel members clamped using a $\frac{1}{2}$ in-13 NC steel bolt. $C = \frac{k_b}{k_b + k_m}$

	Stiffnesses, M lbf/in			
Bolt Grip, in	k_b	k_m	C	$1 - C$
2	2.57	12.69	0.168	0.832
3	1.79	11.33	0.136	0.864
4	1.37	10.63	0.114	0.886

Initial Torque in Bolt

$$T = \left[\left(\frac{d_m}{2d}\right)\left(\frac{\tan\lambda + f\sec\alpha}{1 - f\tan\lambda\sec\alpha}\right) + 0.625 f_c\right] F_i d \qquad \text{(c)}$$

- Define term in brackets as *torque coefficient K*

$$K = \left(\frac{d_m}{2d}\right)\left(\frac{\tan\lambda + f\sec\alpha}{1 - f\tan\lambda\sec\alpha}\right) + 0.625 f_c \qquad (8\text{–}26)$$

$$T = K F_i d \qquad (8\text{–}27)$$

Recommended Preload

$$T = K F_i d \qquad (8\text{–}27)$$

$$F_i = \begin{cases} 0.75F_p & \text{for nonpermanent connections, reused fasteners} \\ 0.90F_p & \text{for permanent connections} \end{cases} \qquad (8\text{–}31)$$

$$F_p = A_t S_p \qquad (8\text{–}32)$$

Typical Values for Torque Coefficient *K*

$$T = K F_i d \qquad (8\text{–}27)$$

- Some recommended values for *K* for various bolt finishes is given in Table 8–15
- Use *K* = 0.2 for other cases

Table 8–15

Torque Factors *K* for Use with Eq. (8–27)

Bolt Condition	*K*
Nonplated, black finish	0.30
Zinc-plated	0.20
Lubricated	0.18
Cadmium-plated	0.16
With Bowman Anti-Seize	0.12
With Bowman-Grip nuts	0.09

Bolt and Member Loads

- **Initial Load (Preload)** $F_i = K_i\, A_t\, Sp$

For ordinary usage, $F_i = 0.9A_tS_p$

- **Resultant bolt load with external load (P) is**

$$F_b = P_b + F_i = CP + F_i \qquad F_m < 0 \tag{8–24}$$

- **Resultant load on the members with external load (P) is**

$$F_m = P_m - F_i = (1 - C)P - F_i \qquad F_m < 0 \tag{8–25}$$

- **These results are only valid if the load on the members remains negative, indicating the members stay in compression.**

Bolt Factor of Safety

Tensile Stress in the Bolt

$$\sigma_b = \frac{F_b}{A_t} = \frac{CP + F_i}{A_t}$$

$$n_p = \frac{S_p}{\sigma_b} = \frac{S_p}{(CP + F_i)/A_t}$$

Example 1: Centrically Bolted Connection

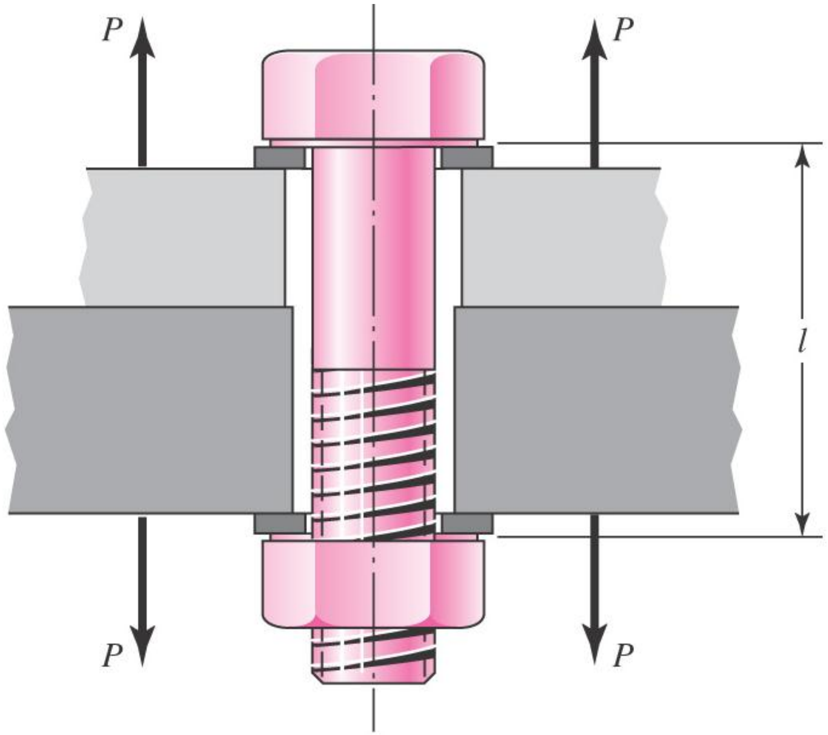
For bolt assembly with 8 bolts, the stiffness of each bolt (k_b) is 1.0 MN/mm and the stiffness of the members (k_m) is 2.6 MN/mm. The joint is preloaded. Assume an external static load of 40 KN is applied and is distributed equally among the bolts. It has been determined that M6x1 Class 5.8 bolted will be used.

a. Calculate the force in the bolts and the members

b. Determine the best factor of safety in the bolt.

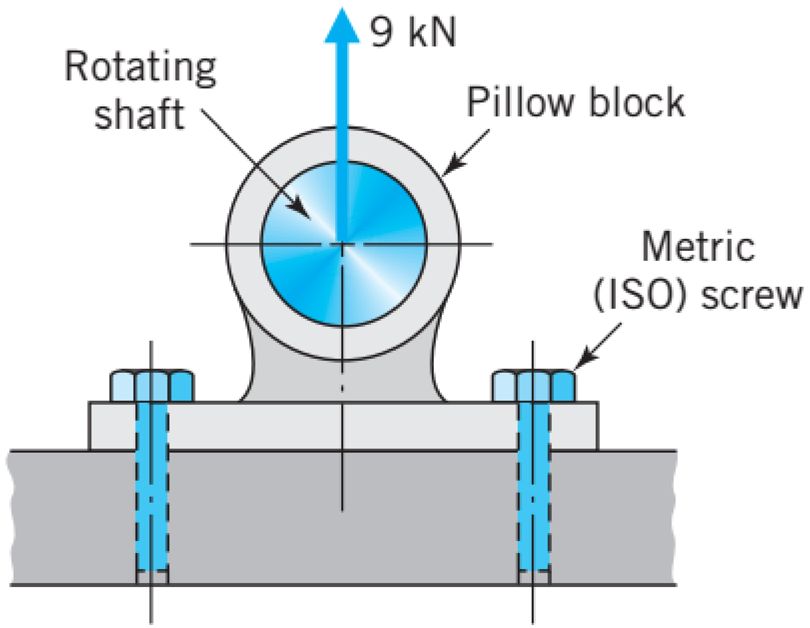
c. Determine the maximum external load that can be applied to joint without exceeding the proof strength of the bolts.

e. Determine the maximum external load that can be applied to joint causing the members to separate.



Example 2: Centric Bolted Connection Design

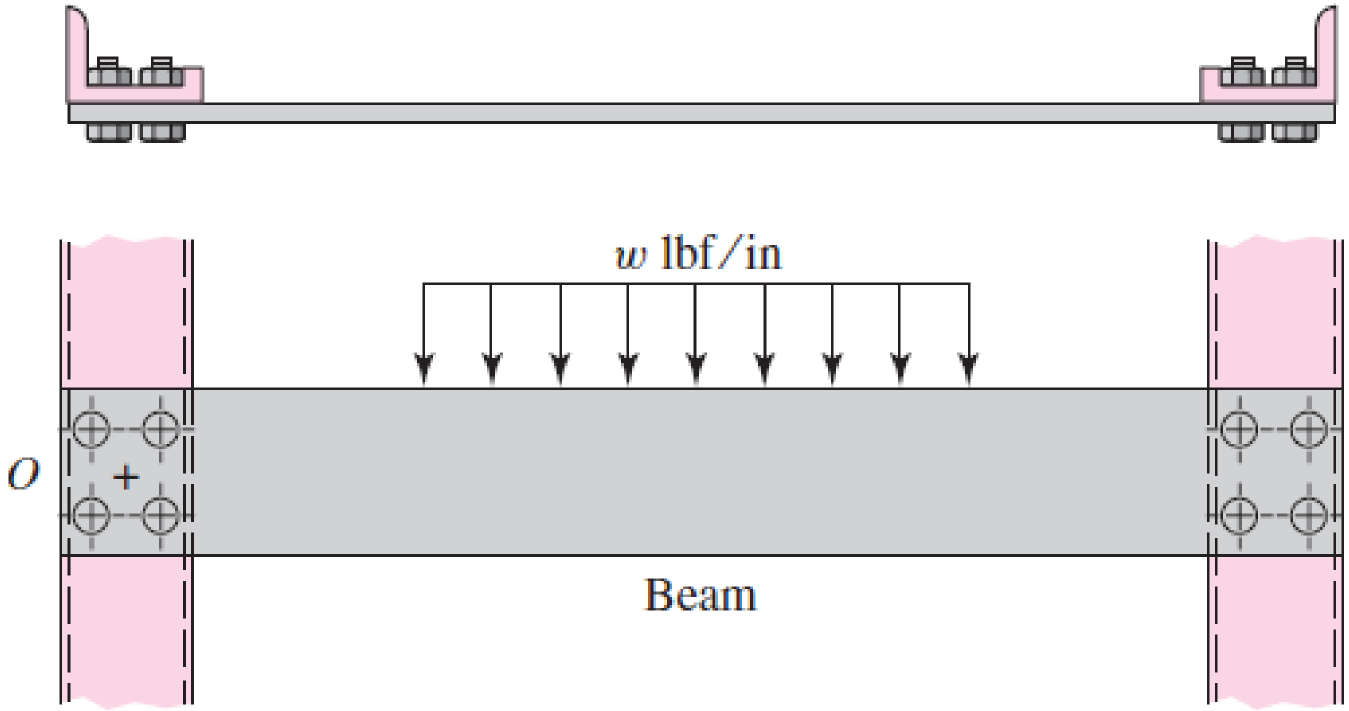
The Figure shows a ball bearing encased in a “pillow block” and supporting one end of a rotating shaft. The shaft applies a static load of 9 kN to the pillow block, as shown. Select appropriate metric (ISO) screws for the pillow block attachment and specify an appropriate tightening torque.



Eccentrically Loaded Bolted Connections

- *Eccentric* loading is when the line action of the load does not pass though the centroid of the geometric pattern of the fasteners.
- Requires finding moment about centroid of bolt pattern

Fig. 8–27*a*



Shear Loads in Eccentric Loading

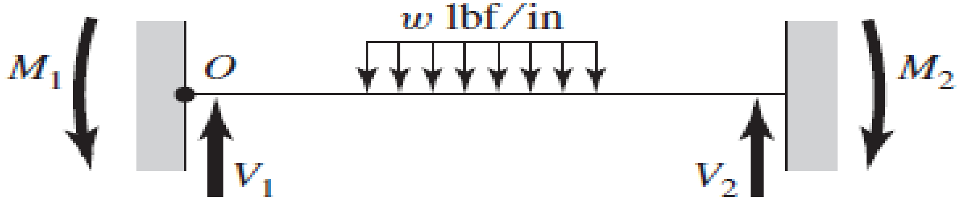
- ***Primary Shear:*** $F' = V_1/n$

- ***Secondary Shear,*** due to moment load around centroid:

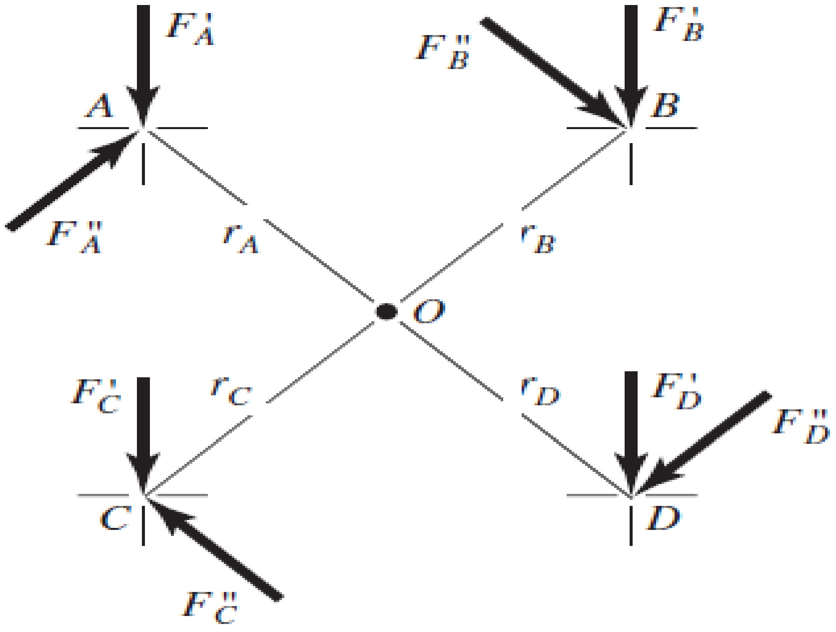
$$M_1 = F''_A r_A + F''_B r_B + F''_C r_C + \cdots$$

$$\frac{F''_A}{r_A} = \frac{F''_B}{r_B} = \frac{F''_C}{r_C} \qquad (8\text{–}57)$$

$$F''_n = \frac{M_1 r_n}{r_A^2 + r_B^2 + r_C^2 + \cdots}$$



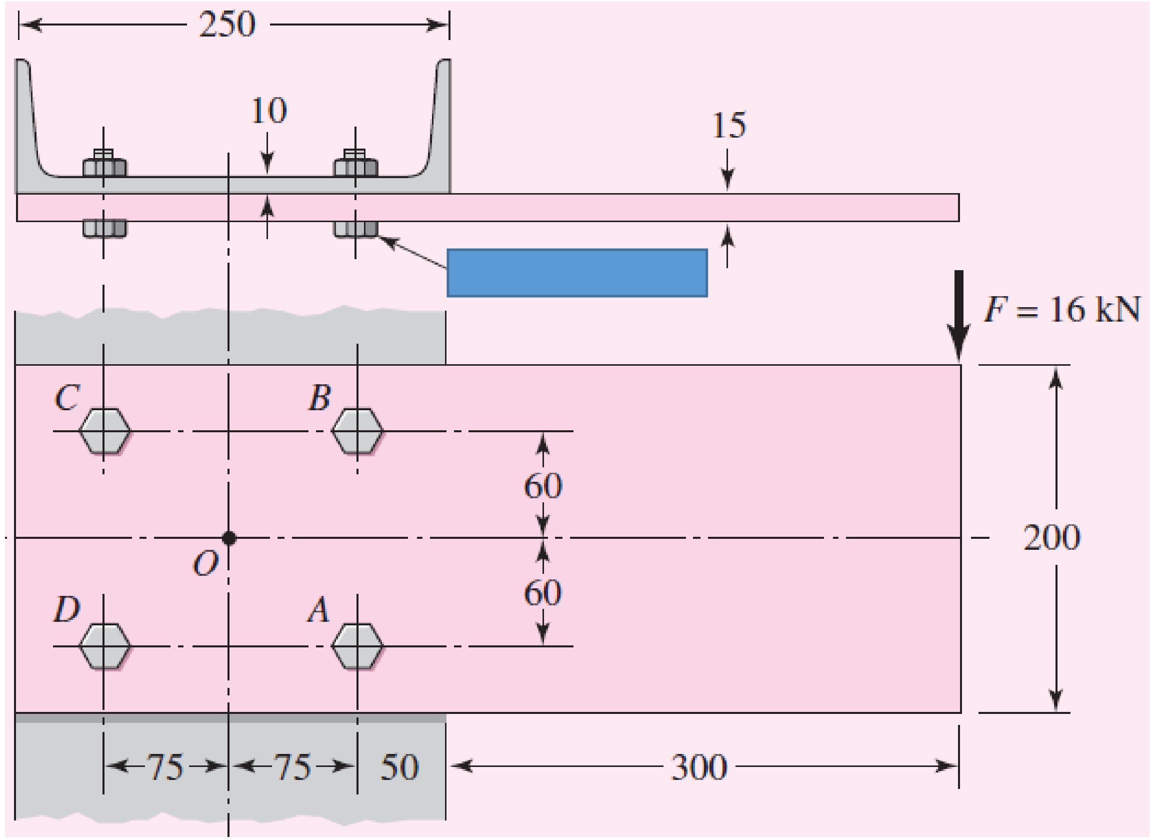
(b)



(c)

Example 3 – Eccentrically Loaded Bolted Connection Design

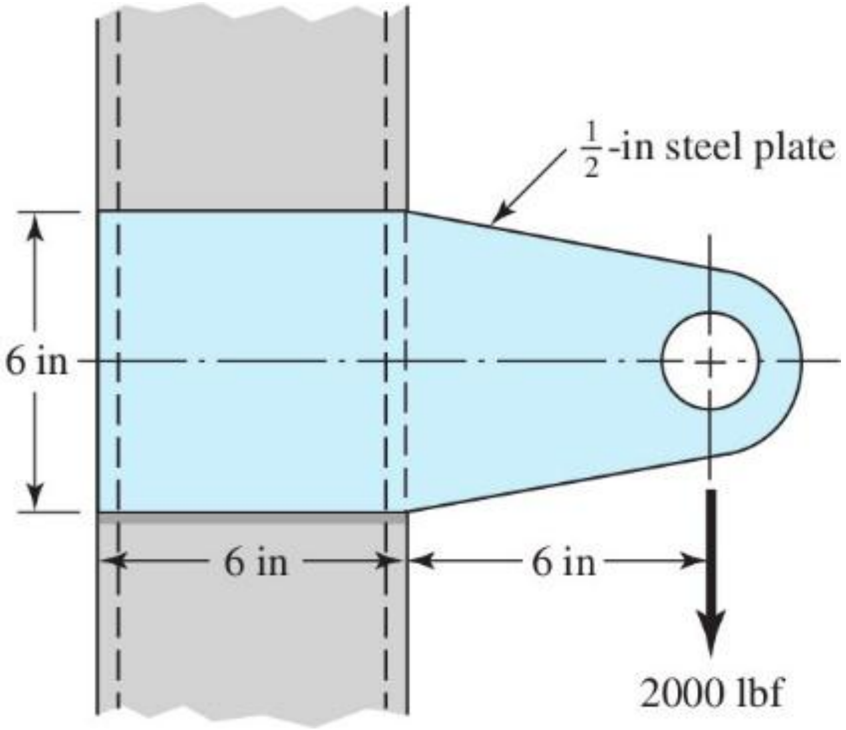
The Figure shows a 15 by 200-mm rectangular steel bar cantilevered to a 250 mm steel channel using four tightly fitted bolts located at A, B, C, and D.
The joint is subject to an eccentric load of 16 KN as shown.
You are the engineer. Specify and ISO bolt and tightening load for the application.



Sample Problem 1

Specify a bolt pattern for 4 bolts and determine the size of the bolts.

Problem 8–79



Permanent Joints

- Welding
- Soldering
- Brazing
- Bonding

Welding Symbols

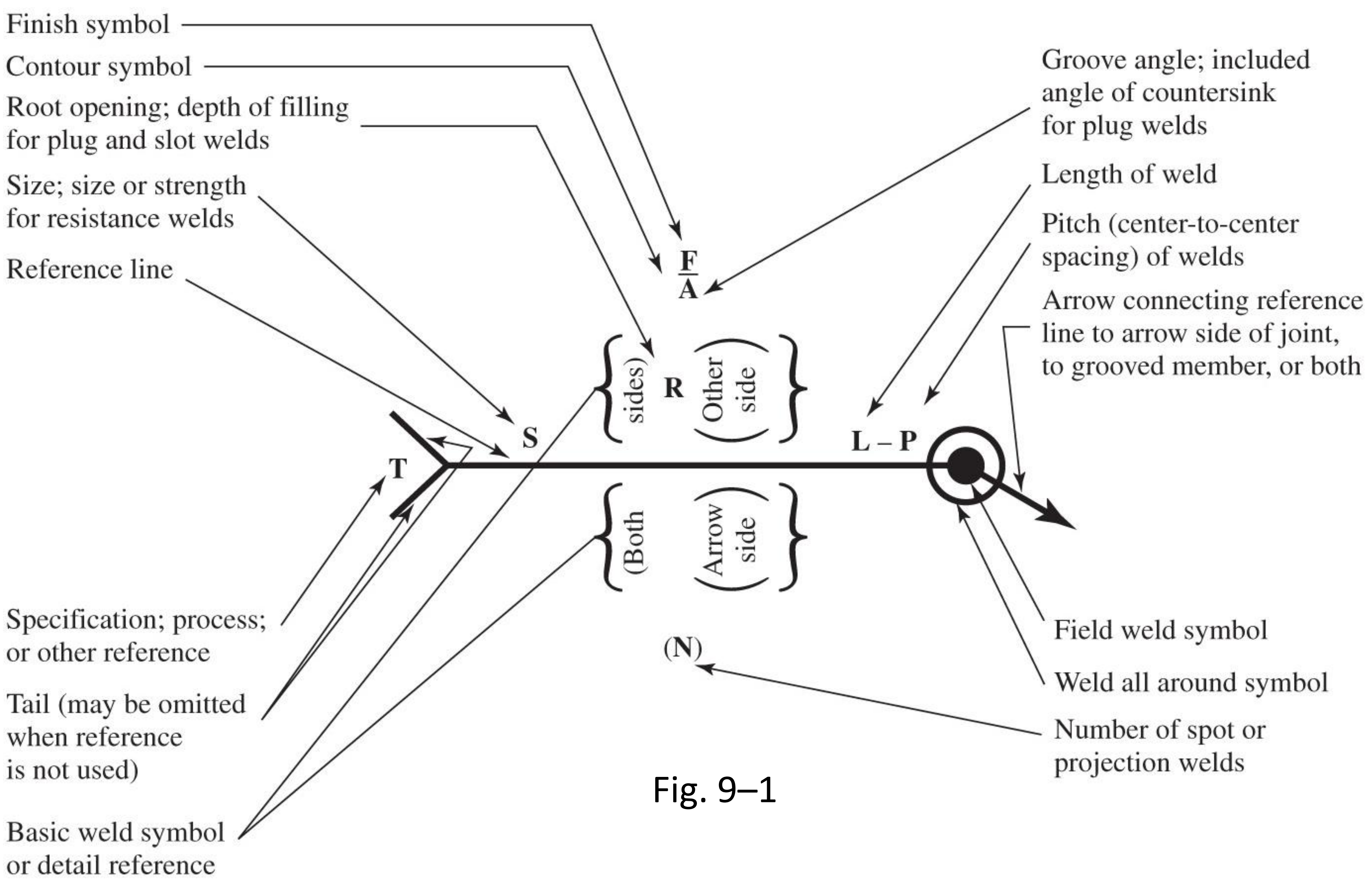
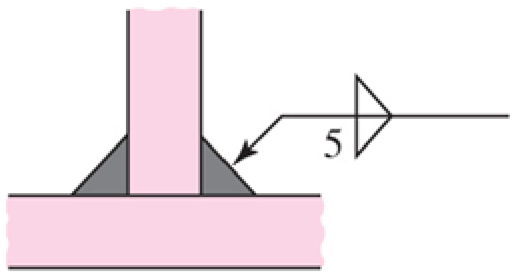


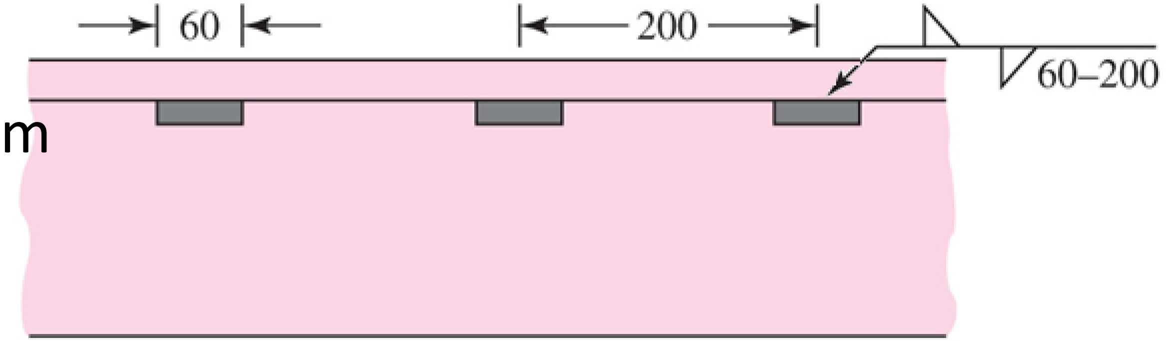
Fig. 9–1

Welding Symbol Examples

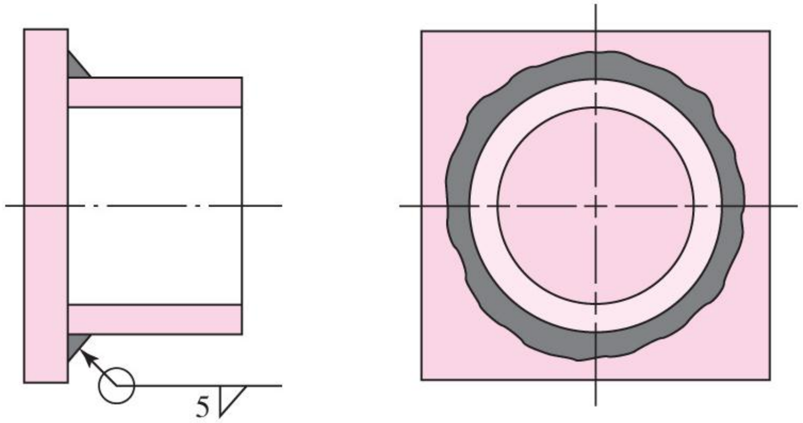
- Weld leg size of 5 mm
- Fillet weld
- Both sides



- Intermittent and staggered 60 mm along on 200 mm centers



- Leg size of 5 mm
- On one side only (outside)
- Circle indicates all the way around



Welding Symbols

- ***Arrow side*** of a joint is the line, side, area, or near member to which the arrow points
- The side opposite the arrow side is the *other side*
- Shape of weld is shown with the symbols below

Type of weld							
Bead	Fillet	Plug or slot	Groove				
			Square	V	Bevel	U	J

Fig. 9–2

Butt (Bead) Joint Loaded in Tension

- Simple butt joint loaded in tension or compression
- Stress is normal stress

$$\sigma = \frac{F}{hl} \qquad (9\text{–}1)$$

- Throat *h* does not include extra reinforcement
- Reinforcement adds some strength for static loaded joints
- Reinforcement adds stress concentration and should be ground off for fatigue loaded joints

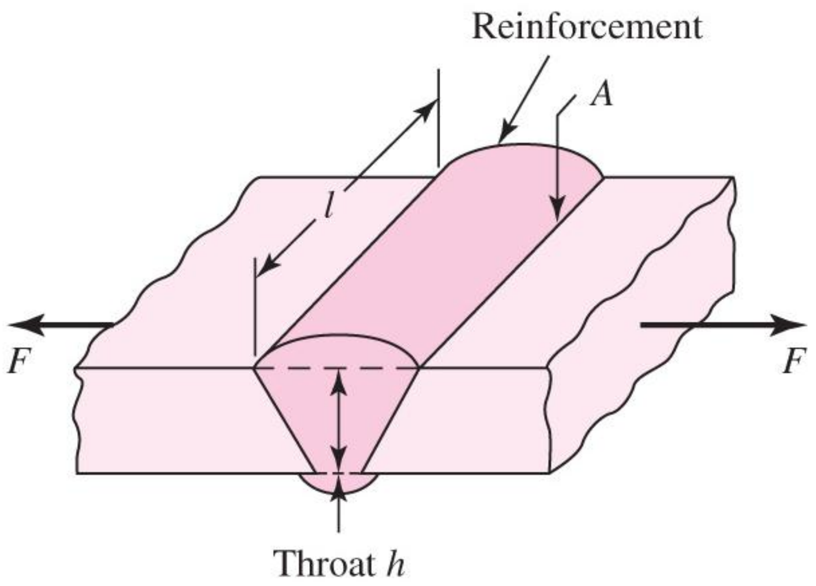


Fig. 9–7*a*

Butt Joint Loaded in Shear

- Simple butt joint loaded in shear
- Average shear stress

$$\tau = \frac{F}{hl} \qquad (9\text{–}2)$$

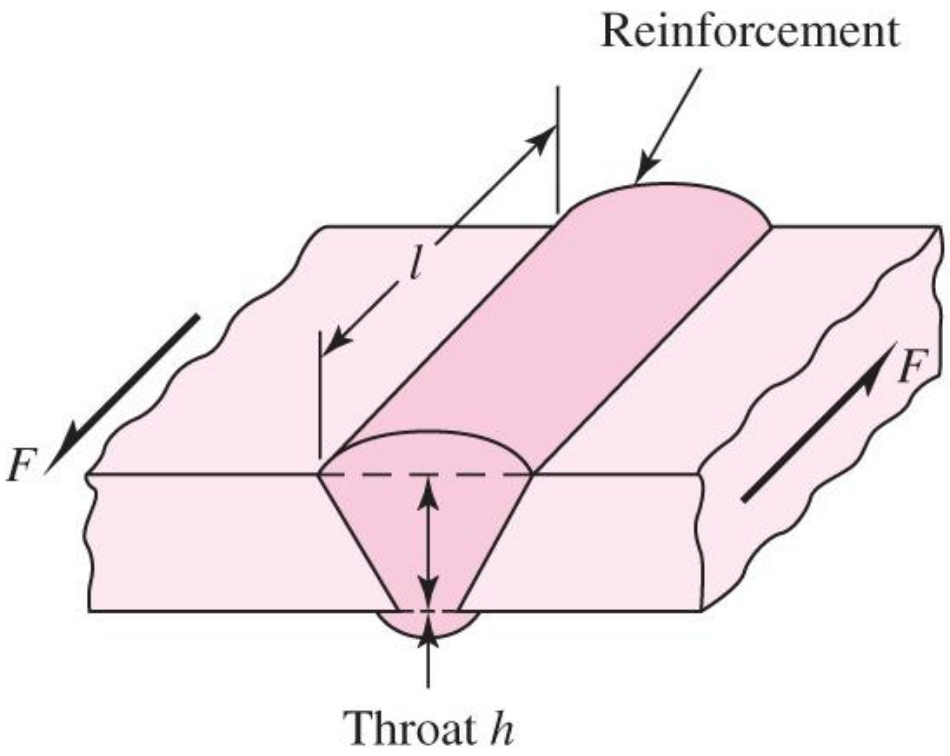
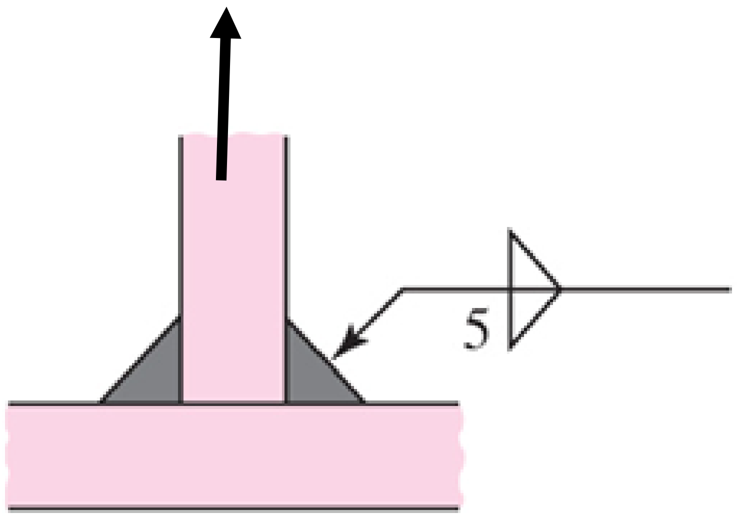


Fig. 9–7*b*

Fillet Weld Loaded with Transverse Load

- Assume the external load is carried entirely by shear forces on the minimum throat area.

$$\tau = \frac{F}{0.707hl} = \frac{1.414F}{hl} \qquad (9\text{–}3)$$



- By ignoring normal stress on throat, the shearing stresses are inflated sufficiently to render the model conservative.

Fillet Welds Loaded in Shear

Same equation also applies for simpler case of simple shear loading in fillet weld

$$\tau = \frac{F}{0.707hl} = \frac{1.414F}{hl} \qquad (9\text{–}3)$$

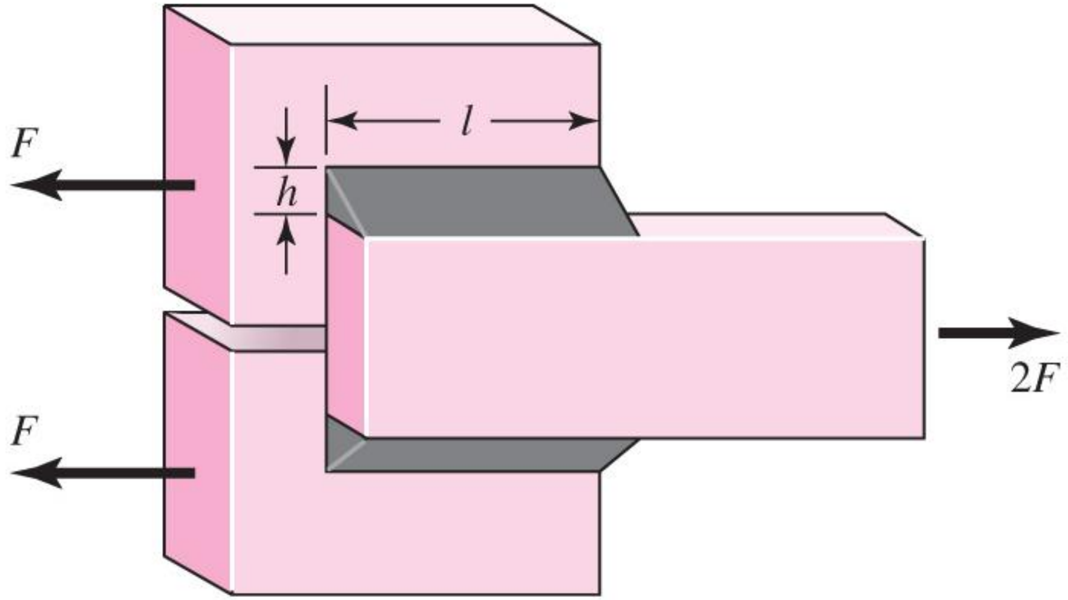


Fig. 9–11

Fillet Welds Loaded in Shear

- Fillet welds carrying both direct shear *V* and moment *M*
- *Primary shear*

$$\tau' = \frac{V}{A}$$

- *Secondary shear*

$$\tau'' = \frac{Mr}{J}$$

- *A* is the throat area of all welds
- *r* is distance from centroid of weld group to point of interest
- *J* is second polar moment of area of weld group about centroid of group

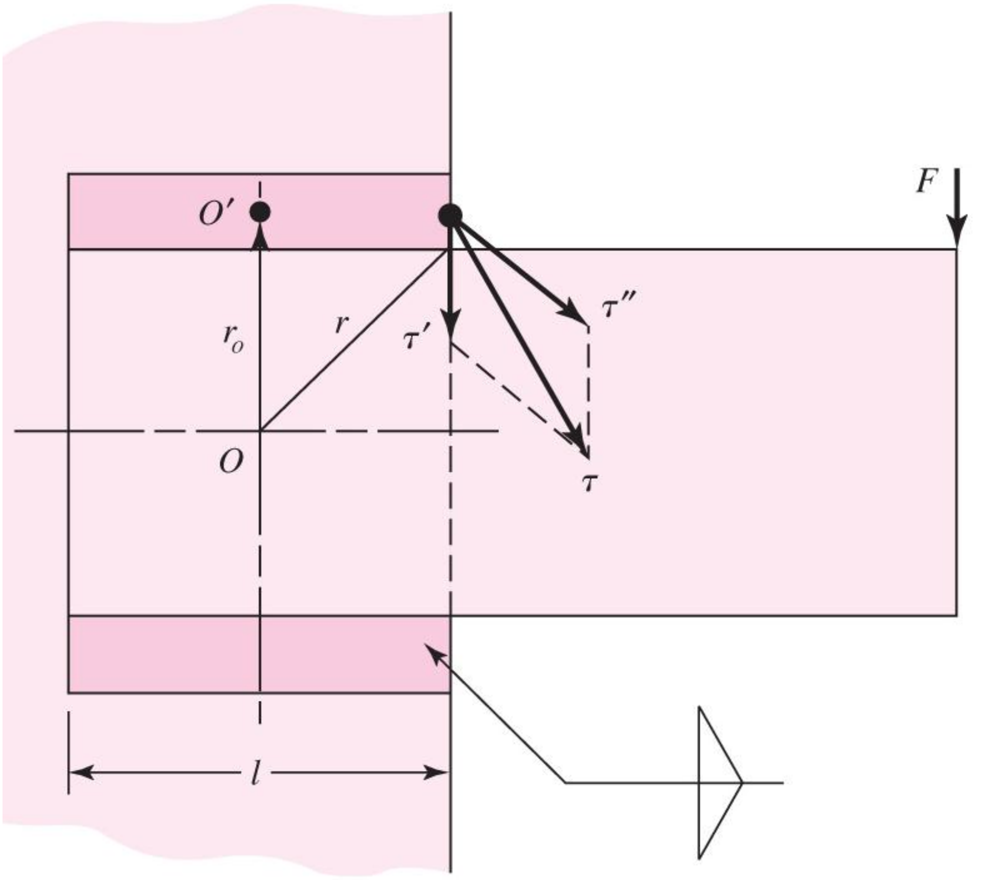
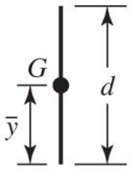
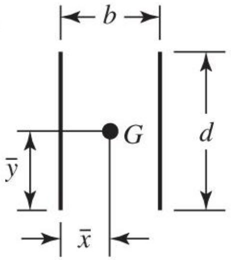
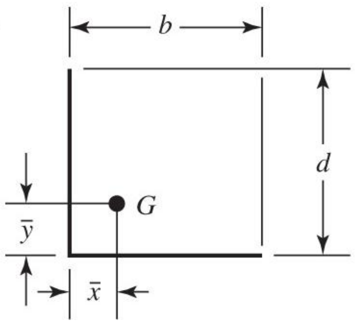
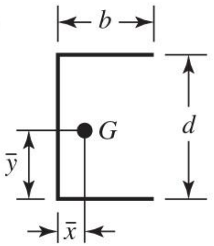
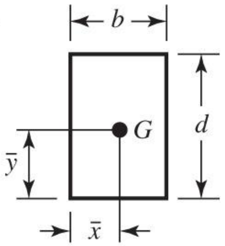
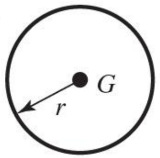


Fig. 9–12

Common Torsional Properties of Fillet Welds (Table 9–1)

Weld	Throat Area	Location of G	Unit Second Polar Moment of Area
1. 	$A = 0.707\,hd$	$\bar{x} = 0$ $\bar{y} = d/2$	$J_u = d^3/12$
2. 	$A = 1.414\,hd$	$\bar{x} = b/2$ $\bar{y} = d/2$	$J_u = \dfrac{d(3b^2 + d^2)}{6}$
3. 	$A = 0.707h(b + d)$	$\bar{x} = \dfrac{b^2}{2(b+d)}$ $\bar{y} = \dfrac{d^2}{2(b+d)}$	$J_u = \dfrac{(b+d)^4 - 6b^2d^2}{12(b+d)}$

Common Torsional Properties of Fillet Welds (Table 9–1)

4.		$A = 0.707h(2b + d)$	$\bar{x} = \dfrac{b^2}{2b + d}$ $\bar{y} = d/2$	$J_u = \dfrac{8b^3 + 6bd^2 + d^3}{12} - \dfrac{b^4}{2b + d}$
5.		$A = 1.414h(b + d)$	$\bar{x} = b/2$ $\bar{y} = d/2$	$J_u = \dfrac{(b + d)^3}{6}$
6.		$A = 1.414\,\pi hr$		$J_u = 2\pi r^3$

*G is centroid of weld group; h is weld size; plane of torque couple is in the plane of the paper; all welds are of unit width.

Fillet Welds Loaded in Bending

- **Note that the Fillet welds carry both shear *V* and moment *M***

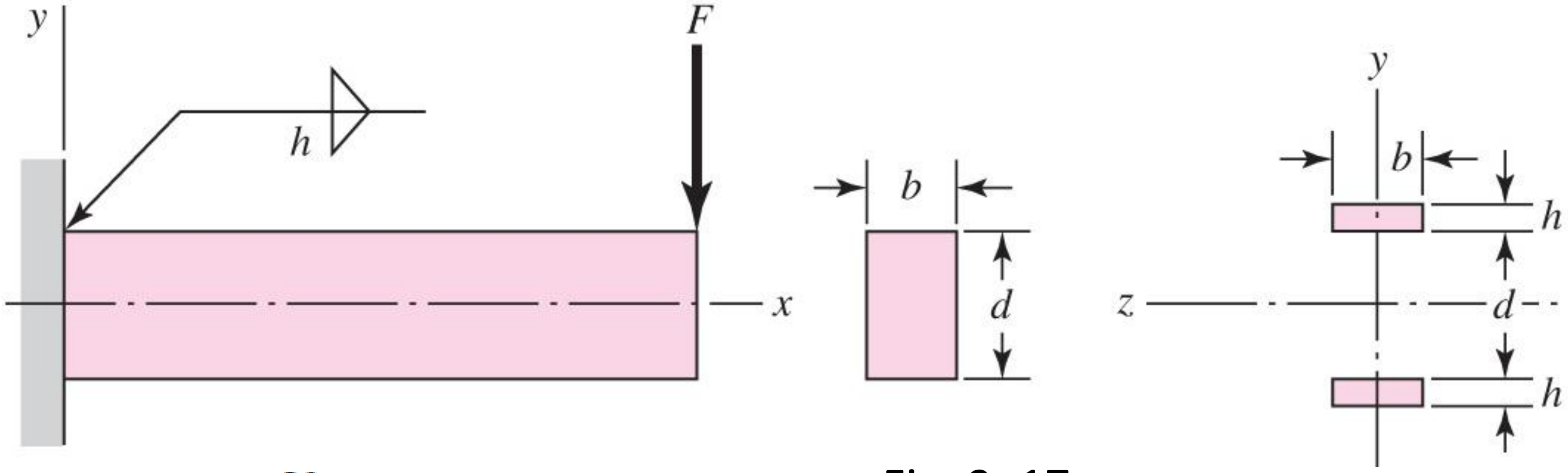


Fig. 9–17

Primary Shear $\tau' = \dfrac{V}{A}$

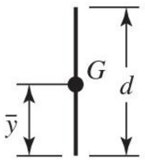
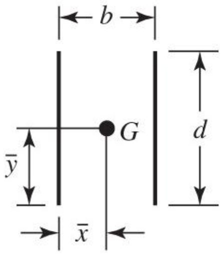
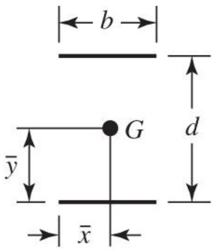
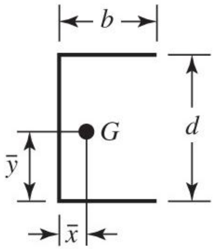
Secondary Shear $\tau'' = \dfrac{Mc}{I} = \dfrac{Md/2}{0.707hbd^2/2} = \dfrac{1.414M}{bdh}$

Total Shear $\tau = (\tau'^2 + \tau''^2)^{1/2}$

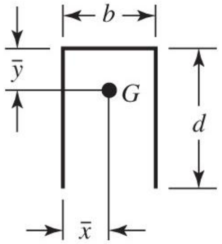
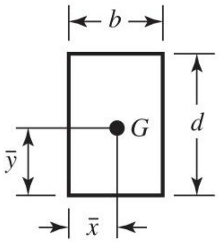
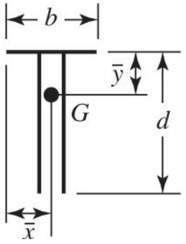
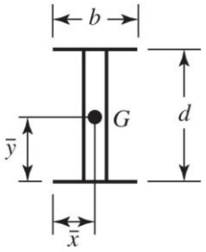
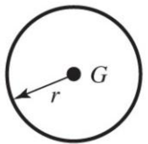
$$I_u = \frac{bd^2}{2}$$

$$I = 0.707hI_u = 0.707h\frac{bd^2}{2}$$

Bending Properties of Fillet Welds (Table 9–2)

Weld	Throat Area	Location of *G*	Unit Second Moment of Area
1. 	$A = 0.707hd$	$\bar{x} = 0$ $\bar{y} = d/2$	$I_u = \dfrac{d^3}{12}$
2. 	$A = 1.414hd$	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_u = \dfrac{d^3}{6}$
3. 	$A = 1.414hb$	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_u = \dfrac{bd^2}{2}$
4. 	$A = 0.707h(2b + d)$	$\bar{x} = \dfrac{b^2}{2b + d}$ $\bar{y} = d/2$	$I_u = \dfrac{d^2}{12}(6b + d)$

Bending Properties of Fillet Welds (Table 9–2)

5.		$A = 0.707h(b + 2d)$	$\bar{x} = b/2$ $\bar{y} = \dfrac{d^2}{b + 2d}$	$I_u = \dfrac{2d^3}{3} - 2d^2\bar{y} + (b + 2d)\bar{y}^2$
6.		$A = 1.414h(b + d)$	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_u = \dfrac{d^2}{6}(3b + d)$
7.		$A = 0.707h(b + 2d)$	$\bar{x} = b/2$ $\bar{y} = \dfrac{d^2}{b + 2d}$	$I_u = \dfrac{2d^3}{3} - 2d^2\bar{y} + (b + 2d)\bar{y}^2$
8.		$A = 1.414h(b + d)$	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_u = \dfrac{d^2}{6}(3b + d)$
9.		$A = 1.414\pi hr$		$I_u = \pi r^3$

Strengths of Welded Joint

Table 9–3

Minimum Weld-Metal Properties

AWS Electrode Number*	Tensile Strength kpsi (MPa)	Yield Strength, kpsi (MPa)	Percent Elongation
E60xx	62 (427)	50 (345)	17–25
E70xx	70 (482)	57 (393)	22
E80xx	80 (551)	67 (462)	19
E90xx	90 (620)	77 (531)	14–17
E100xx	100 (689)	87 (600)	13–16
E120xx	120 (827)	107 (737)	14

*The American Welding Society (AWS) specification code numbering system for electrodes. This system uses an E prefixed to a four- or five-digit numbering system in which the first two or three digits designate the approximate tensile strength. The last digit includes variables in the welding technique, such as current supply. The next-to-last digit indicates the welding position, as, for example, flat, or vertical, or overhead. The complete set of specifications may be obtained from the AWS upon request.

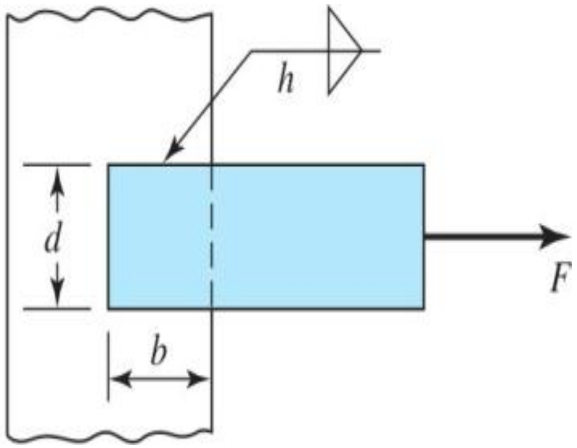
1. Let τ_{allow} = Min ($0.3S_{ut}$ or $0.4S_y$) of the Parent Material
2. The weld (joint) MUST be stronger than the parts welded together.

   $\tau_{allow} < S_y$ of the Electrode
3. Use the cheapest Electrode that satisfies this condition

Welding: Example 1 and Example 2

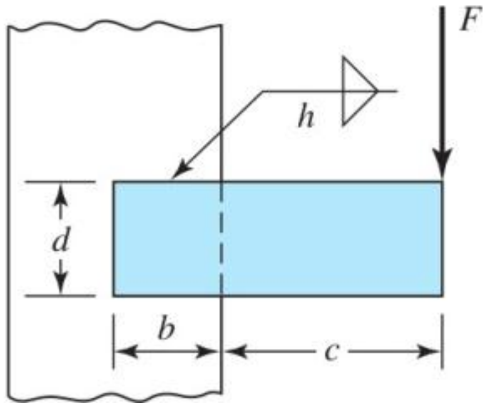
Example 1:
The Figure shows a horizontal steel bar of thickness (h) of 5 mm loaded in steady tension and welded to a vertical support.
b = 50 mm and d = 50 mm
Find the load (F) that will cause an allowable shear stress (τ_{allow}) of 140 MPa.

Problems 9–1 to 9–4



Example 2:
The Figure shows a horizontal steel bar of thickness of 5 mm welded to a vertical support as shown
b = 50 mm, d = 50 mm and c = 150 mm F = 10 KN
The bar is 1020 HR steel and the support is 1015 HR steel.
Specify the weld.

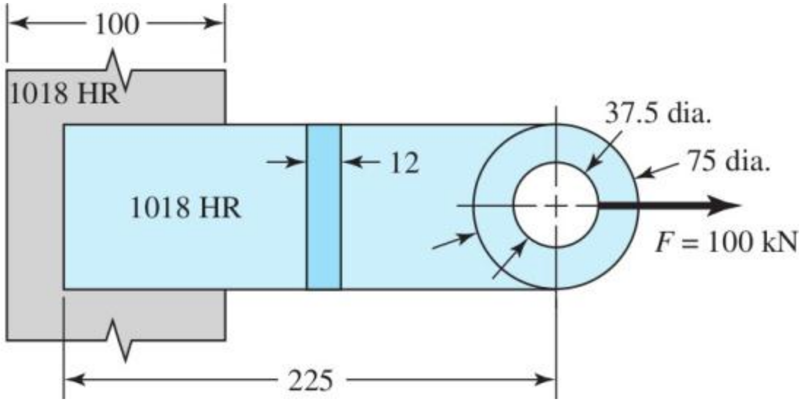
Problems 9–17 to 9–20



Welding: Example 3 and Sample Problem

Example 3:
The attachment shown is made of 1018 HR Steel 12 mm thick. The static force 10 kN is applied axially.
The member is 75 mm wide. Fillet weld is used.
Provide specifications of the weld.
Required: Weld pattern, electrode number, length of weld ,and leg size.

Problem 9–34
Dimensions in millimeters.



SAMPLE PROBLEM
The attachment shown is made of 1018 HR Steel 12 mm thick. The attachment length (L_1) is 225 mm.
The static force 10 kN is applied vertically.
The member is 75 mm wide. Fillet weld are used.
Provide specifications of the weld.
Required: Weld pattern, electrode number, length of weld ,and leg size.

Problem 9–35
Dimensions in millimeters.