Chapter Nine

Design of Permanent Joints (Welding) (تصميم الوصلات الدائمية (اللحام

9–1 Welding Symbols

A weldment is fabricated by welding together a collection of metal shapes. The welds must be precisely specified on working drawings, and this is done by using the welding symbol as shown in Fig. 9–1,

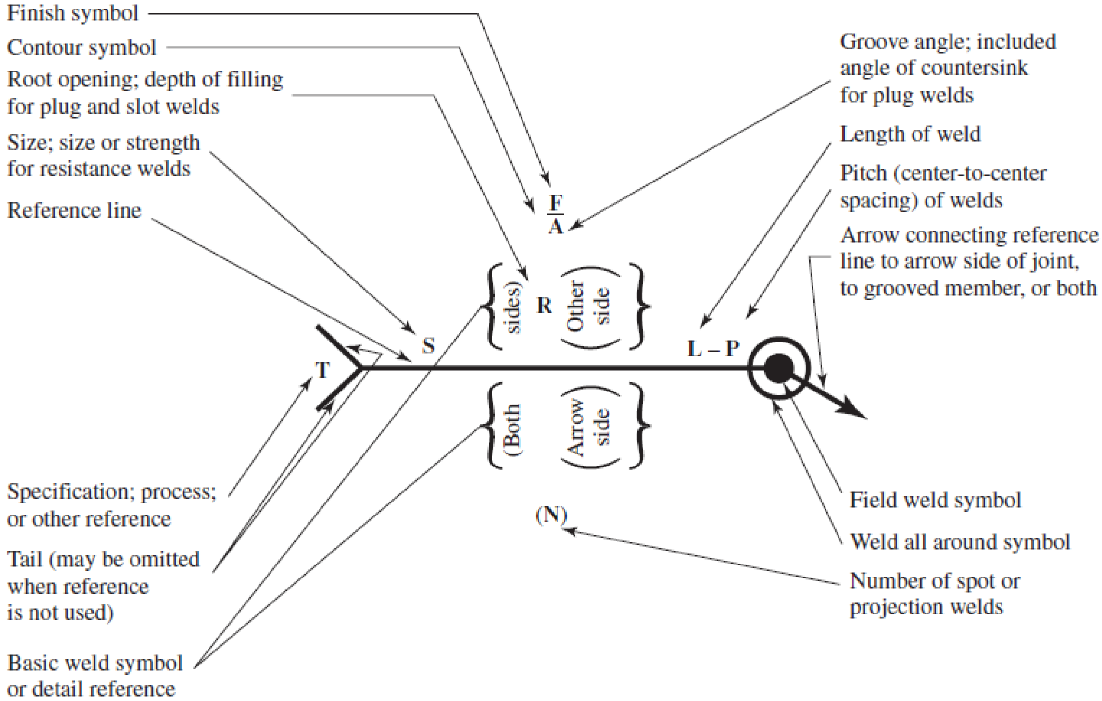


Fig. 9–1

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

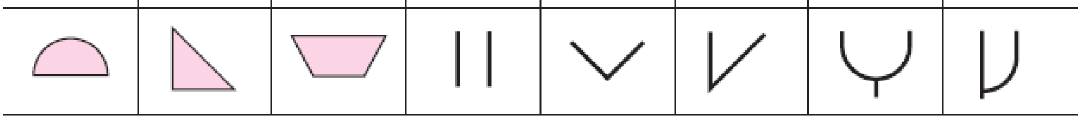


Figure 9–2 Arc- and gas-weld symbols.

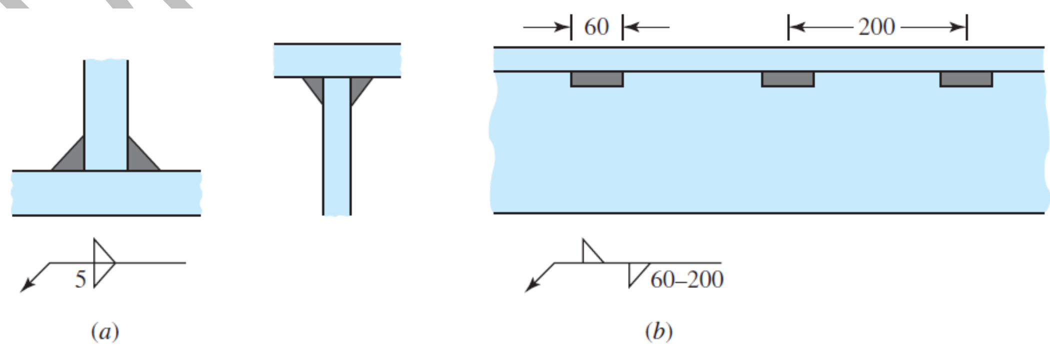


Figure 9–3:Fillet welds. اللحام التراكبي (*a*) The number indicates the leg size; the arrow should point only to one weld when both sides are the same. (*b*) The symbol indicates that the welds are intermittent and staggered 60 mm along on 200-mm centers

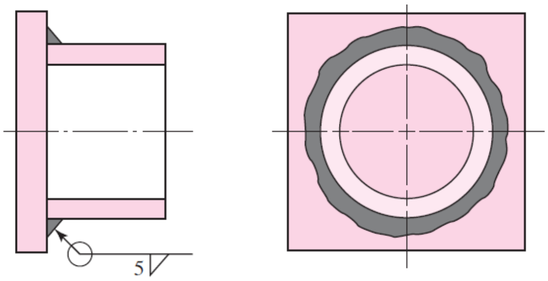


Figure 9–4 indicates the around welding

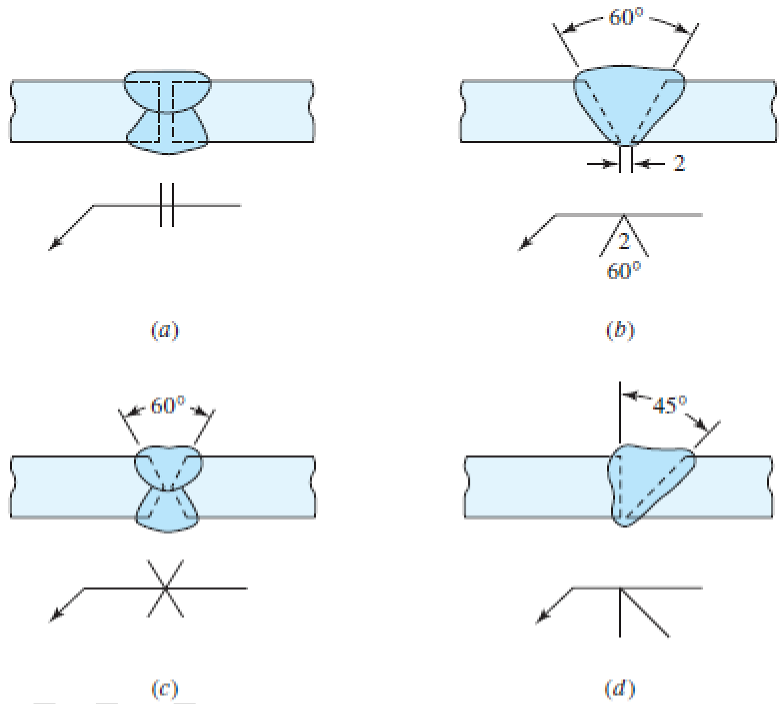


Figure 9–5

Butt or groove welds: (*a*) square butt-welded on both sides; (*b*) single V with 60° bevel and root opening of 2 mm; (*c*) double V; (*d*) single bevel.

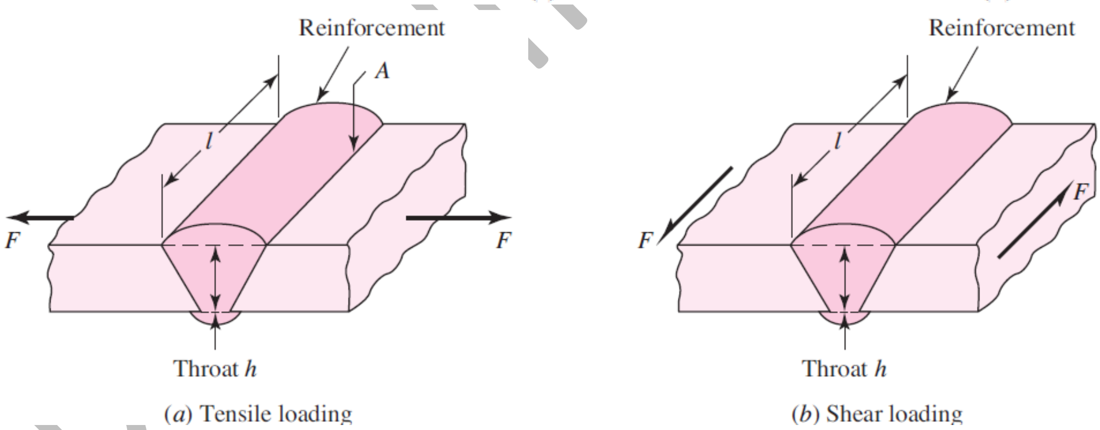


Figure 9–7 A typical butt joint اللحام التناكبي.

9–2 **Butt and Fillet Welds**

1- Butt Welds

Figure 9–7*a* shows a single V-groove weld loaded by the tensile force *F*. For either tension or compression loading, the average normal stress is

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

From figure 9–7*b*, the average shearing stress is

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

where h is the weld throat and l is the length of the weld, as shown in the figure. Note that the value of h does not include the reinforcement

2-Fillet Welds

Consider the external loading to be carried by shear forces on the throat area of the weld, Figure 9–11. By ignoring the normal stress on the throat, the shearing stresses are inflated sufficiently to render the model conservative.

For this model, the basis for weld analysis or design employs the shearing stress is:

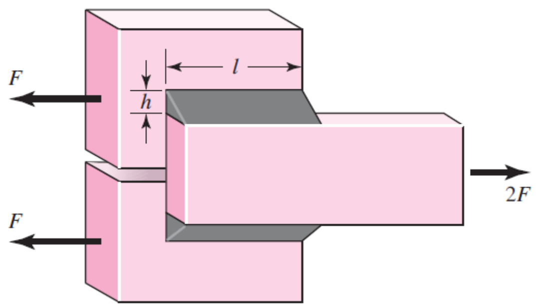


Figure 9–11: Parallel fillet welds.

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

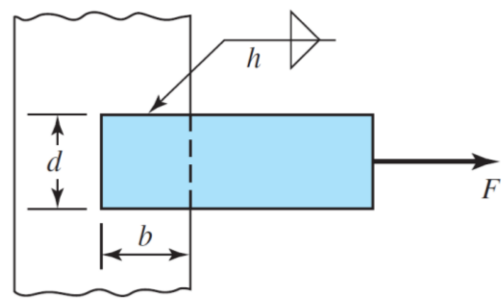
t : the welding line throat
h : the welding line height
l : the welding line length

Example 9-1:

The figure shows a horizontal steel bar of thickness h loaded in steady tension and welded to a vertical support. Find the load F that will cause an allowable shear stress, $\tau_{all} = 140\ MPa$, in the throats of the weld. $b = 50\ mm, d = 30\ mm\ h = 5\ mm$

Solution

Given, b = 50 mm, d = 30 mm, h = 5 mm, $\tau_{all} = 140\ MPa$.



From eq. $(9-3)$ $\quad F = 0.707\ hl\tau_{all}$
$= 0.707(5)[2(50)](140)(10^3) = 49.5$ kN

9–3 **Stresses in Welded Joints in Torsion**

Figure 9–12 illustrates a cantilever of length l welded to a column by two fillet welds. The reaction at the support of a cantilever always consists of a shear force V and a moment M.

The shear force produces a *primary shear* in the welds of magnitude

$$\tau' = \frac{V}{A} \qquad (9\text{-}4)$$

where A is the throat area of all the welds.

The moment at the support produces *secondary shear* or *torsion* of the welds, and this stress is given by the equation

$$\tau'' = \frac{Tr}{J} \qquad (9\text{-}5)$$

Since the throat width of a fillet weld is $0.707h$, the resulting second moment of area is then a *unit second polar moment of area*, the relationship between J and the unit value is

$$J = 0.707hJ_u \qquad (9\text{-}6)$$

J_u can be taken from table 9-1

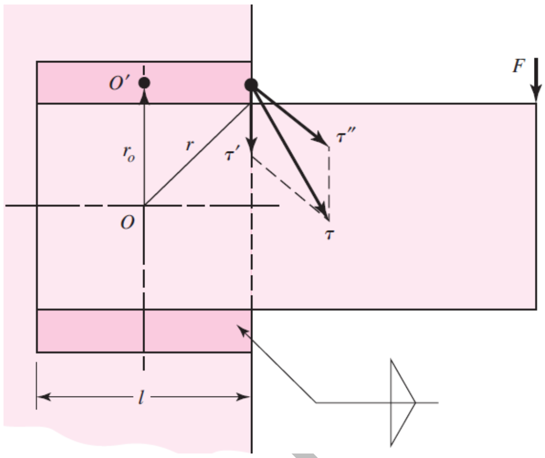
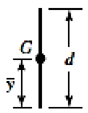
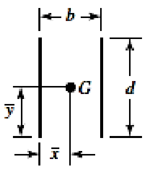
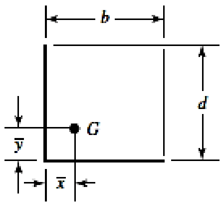
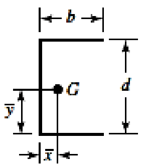
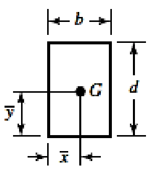


Figure 9–12 Torsion in the welds

Table 9–1: Torsional Properties of Fillet Welds*

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

Example

A 50-kN load is transferred from a welded fitting into a 200-mm steel channel as illustrated in Fig. 9–14. Estimate the maximum stress in the weld.

(*a*) Label the ends and corners of each weld by letter. See Fig. 9–15. Sometimes it is desirable to label each weld of a set by number.

(*b*) Estimate the primary shear stress τ'. As shown in Fig. 9–14, each plate is welded to the channel by means of three 6-mm fillet welds. Figure 9–15 shows that we have divided the load in half and are considering only a single plate. From case 4 of Table 9–1 we find the throat area as

$$A = 0.707(6)[2(56) + 190] = 1280 \text{ mm}^2$$

Then the primary shear stress is

$$\tau' = \frac{V}{A} = \frac{25(10)^3}{1280} = 19.5 \text{ MPa}$$

(*c*) Draw the τ' stress, to scale, at each lettered corner or end. See Fig. 9–16.

(*d*) Locate the centroid of the weld pattern. Using case 4 of Table 9–1, we find

$$\bar{x} = \frac{(56)^2}{2(56) + 190} = 10.4 \text{ mm}$$

This is shown as point O on Figs. 9–15 and 9–16.

(*e*) Find the distances r_i (see Fig. 9–16):

$$r_A = r_B = [(190/2)^2 + (56 - 10.4)^2]^{1/2} = 105 \text{ mm}$$

$$r_C = r_D = [(190/2)^2 + (10.4)^2]^{1/2} = 95.6 \text{ mm}$$

These distances can also be scaled from the drawing.

Figure 9–14

Dimensions in millimeters.

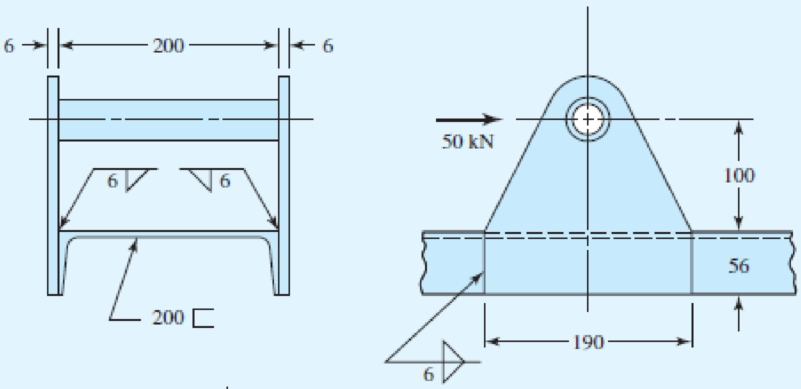


Figure 9–15

Diagram showing the weld geometry on a single plate; all dimensions in millimeters. Note that V and M represent the reaction loads applied by the welds *to the plate*.

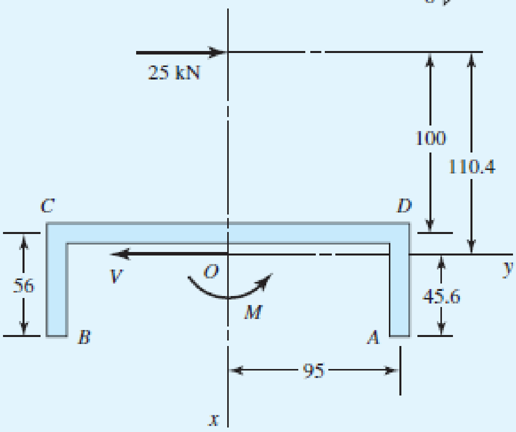
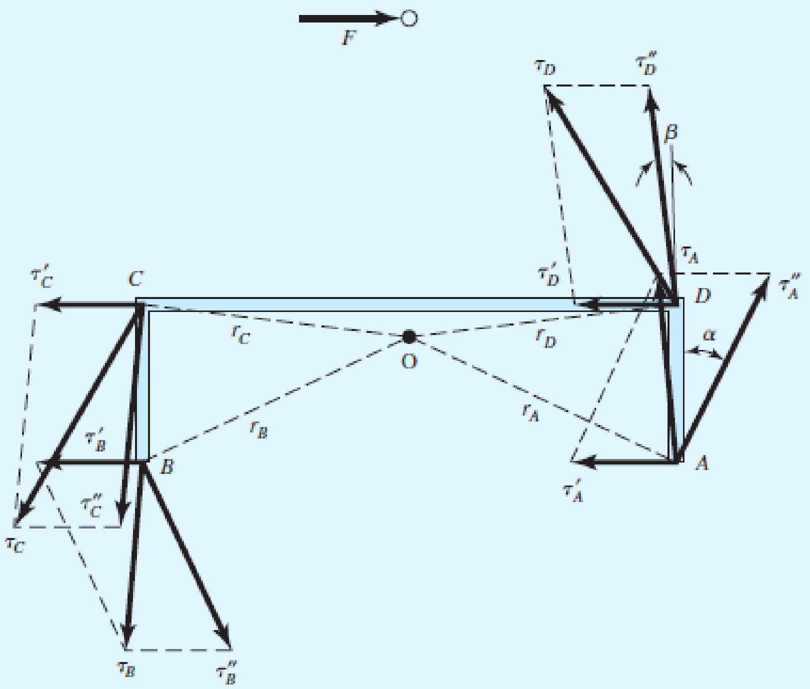


Figure 9–16

Free-body diagram of one of the side plates.



(*f*) Find *J*. Using case 4 of Table 9–1 again, with Eq. (9–6), we get

$$J = 0.707(6)\left[\frac{8(56)^3 + 6(56)(190)^2 + (190)^3}{12} - \frac{(56)^4}{2(56) + 190}\right]$$
$$= 7.07(10)^6 \text{ mm}^4$$

(*g*) Find *M*:

$$M = Fl = 25(100 + 10.4) = 2760 \text{ N} \cdot \text{m}$$

(*h*) Estimate the secondary shear stresses τ'' at each lettered end or corner:

$$\tau''_A = \tau''_B = \frac{Mr}{J} = \frac{2760(10)^3(105)}{7.07(10)^6} = 41.0 \text{ MPa}$$

$$\tau''_C = \tau''_D = \frac{2760(10)^3(95.6)}{7.07(10)^6} = 37.3 \text{ MPa}$$

$$\tau_A = \tau_B = \sqrt{(19.5 - 41.0 \sin 25.64°)^2 + (41.0 \cos 25.64°)^2} = 37.0 \text{ MPa}$$

Similarly, for *C* and *D*, $\beta = \tan^{-1}(10.4/95) = 6.25°$. Thus

$$\tau_C = \tau_D = \sqrt{(19.5 + 37.3 \sin 6.25°)^2 + (37.3 \cos 6.25°)^2} = 43.9 \text{ MPa}$$

(*k*) Identify the most highly stressed point:

Answer
$$\tau_{max} = \tau_C = \tau_D = 43.9 \text{ MPa}$$

9–4 **Stresses in Welded Joints in Bending**

Figure 9–17*a* shows a cantilever welded to a support by fillet welds at top and bottom. A free-body diagram of the beam would show a shear-force reaction *V* and a moment reaction *M*. The shear force produces a primary shear in the welds of magnitude

$$\tau' = \frac{V}{A} \quad \ldots\ldots\ldots\ldots\ldots (a)$$

where A is the total throat area.

$$\tau'' = \frac{Mc}{I} \quad \ldots\ldots\ldots\ldots(b)$$

$$I = 0.707hI_u \quad \ldots\ldots.(c)$$

$$\boldsymbol{\tau} = \sqrt{\boldsymbol{\tau}'^2 + \boldsymbol{\tau}''^2} \quad \ldots\ldots\ldots\ldots(\boldsymbol{d})$$

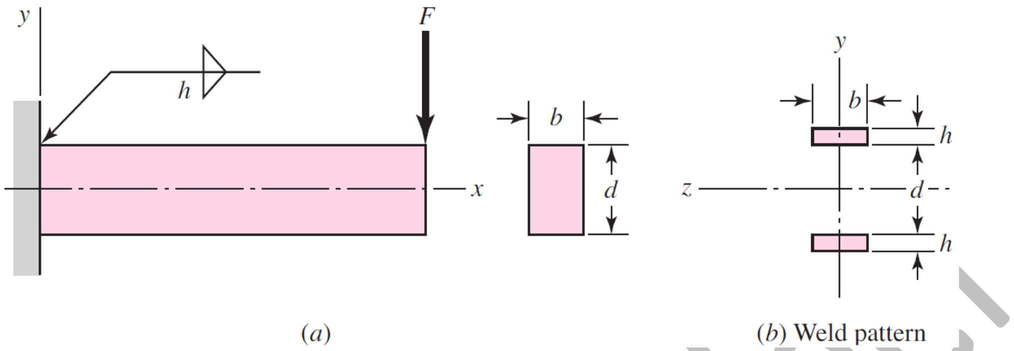
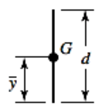
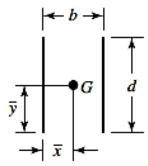
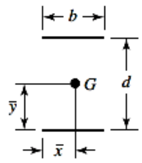
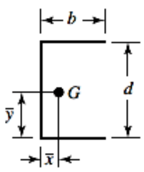
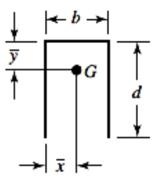
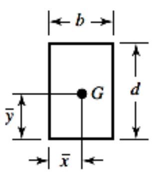
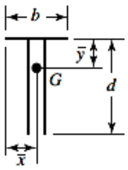
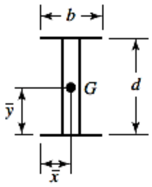


Figure 9–17: A rectangular cross-section cantilever welded to a support at the top and bottom edges.

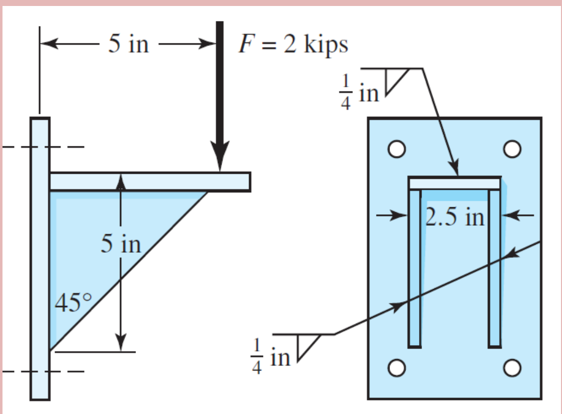
Table 9–2: Bending Properties of Fillet Welds*

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

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

Example (Bending Welds) (P 9 - 48)

The figure shows a welded steel bracket loaded by a static force F. Estimate the factor of safety, if the allowable shear stress in the weld throat is 18 kpsi.



$h = 0.25\ in, \quad b = 2.5\ in, \quad d = 5\ in.$

Table 9 − 2, case 5: $A = 0.707h\ (b + 2d)$

$= 0.707(0.25)[2.5 + 2(5)]$

$= 2.209\ in^2$

$$\bar{y} = \frac{d^2}{b+2d} = \frac{5^2}{2.5+2(5)} = 2 \text{ in}$$

$$I_u = \frac{2d^3}{3} - 2d^2\bar{y} + (b+2d)\bar{y}^2$$

$$I_u = \frac{2d^3}{3} - 2d^2\bar{y} + (b+2d)\bar{y}^2$$

$$I_u = \frac{2\times5^3}{3} - 2(5^2)(2) + (2.5 + 2(5))(2^2) = 33.33\ in^3$$

$$I = 0.707\ h\ I_u = 0.707\left(\frac{1}{4}\right)(33.33) = 5.891\ in^4$$

Primary shear:

$$\tau' = \frac{F}{A} = \frac{2}{2.209} = 0.905 \text{ kpsi}$$

Secondary shear (the critical location is at the bottom of the bracket):

$$y = 5 - 2 = 3 \text{ in}$$

$$\tau'' = \frac{My}{I} = \frac{2(5)(3)}{5.891} = 5.093 \text{ kpsi}$$

$$\tau_{\max} = \sqrt{\tau'^2 + \tau''^2} = \sqrt{0.905^2 + 5.093^2}$$

=5.173 kpsi

$$n = \frac{\tau_{\text{all}}}{\tau_{\max}} = \frac{18}{5.173} = 3.48$$

EXAMPLE 9–4 Perform an adequacy assessment of the statically loaded welded cantilever carrying 500 lbf depicted in Fig. 9–20. The cantilever is made of AISI 1018 HR steel and welded with a $\frac{3}{8}$-in fillet weld as shown in the figure. An E6010 electrode was used, and the design factor was 3.0.

(*a*) Use the conventional method for the weld metal.

(*b*) Use the conventional method for the attachment (cantilever) metal.

(*c*) Use a welding code for the weld metal.

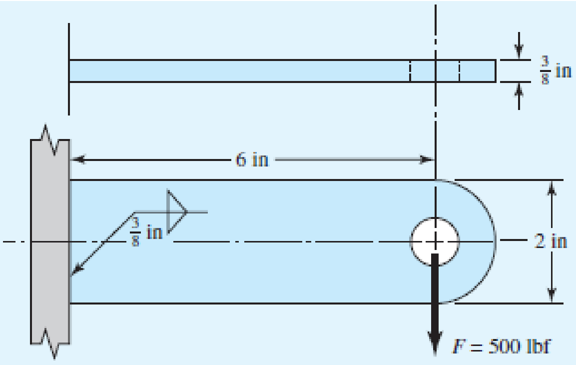
Solution (*a*) From Table 9–3, S_y = 50 kpsi, S_{ut} = 62 kpsi. From Table 9–2, second pattern, b = 0.375 in, d = 2 in, so

$$A = 1.414hd = 1.414(0.375)2 = 1.06 \text{ in}^2$$

$$I_u = d^3/6 = 2^3/6 = 1.33 \text{ in}^3$$

$$I = 0.707hI_u = 0.707(0.375)1.33 = 0.353 \text{ in}^4$$

Figure 9–20



Primary shear:

$$\tau' = \frac{F}{A} = \frac{500(10^{-3})}{1.06} = 0.472 \text{ kpsi}$$

Secondary shear:

$$\tau'' = \frac{Mr}{I} = \frac{500(10^{-3})(6)(1)}{0.353} = 8.50 \text{ kpsi}$$

The shear magnitude τ is from the vector addition

$$\tau = (\tau'^2 + \tau''^2)^{1/2} = (0.472^2 + 8.50^2)^{1/2} = 8.51 \text{ kpsi}$$

Secondary shear:

$$\tau'' = \frac{Mr}{I} = \frac{500(10^{-3})(6)(1)}{0.353} = 8.50 \text{ kpsi}$$

The shear magnitude τ is from the vector addition

$$\tau = (\tau'^2 + \tau''^2)^{1/2} = (0.472^2 + 8.50^2)^{1/2} = 8.51 \text{ kpsi}$$

The factor of safety based on a minimum strength and the distortion-energy criterion is

Answer

$$n = \frac{S_{sy}}{\tau} = \frac{0.577(50)}{8.51} = 3.39$$

Since $n \geq n_d$, that is, $3.39 \geq 3.0$, the weld metal has satisfactory strength.

(*b*) From Table A–20, minimum strengths are $S_{ut} = 58$ kpsi and $S_y = 32$ kpsi. Then

$$\sigma = \frac{M}{I/c} = \frac{M}{bd^2/6} = \frac{500(10^{-3})6}{0.375(2^2)/6} = 12 \text{ kpsi}$$

Answer

$$n = \frac{S_y}{\sigma} = \frac{32}{12} = 2.67$$

Since $n < n_d$, that is, $2.67 < 3.0$, the joint is unsatisfactory as to the attachment strength.

9–5 **The Strength of Welded Joints**

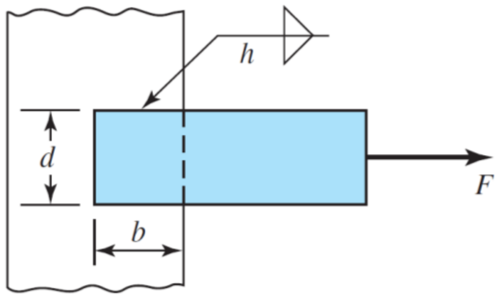
The matching of the electrode properties with those of the parent metal is usually not so important as speed, operator appeal, and the appearance of the completed joint.

The properties of electrodes vary considerably, but Table 9–3 lists the minimum properties for some electrode classes. It is preferable, in designing welded components, to select a steel that will result in a fast, economical weld even though this may require a sacrifice of other qualities such as machinability.

Under the proper conditions, all steels can be welded, but best results will be obtained if steels having a UNS specification between G10140 and G10230 are chosen.

Example 9-2:

For the weldment shown in Fig., the electrode metal is E7010, what is the allowable load on the weldment? $b = 50\ mm, d = 30\ mm\ h = 5\ mm$



Solution:

From table 9-6 $f = 513$ N/mm

$F = f\ l = 513[2(50)] = 51.3$ kN

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

Table 9–4 Stresses Permitted by the AISC Code for Weld Metal

Type of Loading	Type of Weld	Permissible Stress	n*
Tension	Butt	$0.60S_y$	1.67
Bearing	Butt	$0.90S_y$	1.11
Bending	Butt	$0.60–0.66S_y$	1.52–1.67
Simple compression	Butt	$0.60S_y$	1.67
Shear	Butt or fillet	$0.30S_{ut}^{\dagger}$	

*The factor of safety *n* has been computed by using the distortion-energy theory.

†Shear stress on base metal should not exceed $0.40S_y$ of base metal.

Table 9–5 Fatigue Stress-Concentration Factors, K_{fs}

Type of Weld	K_{fs}
Reinforced butt weld	1.2
Toe of transverse fillet weld	1.5
End of parallel fillet weld	2.7
T-butt joint with sharp corners	2.0

IMPORTANT NOTES

- The best welded steels have a tensile strength in the hot-rolled condition in the range of 410 to 480 MPa, so a cold-drawn bar has its cold-drawn properties replaced with the hot-rolled properties in the vicinity of the weld.
- Table 9–3 lists the minimum properties for some electrode classes.
- It is important to observe that the electrode material is often the strongest material present a welded joint.
- Table 9–4 lists the formulas specified by the code for calculating these permissible stresses for various loading conditions
- Finally, remembering that the weld metal is usually the strongest, do check the stresses in the parent metals.

Table 9-6

Schedule A: Allowable Load for Various Sizes of Fillet Welds

	Strength Level of Weld Metal (EXX)						
	60*	70*	80	90*	100	110*	120
	Allowable shear stress on throat, MPa of fillet weld or partial penetration groove weld						
$\tau =$	124	145	165	186	207	228	248
	Allowable Unit Force on Fillet Weld, N/mm						
$^{\dagger}f =$	$87.67h$	$102.52h$	$116.66h$	$131.5h$	$146.35h$	$161.2h$	$175.34h$
Leg Size h, mm	Allowable Unit Force for Various Sizes of Fillet Welds N/mm						
25	2192	2563	2916	3288	3659	4030	4383
22	1929	2255	2566	2893	3220	3546	3857
20	1753	2050	2333	2630	2927	3224	3506
16	1403	1640	1866	2104	2342	2579	2805
12	1052	1230	1400	1578	1756	1934	2104
11	964	1127	1283	1447	1610	1773	1927
10	877	1025	1167	1315	1463	1612	1753
8	701	820	933	1052	1171	1290	1403
6	526	615	700	789	878	967	1052
5	438	513	583	658	732	806	877
3	263	308	350	395	439	484	526
2	175	205	233	263	293	322	351

*Fillet welds actually tested by the joint AISC-AWS Task Committee.
$^{\dagger}f = 0.707h\,\tau_{all}$.

... Weldment Design, D412, The James F. Linc

Example 9-3 (Torsion welds) (P 9-17)

A steel bar of thickness h, to be used as a beam, is welded to a vertical support by two fillet welds as shown in the figure.

(a) Find the safe bending force F if the allowable shear stress in the welds is tallow.

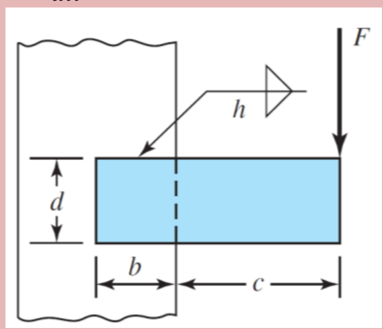
(b) In part a, you found a simple expression for F in terms of the allowable shear stress. Find the allowable load if the electrode is E7010, the bar is hot-rolled 1020, and the support is hot-rolled 1015.

Solution

(a) $b = d = 50$ mm, $c = 150$ mm, $h = 5$ mm, and $\tau_{all} = 140\ MPa$

Primary shear, from Table 9-1, Case 2

Note: b and d are interchanged between problem figure and table figure. Note, also, F in kN and τ_{all} in MPa

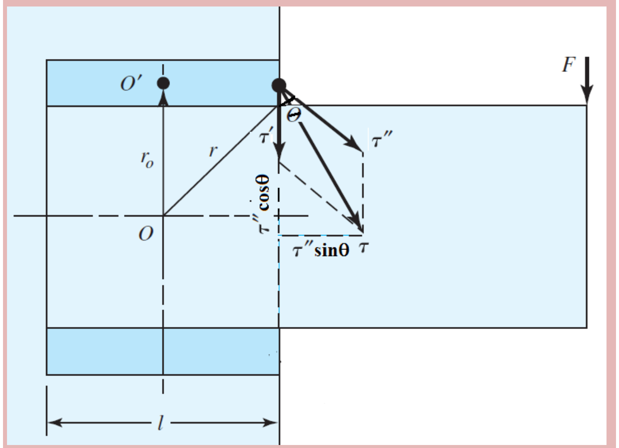


$$\tau' = \frac{V}{A} = \frac{F(10^3)}{1.414(5)(50)} = 2.829F$$

Secondary shear (Table 9-1, Case 2)

$$J_u = \frac{d(3b^2 + d^2)}{6} = \frac{50(3(50)^2 + (50)^2)}{6}$$
$$= 83333\ mm^3$$

$$J = 0.707\, h\, J_u = 0.707(5)(83333)$$
$$= 294626 \text{ mm}^4$$



$$r_A = \sqrt{25^2 + 25^2} = 35.4\, mm$$

$$\tau'' = \frac{Mr_A}{J} = \frac{175F(10^3)(35.4)}{294626} = 21F$$

$$\tau_{all}^2 = (\tau'' \sin\theta + \tau')^2 + (\tau'' \cos\theta)^2$$
$$= (21F\cos 45 + 2.829F)^2 + (21F \sin 45)^2$$
$$\tau_{all} = 23.1F \quad (*)$$
$$140 = 23.1F$$
$$F = 6.06\ kN$$

(b): (weld strength)

For **E7010** $\tau_{all} = 145$ MPa (Table 9-6)

1020 HR bar:$S_u = 380\ MPa, S_y = 210\ MPa$

1015 HR support $S_u = 340\ MPa,\ S_y = 190\ MPa$

E7010 $S_u = 482\ MPa, S_y = 393\ MPa$ (Table 9-3)

The support controls the design.

Table 9-4: $\tau_{all} = (0.3S_u \text{ or } 0.4S_y) = 0.3(340) \text{ or } 0.4(190) = (102 \text{ or } 76)$

select $\tau_{all} = 76\ MPa$

The allowable load, from Eq. (*) is

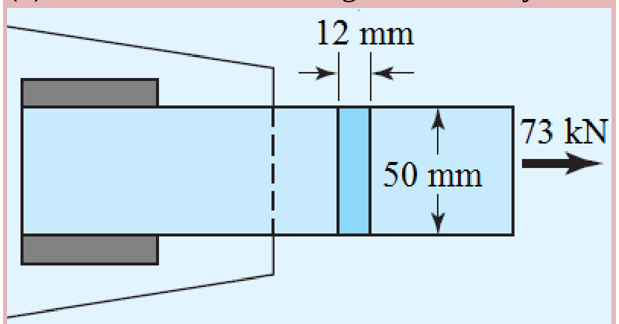
$\tau_{all} = 23.1F \rightarrow 76 = 23.1F \rightarrow F = 3.29\ kN$

EXAMPLE 9–5

A 12 mm by 50 mm rectangular-cross-section 1015 bar carries a static load of 73 kN. It is welded to a gusset plate with a 10 mm fillet weld 50 mm long on both sides with an E70XX electrode as depicted in the figure. Use the welding code method.

(*a*) Is the weld metal strength satisfactory?

(*b*) Is the attachment strength satisfactory?



Solution

(*a*) From Table 9–6, (من الكتاب).

Allowable force per unit length for a 10 mm E70 electrode metal is 1025 N/mm of weldment; thus

$F = 1025l = 1025(50\text{x}2) = 102.5$ kN

Since 102.5 > 73 kN, weld metal strength is satisfactory.

(*b*) Check shear in attachment adjacent to the welds.

S_y= 190 MPa (Table A–20)

The allowable attachment shear stress is

From Table 9–4

$$\tau_{all} = \begin{cases} 0.4S_y = 0.4(190) = 76\ MPa \\ 0.3S_u = 0.3(340) = 102\ MPa \end{cases}$$

$$\tau_{all} = 76\ MPa$$

The shear stress τ on the base metal adjacent to the weld is

$$\tau = \frac{F}{2hl} = \frac{73000}{2(10)(50)} = 73\ MPa$$

Since $\tau_{all} \geq$, the attachment is satisfactory near the weld beads.

The tensile stress in the shank of the attachment is

$$\sigma = \frac{F}{tl} = \frac{73000}{12(50)} = 122\ MPa$$

The allowable tensile stress σ_{all}, from Table 9–4, is $0.6S_y$ and, with welding code safety level preserved,

$$\sigma_{all} = 0.6S_y = 0.6(190) = 114\ MPa$$

Since $\geq \sigma_{all}$, the shank tensile stress is not satisfactory

To overcome this problem a new dimensions or new material may be selected. let $\sigma = \sigma_{all} = 114$ MPa

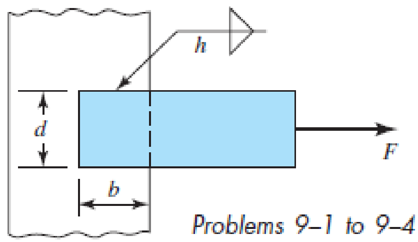
$$\sigma = \frac{F}{tl} = \frac{73000}{t(50)} = 114 \text{ MPa}$$

$$t = 12.8 \text{ mm, say } 13 \text{ mm} \qquad \text{[Ans]}$$

PROBLEMS

9–1 to 9–4 The figure shows a horizontal steel bar of thickness h loaded in steady tension and welded to a vertical support. Find the load F that will cause an allowable shear stress, τ_{allow}, in the throats of the welds.

Problem Number	b	d	h	τ_{allow}
9–1	50 mm	50 mm	5 mm	140 MPa
9–3	50 mm	30 mm	5 mm	140 MPa



Problems 9–1 to 9–4

9–5 to 9–8 For the weldments of Probs. 9–1 to 9–4, the electrodes are specified in the table. For the electrode metal indicated, what is the allowable load on the weldment?

Problem Number	Reference Problem	Electrode
9–5	9–1	E7010
9–7	9–3	E7010

9–9 to 9–12 The materials for the members being joined in Probs. 9–1 to 9–4 are specified below. What load on the weldment is allowable because member metal is incorporated in the welds?

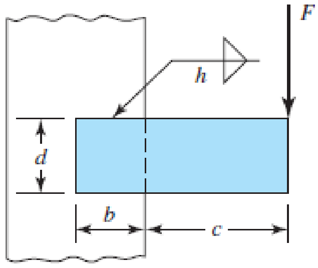
Problem Number	Reference Problem	Bar	Vertical Support
9–9	9–1	1018 CD	1018 HR
9–11	9–3	1035 HR	1035 CD

9–17 to 9–20 A steel bar of thickness h, to be used as a beam, is welded to a vertical support by two fillet welds as shown in the figure.

(*a*) Find the safe bending force F if the allowable shear stress in the welds is τ_{allow}.

(*b*) In part *a*, you found a simple expression for F in terms of the allowable shear stress. Find the allowable load if the electrode is E7010, the bar is hot-rolled 1020, and the support is hot-rolled 1015.

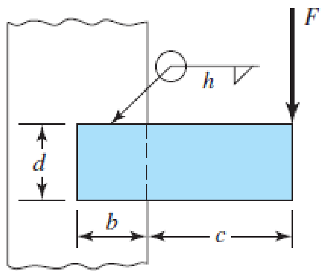
Problem Number	b	c	d	h	τ_{allow}
9–17	50 mm	150 mm	50 mm	5 mm	140 MPa
9–19	50 mm	150 mm	30 mm	5 mm	140 MPa



Problems 9–17 to 9–20

9–21 to 9–24 The figure shows a weldment just like that for Probs. 9–17 to 9–20 except there are four welds instead of two. Find the safe bending force F if the allowable shear stress in the welds is τ_{allow}.

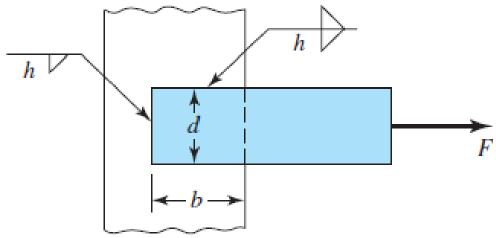
Problem Number	b	c	d	h	τ_{allow}
9–21	50 mm	150 mm	50 mm	5 mm	140 MPa
9–23	50 mm	150 mm	30 mm	5 mm	140 MPa



Problems 9–21 to 9–24

9–25 to 9–28 The weldment shown in the figure is subjected to an alternating force F. The hot-rolled steel bar has a thickness h and is of AISI 1010 steel. The vertical support is likewise AISI 1010 HR steel. The electrode is given in the table below. Estimate the fatigue load F the bar will carry if three fillet welds are used.

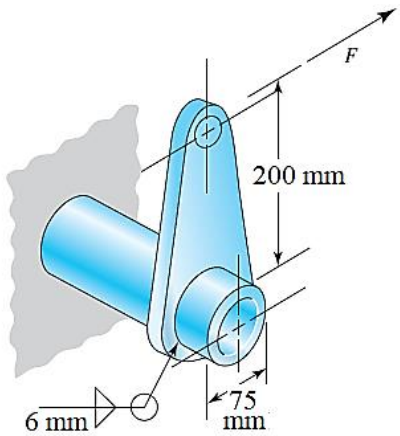
Problem Number	b	d	h	Electrode
9–25	50 mm	50 mm	5 mm	E6010
9–27	50 mm	30 mm	5 mm	E7010



Problems 9–25 to 9–28

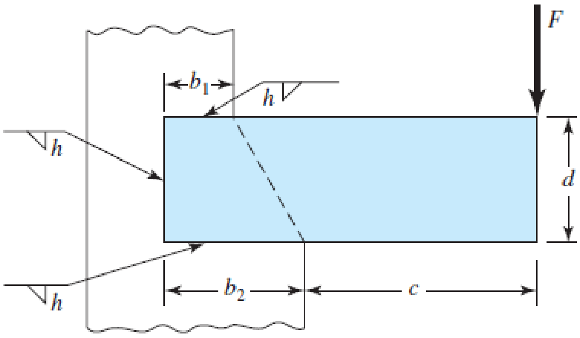
9–29 The permissible shear stress for the weldment illustrated is 140 MPa. Estimate the load, F, that will cause this stress in the weldment throat.

Problem 9–29

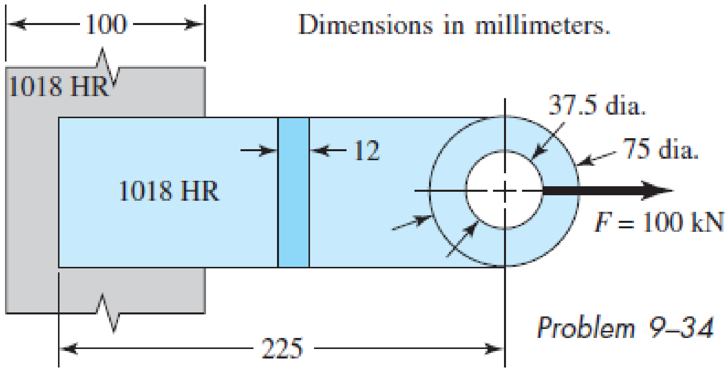


9–31 A steel bar of thickness h is subjected to a bending force F. The vertical support is stepped such that the horizontal welds are b_1 and b_2 long. Determine F if the maximum allowable shear stress is τ_{allow}.

b_1	b_2	c	d	h	τ_{allow}
30 mm	50 mm	150 mm	50 mm	5 mm	140 MPa



9–34 The attachment shown in the figure is made of 1018 HR steel 12 mm thick. The static force is 100 kN. The member is 75 mm wide. Specify the weldment (give the pattern, electrode number, type of weld, length of weld, and leg size).



Problem 9–34